KEYNOTE ADDRESSES

Forest Products and the Environment: A Productive Symbiosis

Howard N. ROSEN[1]

Abstract
Symbiosis can be defined as a mutually beneficial relationship. Can there be a symbiotic relationship between forest products and the environment? If there is symbiosis of forest products and the environment, human beings are central to the process. Historically forests have always played a significant role in the human environment. At one end of the relationship, forests help provide the oxygen in the air we breathe, as well as basic needs of shelter, food, and fuel. On the other end of the relationship, a healthy environment with little pollution, fewer weather extremes, and a reduction in forest fires, can advance the use of forest products. Over time the relationship between forest products use and environment has changed. As human population has significantly increased, we have begun to look at the need for a positive, sustainable relationship of forest products use in the human environment.

How important is the forest to the human environment? Forests cover about 30 percent, 3.9 trillion hectares, of the total land area of the world. Each hectare averages about 110 metric tons of biomass from which 6.6 billion of the world's people consume a significant variety of products. As our world population and forest products consumption continues to grow, the symbiotic relationship between forest products and the environment becomes more complex.

There are several critical contemporary issues related to forest products and the environment. For example, the use of wood to provide energy is a worldwide need, since about half the wood consumed in the world provides energy—from fuel for a wood stove to input for an electric power plant. The use of forest products can also play a role in the sequestering of carbon to ameliorate climate change and reduction of forest fire risk. Finally, the use of wood compared to other raw materials, can have an environmental advantage.

The continued beneficial relationship between the use of forest products and a healthy human environment should be a focus of research in wood science and forest products.

Key words: Shelter, forest fire, fuel, energy, climate change

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Taiwan Forestry – Current Status and Strategy to Global Warming

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Abstract

A new stage to challenge the mission of alleviating the threats and harms resulted from global climate change is coming since the Kyoto Protocol came into effect on February 16, 2005. Forest resources cover 58.5% of the land area in Taiwan, and contribute much to ecological conservation, water and soil conservation, and forest products industry development. The estimated 296 million tons of greenhouse gas emitted in 2004 represented an increase of 185% as compared to 157 million tons in 1990 for Taiwan. Overall, carbon dioxide emissions account for 85% of total greenhouse gases, and Taiwan is ranked as 22nd among all the countries in the world.

Strategies for the reduction of greenhouse gas emission and the promotion of means by which societies can assist are proposed in this paper. Emphasis is placed on corresponding specific policies for the forestry sector and plans for the options of carbon sequestration, carbon conservation, and carbon substitution are presented. Eighty seven percent of greenhouse gas emissions resulted from the activities of the energy sector, and an estimated 0.54 kg of carbon dioxide emission is produced per 1 kwh of electric power consumed. Consequently, Taiwan faces more pressure on greenhouse gas reduction than other countries, and the cost for reducing 1 ton of carbon dioxide emission will be US$400.

Research analyses and surveys on the contribution to carbon sequestration from forest resources management are demonstrated. The current status of wood-based materials production and utilization and their contribution to carbon sequestration is under investigation. The potential implications of a reduction of carbon dioxide emission and carbon sink through government promotion of wood framed housing construction are presented. Results of an investigation of energy consumption, carbon dioxide emission, and carbon sequestration attributed to the various forest product industries are demonstrated.

Key words: Global warming, greenhouse gas, carbon sequestration, forest products

Introduction

The concentration of carbon dioxide in the global atmosphere was 280 ppm before the Industrial Revolution in the 18th century and increased to 368 ppm in 2000. It is expected to go up immensely from 540 to 970 ppm by the year 2100. The increasing greenhouse gases concentration will enhance the greenhouse effects through temperature rise. The global temperature rose 0.5 ℃ during 20th century and is expected to rise a further 3.1℃ between the years of 2017 and 2100. The greenhouse effects will bring major impacts on global climate, environment, and the economy of societies. These include massive recession of glaciers during the 21st century, rises of global average temperature and sea

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level, increasing human health threats especially for low income people living tropical and subtropical areas, reducing biodiversity of ecological system, negative influence on the life cycle, occurrence, frequency, strength of extreme weather and climate, and risks on societies and economy for people living on islands and along coastal areas.

In 2004, Japan was hit by a record-breaking 11 typhoons. They caused 220 deaths and US$9.3 billion dollars in losses. During the same summer season, the United States was hit by 4 hurricanes within 5 weeks. This is the most serious natural disaster within the last 100 years, causing 9.4 million civilians to be displaced, US$40 billion dollars insurance loses, and one fifth of all houses damaged in Florida. In Taiwan, the average number of continuous cloudless days increased from 4 days to 10 days during the past 50 years, indicating the tendency of drought. Furthermore, losses of more than US$125 billion dollars in properties and US$30 billion dollars in insurance claims resulted from the Katrina hurricane in 2005 in the United States. Based on NatCatSERVICE data, climate related catastrophes have increased about six times since 1950, while the events related to earthquakes, volcano eruptions, and tsunamis have increased slightly. A conference held by the Munich Climate Insurance Initiative (MCII) in 2006 reached an agreement that the major reason for global economic losses was due to the continuous change of extreme weather patterns.

In order to alleviate global greenhouse effects and the resulting abnormal global climate changes caused by anthropogenic greenhouse gases, an Intergovernmental Panel on Climate Change (IPCC) was organized by United Nations in 1988 to investigate overall global climate situations. IPCC established United Nations Framework Convention on Climate Change (UNFCCC) in May 1992 and it came into effect in 1994. In 1997, the third meeting of the conference of the parties (COP3) held by United Nations passed the Kyoto Protocol, requiring 38 developed countries plus European countries to hold greenhouse gases (GHGs) emission levels back to 1990 level with a further 5.2% reduction during 2008 and 2012.This came into effect on February 16, 2005. The Kyoto Protocol reveals important agreements signed by most of countries. First, the correlation between greenhouse effect and anthropogenic GHGs emission is recognized by many countries among international societies. Second, GHGs can be economic valuable goods instead of bad ones. Third, international societies are under an obligation to share variable extent of responsibility for GHGs reduction. Fourth, the supply/demand structure and energy prices will undergo certain transformation. Fifth, both competitions of new technological industries and trade barriers have been initiated.

In Taiwan, the estimated 296 million tons of GHGs emitted in 2004 represented an increase of 185% as compared to 157 million tons in 1990. Overall, carbon dioxide emissions account for 85% of total GHGs, and Taiwan is ranked as 22nd among all the countries in the world. This means an average of 11.26 tons of carbon dioxide emitted per person in Taiwan and ranked as 18th among all the countries in 2004. Several reasons are identified for GHGs reduction based on the Taiwanese point of view as follows: 1) to reduce the greenhouse effect; 2) to express concerns and obligations through GHGs reduction; 3) to prevent trade barriers; 4) to activate R&D of technologies and industrial development; 5) to improve international relationships through partner countries associated with GHGs reduction manipulation.

Forestry sector solution

The Kyoto Protocol established some carbon sequestration mechanisms to deal with GHGs reduction issues. Emissions Trading (ET) allows an emission quota to be traded among developed countries. If any country cannot reach the target quota, it may purchase certain GHGs from the other country which has greater ability to reduce GHGs. A Clean Development Mechanism (CDM) allows each country to deduct carbon dioxide conserved in forests from actual GHGs emission. In other words, a carbon sink is included during the carbon dioxide emission estimation. Both public and private sectors can adopt this mechanism as a potential opportunity across countries. Joint Implementation (JI) allows a group of countries to complete overall reduction target in GHGs emission with more or less than assigned quota for each country.

The contribution to the reduction of GHGs emission from forestry and agriculture sectors was recognized by UNFCCC and the Kyoto Protocol, and was included in Land Use, Land Use Change and Forestry (LULUCF). UNFCCC recommended approaches with cost effectiveness or the lowest cost to fight climate changes. The reduction of GHGs emission can be enhanced by creating carbon sinks. The recognized approaches include afforestation, reforestation, revegetation, forest management, cropland management, and grazing management. Afforestation changes a non-forestland over 50 years into a forestland through planting, seedling, or natural seedling. Reforestation changes a land in non-forest status before 1989 into a forestland. Revegetation means a land with certain planting activities for the purpose of carbon storage at minimum 0.05 hectares after 1990. Forest management shall keep biodiversity, productivity, and sustenance in managing and using forestlands to meet the expected ecological, economical and social functions of forests.

Current status and strategy of Taiwan

Total carbon dioxide emission in Taiwan is about 1% of the global estimate. And the cost of reducing GHGs is especially high, i.e., second only to Brazil. It requires a cost of US$400 dollars to reduce one ton of carbon dioxide as reported by Environmental Protection Administration (EPA) of Taiwan while the price of carbon trade was only 1.68 to 3.8 pounds in England and 1 to 2 US dollars in the United States in 2004. There were four phases included in the integrated structure for GHGs reduction strategy. These include establishing legal base for GHGs reduction operation, enhancing the potential of GHGs reduction technology, improving the potential of marketing mechanism, and promoting social behaviors (Chien, 2006).

In the phase of legislation, the drafts of laws regulating responsibility, reduction strategy, education and promotion, and penalty were passed by Executive Yuan on September 2006. In the phase of GHGs reduction technology, the EPA first introduced inventory examination to major industries including power, petrochemicals, steel, pulping and paper, and cement and selected 12 model companies in 2004. The EPA then continued to enlarge scales from traditional power-consumed industries to other major industries such as automobile, semiconductor, photoelectric, and environmental industries. GHGs inventory examination helps a company establishing GHGs emission inventory, which insure the company advantages in long-term competition and manage the GHGs risks. The government also promoted the voluntary reduction of GHGs to individual industry. Currently, the Ministry of Economic Affairs has agreements for voluntary reduction of GHGs emission with seven industries. The EPA has also signed agreements with the Thin Film Liquid Crystal Monitor Association and the Semiconductor Association for voluntary reduction of GHGs emission.

In the phase of promoting the potential of social behavior, the project focuses on the reduction carbon dioxide emission based on individuals or families. The aims of the project include educating civilians both in carbon dioxide reduction and resource saving in order to change living attitudes; assisting civilians to reduce utility expenses and upgrade environmental living quality; reducing energy/resources demand, alleviating environmental loads; and establishing partner relationships among domestic industries, academia, and government. The framework of strategies promoting the reduction of carbon dioxide emission include using low-carbon vehicles and mass transportation systems, enhancing regulations on energy efficiency management of commercial electric products, using environmentally-friendly goods starting from the government sector to activate markets of green consumer goods, reinforcing the local promotion activities on the reduction of GHGs, offering the concept of GHGs reduction in a mandatory education system, and encouraging civilians to plant trees in every community. It is expected to have ten thousands families responding to the reduction of carbon dioxide emission activities after one year. The target of carbon dioxide emission reduction is set to10% per family unit, i.e., equivalent to 0.782 tons, and the benefits will be 78.2 thousand tons every year. In the case of one million families joined the reduction activities, the benefits will be 782 thousand tons a year, which is equivalent to 1.2% of carbon dioxide emitted by the housing and transportation sector.

A strategy of carbon taxes was also established regarding air pollution since July 1, 1995. A tax of US$ 0.6 cents/liter for unleaded gasoline and diesel was added when people fill up vehicles, which results US$90.3 million income for the government. There is US$ 120.3 million in income taxed from industries, i.e., US$ 4.5/m^3 for fuel oil and US$5.15/ton for coal.

The conclusions of the 2005 National Energy Conference were accepted by the Sustainable Development on Taiwan Economy Conference of Executive Yuan. The level of GHGs emission will be limited to 335 million tons by the year 2020, which will be 107 million tons less than the expected rise without any control. This level will be maintained after 2020 and may be reduced even more with energy technology breakthroughs. The GHGs emission of 170 million tons must be eliminated by the year 2025, which will cost US$ 22.2 billion (1991 base) or US$ 220/ton and cause a 2.8% loss in GDP.

Current status and strategy of forest sector

Taiwan has a total forest cover of 2.1 million hectares (58.5% of land area) with an inventory of 358 million m^3 or 171 m^3/ha in Taiwan (1994). Major forest types are hardwood and mixed forest (78.8%) with an abundance of bamboo (7.2%). It is made up of 79.1% natural forests and 29.9% plantation forests. The total carbon stored in the forests was 158.7 million tons in 1994 or carbon sequestration of 4.15 million tons in 2006 (*Chiou et al.*, 2006). In 2025, the carbon sink should increase 123.3 million tons (3977 tons/year) due to forest growth, based on the 1994 levels. There were 83,764 hectares of new plantations established between 1990 and 2004, the accumulated carbon around 1.611 million tons. The estimated carbon storage would be 7.785 million tons based on the same growth rate until 2025.

The Council of Agriculture (COA) has initiated up a “Climate Change and Kyoto Protocol- Agriculture and Forest Issue Working Group.” The mission includes enhancing forest management and plantation area, establishing a GHGs inventory base for the

agriculture and forestry sectors, derivation and simulation of reduction of GHGs emission in agriculture and forestry sectors, and estimation of cost and potential of reduction on GHGs emission. In advance, the Forest Bureau set up a "Contribution on Carbon Sequestration through Forest Resources Management Working Group." In 2006, the working group supported several competitive research projects dealing with carbon sequestration issues for US$ 1.64 million. In order to integrate carbon management of forests, polices are emphasized on improving carbon sequestration by increasing forest resources, improving carbon conservation through maintaining healthy forests, and establishing carbon management polices and economic analysis (Chang, 2005).

Therefore, three phases are involved in strategies. The first phase to improve function of carbon sequestration has three plans. The plan to increase forest resources covers several projects which include establishing forests along the seashore, promoting landscaping in flat areas, assisting afforestation overseas, and reforestation on public forest lands. The reforestation plan includes forestation on farmlands in mountain areas above 1500 m in altitudes, retrieving leased land for afforestation, and reforestation in areas of landslides. Total area of afforestation through this phase will be 11,130 hectares from 2005 until 2025. It can accumulate 63 thousand tons of carbon sequestration by 2025. The third plan to increase carbon uptake through forest management includes projects for raising forest growth by tending plantation and upgrading sustainable utilization of plantation. It is scheduled to do pruning, thinning, and other forest management for 1.13 million hectares between 2005 and 2025, or 53.8 thousand hectares per year. Ten percent of additional carbon sequestration (0.295 tons of carbon per hectare) can be expected through enhancing plantation forest management, which results in additional 3.62 million tons of carbon sequestration by 2025.

The second phase to improve carbon conservation also has three plans. The plan to maintain healthy forests supports three major projects, including preventing forests from invasion of diseases and insects, strengthening forest fire management, and reinforcing forest management to prevent abnormal damages of forests. The second plan to maintain the stable ecological system and improve carbon storage function includes projects for limiting forestland transfer in reservation areas through reinforcing management and reducing carbon emission from soil conservation. The plan for improving efficiency of forest products utilization includes projects for reducing wastes by improving wood processing technology, extending the life cycle of forest products, and recycling and reusing forest products.

The third phase to establish systematic investigation, monitoring, and validation of the carbon inventory and to improve the efficiency of carbon management has five plans. The first plan is to establish an estimation base for carbon inventory and a dynamic monitoring system. This plan covers three major projects including developing approaches for carbon storage estimation in the forest sector, operating the fourth forest resources survey as data base, and constructing a monitoring system for dynamic changes of forest resources. For example, an increase of 2.14% annual rate (4.455 million tons of carbon sequestration per year) is expected based on the data of the third forest resources survey, afforestation, plus the reduction of losses from harvest and forest fire or other impacts. The second plan is to develop a generally recognized inspection mechanism which includes projects for establishing an information system of carbon management for decision making and setup of an inspection system for carbon estimation to coordinate with international systems. The third plan is for advanced research on carbon

management evaluation. Major projects in this plan include simulations on the reduction of carbon dioxide, analysis on the potential of carbon dioxide reduction, and investigation of polices of resources management and related efficiency evaluation. The fourth plan is to establish a carbon trade system based on forest resources and initiate cost effectiveness analysis. Projects cover cost analysis on the reduction of carbon dioxide emission and establishment of a carbon trade mechanism in the forest sector. The other plan is to keep pace with up-to-date global trends, which encourage representatives from government, industries, and research institutes to attend international conferences to exchange experiences and analyze strategies and trends on carbon management in forestry sectors with those from other countries.

Current status and strategy of forest products industries

The annual harvest has been about 30~40 thousand m^3 since 2000 in Taiwan which is only 3% of the harvest 30 years ago, due to changes in government forest management policy in recent years. More than one million m^3 of logs were imported in 2005, i.e., 70% from Malaysia and 10% from New Zealand. Sawn lumber was imported from Indonesia (22.9%), Malaysia (21.1%), Canada (15.1%), and New Zealand (7.5%) amounting to 1.5 million m^3. Total consumption of plywood panels was 1.55 million m^3 with 55.5% imported. Exports of forest products dropped from 36% to 6% within a decade due to the rises in production costs and moving the production base overseas for many companies (*Lin et al.* 2005). The domestic consumption of plywood panels was up further to 97% in 2005 (TPMEA 2006). Taiwan stopped manufacturing MDF and particleboard completely from 2002. Amounts of both imported panels were about equal, i.e., 255 thousand m^3 for MDF and 247 thousand m^3 for particleboard in 2005 and total annual consumption was between 490 and 642 thousand m^3 in the past 10 years. The Forest Bureau set up a target of providing an annual domestic forest harvest of 500 thousand m^3, raising annual consumption of local products from currently 1% up to 10%.

The annual pulp production is 392 thousand tons, using 99.6% imported chips or round woods as raw materials, and 1.54 million tons in 2006. A total of 103 companies produce 4.65 million tons of paper and paper board products, including 3.25 million tons for the domestic market and 1.41 million tons of exports, plus 1.53 million tons of imports. In 2005, Taiwan was ranked as 11^{th} among major paper manufacturing countries in the world based on annual average paper consumption per capita. In 2006, the annual average paper consumption was 208.2 kg/person, a 4% decrease from 2005. Paper manufacturing is an environmental friendly industry in Taiwan. There are 80.9% (3.22 million tons) of raw materials from domestic waste paper collection and the waste paper recovery rate can be as high as 68.3%. In addition to 0.761 million tons of imported waste paper, the waste paper utilization rate reached to 85.6% in 2006.

To deal with the issue of the reduction of carbon dioxide emissions, 16 paper companies invested US$ 3.37 million for facilities or procedures for saving energy. It is estimated that a reduction of 176 thousand tons carbon dioxide emission occurred in 2005. One company gave 17.76 million seedlings to forest land owners between 1998 and 2006, which is equivalent to establishing 7,880 hectares of forests. It is estimated that carbon dioxide emissions would be 1.46 – 1.51 tons when burning 1 ton of waste paper, while 0.57 tons of carbon dioxide emission would be resulted due to power consumption by using recycled waste paper in paper mills. This means 0.89 -0.9 tons of carbon dioxide emission less from every ton of waste paper as raw material. Therefore, the paper industry recycled waste paper for 3.22 million tons and could save about 2.86 – 2.9 million tons of

carbon dioxide emission in 2006. It is also equivalent to the carbon storage ability of 0.268 million hectares of forests and can save US$ 0.449 billion in garbage processing costs. Paper companies also manage forest resources by establishing domestic forests of 13,061 hectares and overseas forests for 152 thousand hectares, which can conserve up to 1.98 – 2.48 million tons of carbon dioxide.

The strategy for dealing with enhancing efficiency of carbon substitution can be tackled based on plans of enhancing forest products to replace high energy-consumption materials. Currently housing construction is dominated by reinforced concrete (RC) - 95% in Taiwan. The energy consumed during cement production constitutes 30.9% of energy from all construction materials. To promote a green building policy, the government is encouraging the introduction of wood-framed construction, including structural light framing, post and beam, and log home methods. The building codes for wood-framed housing construction have been updated, criteria of structural lumber products for engineering purposes released, and construction handbooks published. The total carbon dioxide emission for an average 190.42 m^2 size wood-framed house is 10,801 kg, including 21% wood-based materials processing and 78% non-wood building materials processing (Wang, 2006). The average usage of wood materials will be 0.2133 kg/m^2 for wood-framed housing construction and estimated carbon dioxide emission will be 56.73 kg/m^2, while 247.08 and 197.92 kg/m^2 for RC and steel structures, respectively, which are 4.35 and 3.49 times that of wood-framed structures.

Literature

Chang, B. 2005: Policies of Taiwan Forestry Bureau on the Carbon Sequestration. *Proc. Conference on Contribution of Forest Management to Carbon Dioxide Sequestration, Taipei, Taiwan, Oct. 2005.*

Chien, H. J. 2006: Strategy on the Greenhouse Gases Reduction. *Proc. 2006 Conference on Forest Carbon Sequestration, Taipei, Taiwan, Dec. 2006.*

Chiou, C.R., Wang, J. M., Liang, Y. C. 2006: Estimation on the Carbon Sink in Taiwan Forests. *Proc. 2006 Conference on Forest Carbon Sequestration, Taipei, Taiwan, Dec. 2006.*

Lin, J.C., Wu, C.S., Chen, Y.H. 2005: Analyzing the Consumption and Flow of Wood Materials in Taiwan. *Forest Products Industries 24(1):1-14..*

TPMEA, 2006: Plywood Industry in Taiwan. *Taiwan Plywood Manufacturers & Exporters Association, ROC, 2006*

Wang, S. Y. 2006: Forest, Wood Utilization, and Green Buildings. *Wood-based Building Structures, 10, 110-134 (2006).*

Forest Products: Need for a Rethink

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Abstract
The world is changing and people's expectations are changing; and very quickly too! So too must forestry and forest products. While it is recognized that technology has played an important role in improving utilization and reducing waste, such as through composite technology, improved pulping techniques and new materials, forestry, especially tropical forestry, lags behind. One reason is that the profession has not been able to attract the best minds into the profession. The number of PhD thesis on forestry per annum is still limited.

Funding for forest research has remained a problem for many parts of the world, particularly within the developing world. Yet, forestry is fast gaining popularity due to greater awareness and concern about the environment worldwide. Issues of climate change and carbon credits offer a whole world of opportunity for forestry, which must look beyond wood and timber. Water is a major product of the forestry landscape, but is forestry capturing the full economic benefit of that resource? Minor forest products, especially bamboo, can be potentially important for sequestration of carbon as well as being important forest products.

Thus, forestry is well positioned to be a very important sector in the world but it needs competent, committed and qualified professionals. Furthermore, the professional forester must be made legally a registered profession akin to the Registered Engineer. Forestry and Forest Products must become attractive professions in order to attract the best young minds.

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Wood and Competing Materials

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Abstract
Wood is classified as an old material such as stone, brick, pottery, glass, bronze, iron, etc. The composite material wood which is built up from cellulose, hemicellulose and lignin, forms tubular cells or fibres, and is designed and produced by nature to meet very specific multifunctional needs (strength and stiffness to form a stem, a column and a transport function for liquids as well). This very sophisticated and efficient composite structure enabled the species tree to compete with other plants and to overrule them in many regions of the world.

Wood withstands damaging effects in the growth environment in an outstanding way but also damaging effects in unnatural environments after trees have been felled and processed into components. Variability and heterogeneity are inherent traits of the material and the structure of wood, at any level one cares to visualize it, but it is highly optimized according to the needs of trees. Different species have different structures because they exploit different environments and the same environment in different ways. Reflecting this diversity is the key to survival in nature, but it is also a big challenge to use wood as an engineering material.

We live in a world of materials and we create objects out of materials. These designed objects may have a predominantly functional purpose or a purely symbolic or decorative purpose. This combination probably is most obvious in architecture and indoor design, both in the applications of wood and wood based materials. The new science and development of strong materials exhibits that wood still is an exceptional material but improved traditional materials and new materials are emerging rapidly. New tools of material selection help us to understand the specific properties of a material and they also show us the path to new "Engineered Wood Products" (EWP) in order to compete with metals, alloys, polymers and new composites. Light weight composites, multifunctional wood based materials and gradient-materials are some of the new materials to be addressed in this lecture.

Key words: Engineered wood; wood composites; material selection; wood material science

Introduction

There are some ten-thousands of materials available to the engineer and the materials are divided into material classes such as metals and alloys, ceramics and glasses, synthetic polymers, natural materials and composites. In designing a structure or device, how is the engineer to choose from this vast menu of materials which best suits the purpose? (Ashby and Jones 2005). Mistakes in selecting the right material can reduce competitiveness and market share but can also cause failures, accidents and even disasters. Material and design

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failures and the accompanying disasters are some of the most prominent headlines in the newspapers. Not to mention the many everyday little accidents and inconveniences due to wrong material design.

Throughout history, materials have limited design possibilities, and ages/periods in which man has lived are named for the materials he used: stone, bronze, iron, …, concrete, plastics. This leads to an evolution of engineering materials as shown in fig. 1.

Winter (1994) has compiled the relative importance of the most common building materials for load bearing structures as shown in Fig. 2. As indicated in Fig. 2 and as we

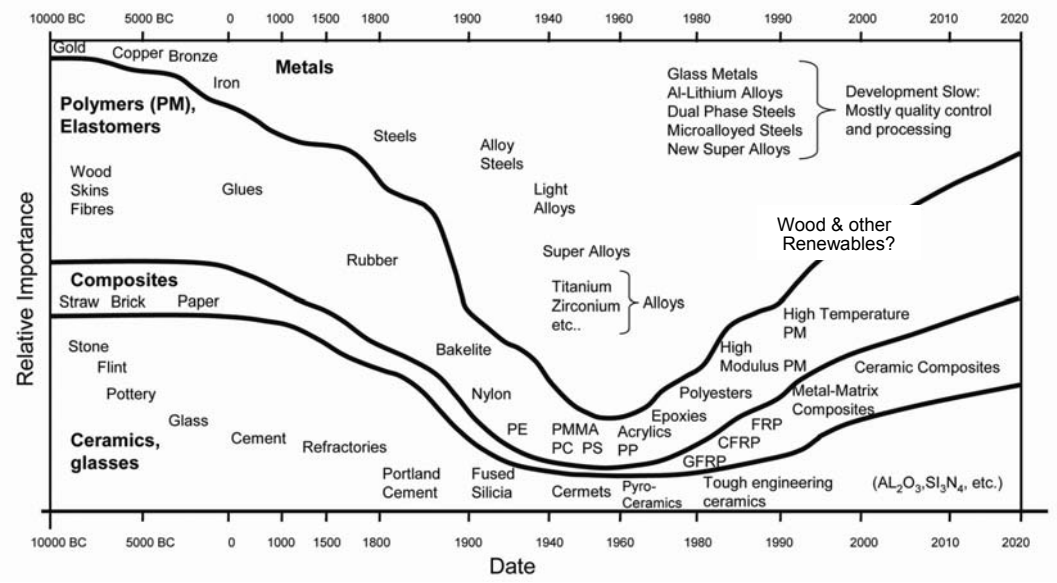

Fig. 1: Relative importance of engineering materials with time (adapted from Ashby 2003)

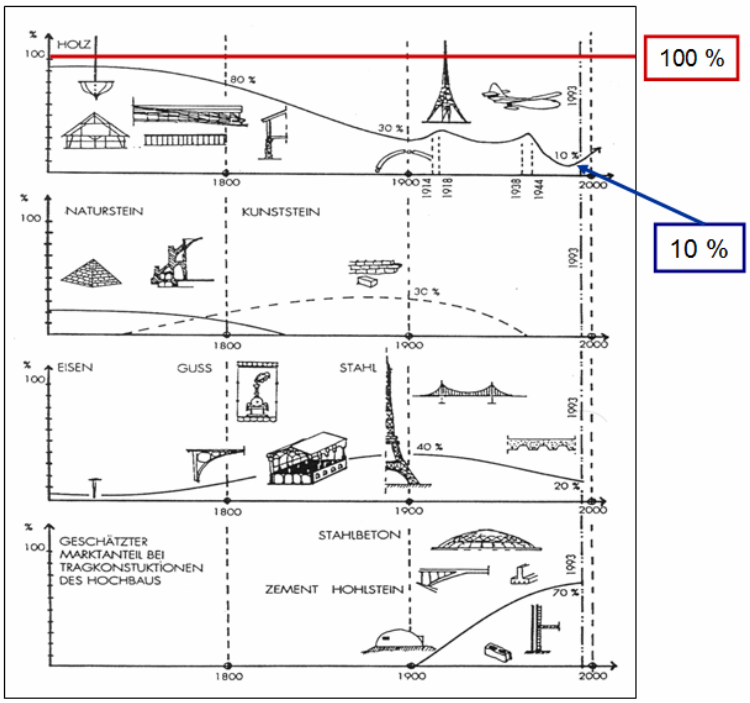

Fig. 2: Relative importance of various building materials for load-bearing structures over a selected time period, adapted from Winter (1994)

From top to bottom: Holz/Wood; Naturstein, Kunststein/stone, bricks; Eisen,Stahl/iron, steel; Zement, Stahlbeton/cement, reinforced concrete

meanwhile know, wood as a load bearing structure has already gone through its “all-time low” due to many reasons such as better wood material engineering and fabricating, availability as a resource in most areas in the world but also to environmental reasons which include renewability of the resource, low environmental impact etc. These facts are also frequently used in various wood promotion campaigns (e.g. CEI-Bois 2006).

Besides straight engineering values also “soft facts” such as environmental issues are becoming more and more important, however, appropriate decision tools are still missing despite of many environmental assessment methods.

Currently materials and processes to shape them are developing faster than at any previous time and the challenges and opportunities they present are greater than ever before. Wood, as one of the oldest, most commonly available and versatile material, has not changed its nature during the engineering history of mankind. Is wood therefore an overmature material or still one of the most promising materials of the future? This question will be elaborated in the current paper.

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General Background

Wood is synthesized by nature, whereas most of the other engineering materials are synthesized and fabricated by man and this makes the big difference between wood and the synthetic materials. Wood is a result of millions of years of material optimization of nature in order to meet the needs of trees and to make the tree one of the most successful plants on earth. Wood grows according to a recipe stored in the genes, rather than being fabricated according to a technical design by man whereas synthetic fabricated materials are to meet a certain design. This makes a big difference in the design strategies of biological materials and technical engineering materials.

Wood substance is familiar to the foresters and wood scientists and is therefore not described in detail. The mechanical properties of wood, as some of the most important properties for engineering materials, have been analyzed and described by many authors on several hierarchical levels or in general (Dinwoodie, 1989; Mattheck and Kubler, 1995; Eberhardsteiner, 2002; Smith *et al.* 2003; Fratzl 2007). Much insight has been gained but much more has to be found in order to fully understand wood as structural material from nature.

Wood composites are material derivatives from wood, designed and produced by man. They represent something in between the natural polymer of wood and a technically fabricated and engineered composite consisting of wood particulates (particles) and a glue or matrix material. Glued wood components and wood based materials form a distinctive material class with the idea of fractioning the raw material and reintegration in order to achieve a new material dimension and/or new material properties including processability. This has consequences such as increasing energy input and homogeneity with increasing disintegration but also decreasing strength and stiffness (Fig. 3).

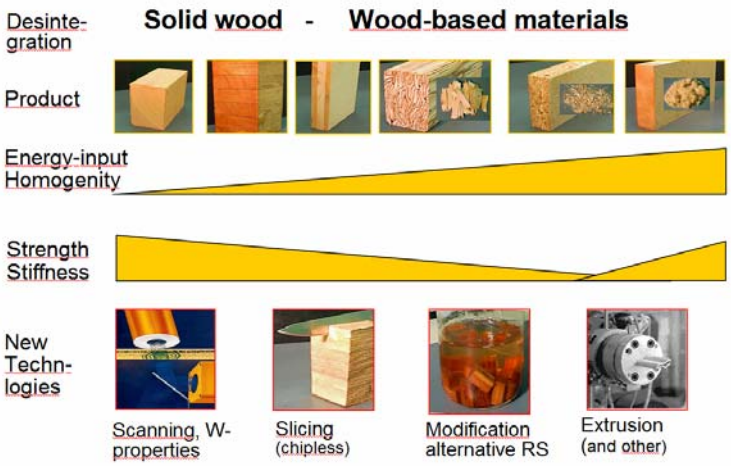

Fig. 3: Disintegration and remanufacturing with different consequences such as change in stiffness and strength properties (Teischinger 2001)

There are many differences between plant-based materials and fabricated materials. Plant-based materials derive from plant growth, which can be seen as a dynamic process of material production to create the body of a plant with emphasis on meeting each change and the needs of a growing plant, whereas fabricated technical materials are a result of a designed production process. This leads to differences in the two material types which are thoroughly discussed by many authors e.g. Niclas (1992), Fratzl (2007), Hofstetter *et al.* (2007).

Besides the material itself there is also a difference in how to create or fabricate a component part. An engineer selects a material to fabricate a component part according to an exact design whereas nature goes the opposite way and grows both the material and the whole organism (e.g. a plant) using the principles of (biologically controlled) self-assembly (Fratzl 2007). The differences between biological materials and engineering materials are summarized in Table 1.

Table 1: Differences between bio-based materials and technically engineered materials (based on Fratzl, 2007)

Biological material	**Engineering material**
"Light" elements dominate: C, N, O, Ca, P, S, Si, …	Large variety of elements: Fe, Cr, Ni, Al, Si, C, N, O, …
Growth by biologically controlled self-assembly (approximate design)	Fabrication from melts, powders, solutions etc. (exact design)
Adaption of form and structure to the function (also according to changing environmental conditions)	Selecting of material according to function
Healing: capability of self repair	Secure design (considering possible maxim loads as well as fatigue)
Hierarchical structure at all levels	Beyond micro-structure: homogenous

Using wood as a material derived from this plant we have to cope with the history of self-assembly which causes all the features such as annual ring patterns, grain deviation, knots, pitch pockets, density variations and generally spatial variations in the wood properties. This huge variety in the raw material wood is a challenge to analyze wood and measure wood properties respectively and to place them along the added value chain in the best possible way as described by Teischinger (2003).

The Material Selection Process

Different classes of materials such as metals and alloys, ceramics and glasses, polymers, natural materials and composites exhibit various classes of properties. These properties encompass general and specific physical and mechanical properties (density, stiffness, strength, conductivity etc.), environment interaction (corrosion, durability), production properties (ease of manufacture, finishing etc.), aesthetic properties (colour, texture) and economic properties (price and availability, recyclability). Fig. 4 shows how the properties of the various engineering materials affect the way in which products are designed.

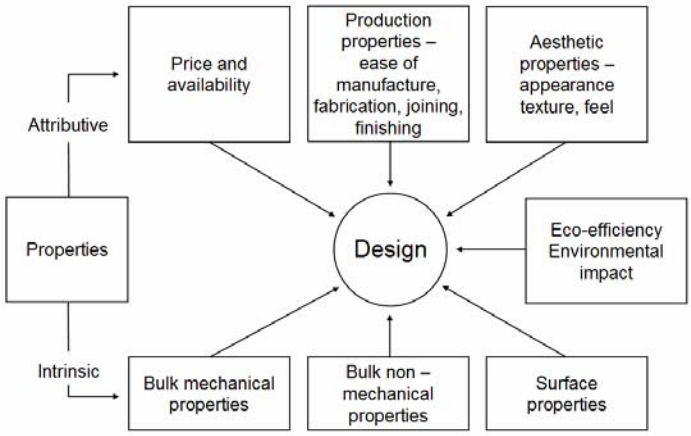

Fig. 4: How the properties of engineering materials affect the way in which products are designed (adapted from Ashby (2005) and further developed)

Design to minimize adverse impacts of engineering products and structures on the environment ("green design") is assuming an increased importance in all branches of engineering. Eco-impact thus becomes an additional metric to be optimized along with performance and cost but the problem is a complex one: eco-impact can be associated with the extraction and refinement of the material, with the manufacture of a product/structure from it, with the use of that product or structure and with its disposal (Wegst and Ashby, 2002). Life cycle assessment (LCA) as described by Murphy (2004) has become a common system analysis tool for evaluating environmental impacts over the whole life cycle of a product, process or activity from the "cradle" (raw materials acquisition) to the "grave" (disposal or recycling). Meanwhile many LCAs are available for wood as a material and wood in construction and various other uses but also comparisons to other materials (Lippke *et al.,* 2004) and various studies are compiled by BRE (Building Research Establishment, 2004).

As wood and many other competing materials are used in different applications, one has to differentiate between material selection in structural design, engineering design, industrial design etc. For each design different approaches are appropriate and common. This makes a general analysis of a wood material choice very complex and is also a major challenge for the wood industry to provide a proper material portfolio (solid wood, different wood species and grades, wood based materials, engineered wood products etc.). Each of the materials within this portfolio has to be described and categorized by material property values and design values. Something which still causes problems for wood as a very versatile, inhomogeneous and anisotropic material based on hundreds or thousands of commercially used wood species and each species exhibiting are a large variability of properties.

Over centuries, man has learned to use materials effectively and especially with traditional materials (stone, wood, brick etc.) rules of thumb were developed to aid in planning and building structures. These rules were based only on experience and using these rules, skilled artisans were able to construct and produce long-lasting structures (Stalnaker and Harris, 1997). More recently, however, engineers have learned to design structures and devices in ways that are based on engineering principles, which also requests a new material knowledge approach.

Unfortunately, wood as one of the most traditional materials lost track in this new approach to material design using synthetically produced materials and composites. They

are mostly designed and produced for a specific task: they are required to do things, to undergo purposeful change. They play an active part in the way the structure or device works and are therefore called **functional materials**. The next step in material development to achieve advanced materials, which will be discussed later on, are so-called **smart materials**.

Material properties limit performance and a way of surveying properties is needed so as to get a feeling for the values design-limiting properties can have. Seldom does the performance of a component depend on just one property. More often it is a combination of properties that matter, for instance, of the strength-to-weight ratio (σ_f/ρ), or stiffness-to-weight ratio (E/ρ), which enter lightweight design. This suggested the idea by Ashby (2003) of plotting one property against another, mapping out the field in property space occupied by each material class. The resulting charts are helpful in many ways, as they condense a large body of information into a compact but accessible form (Fig. 5).

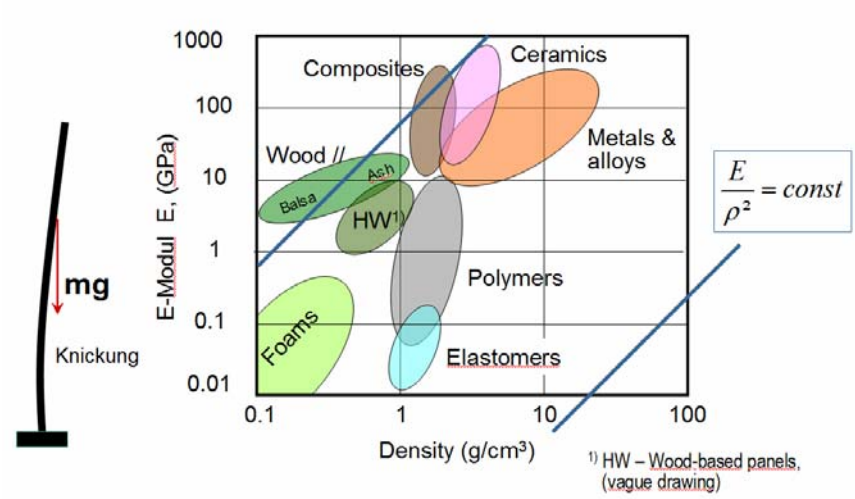

Fig. 5: Idea of a Materials Property Chart (derived from Ashby 2003): Young`s Modulus, E, is plotted against the density, ρ, on a log scale. A contour derived from the issue of an elastical column buckling by $E/\rho^2 = const.$ deploys several material clusters to be selected

A material has certain attributes such as density, strength, cost etc. and a design demands a certain profile of these. As performance of a component is mostly limited by a combination of various property specific target functions (E/ρ – light/stiff component, σ^2_f/E – design for a spring, etc.) can be developed and applied to the Ashby maps in order to screen the best possible material class. Sometimes also the inverse problem is interesting when a new material is to be developed (or has emerged). How can applications for new materials be identified? This question can even be applied to newly improved materials.

New Advanced Wood Materials and Composites

During the last high-tech century wood has not been a key material. The engineering image of wood and wood-based materials has been one of "low-tech" or "second tier" material (Fridley, 2002). In opposition to this misperception, however, is the fact that the use of wood and wood-based materials in construction, by weight, exceeds that of steel or concrete each year.

Mainly, two main developments, the increasing environmental consciousness and the emerging of new "Engineered Wood Products" (EWP) combined with more sophisticated grading systems for lumber continue to be developed and successfully introduced into the engineering and construction marketplace. Some of the key recent advances and trends such as raw material assessment, grading, improvements in the primary and secondary wood processing are reviewed by Fridley (2002) and Teischinger (2003), where the non-destructive evaluation (NDE) of wood is one of the key-issues. Following the grading process, improvements in assigning appropriate design values for use by both design codes and design engineers has also been a targeted effort.

The current development of wood as an engineered product as well as a commodity mass product is based on several drivers:

- Cost efficiency and competitiveness to other materials
- Raw materials situation for wood, but also for other materials, including renewable resources and/or recyclability etc.
- Ecological aspects, consumer awareness of materials

The driving force behind the development of many wood-based composite materials is many-fold such as the response to the changing wood resource (wood from thinnings, short rotations, by-products from processes, etc.), the need to meet increased and/or specific performance demands for the materials, producing larger, two-dimensional elements and cost-efficient processes etc. Additionally, both consumer interest and traditional virgin resource limitations will drive further utilization of recycled materials for wood-based panels such as particleboard and MDF. The limiting factor for further use and utilization of recycled material for wood-based composites is one of sorting and handling as shown in the COST Action E 31 "Management of recovered Wood" (http://www.ctib-tchn.be/coste31/frames/f_e31.htm).

The latest trend in wood-based composite materials is toward the use of synthetic materials and substances (in a few cases also bio-based materials) in combination with wood or wood-based materials. Some examples of hybrid wood and wood-based composites are given in Table 2.

One of the major challenges for wood-based materials is the high variability of the natural resource (Fig. 6), but modern engineered materials should exhibit a very small variation of properties and at least they have to meet threshold-values given by various standards.

Table 2: Examples of hybrid wood materials

Technology/material	**Example of hybrid materials**	**Reference, further reading**
Synthetic reinforcement	Glulam	Borström (1999)
Thermoplastic and thermosetting matrices	Wood plastic composites (WPC) for various uses	Bledzki and Sperber (2005)[1)], Stark (2005)[1)] Smith and Wolcott (2006)
Polymer impregnation	Modified wood	Hill (2006)
Nanotechnology	Nano-reinforced composites	Atalla et al. (2004)
Wood and natural fibre sources and natural polymer sources	"Green Composites"	Baillie (2004)
Sandwich and foamed	Light-weight composites	Gibson and Ashby (2001)

structures		

[1)] and various other conference series

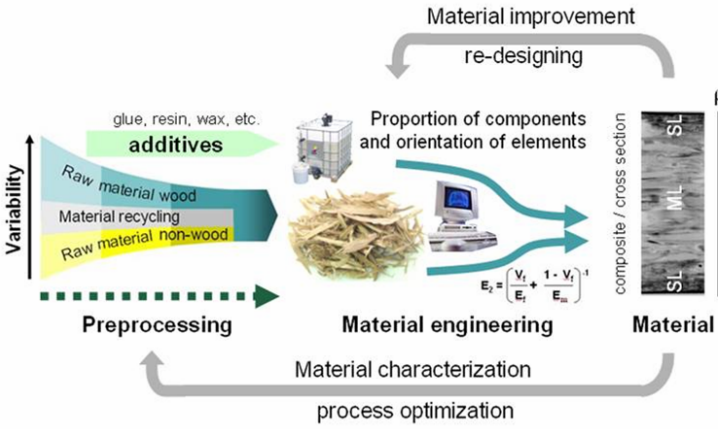

Fig. 6: The challenge of materials design and processes based on bio-based raw materials, which have a high variability (© Müller, Teischinger 2007)

Exceeding the threshold values mostly means higher raw material costs, reduced yield, higher process costs etc. and therefore reduced competitiveness. In many applications (they are rarely open for wood materials) such as transport and automotive industries, aeronautics, etc. only a small material property slot is allowed in order to meet the restrictions of weight limits in the final product (car, plane, sports equipment, etc.).

The search for new, improved or alternative materials, whether through experiment or simulation, has been a slow and arduous task, punctuated by infrequent and often unexpected discoveries. More recently various tools for the development of materials are proposed and discussed. Rajan (2005) outlines a process of "materials informatics" for material selection, development and discovery based on the application of computational methodologies to processing and interpreting scientific and engineering data concerning materials.

Materials mechanics provides mathematical tools based on knowledge of physical and chemical processes and on data mining. These tools serve as computational engine for integrating materials science information across length scales. Numerical mechanics also provides an accelerated means of fusing data and recognition in a rapid yet robust manner. The goal of data mining is the extraction of knowledge and insight in massive databases.

Numerical simulations and engineering methods have become an inherent part of material and product design in many industry branches. They contribute to considerable savings of cost and time, to an improved quality of the products, and the (resource) efficiency of product processes. Wood shows an extreme anisotropic and hierarchical structure on several length scales which limits the application of numerical methods like the Finite Element Analysis method. Elucidating the effects of the microstructure on the macroscopic properties is the major advantage of innovative multi-scale approaches (particularly appealing for wood), which provide enhanced insight into the functionality of the material and allow the prediction of the macroscopic behaviour (Böhm 2004, Hofstätter *et al.* 2007).

Materials of the Future

The huge field of applications where wood can also be applied (structural design, packaging, specific technical application, etc.) will evolve over the next decade to follow the increasing demand for structural performance, multifunctionality, and environmental and sustainability requirements. Resource efficiency in material design and fabrication and the potential for new design solutions will be an important issue. New materials need adequate manufacturing systems including new forming, joining, assembly, surface protecting and painting processes. Several studies and material roadmaps are already highlightening the future of materials in general (e.g. European Platform for Advanced Engineering Materials and Technologies, http://www.eumat.org).

Can wood and wood-based materials meet these challenges? An answer can be drawn from specific wood related initiatives such as the US Forest Products Industry Technology Roadmap (http://www.agenda2020.org), the strategic research agenda from the European Forest-Based Sector Technology Platform (http://www.forestplatform.org) or specific research programmes such as the Finnish-Swedish "Wood Material Science and Engineering Research Programme", which is compiled by Poppius-Levlin et al. (2007).

Analyzing possible ways of shaping the materials of the future, one can also refer to Gordon (1991):

> *"The cheapening and improvement of iron and steel during the eighteenth and nineteenth centuries was the most important event of its kind in history. ... Metals, however, do not have the monopoly of strength. Some of the best combinations of lightness and strength are afforded by non-metals and the strongest substances in existence are the recently discovered "whisker" crystals of carbon and of ceramics. As the subject is developing, it now seems very possible that the coming of new engineering materials will resemble much improved versions of wood and bone more closely than metals*."

Summary and Future Outlook

- We are living in a world of tens of thousands of synthetic and natural materials available.
- The forestry-wood chain is responsible for one of the most abundant and most versatile renewable materials in the world.
- Wood and wood based materials are very efficient engineering and design materials, but huge innovation in material understanding and design is necessary in order to stay competitive with other materials.
- New ideas and new tools of materials informatics are necessary for the development of better and the discovery of new wood-based materials and composites.
- At the moment advanced wood composites are of minor importance, a huge impact to develop advanced wood based materials and composites is necessary for the future.
- Wood and other renewable resources need to match in order to create a new family of materials and composites based on renewable materials Bailie (2004).

Literature

Ashby, M.F. 2003: Materials selection in mechanical design. *Butterworth Heinemann, Oxford, 2003.*

Ashby, M.F., Jones D.R.H., 2005: Engineering Materials 1. An introduction to properties, applications and design. *Elsevier Butterworth-Heinemann, Oxford., 2005.*

Atalla *et al*., 2004: Nanotechnology for the Forest Products Industry. *Vision and Technology Roadmap*. TAPPI Press, Atlanta, GA., 2004, ISBN: 1-59510-087-3.

Baillie, C. (Ed.), 2004: Green composites: Polymer composites and the environment. *Woodhead Publishing Limited, Cambridge, 2004.*

Bledzki, A.K., Sperber, V.E. (ed.), 2005: Wood and Natural Fibre Composites, Scientific Presentations 1999-2005. *PPH ZAPOL, Dmochowski, Szczecin, Polen, 2005, ISBN 83-89260-89-1.*

Böhm, H. 2004: A short introduction to continuum micromechanics. *In Mechanics of Microstructured Materials, Böhm. H. (Ed.), CISM Lecture Notes no. 464, Springer Verlag, Wien, New York, 2004.*

Borström, L. (Ed,), 1999: 1st RILEM Symposium on Timber Engineering. *Proceedings, RILEM Publication, Chachan Cedex, 1999, ISBN: 2912143101.*

BRE (Building Research Establishment) 2004). *www.woodforgood.com*.

CEI-Bois (Ed.), 2006: Tackle Climate Change: Use Wood. *CEI-Bois Brussels., 2006, www.cei-bois.org*.

Dinwoodie, J.M., 1989: Wood: Nature's Cellular, Polymeric Fibre-Composite. *The Institute of Metals, London*, 1989.

Eberhardsteiner, J., 2002: Mechanisches Verhalten von Fichtenholz – Experimentelle Bestimmung der biaxialen Festigkeitseigenschaften [Mechanical behavior of spruce – Experimental determination of biaxial strength properties]. *Springer Verlag, Wien, New York, 2002.*

Fratzl, P., 2007: Biomimetic materials research: what can we really learn from nature's structural materials? *J.R. Soc. Interface,* 4: 637-642.

Fridley, K. F., 2002: Wood and Wood-Based Materials: Current Statute and Future of a Structural Material. *Journal of Materials in Civil Engineering*, *91-96 (March/April 2002).*

Gibson, L. J., Ashby, M. F., 2001: Cellular solids, structure and properties. *Cambridge University Press, Cambridge, UK*.

Gordon, J.E., 1991: The New Science of Strong Materials. *2nd eEdition., Rrepr.int, Penguin Books, London*.

Hill, C.A.S., 2006: Wood Modification. Chemical, Thermal and other Processes. *John Wiley & Sons, Ldt., Chichester, West Sussex.*

Hofstetter, K., Hellmich, C., Eberhardsteiner, J., 2007: Micromechanical modelling of solid-type and plate-type deformation patterns within softwood materials. A review and an improved approach. *Holzforschung, 61, 343-35* .

LeVan, S.L., "Benefits from wood engineering research," *In Wood engineering in the 21st century – Research needs and goals. ASCE, Reston, VA, 1998.*

Lippke, B., Wilson, J., Perez-Garcia, J.P., Bowyer, J., Meil, J., 2004: CORRIM: Life-Cycle Environmental Performance of Renewable Building Materials. *Forest Products Journal, 54(6): 8-19.*

Müller & Teischinger (2007): Wood COMET, Application for a K1 centre. *Unpublished. FFG, Vienna.*

Matteck, C., Kubler, H. 1995: The internal optimization of trees. *Springer, Berlin.*

Murphy, R., 2004: Life cycle assessment. *In Green composites: Polymer composites and the environment. Baillie, C. (Ed.), Woodhead Publishing Limited, Cambridge.*

Niklas, K.J. 1992: Plant Biomechanics. An Engineering Approach to Plant Form and Function. *The University of Chicago Press, Chicago, IlL.*

Poppius-Levlin, K., Johansson, B. (Eds.) 2007: Wood Materials Science and Engineering, Final Report. *AoF, Tekes, Formas, VINNOVA, Stockholm., 2007, ISBN 978-91-540-5993-5.*

Rajan, K., 2005: Material informatics. *Materials Today, 10, 38-45.*

Smith, I., Landis, E., Gong, M., 2003: Fracture and Fatigue in Wood. John *Wiley & Sons Ltd., Chicester.*

Smith, P.M, Wolcott, M.P. 2006: Opportunities for Wood/Natural Fibre-Plastic Composites in Residential and Industrial Applications. *Forest Products Journal, 56:3, 4-11.*

Stalnaker, J.J., Harris, E.C., 1997: Structural Design in Wood, 2nd ed. *Chapman & Hall, New York.*

Stark, N (Ed.), 2005: *Proc. 8th International Conference on Woodfiber-Plastic Composites, Forest Products Society, Madison, WI, 2005, ISBN 1-892529-44-0 (and earlier proceedings of this series).*

Teischinger, A., 2001: Holztechnologien für die Zukunft (Wood Technologies for the Future). Herausforderung für Forschung und Lehre (1). *Holzforschung und Holzverwertung, 53: 1, 12-14.*

Teischinger, A., 2003: Wood properties of the raw material: challenges for new processes and products. *In Wood research - Knowledge and concepts for future demands*. *EMPA, Swiss Federal Laboratories for Materials Testing and Research, 115/50, 95-105; EMPA, CH-8600, Dübendorf.*

Teischinger, A., 2006: Holz – optimierter Hochleistungswerkstoff der Natur und Herausforderungen bei der technologischen Nutzung. *In LIGNOVISIONEN Band 14, Universität für Bodenkultur Wien, 2006, ISSN 1681-2808.*

Wegst, U., Ashby, M.F., 2002: Material selection and Design of products with low environmental impact. *Advanced. Engineering Materials* 4: 378-383.

Winter, W., 1994: "Holz – ein Bau"stein:" des 21. Jahrhunderts," *Bauen mit Holz*, 96(4): 274-280.

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A Discussion on the Development of the Furniture Industry & Ecological Environmental Symbiosis

Jack CHEN[1]

Abstract

After the announcement of the Kyoto Protocol, countries and companies world-wide are more aware of the greenhouse effect which is caused by the increasing exhaust of carbon dioxide. Wooden house and furniture are promoted as a result. On the other hand, world demand for forest products is increasing because of the continuous rising population. We are faced with insufficient global forest resources, damaged natural ecology, and insufficient fresh water resources due to excessive deforestation in some areas. At this moment, the merits and demerits between industry development and environmental protection is a serious subject for our consideration. And so is decision making.

Starting from the furniture product categorization and the current situation of the global furniture market, this article discusses strategies for industry competitive advantage and the reactions to the environmental issues. In addition, CAPFA (Council of Asia Pacific Furniture Association) and WFC (World Furniture Constitution) are included as well, discussing their organizational goals and ways of integrating Asian-Pacific resources to create global values for the industry.

Based on business managerial strategy and transnational furniture associations, this article discusses how to compete and cooperate with others in order to promote product value, and how to react to the global environmental issues. Further, it explains what furniture industries need to do now and further into the future. It is true that the environmental issues can threaten the industry. However, if we know how to seize it as an opportunity of utilization, this may lead to more competitive advantages.

Introduction

The production value of the global furniture industry reached about 300 billion US dollars in 2006. More than 150,000 companies operating in Asia generate production values up to 70 billion US dollars during the year. According to estimates, wooden furniture accounts for 60% to 70% of the total furniture market. As a result, timber is massively required and consumed by this industry. If the requirement of wooden furniture keeps increasing, and the speed of afforestation falls behind deforestation, it may lead to increasing environmental destruction, forest resource depletion, and a decrease in groundwater availability.

On February 16, 2005, representatives from various countries signed the Kyoto Protocol. This reminds all global citizens of the responsibility to reduce the environmental damage caused by human activities. The adoption of wooden houses and furniture provides

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positive effects to both the environment and world population by reducing the output of carbon monoxide and energy. However, the excessive consumption of wooden products could finally harm the environment and people if it results in the depletion of forest resources and an unbalanced ecological system. Hence, furniture industry businesses are forced to reconsider how to properly utilize the forest resources, create more values for customers, and strive hard to sustain the natural environment.

The first part starts from the furniture industry, explaining about the classification of the modern furniture, and states several benefits of wood furniture. Then an overview of the global furniture market is discussed to show the distribution and major players among this industry. The second part goes into the industry managerial strategies, from the general competitive strategy (ie. cost leadership, differentiation, and focus) to business cooperative strategy, accessing the managerial tactics and business co-opetition among the industry, and then discusses the relationship between the mentioned strategies and environmental protection. The third part talks about the overall prospects, introduces the establishment and objects of CAPFA (Council of Asia Pacific Furniture Association), international furniture of organizations, the contribution of furniture, and to environmental topic efforts and feasible directions for the future. Based on the above topics, the author then proposes conclusions and suggestions in the final section.

Furniture Industry and an Overview of Global Furniture Market

Furniture Industry

Furniture is the collective term for the movable objects which may support the human body, provide storage, or hold objects on horizontal surfaces above the ground. Storage furniture (which often makes use of doors, drawers, and shelves) is used to hold or contain smaller objects such as clothes, tools, books, and household goods. The gathering of companies which provide services of designing, manufacturing, marketing, and selling furniture products to satisfy customers' needs is defined as the Furniture Industry. There are manifold furniture products and can be classified by different criteria as shown in Table 1.

Table 1: Classification of Furniture Products

by Function	Chair, Table, Cupboard, Bedding Set, etc.
by Location	Living Room, Bedroom, Kitchen, Dinning Room, Outdoor, Office, Public Area, etc.
by Material	Wooden, Metallic, Bamboo, Rattan, Plastic, Stone, Upholstery, etc.
by Product Type	Bedding Set, Upholstery, Dinning Table and Chairs, Kitchenware, Office Desks & Chairs, Steel-tube Chairs, Sofa Sets, etc.

Source: The General Guidance, TAIWAN FURNITURE

Good furniture designs and material selections may save labor input and keep the human body from feeling tired easily. Particular wooden products can adjust the indoor temperature and moisture, transpire pleasant aromas, absorb toxic materials in the air, and release far-infrared to increase the blood circulation of the human body. A brief explanation about functions of wooden furniture is summarized in Table 2.

Global Market Analysis

As demonstrated in Figure 1, the United States is the biggest manufacturing country generating around 20% of global industry production. We also noticed the fast pace at which Asia area has become the major production base for the world-wide furniture

Table 2: Functions of Wooden Furniture

Temperature Adjustment	Wood provides the ability of adjusting interior temperature better than other materials such as rockwool, concrete cement, bricks, etc.
Moisture Adjustment	Wood may adjust the air moisture through changing the water content of material itself.
Cell Porosity	The cell structure of wood may absorb the sound in the air and provide sound-proof function.
Coefficient of Friction	Unlike the slippery surface of marble and tile, the log provides mid-level coefficient of friction.
Comfortable Touch	Unlike metallic, tile-on-surface, or marble-made products, wooden furniture provides a warm and pleasant sense of touch.
Visual Comfort	Low light-reflection ratio and keep eyes feel comfortable.
Pleasant Smell	Certain woods may transpire pleasant smell and phytoncidere into the air.

Source：http://www.osaka888.com.tw/index-3.htm

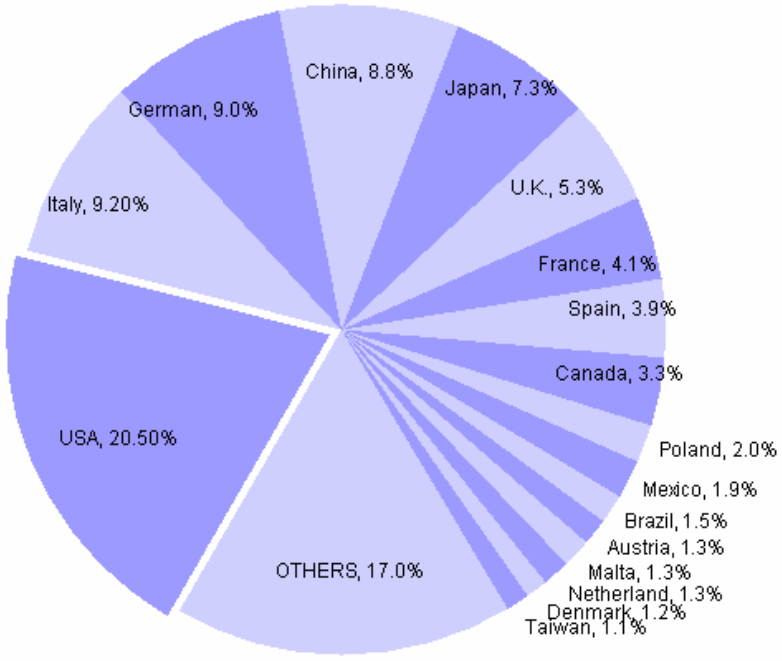

Fig. 1: Global Furniture Production

Source: ASIAN MIND, WORLD VISION, an Annual Publication of CAPFA, 2006

market within a very short of period. In 2006, numbers of furniture businesses located in Asia reached 150,000 and the total production value accounted for 80 billion US dollars. During the same time, the total amount of global furniture trade came to 86 billion US dollars. Among the trading business, major furniture consumption countries such as US and other European countries have continuously increased their purchasing quantity and value. The ratio of imported value against product consumption accounts for about 40% ~ 60% among the major countries. The US consumed about 80billion dollars (26 billion dollars by import) as the biggest furniture consuming country in 2006. Germany, France, the United Kingdom, and Japan are ranked behind. The sum of the top five consuming countries reached 51 billion US dollars which represents 60% of the global furniture trading business.

According to industry estimation, wooden furniture accounts for 60% to 70% of the total market. The production value of wooden furniture increased 28.4% in 2006 (from 9 billion USD in 2005 to 12.7 billion USD in 2006). Such statistics show the trend of the global furniture industry, especially the strong growth in the Asia-Pacific area. With the increasing demand for wooden furniture, the needs of forest resources from the furniture industry are also dramatically increased. This phenomenon will definitely affect the global forest environment. While keeping pace with industry development, the issue of managing and utilizing forest resources in order for everyone to prosper is a very important subject.

Industry SWOT Analysis and Strategy

The output value of the whole furniture industry is huge. Due to low entry barriers, there are large numbers of firms which lead to high competition. How to increase the competitive advantage to face the global competition while remaining conscious of environmental protection becomes a great issue. The Following SWOT analysis, looks at ways to use green marketing strategy, strategy alliance as well as integration of regional economics in order to promote the whole value chain.

SWOT Analysis

Through the following SWOT analysis, global development as well as the supply and demand situation of the furniture industry is clearly identified. Meanwhile, the higher competition and consciousness of environmental protection is transforming the furniture industry to obtain more business opportunities by adopting innovation strategies.

Table 3： SWOT Analysis

External Environment	**O - Opportunity**	**T – Threat**
	♦ Rise of Population, Consumption Ability, and Living Standard ♦ Improvement in office environment, the office furniture becomes a large market ♦ Establish of International Organization	♦ The Increase of Raw Material Price and Labor Cost ♦ Global Competition ♦ Concerns on Environmental Issue
Internal Environment	**S - Strength**	**W - Weakness**
	♦ Mature Manufacturing -Economies of Scale ♦ Diversification -Economies of Scope ♦ Developed Industry Alliance and Co-opetition ♦ Benefits of Global Specialization, Regional Integration, and Industry Clustering	♦ High Dependence on Wood Resource ♦ Lack of Design Ability and Brand Management ♦ Expansive Cost on Transportation and Promotion

Competitive Strategy

From Competitive Strategy (Free Press: 1980), Michael Porter identifies Overall Cost Leadership and Differentiation to be fundamental competitive strategies. As to the cost

down activities, business may implement MIS (Management Information System) and value chain management systems to obtain rapid & accurate information as well as to reduce the overall cost. For a differentiation strategy, businesses should build their own brand to promote better quality products and services which may increase their value. An Integration strategy is a good way to diversify products. To enforce natural resource advantages, international specialization should be created, as well as organizations and constitution may help them to achieve the integration. In aspect of sustainable business operation, the integration of information and value chain may shorten the response time and therefore increase the efficiency and value.

To touch upon the aspect of economic resource, the furniture industry should find ways to lower overall costs especially on material cost, pay attention to research better substitutes which are environmental friendly. To use wood recourses more efficiently, we may adopt methods such as optimum cutting, plywood, recycling, compounding, compressing, and so on. On the one hand it can reduce cost and increase competitive advantage. On the other hand, by proper design of wood processing, the forest resource can be used effectively. In aspect of differentiation, the setups of environmental protection standards are required by each business. Moreover, businesses are differentiated by using social marketing strategy on management, as well as by proceeding green marketing toward products to assure consumers of the product quality.

Cooperative Strategy

Value Chain Integration

The furniture industry value chain connects the process of research and development of related components, product design, manufacturing, logistics, marketing, and after-sale service. Items mentioned above are usually being taken as short-term concerns. For example, product designs, substitute materials, manufacturing process improvement, and information system implementation emphasized to support managerial decision makings. To sustain business management, most leading companies undertake activities like financial planning, human resource control and education, comprehensive market planning, brand management, service network construction, and so on. With more entities putting emphasis on long-term considerations, the industry will become more competitive.

Alliance for Industry Cooperation

In the past, companies competed with others within the same industry. However, businesses nowadays are forced to face the competition from the entire business environment. Due to rapid change in the furniture industry, all members must now strive to manufacture products suitable for the macroeconomic environment. Besides, the relationships among the group turn out to be highly complex and interactive. To satisfy the market needs of product customization and diversification, it is necessary to develop more stimulated activities of searching for shared resources and cooperation among the industry.

Facing the rapid changes of the industry environment, enterprises shall be able to have insight into opportunities through the process of global economic integration. There are needs for the furniture industry to forge strategic alliances, integrate upstream and downstream suppliers to obtain closer cooperation, expand the flexibility of order processing by adopting global specialization to reduce the labor needs, and to utilize marketing strength and production efficiency as the base of promoting international

competition. With such efforts on coordinating procedures of manufacturing and distributing, businesses are turning from local manufacturing companies to marketing companies which serve as global logistics management centers.

Global Specialization and Regional Integration
The world is getting flat, thus the structure of the furniture industry is influenced deeply. Global specialization and regional integration have become a critical issue for the furniture industry. China, the spotlight of world, has become the center of furniture production and also a huge potential market itself. In 2005, China surpassed Italy to be the number one position of furniture export country.

There are many components of furniture products, such as timbers, cloth material, furs, paints and so on. A proper allocation of global resources contributes to the development of furniture industry. Having a flawless supply chain is a key success factor for businesses located at nearby areas to promote industry development. The forming of industry clusters has become a global phenomenon. It plays a very important role to highly integrate the industry chain, strengthen the competitiveness of the entire group, and to promote the efficiency on flows of capital, human resource and information.

Co-opetition and Ecological Environment
In the short-term operation, businesses shall put more emphasis on instilling the concept of environmental protection into product designs. For instance, joining an industry organization and helping companies implement total quality control management and ISO 14000 to avoid the processing inaccuracy or related pollution caused by the entire production chain. Members of this industry shall commit to provide products of market needs, set up standards to better facilitate resources and to form the controlling mechanism for the earth. Companies within the industry must strictly follow the regulations to fit the environmental requirements. Those companies which do not follow the rules shall be blocked for further operation through legal procedures.
As to long-term business management, social benefits must be considered together with company benefits. Business shall transform focus into a broader view, such as the designing of brand image and green marketing, recognizing related environmental issues, increasing performance of environmental protection controls, and acknowledging the value of green marketing. To avoid or reduce harmful influences to the natural environment, furniture organizations shall lead all members to implement those workable management systems and methods to minimize the pollution and to utilize resources effectively.

Moreover, it is suggested that wooden furniture shall be tagged with the place of material origin and the environmental certificate. With a social-oriented strategy, all members of this industry need to think about the social benefits as a whole, set up standards and regulations regarding environmental protection issues, and to increase the global resource management of the entire forest environment to sustain the development of furniture industry and the forest resources.

Transnational Furniture Industry Organization
Council of Asia Pacific Furniture Association, CAPFA
Founded in 1980, the Council of Asia Pacific Furniture Association (CAPFA) has stepped into the 27th year successfully. For the past 27 yeas, it has provided the services and communication channel among the related organizations in Asian countries. CAPFA

remains committed to its mission statement - "*Promote the integration of international resources and dedicate to the prosperity of furniture industry*". Members of CAPFA gradually establish consensus in many ways. Meanwhile, CAPFA also coordinates the operational strategy between individual processes. Not only limited to the Asia Pacific region but also expanding to geographic areas such as the European Union, Northern America, Middle East, Russia, etc. CAPFA is actively furthering the cooperation among international enterprises and attempting to achieve a win-win situation from the affiliation.

World Furniture Confederation, WFC

The WFC begain from the 1st World Furniture Congress, which was held in Balearic Islands, Spain, in May, 2006. The 2nd World Furniture Congress is scheduled to be held at the China International Furniture Expo in Shanghai, Sept. 12-15. The congress will announce the establishment of World Furniture Confederation. Objectives of the WFC are to create values for the world wide furniture industry, eliminate trading barriers of furniture products and materials used during the production chain, encourage cooperation among members, help to establish regional furniture industry organizations, and to organize annual World Furniture Congress.

The meeting is focused on issues such as corporate strategic management, product design and development, information technologies, marketing, and branding. Other topics include retailing, logistics and worldwide industry cooperation. This event will bring together symbolic characters and executives from world-wide furniture industry to discuss and share their insights on "Globalization: Influences on Cooperation and Development". The congress program addresses crucial topics, such as changes and challenges of global trade, sustainable development, intellectual property rights, market information, and development trend. More practical issues are addressed as well, including the progress of manufacturing technology, management software implementation, best managerial practices and regional developments. In addition, western delegates may gather valuable insights into expanding business such as sourcing, manufacturing, and selling in Asia area.

Integrating Asia Pacific's Resources, Creating Global Value

The international furniture industry can be separated into three territories: the European Union, North America, and Asia Pacific and prospective states around the world. The rising economics in Asian area has transformed major furniture production countries to a different strategic thinking, thus the Asian region has become the production base or the OEM center. This trend not only leads to economic growth, but also stimulates the domestic demands in the Asian region.

CAPFA, attempting to activate the global furniture industry, will hold the world furniture congress to share all the enthusiasm with the European Furniture Manufacturers Federation (UEA) and the American Home Furnishings Alliance (AHFA). The conference will cover issues including design, production, marketing, retailing, etc. Toward product design, the association puts focus on how to create added value for the enterprises; as to the production, it emphasizes how to surmount the technology and quality standards by strategic outsourcing from European and American enterprises. As for Marketing, we will discuss how promotional activities initiated the predominance for developed countries and how those could have benefited from opportunities in Asian market. Also, retail systems will be investigated to understand industry maturity in

European and American markets, and how to apply the systems to the build-up of new markets in Asia.

Furthermore, the global village has become boundless. No single region, country, or enterprise can survive with a close-door policy. Thus, studies on cross regional cooperation and information technology implementation may act as efficient approaches for pursuing the continuous improvement process to overcome international competition. There is no limitation for cooperation, for example, "Designed in Europe or America and made in Asia", "Marketing in Europe or America and retailing in Asia", "Europe or America branding & Asian producing", "Branding and manjufacturing in Asia, retailing in Europe or America" and so on. The advantage of cooperation is to join each company's strengths for creating greater value. Therefore, integration of the communication network and resources becomes essential for the time being.

Concerns about Environmental Issues
On February 16, 2005, representatives from various countries signed the Kyoto Protocol. This reminds all global citizens of the responsibility to reduce the environmental damage caused by human activities. The adoption of wooden house and furniture provides positive effects to the natural environment and health of humans in ways such as reducing the output of carbon monoxide and transpiring phytoncidere, however, the excessive consumption of wooden products will finally harm to the environment and populations caused by insufficient forest resources and the unbalanced ecological system. Hence, furniture industry businesses are forced to reconsider how to properly utilize the forest resources, create more values for customers, and strive hard to sustain the natural environment.

In 1996, the International Organization for Standardization announced the ISO 14000 series environmental management standards to help organizations minimize how their operations negatively affect the environment. The existence of such standards allows organizations to focus on specific environmental related criteria. The fact that companies may need environmental management certification to compete in the global marketplace could easily overshadow all ethical reasons for environmental management. In Europe, many organizations registered ISO 9000 primarily to meet the growth from customer demands. ISO 9000 quality registration has become necessary to do business in many areas of commerce. Similarly, the ISO 14000 management system registration may become the primary requirement for doing business in many regions or industries.
With the rising importance of internationalization, furniture industry associations or organizations have been established. The objectives of such platforms aim to build up transnational economic cooperation and to enhance the industry competitiveness by sharing all members with market information, business experiences, manufacturing techniques, and managerial methods. Industry competitive advantages are hence generated by the transformed market-oriented product supply, and by the combination of industry chain clustering and existed business advantages.

Conclusion & Suggestion
To sum up, a general picture of the global furniture industry and future market trend is introduced. Through the SWOT analysis on this industry, an explanation about business co-opetition, strategies such as cost leadership, differentiation, transnational cooperation, and global specification & integration are illustrated as being able to provide positive support to enhance the industry competitive advantages. Besides, the global warming

phenomenon caused by the "greenhouse effect" needs to be addressed. Such environmental concern leads to a bright future of market needs on wooden furniture and helps to develop the industry. At the same time, the management and control of forest resources is getting more attention. All members of this industry need to think about the social benefits as a whole, set up standards and regulations regarding environmental protection issues, and to increase the global resource management of the entire forest environment to sustain the development of furniture industry and the forest resources. Suggestions to the furniture industry:

A. Sourcing and developing substitutive materials to meet requirements on environmental regulations with low cost.
B. Creating high value-added products by adopting market segmentation and differentiation strategy to increase the market value of wooden furniture goods.
C. Forming alliances for merchandising and purchasing timbers at the place of origin. Products shall be tagged with information regarding the place of origin.
D. Introducing factory management to effectively reduce wood consumption through streamlining production and implementing information management systems.

5.2 Suggestions to the transnational furniture organizations:

A. With the rising importance of society internationalization, furniture industry associations and organizations are developing. Objectives of such platforms aim to build up transnational economic cooperation and to enhance the industry competitiveness by sharing all members with market information, business experiences, manufacturing techniques, and managerial methods. Industry competitive advantages are hence generated by the transformed market-oriented product supply, the combination of industry chain clustering, and the existed business managerial advantages.
B. Enterprises shall pay more attention to issues regarding the environmental protection while aggressively pursuing the increase of product development and sales revenue. The most important and practical task ahead is to implement policies of environmental protection among the industry chain through implementing the organization's mission statement and commitment. Organizations shall have responsibilities of educating, consulting, and helping members to execute quality assurance systems like ISO 14000. This may help businesses not only to increase management precision and efficiency on manufacturing procedures and resource control, but also to decrease the loss and consumption of raw materials. Moreover, such efforts on following environmental related policies may contribute to keep health of the global population and the sustainability of forest environment.
C. As a member of the global society, all enterprises must undertake the responsibilities of maintaining the balance of the ecosystem. During the procedure of manufacturing and transport to consumers, manufacturers shall put an effort into considering how to avoid excessive exhaust emission. Concerning the consumption of wood materials, wooden furniture manufacturers shall best utilize current forest resources and apply related management policies to maintain the balance of the carbon dioxide. For the moment, there are some enterprises starting actions on protecting the survival of global forests, for example, purchasing lands located at tropical rain forest areas, maintaining the terrain features, or executing the forest reviving project to slow down the speed of massive forest destruction caused by economic development.

References

李瑞珍 Louis Lee, (2006), 木質家具工業經營策略與運籌管理 (The wooden Furniture Industry Strategies and Logistics Management), The General Guidance, Taiwan Furniture, p517-522

高義芳 Yie-Fang Kao, (2006), 全球市場分析 (The Global Markets of Furniture), The General Guidance, Taiwan Furniture, p510-513

胡景初 Jing-Chu Hu, (2005), The Present and Development Trend of Chinese Furniture Industry, Wood Working Machinery, No. 4, p1-p5

陳燕木 Jack Chen, (2006), ASIAN MIND, WORLD VISION, An Annual Publication of CAPFA

聶微 Nie Wei, (2003), 突破綠色壁壘: 家具企業實施 ISO14001 實務指南 (Rules and Practices of Furniture Industry to apply ISO14001), 北京: 中國標準出版社 (Standards Press of China in Beijing)

Porter, Michael E. (1985) Competitive Advantage: Techniques for Analyzing Industries and Competitor, The Free Press (1980)

Xu-Meiqi, (2005), Demand and Supply of Raw Materials for the Chinese Furniture Industry, International Wood Industry, Vol. 35, p30-p32

Yasumasa Kosuga, (2007), Reactions to the Radical Changes on the Structure of Furniture Industry, Home Living World

Forest Products and Environment – A Productive Symbiosis

Ute SEELING[1]

Abstract
Forests cover one third of the earth. They play a central role for the protection of nature and climate. At the same time they secure the human basis for life by delivering clear water, fertile soils and an extraordinary biodiversity.
Beside of all these natural benefits of forests, sustainably managed forests have also the essential role of wood production. Wood is the world's most important raw material – and it is a renewable resource.
The demand for forest products is predicted to constantly increase into the future – both for production of wood-based products but also for the production of energy and heating.
To satisfy this rising demand without destroying the forests, the following must occur:

- The forest area needs to be extended,
- The availability of wood must be increased,
- Suitable sustainable management concepts should be developed,
- The utilization of the wood should be optimised by innovative products and sources of energy and production processes optimized.

To optimise the utilisation of timber and the multiple benefits of forests, management models are important to explore various alternatives.
A comparison of wood-based products and sources of energy with competitive materials can only be done on the basis from complex life cycle assessments (LCA) which refer also the ecological achievements of the forests.

Introduction

About 3.837 billion ha forests worldwide cover nearly 30 % of the earth's surface. The largest forest areas can be found in Asia, South America and Central Africa. The extremely high biodiversity of forest ecosystems make them the most important elements for the planet. Forests are habitat for plants, animals and people but also relevant for the climate, the soil and the water. Besides, forests deliver a high range of timber and non-timber products.

Of the nearly 3.5 billion m³ timber harvested every year worldwide, half are used as raw material for wood products and half are used for energy and heat production. This makes timber – with regard to the weight and volume - the most important raw material in the world (Table 1).

In 1992, more than 100 heads of state met in Rio de Janeiro for the first International Earth Summit convened to address urgent problems of environmental protection and socio-economic development. They signed the Convention on Climate Change and the Convention on Biological Diversity, endorsed the Rio Declaration and the Forest Principles, and adopted Agenda 21, a 300-page plan for achieving sustainable development in the 21st century. In these documents the important role of sustainable forest management and the utilisation of timber were underlined.

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Table 1: Yearly production respectively harvest of timber in 1997 compared to other important raw materials for constructions

Material	**Utilised weight**	**Utilised volume**
Roundwood	2.1 Brd. t	3.5 Brd. m³
Industrial Roundwood	1.0 Brd. t	1.7 Brd. m³
Cement	1.1 Brd. t	1.0 Brd. m³
Steel	0.8 Brd. t	0.1 Brd. m³
Plastics	0.09 Brd. t	0.08 Brd. m³
Aluminium	0.02 Brd. t	0.007 Brd. m³

Nevertheless, in the following process of implementing the summit's conclusions into European and national programs, many other raw materials and energy sources played a bigger role in the political and public awareness.

The Contribution of Forests and Forestry to a Better Environment

It can be stated that forests are an important element in the global ecosystem. On the one hand vital forests require a sound environment but on the other hand the forest growth contributes to the improvement of environmental conditions – air and water quality, soil, climate, etc.

Forests are Indispensable for the Climate

Tree growth itself has some positive environmental effects: the transformation of solar energy to chemically stored energy; the absorption of CO2 and the accumulation of carbon in the timber as well as the reduction of pollutants in the air.

Through these mechanisms, forests influence not only the local and regional but also the global climate. Nevertheless, the totally stored carbon in forests is only 1648 Gt which is relatively low compared to the oceans (38000 Gt). The annual potential to transform carbon is nearly the same (+2 Gt/a) of forests and oceans. Nevertheless, while forests contribute to the stabilisation of the climate they are at the same time severely at risk through global warming.

Forests are Water Filters and Water Pumps

Forests are vital for the water regime by filtering and storing water.
Through the beneficial water-retaining ability of forest soils and the surface texture of such ecological systems, forests store substantially more and higher quality precipitation water than all other land use forms.

Forests improve the water quality. Water pollution is minimized by bonding various substances in the humus complexes of forest soils and the use and storage in the production of woody biomass. The presence of the forest ensures a constant water supply and prevents rapid surface drainage. Precipitation is absorbed by the large water retention capacity. The slower surface drainage and the deep root systems under forests significantly decrease the risk of erosion.

Because of the high quality the ground water under forest ecosystems, it is highly appreciated and intensively used as drinking water. This can endanger the vitality of forests if it leads to a drawdown of the groundwater level.

Forests – the Perfect Protection for Soils

Soils play a decisive role in forest health. Rain water running off trees gets trapped in the soil like a sponge where it is retained for trees and plants as a water source. This also serves to limit water run-off into streams and filters various minerals and impurities from the water before it reaches streams and rivers. Plant life including trees is essential for maintaining the integrity of the soil. If plants are removed (e.g. deforestation or loss due to fire) then the soil is more at risk from erosion. This risk increases on steeper stands. In functioning forest ecosystems in Central Europe, 99.5% of the precipitation is stored or transported within the soil; on a meadow it is only 88% and on a corn field only 66%. Trees depend on soil for stability, nutrients, and water. Most nutrient cycling takes place in the top 50 cm (about two feet) of soil where supplies of air, water and food allow micro-organisms to thrive.

On the relatively young soils in Central Europe the forest is also crucial for the supply of organic material. Each year a hectare forest adds up to 15 tons organic material to the soil. With tropical rain forests there can be up to 200 tons. In contrast to this, a meadow creates only 1 ton per hectares per year. Forest soils depend on the protection of the trees for their production of organic materials, the nitrogen supply from the atmosphere, and the maintenance of moisture. If the soil of the forest is well protected it permits the optimal growth of the trees.

Forest Ecosystems have the Highest Biodiversity

Forests contain the greatest assemblages of species found in any terrestrial ecosystem, and the status of biodiversity is, in itself, an indicator of forest condition. Forests encompass biodiversity at the ecosystem level, the species level, and the genetic level. Forest biodiversity is perceived as a benefit in itself, but perhaps no other ecosystem is subject to so many different interpretations. The conservation and exploitation of biodiversity are variously supported on scientific, economic, aesthetic, cultural and moral grounds.

Measuring forest biodiversity is beset by problems. Indicators of biodiversity status, at any level, are still controversial, and the data needed to support their development are incomplete:

- Genetic diversity is still largely unmapped
- Many species remain unknown to science
- Baseline and trend data are largely lacking; and
- Detailed systematic monitoring is beyond the resources of even the high-income countries.

Moderate estimates of future species extinction rates in tropical forests range from 1 to 5 percent per decade. However, such estimates have high and largely unknown levels of uncertainty, because of both the uncertainty of the underlying data and the assumptions on which they are based.

Sustainable Forest Management as Key to Maximise the Ecological Benefits of Forests

Primary forests are ideally in a balanced situation, in which the bonding and the release of carbon in form of CO_2 are nearly the same. In these forests the carbon storage is saturated, and no additional CO_2 can be derived from the atmosphere. These forests are rare and often protected because of the high degree of naturalness.

All other forests can have an effect as carbon sinks if they are managed sustainably. Under sustainable forest management timber is harvested and utilised and the newly grown forests bind additional carbon by growing and producing new wooden biomass (Fig.1).

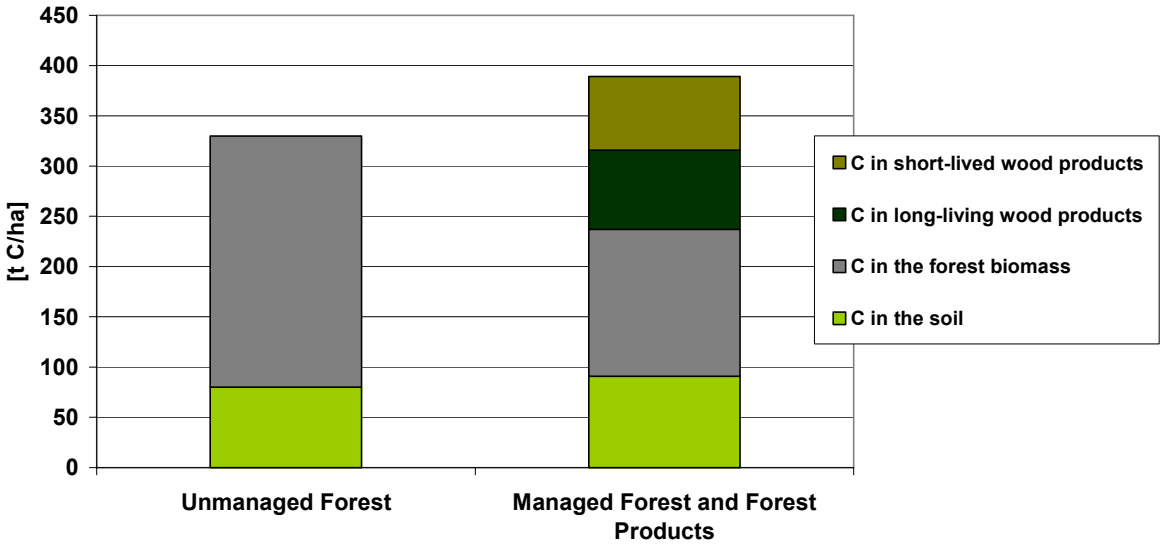

Fig. 1: Comparison of C-storage in forests and wood products (acc. to Profft, 2005)

This positive effect can only be used if the management of the forests is sustainable. Therefore for example the Ministerial Conference on the Protection of Forests in Europe (MCPFE) has defined ecological, economic and social criteria for a sustainable forest management.

The Global Trend to Renewable Resources – A Trend *Pro Wood*

Forests deliver a wide range of products, and in many counties the most important forest product remains timber. For wood and wood products the global demand will increase nearly 50 % until 2010 – compared to 1991. This increase is predicted for all wood products – from fuel wood to high value sawn timber (Fig. 2).

Other forest products can contribute significantly to local economies. In the Pacific Northwest, for example, is a whole industry utilising wild-harvested evergreen plant materials for floral arrangements. A most important group of forest products are edibles. There are not only mushrooms and huckleberries but also medical plants. Some of these products have an extraordinary importance in specific regions. Globally there is a trend of increasing demand towards renewable resources, which will continue in the future. Therefore three different aspects are intensively discussed how to increase the harvestable timber volume:

- To increase the management intensity in plantations and also to widen the plantation area. Plantations have a much higher productivity because they are much more intensively managed. Whereas the rotation period of middle European forests are about 80-150 years, in plantations the target is a rotation period of about 12-15 years. To reach these short terms plantations are fertilised and insecticides and herbicides are used.

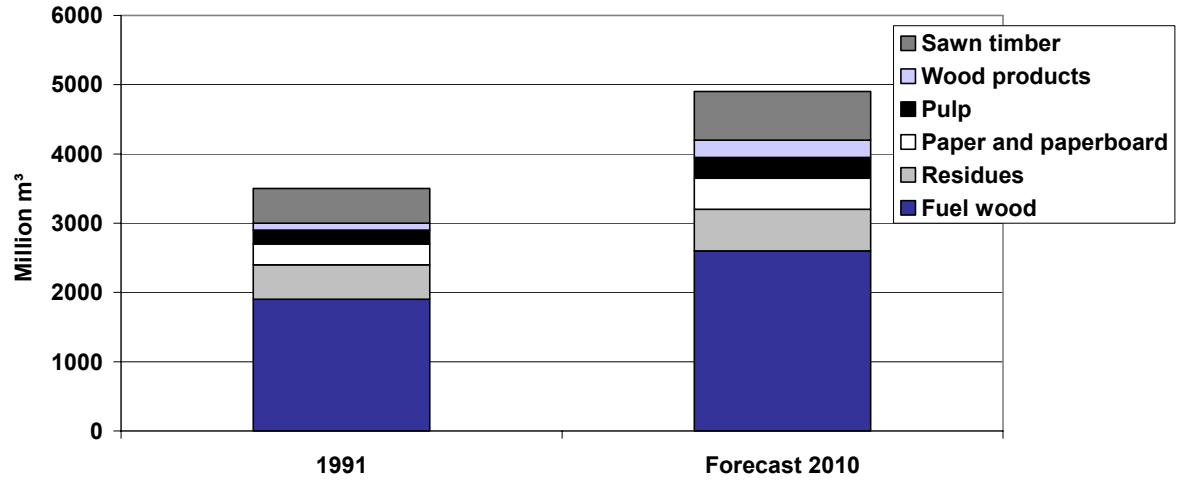

Fig. 2: Global utilisation of the timber and wood products per year (acc. to Kürsten, 2002)

The result is that for example it is predicted that in New Zealand on 1.8 million ha plantations the timber production will be as high as on 5 million ha traditionally managed forests in Germany (Fig. 3).

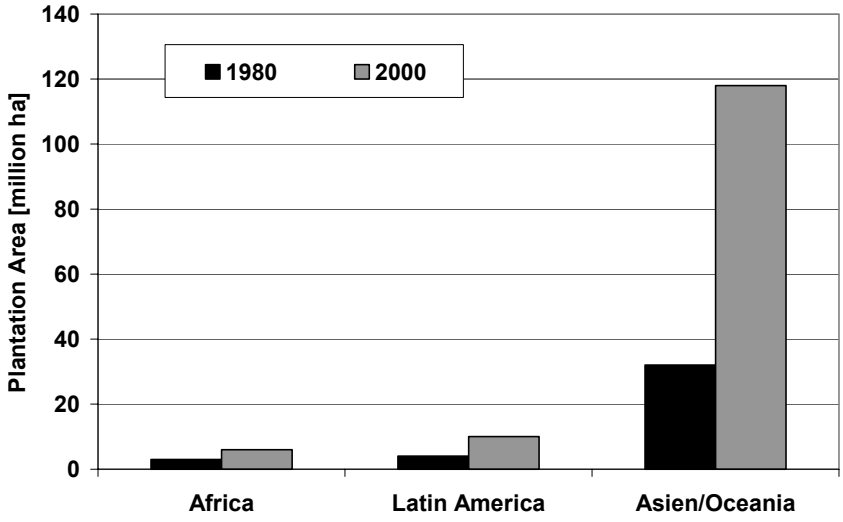

Fig. 3: Area of forest Plantations in the different regions (acc. to Kürsten, 2002)

- To use also smaller diameter timber mostly from upper parts of the trees. Since many years there is intense research done in the field of "small diameter logs". This should be continued and widened so that new products will be developed for the utilisation of crown material.

- To motivate the forest owner to manage his forest which means to increase the availability of timber. In many European regions the forests are still underutilised – mainly in small private properties. The size is often even less than 1 ha. Therefore the owner has less interest in utilisation and an important part of the potentially harvestable resource fails to reach the market.

Forest Products – Eco-Efficient as Raw Material and an Energy Resource
Forestry production differs from other natural (primary) production processes like agriculture mostly by its long duration of at least several decades up to even hundreds of years. Furthermore the lifetime of forest products varies in a wide range from typical consumption products like paper to really long-living products like construction timber (Fig. 4). In the average forest products have in Middle-Europe a lifetime of about 20 years.

Products	Fuelwood, Residues	Paper, Pulp, Packaging	Pallettes, Masts	Furniture, Wood Products	Parquet	Construction Timber
Av. service life	1 year	3 years	11 years	25 years	43 years	51 years
Perc. of C	9.8 %	35.8 %	0.5 %	30.8 %	0.8 %	22.3 %
	Short-lived products: 46.1 %			Long-living products: 53.9 %		

⇨ **The calculated average service time for wood products is 21 years.**

Fig. 4: Comparison of the service time of wood based products

To Store CO_2 – Utilise the Forests
Depending on the tree species and the roundwood assortment it is only necessary to consume in the production process until the logs are stored at the forest road between 1.1 and 4.2 % of the energy stored in the wood. Also regarding the CO_2-balance forestry production is unique: to produce 1000 kg absolutely dry timber the tree extracts 1851 kg CO2 form the atmosphere. Related to the CO_2 stored in a spruce log only 0.7 % is set free by using the chain saw and the harvester to fell the tree. This calculation has already taken into consideration all sources of energy for the earlier production steps.

Also the production of lumber is - compared with other construction materials – done by a low consumption of energy and thereby contributes to save CO_2. For the production of fresh sawn timber from Norway spruce between 155 and 510 MJ/m^3 is needed. This value includes all steps for debarking, sawing, sorting and packaging even the fuel for the traffic within the plant.

In many cases the lumber produced in the sawmill is technically dried for quality reasons. This drying process requires both electrical and thermal energy (heat energy). But even the dried sawn timber needs only 15 % of the totally saved energy.
All wood products and even engineered wood products are characterised by low primary energy consumption.

To Save Energy – Use More Timber

Many materials which were made of timber in the past could again be replaced by modern wood products nowadays in an ecologically sensible manner. For example, if wood is used as a construction material (building timber, window, furniture) instead of other materials which don't bind CO_2 during the production process but even have needed fossil energy the CO_2 level of the atmosphere can benefit. Therefore in many industrialised countries nowadays research and development is supported to develop new products using wood fibre.

The higher demand for timber has led to an increasing price level but also to a higher appreciation so that wood products are developed with a higher yield rate than in the past. In these research activities the recycling process is also considered.

Wood – Pure Energy even after Utilisation

After the utilisation of the wooden fibre in different products – even after the potential recycling of the fibre - the energy content can be consistently used and represents thereby a source of renewable energy, which can replace fossil sources of energy and their CO_2-emission. Using the example of the timber roof which had been constructed in 2000 in Hannover (Germany) for the World Fair EXPO it has been calculated that at the end of the life of the building its 5,200 m3 wood and wood products can be converted into energy equivalent to the annual requirements for heating energy of 1600 single family houses (100 m² size) with low energy standard.

In principle wood is biologically degradable, whereby the natural material cycle is closed. Besides the cycle is also closed if the wood is used energetically. The large difference can be shown by the CO_2 balance: substituting energy means decreasing CO_2 emissions.

Conclusions

Forests and forest products have a lot of environmental advantages. So they form a kind of productive symbiosis – irrespective if the wood is used as raw material or an energy resource.

There is a lot of discussion on how the global forest resource can be used in the best way. The answer will probably be different in different regions of the world. A resilient comparison of the different alternatives for acting can only be done on the basis of simulation models. Because of the high number and complex interrelations it will be necessary to combine the different modelling approaches to evaluate the comparative advantages for the climate, soil and the environment, for example, of the different scenarios.

Literature and sources

Houghton, J. (1997): Globale Erwärmung - Fakten, Gefahren und Lösungswege. Berlin, Heidelberg: Springer Ed., 30 pages (German).

Kürsten, Ernst (2002): Perspektiven der Holznutzung weltweit; http://www.holz.uni-goettingen.de (German).

Schweinle, J.; Thoroe, C. (1997): Zur Ökobilanzierung der Rohholzproduktion in Deutschland. Forstarchiv, 52, 5: 110-116. (German).

Wegener, G.; Zimmer, B. (2000): Wald als nachhaltige Energie- und Rohstoffquelle. Forst und Holz 55, 18: 588-594. (German).

Wegener, G.; Zimmer, B., Frühwald, A., Scharai-Rad, M. (1997): Ökobilanzen Holz. Fakten lesen, verstehen und Handeln. Informationsdienst Holz, Deutsche Gesellschaft für Holzforschung (Editor), München. (German).

Wegener, Gerd; Zimmer, Bernhard: Holz als Rohstoff , in: Der deutsche Wald; out of: Der Bürger im Staat, 31. Jahrgang, 2004. (German).

Zimmer, B.; Wegener, G. (1996): Stoff- und Energieflüsse vom Forst zum Sägewerk. Holz Roh Werkst. 54, 4: 217-223. (German).

The Role of Wood Products in Meeting Ecological Objectives of Sustainable Forest Management.

R. James BARBOUR[1]

Abstract

Human populations continue to place greater demands on forests to provide a wide variety of ecosystem services. Among other things, both public and private natural resource managers are expected to find ways to enhance wildlife habitat, sustain rare and endangered plant and animal species, conserve soils, and provide clean water and air. Private landowners continually search for ways to efficiently provide products and services. Public land managers struggle to find a formula that balances the public's seeming desire to "allow nature to run its course" against concerns about support of rural economies, the effects of natural disturbances such as fire or insect outbreaks, and the time it takes for previously harvested forests to regain old-forest characteristics. Intensive and extensive wood production management strategies can play a role in accomplishing these objectives on both private and public land. On private land, wood production provides a major economic incentive to keep forests on the land. In many places the alternative is either conversion to agriculture or development of land for other human uses. Government regulators who seek to protect biological diversity or other non-commodity values on private land must understand that regulations do not always have the intended effect and can actually speed replacement of forests with other uses. Public land managers have a different type of challenge. Their budgets often are insufficient to accomplish management goals or they are faced with conditions where excess woody biomass can lead to undesirable disturbances or unacceptably slow development of older forest structure. In these cases, harvest of wood can provide needed financial resources or its removal can lead to more desired forest structural conditions.

Key words: Sustainable forest management, wood production, fire, natural disturbances, land use change, ecosystem services

Introduction

As human populations grow or our geographic extent expands we alter the composition, structure, and function of the Earth's forests. We frequently influence the operation of the ecological processes that shaped forest conditions during pre-industrial times. For example, fires once moved freely across large parts of the world. Sometimes these fires were started by aboriginal people and sometimes they were initiated by natural events, but in either case, once wildfires started it was difficult for people to affect their progress or path. When post-industrial humans began to control landscape-scale fires, we sometimes affected forest composition and structure and the ecological processes that previously controlled them in unintended ways (Arno and Fiedler, 2005). A more subtle example occurs when humans intentionally or unintentionally move species around the planet. If these introduced species become established in new ecosystems they alter those systems and the ecological processes that govern them in ways that are difficult to anticipate and are often irreversible. But perhaps the most dramatic example of how we change forest

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vegetation and the ecological processes that operate within those forests is when we harvest or clear indigenous[2] forests.

This activity has caused many people who care deeply about the natural world to conclude that the practice of commercial forestry is a destructive process. When one looks at the extent to which humans have altered indigenous forests since the dawn of the industrial age, it is not easy to refute this claim. On the other hand, when one thinks of the sheer size of the human population it is hard to imagine how we could return things to the way they were during pre-industrial times (Deckker-Robertson and Libby, 1998). Added to this, as we begin to understand the importance of vegetative succession, structure, and function at the landscape scale, it is difficult to see how by themselves networks of parks, preserves, and reserves that exclude wood production and truly protect these processes are sustainable in many parts of the world, given current human population distribution and landownership patterns.

Recognition of the complexity inherent in conceiving and implementing strategies that both conserve biological diversity and allow a broad suite of ecological processes to function across large landscapes has led some groups to augment what can be accomplished using parks, preserves, and reserves. The wordings of definitions for sustainable forest management differ somewhat, but in general they agree that this practice involves management in ways that allow delivery of a combination of ecological, economic, and social benefits indefinitely. The Society of American Foresters, for example, defines sustainable forest management as, "*the capacity of forests ranging from stands to eco-regions, to maintain their health, productivity, diversity, and overall integrity, in the long run, in the context of human activity and use*" (Helms, 1998). When I think about the potential role wood production might play in sustainable forest management, I consider two broad possibilities. The first has to do with management behaviours associated with post-industrial human populations moving into indigenous forests either across a frontier into large blocks of indigenous forest or from population centres into remnants of indigenous forests. The second has to do with management of forests in developed areas where the indigenous forests already have been removed. This may include a wide variety of management options for large blocks of forest – comprised of either native or non-native tree species- perhaps composed of mixed public and private ownership, or the diffusion of human populations into the forest for habitation. In each of these cases my main interest is whether the economic or financial incentives associated with wood production can play a role in helping landowners or government managers justify management in ways that conserve or enhance the range of biological diversity potentially produced in that forest or the potential for a broad suite of ecological processes to play out across space and time. Most of all, I am curious about ways to use wood production to avoid the long-term removal of the forest cover through conversions to agriculture or by development for non-forest uses such as human habitation.

Extraction of forest products is often the motivation for entering large blocks of indigenous forests but once we enter them, humans tend to develop land for agriculture, habitation, and recreation. These activities often greatly increase regional economic prosperity, but they can dramatically change both vegetation and ecological processes (Rudel and Roper, 1997). This cascade of events frequently completely changes

[2] By indigenous forests I am referring to forested ecosystems that have not been intentionally altered by postindustrial societies. I am not considering changes brought about by aboriginal cultures or changes in atmospheric or climatic conditions potentially caused by industrial societies.

vegetative cover types, removes or erodes soils, alters the courses of streams and rivers, and results in other physical changes that are not consistent with the ecological conditions that previously existed on the land (Maser, 1994). Opportunities may, however, exist to incorporate wood production into strategies to conserve these unique resources, particularly in situations where some fragmentation of the indigenous forest has occurred but ecological systems have not yet been substantially altered (Barbour *et al*., 2005).

In the context of forests that have already been substantially altered by the activities of post-industrial societies, I am curious about whether the growth of trees for wood production could play a role in maintaining biological diversity by diminishing the incentives for land conversion either to agricultural or human occupation. This course of action could lead to many different outcomes in terms of how lands managed primarily for wood production contribute to the overall biological diversity of a region. At one extreme is the notion that a forest is better than a farm and a farm is better than a building, so any situation where trees are maintained on the land is a positive outcome. This line of thinking could lead to situations where affluent societies scatter houses across broad landscapes, and, although tree cover is maintained, the forest no longer functions as a working forest either in an industrial or ecological sense (Alig *et al.,* 2000*)*. Under this scenario, natural disturbances are generally seen as highly undesirable. Preventing them could result in forested landscapes that function quite differently than their pre-industrial precursors and, therefore, deliver a different set of ecosystems services. At the other extreme is the idea that managed forest can function in much the same way as indigenous forests. Strict preservationists would probably argue that this is an unattainable goal, while strict utilitarians might argue that it is unnecessarily restrictive.

As I discuss my ideas on this topic, it is worth remembering that most of my professional experience is in the Pacific Northwest region of the United States and in central Canada. My views are inevitably colored by those experiences, but I will try to use the literature to frame my discussions in a broader sense. I want to be clear that what follows is intended to provoke thought, not to advocate any one policy or land management strategy.

Wood to Burn or Wood to Build With?

When thinking about the role of wood in sustainable forest management, it is essential to differentiate between domestic fuelwood and industrial wood. Domestic fuel wood presents a much more vexing problem than industrial wood, because its economic value is low and when it is used for home heating and cooking it is almost always produced relatively close to where it is used. The people who use it tend to be poor, although that is changing as newer technologies such as pelletization, liquefaction, and gasification, offer people in developed countries reasonable alternatives for selecting wood as a domestic fuel. Concerns about the availability and environmental effects of fossil fuels are also causing industrialized nations to look more closely at wood as a fuel for industrial processes, particularly cogeneration of steam for industrial processes and electrical power production. I have limited my discussions to wood grown for industrial applications. This ignores a major driver of alteration of indigenous ecosystems associated with wood use - the gathering of fuel wood and growth of food by the world's poor - but it also focuses the discussion on situations where the economic value of the wood is likely to pay for cost of management and perhaps provide sufficient incentives to landowners to entice them to keep there land in forests.

Zoning or Integrating?

Zoning and integration are two very different approaches to sustaining ecological conditions and processes. Under zoning the uses of forestlands are segregated in much the same way that some governments allocate land to different types of industrial, agricultural, residential, and other activities (Binkley, 1997). Integration, also known as compatible forest management (Haynes, *et al.,* 2003), attempts to combine wood production with activities designed to conserve biological diversity and accommodate natural disturbance processes on the same landscape.

Zoning: Treating wood as an agricultural crop and managing plantations as intensively as feasible could allow growth of the world's industrial wood needs on a relatively small land area (Sedjo, 1983, 1999). Concentrating wood production in intensively managed plantations would theoretically free up other forests to provide non-timber-related ecosystem services. An added benefit is the fact that industrial plantations are often established on economically marginal agricultural land, not at the expense of indigenous forests (Sedjo, 1999). On the other hand, many of these plantations, particularly those in tropical areas, comprise nonnative species that may contribute little to native biological diversity (Boyer, 2001). Boyer (2001) uses the literature to make the case that complete reliance on plantations for wood production could inadvertently reduce the market value of natural forests. Fewer opportunities for income on the part of forest landowners could make them more likely to clear their land, convert it to agriculture, or sell it for development. In an ironic twist, if both Boyer's (2001) and Sedjo's (1999) assumptions are correct, a wholesale move to a zoning strategy could result in conversion of marginal cropland in some places to industrial wood plantations, perhaps even non-native plantations in the tropics, as native forests no longer supported by wood production in other regions are cleared for crops or development. In reality it seems unlikely that a wholesale shift to zoning is likely anytime soon, but both Sedjo (1999) and Boyer (2001) have presented statistics to show there has been a steady increase in the worldwide area of forest plantations with a corresponding increase in the proportion of the world's wood supply derived from them. For example, in the United States two-thirds of the softwood timber harvest will soon come from managed stands of native species that occupy only 10% of the timberlands (Haynes *et al.,* 2007).

A situation like the one envisioned by Boyer (2001) already exists in the U.S. interior West where fire suppression has created many densely stocked stands. The result is that stands in places and forest types where non-lethal fires were the rule during pre-industrial times are now at risk for stand-replacing fires (Hann *et al.,* 1997). Federal and state budgets are insufficient to support thinning or prescribed fire programs that will change stand and landscape vegetative composition and structure back to a more resilient condition and some policymakers have proposed using revenues derived from selling wood removed during fire-hazard-reduction treatments as a financing mechanism. This concept has even been embedded in U.S. Federal law (Healthy Forest Restoration Act, 2003), but fire-hazard-reduction programs have not moved ahead at the pace policymakers would like for two reasons. Many environmental groups oppose the cutting and selling of trees on philosophical grounds or because they are concerned about the ancillary impacts on other resources such as wildlife, soils, and aquatic systems. Even if this opposition did not exist, competition from cheaper wood, often from plantations in the U.S. South and Pacific Northwest, make it difficult to design these treatments so that they breakeven financially (Barbour *et al.,* 2004, Barbour et al., *In Press,* Fight *et al.,* 2004,).

The zoning model does, however, appeal to groups who advocate preservation of natural conditions in places like the U.S. Pacific Northwest where federal and state governments administer substantial portions of the landscape. In this type of situation, one could argue that removing public land from the timber base and replacing it by increasing the productivity of private land might provide an acceptable solution. Interestingly, this concept also has considerable appeal for large industrial landowners who often would prefer to treat their holdings like a farm rather than a forest. If a strict zoning approach were applied then regulations restricting the management of industrial plantations might be kept to a bare minimum, perhaps limited to activities necessary to conserve soils and prevent pollution of adjoining properties.

An extensive analysis of current and hypothetical management policies for Oregon's Coast Range ecological province (Spies *et al.,* 2007) has suggested that such a zoning policy could result in a segregation of the landscape into young forests on private land and old forests on publicly administered land. Following this scenario for a century could leave this province with virtually no middle aged forests. This finding agrees with an earlier study for the area west of the Cascade Mountains in Washington State (Adams *et al.*, 1992, 1994). These studies suggest that important components of biological diversity could fall out of the system unless policies are designed to ensure that either private landowners are given incentives to manage over longer periods (Montgomery *et al*., 2006) or policies for public lands are altered to provide for maintenance of some middle-aged stands. An important factor here is that forests in coastal Oregon are quite long lived (>500 years) and stand-replacing disturbances are relatively infrequent. It is probably reasonable to assume that results modelled by Spies *et al.* (2007) and Adams *et al.* (1992, 1994) would occur in any region where zoning were applied and natural stand replacing disturbance cycles (fires, insects, disease, wind, etc.) occur at relatively long intervals. In places where disturbances are frequent and small in spatial extent zoning could result in a variety of stand ages and structural conditions.

Looking at the problem in a different way, Bruner *et al.* (2001) found that parks in tropical areas were far more effective in protecting biodiversity than the areas adjacent to them. This suggests that for areas on the frontier parks, preserves, or reserves play an important role in stopping or slowing the conversion of indigenous forests to other uses. If various types of preserves and intensively managed areas were combined in a zoning strategy it might be possible to slow the movement of the frontier in places where timber harvest, not land conversion, is the primary objective of local residents. Such a strategy would probably only work if it incorporated the needs of the local residents (Colchester, 1996) such as provisions for fuelwood and access to other ecosystem services. According to Bruner *et al*. (2001) a major factor in determining a park's effectiveness is the density of guards, which suggests that the parks are effective because governments choose to enforce their rules rather than because the local population recognize the importance of conserving biological diversity. Such a lack of support by local people could become important as political systems and public attitudes evolve over time.

I believe that a major aspect of a truly sustainable forest management framework is creating systems that will function during times of political and social uncertainty. This feature is necessary because some of the ecosystems we are trying to protect are so long lived - often 500-1,000 years for a single cycle. This is much longer than many, perhaps most, socio-political systems survive. So to me, it is important to find management

systems that will transcend political systems. This is, of course, a huge goal and admittedly much more than most policy makers, landowners, or forestry practitioners would believe is implied under the precepts of sustainable forest management. In my view, a good way to begin working toward my longer range goal is by finding ways to conserve biological diversity through management of ecosystems that function in ways that are acceptable to large segments of society, are resilient to pressures expected from natural disturbance and management, and provide economic benefits by supplying wood and other ecosystem services.

Integration: In places with mixed public and private landownership inability to provide for the full suite of ecological conditions is a potential shortcoming of the zoning strategy. Returning to the Oregon Coast Range example, Spies *et al*. (2007) showed that zoning could cause certain elements of biological diversity to fall out of the system. One aspect of this result that is important in the U.S. Pacific Northwest is that the range of potential ecological conditions represented in the public and private portfolios are different. Public-private ownership patterns around the world often have a historic context similar to that found in the U.S. Pacific Northwest. As the frontier is settled, individuals and firms generally select what they perceive as the most desirable parcels and leave the less desirable areas for public ownership. Governments may reserve selected high-value areas for public management and latecomers may select marginally productive parcels for private ownership, but as a rule, highly productive areas end up in private ownership and less productive areas end up in the public estate. In the U.S. Pacific Northwest, private land is concentrated on the most productive, lowest elevation, flattest sites closest to water. Public land is concentrated on less productive, higher elevation sites further from water. Other uneven ownership patterns are seen in different countries such as Finland, where the publicly administered land is mainly boreal forests in northern areas and private ownership is concentrated on arable lands to the south (Mayer and Tikka, 2006). In these situations, a zoning strategy could not provide the full range of ecological conditions even if timber harvest were excluded from all of the public land. So if the goal is to find ways that wood production can contribute to providing the full suite of biological diversity and ecological processes using a sustainable forest management framework, then something more than a strict zoning model is needed.

One solution is to persuade private landowners to manage in ways that promote conservation of biological diversity. Montgomery *et al*. (2006) conducted a conceptual analysis for western Oregon that compared potential policies to promote development of old-forest structural conditions while permitting timber harvest on the types of highly productive sites commonly found in the private land portfolio and rare in the public portfolio. They estimated that over 95 years it would cost forest landowners and wood processors about $US 250 million to establish old forest structure on 20% of the private forest land in western Oregon. Compensating the landowners to participate in such a program would cost about $285 per ha, but to achieve this, only the most productive sites could be accepted into the program. This result is corroborated by Haynes, (2007) who estimated that a payment of $US11/ha/yr could entice private landowners in this region to double their rotation ages. These examples provide an idea of how private landowners might be enticed to begin participation in a system that provides more in the way of the full range of biological diversity than can be provided under the existing Northwest Forest Plan for the Recovery of the Northern Spotted Owl (USDA and USDI, 1994). In practice this plan has become a *de facto* zoning policy as demonstrated by Spies *et al.'s* 2007 analysis. To forward the concept of sustainable forest management, governments

and the private sector will probably need to find ways to work together to design integrated regulatory and incentive programs to entice both private landowners and public land managers to select desired management options. Finding ways to manage forest structure that are socially acceptable and financially viable is important to both groups.

Regulations and Voluntary Certification as Licenses to Practice Forestry

Regulation and voluntary certification programs are two very different paths that could lead to widespread adoption of sustainable forest management practices on private land. Governments have long sought to compel private forest owners to behave in ways that society deems acceptable through regulation. According to Waggener (1977) the first forestry regulations developed in Germany during the 18th century as a response to "*the problems of unregulated use of the forest as a common property with an economically undeveloped society*." The problem was that rapid cutting could lead to wood shortages and subsequent collapses in the forest products industry. Early forest regulations were, therefore, intended to mitigate this problem by ensuring an even and sustained yield of forest products. Frontier forest industries often migrate to follow the timber supply and although mill owners might see this as a satisfactory business model the residents of mill towns rarely feel this is an acceptable practice (Waggener, 1977). Regulation of production levels from public land and forestry practices on private land to ensure a sustainable supply of timber are obvious solutions to this problem. Accordingly, early forest practices legislation tends to focus on reforestation of cutover forests. Using the United States as an example, Ellefson *et al*., (1997) outline two additional phases in the evolution of forest regulation on private land. In second-generation programs governments add regulations that cover activities intended to protect specific non-timber related attributes of forest land, such as, streams and other aquatic resources, road-building practices, application of chemicals, prescribed fire, etc. These regulations generally describe standard procedures intended to avoid environmental damage resulting from forestry activities. They are also used as ways to assess and collect forestry related taxes. Third-generation programs tend to move the focus from sustained yield toward sustainability of non-timber related attributes, such as, biodiversity.

Private landowners tend to see such regulations as onerous because they reduce their potential income from forestry practices even though they might contribute to the pubic good. There is always a danger that additional regulation will tip the balance for landowners and cause them to sell off all or parts of their land for conversion to other uses. If that happens, at least some of the biological diversity value of the land will probably be lost.

Certification takes a different approach by attempting to influence landowner behaviour based on consumer choice rather than force of law. Under the certification model landowners who voluntarily participate in programs to manage in more sustainable ways benefit by gaining the good will of the public. Originally it was envisioned that certification would lead to higher prices for wood products from participating lands (Jenkins and Smith, 1999). But there is no real evidence that such premiums have materialized (Gullison, 2003). There is, however, evidence that the landowners who choose to participate in certification programs do change management practices (Newsom *et al*., 2006). There is also a growing trend toward governments embracing certification as a way to ensure that wood sold in their jurisdictions was actually grown in a sustainable manner. In a way, the decisions of governments to use certification as a method to control market access allows the market to set regulatory boundaries because the rules

that ultimately become part of the certification process result from a negotiation among the forest industry, the environmental community, and the public that is brokered by the certification organizations.

Conclusions

It is probably impossible to return forests that have been substantially altered by human activities to the composition, structure, and function that existed in pre-industrial times. For one thing, we do not know with any degree of reliability what was actually there. For another, the ecological potential of these systems has been changed by species extinction, introduction of non-native species, and climate change in ways that we do not understand and could not reverse. A more realistic goal is to establish forest cover that is compatible with the biophysical conditions and provides a suite of ecosystem services that people value and will be willing to protect indefinitely. In some peoples' minds this means stepping back from our forests and letting nature run its course. To others this means finding ways, in which local residents, and society in general, can derive benefits from sustainable forest management systems that they are willing to put before potential short-term gains that might not be indefinitely sustainable. In most cases, wood production will probably play a significant role in sustainable management systems because it will provide an important financial incentive to landowners and local residents. Harvest of trees is also an effective way to control the composition and structure of both tree species and understory vegetation. As result, wood production could provide a funding source to support non-commodity goals.

Literature Cited

Adams, D. M., R. J. Alig, D. J. Anderson, J. A. Stevens, Chmelik, J. T. 1992: *Future* Prospects for Western Washington's Timber Supply. *University of Washington, College of Forest Resources, Institute of Forest Resources Contribution Number 74. 201pp.*

Adams, D. M., R. J. Alig, Stevens, J. A. 1994: An Analysis of Future Softwood Timber Supply in Western Washington. *Western Journal of Applied Forestry 9(3): 81-87. (1994).*

Alig, R., Butler, B., Swenson, J. 200: Fragmentation and national trends in private forest lands: preliminary findings from the 200 RPA assessment. ***In*** *Proceedings, forest fragmentation 2000. Sampson, N., DeCoster, L. (eds.), American Forests (p.34-36),* Washington, DC.

Arno, S.F., Fielder, C.E. 2005: Mimicking Nature's Fire: Restoring Fire-Prone Forests. *Island Press, Washington DC.*

Barbour, R.J., Zaborske, R.R., McClellan, M.H., Christian, L., Golnick, D. 2005: Young-stand management options and their implications for wood quality and other values. *Landscape and Urban Planning 72:79-94.*

Barbour, R.J., Fight, R.D., Christensen, G.A., Pinjuv, G.L., Nagubadi, R.V. 2004: Thinning and Prescribed Fire and Projected Trends in Wood Product Potential, Financial Return, and Fire Hazard in Montana. *USDA Forest Service Pacific Northwest Research Station, Portland, OR. General Technical Report PNW-GTR-606.*

Barbour, R.J., Fried, J. 2007: Potential wood characteristics from fire hazard reduction treatments in Southwest Oregon and Northern California. *Forest Policy and Economics* ***In Press.***

Binkley, C.S. 1997: Preserving nature through intensive plantation forestry: the case for forestland allocation with illustrations from British Columbia. *Forestry Chronicle 73(5):553-559.*

Boyer, J.L. 2001: Environmental implications of wood production in intensively management plantations. *Wood and Fiber Science 33(3):318-333.*

Bruner, A.G., Gullison, R.E., Rice, R.E., de Fronseca, G.A.B. 2001: Effectiveness of parks in protecting tropical biodiversity. *Science 291:125-128.*

Colchester, M. 1996: Beyond 'participation': indigenous peoples, biological diversity conservation and protected area management. *Unasylva 186:33-39.*

Dekker-Robertson, D.L., Libby, W.J. 1998: American forest policy–global ethical tradeoffs. *Bioscience 48(6):471-477.*

Ellefson, P.V., Chen, A.S., Moulton, R.T. 1997: State forest practice regulatory programs: an approach to implementing ecosystem management on private forest lands in the United States. *Environmental Forestry 21(3):421-432.*

Fight, R.D., Barbour, R.J., Christensen, G.A., Pinjuv, G.L., Nagubadi, R.V. 2004: Thinning and Prescribed Fire and Projected Trends in Wood Product Potential, Financial Return, and Fire Hazard in New Mexico. *USDA, Forest Service, Pacific Northwest Research Station, Portland, OR. General Technical Report PNW-GTR-605.*

Gullison, R.E., 2003: Does forest certification conserve biodiversity? *Oryx 37(2):153-165.*

Hann, W.J., Jones, J.L., Karl, M.G., Hessburg, P.F., Keane, R.E., Long, D.G., Menakis, J.P., McNicoll, C.H., Leonard, S.G., Gravenmier, R.A., Smith, B.G. 1997: Landscape dynamics of the basin. ***In*** *An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins. Quigley, T.M., Arbelbide S.J. (Technical editors), Gen. Tech. Rep. PNW-GTR-405. USDA, Forest Service, Pacific Northwest Research Station, Portland, OR: 337-1055.*

Healthy Forest Restoration Act of 2003.

Haynes, R.W. 2007: Integrating concerns about wood production and sustainable forest management in the United States. *Journal of Sustainable Forestry 24(1):1-18.*

Haynes, R.W., Adams, D.M., Alig, R.J., Ince, P.J. Mills, J.R., Zhou, X. 2007: The 2005 RPA timber assessment update. *USDA Forest Service Pacific Northwest Research Station, Portland, OR, Gen. Tech. Rep. PNW-GTR-699. : 337-1055*.

Haynes R.W., Monserud, R.A., Johnson, A.C. (Eds) 2003: Compatible forest management: background and context. ***In*** *Compatible Forest Management*. *Chapter 1. Kluwer Academic Publishers, Dordrecht.*

Helms, J.A. (Ed.) 1998: The Dictionary of Forestry. *Society of American Foresters, Bethesda, MD. 210 pp.*

Jenkins, M.B., Smith, E.T. 1999: The Business of Sustainable Forestry. *Island Press, Washington DC.*

Kay, W.M., Donoghue, E.M., Charnley, S., Moseley, C. 2007: Socioeconomic monitoring of the Mount Hood National Forest and three local communities. *USDA, Forest Service, Pacific Northwest Research Station, Portland, OR, Gen. Tech. Rep. PNW-GTR-701: 97 pp.*

Maser, C. 1994: Sustainable Forestry: Philosophy, Science, and Economics. *St. Lucie Press, Boca Raton, FL.*

Mayer, A.L., Tikka, P.M. 2006: Biodiversity conservation incentive programs for privately owned forests. *Environmental Science and Policy 9(7/8):614-625.*

Montgomery, C.A., Latta, G.S., Adams, D.M. 2006: The cost of achieving old-growth forest structure. *Land Economics 82(2):240-256.*

Rudel, T., Roper, J. 1997: The paths to rain forest destruction: crossnational patterns of tropical deforestation, 1975-1990. *World Development 25(1):53-65.*

Spies, T.A., McComb, B.C., Kennedy, R.S., McGrath, M.T., Olsen, K., Pabst, R.J. 2007: Potential effects of forest policies on terrestrial biodiversity in a multi-ownership province. *Ecological Applications 17(1):48-65.*

Sedjo, R.A. 1983: The Comparative Economics of Plantation Forests: A Global Assessment. Johns Hopkins Press for Resources for the Future, Baltimore, MD.

Sedjo, R.A. 1999: The potential of high-yield plantation forestry for meeting timber needs. *New Forests 17:339-359.*

USDA 1994: Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl. Standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. *USDA Forest Service; U.S. Department of the Interior, Bureau of Land Management [USDA and USDI]. [Place of publication unknown]. 74 pp.*

Waggener, T.R. 1977: Community stability as a forest management objective. *Journal of Forestry 75(11):710-714. (1977).*

IUFRO and the Challenge of Change

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"*All is flux, nothing stays still. Nothing endures but change".*
Heraclitus, 540-480 B.C., Diogenes Laertius*, Lives and Opinions of the Philosophers*

"When memories exceed dreams, the end is near. The hallmark of a truly successful organization is the willingness to abandon what made it successful and start fresh".
Thomas Friedman, 2005, *The World is Flat*

Abstract
The global pace of change has been increasing rapidly. The new level of competition makes "globalization" a threat to those who will not, or cannot, compete. Global forestry is very much a part of that change. The forestry profession is changing as emphasis broadens from management for products to include social and environmental considerations. Plantation forests are increasing rapidly in both area and production, and, even though they account for less than 5% of forest area, are becoming the major source of industrial wood. Future forests are likely to depend heavily on biotechnology and bioengineering to improve both tree growth and wood characteristics. Production of industrial roundwood and of fuelwood continues to increase. Advances in wood science and engineering are being translated into wood technology for improved wood products and more economical processing. The forest industry is essentially a mature industry and must regain its youth by lowering costs, raising its efficiency, and rejuvenating its vision of, and relationship to, the customer. Global business trends call for a greater degree of innovation and an improved awareness of both economics and consumer needs. Innovative science and technology will be critical drivers of economic growth and development in this 21st century. Nanotechnology has the potential for many important applications in improved wood science. Government, academia, and industry are all becoming part of the global picture. International interactions among them are becoming part of our increasingly global world and offer opportunities for global understanding and cooperation. Within IUFRO we can establish the kind of broadly based collaborative programs for which the union was created more than a century ago.

Keywords: Globalisation, plantation forestry, biotechnology, bioengineering, nanotechnology, IUFRO

Introduction

We live in a world of change. It has been changing for thousands of years, but the pace of change has been increasing rapidly. Heraclitus, in his "*Doctrine of flux*", noted the changing world he experienced in ancient Greece 2 ½ millennia ago. History records the increasing rate of change over the years. Those who observe and comment on the current

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situation make more of a point of change, its causes and effects, than ever before. Thomas Friedman's best selling "*The World is Flat"* (2005) has provided a focus on the interconnected, competitive world ours has become. He notes the convergence of technology, commerce, and society that has created a global Web-based playing field, a global collaborative work force, and means for access to information that makes a "flat" world possible. He also notes the new level of competition that makes "globalization" a threat to those who will not, or cannot, compete. Toffler and Toffler (2006) extend this to the revolution in creation and distribution of wealth now sweeping the world, broadly extending the concept of wealth on the basis of time, place, and knowledge.

Global forestry is very much a part of that change. The forestry profession is changing as emphasis broadens from management for products to include social and environmental considerations (the "new" forestry) as other natural resource professionals address new needs and public concerns. International trade in forest products has more than tripled in the last two decades (Fig. 1). International trade in industrial roundwood has increased nearly 50 percent (Figure 2) and trade in paper and paperboard has increased 170 percent during the past two decades (Figure 3), while world population has increased 130 percent (Figure 4, FAO 2006).

Substantial efforts are being made to face the new challenges these changes pose. Those efforts take many forms, such as improvements in plantation forestry and information systems related to forestry, technological improvements in products and processes, and improved knowledge of the science and engineering basic to those technologies. Further, efforts to operate productively and profitably in the "flat" world described by Friedman and others are leading to new understanding of the changing world we live in today and will experience increasingly in years to come. Indicators from this understanding point to the need for sustainable development of the forest resource and the research and education bases that sustain it.

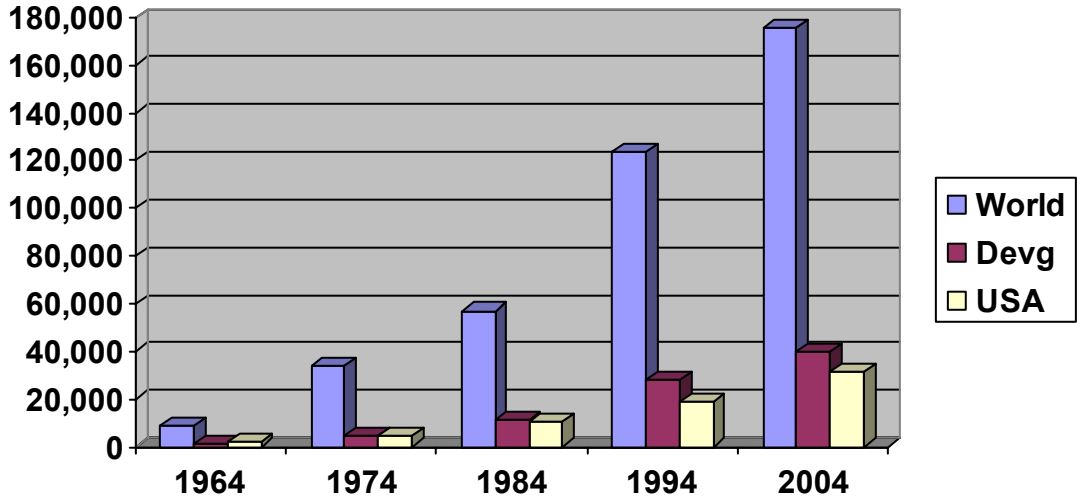

Fig. 1: Imports of Forest Products, World, Developing Countries, and United States (US$ million). Source: Earthtrends, World Resources Institute

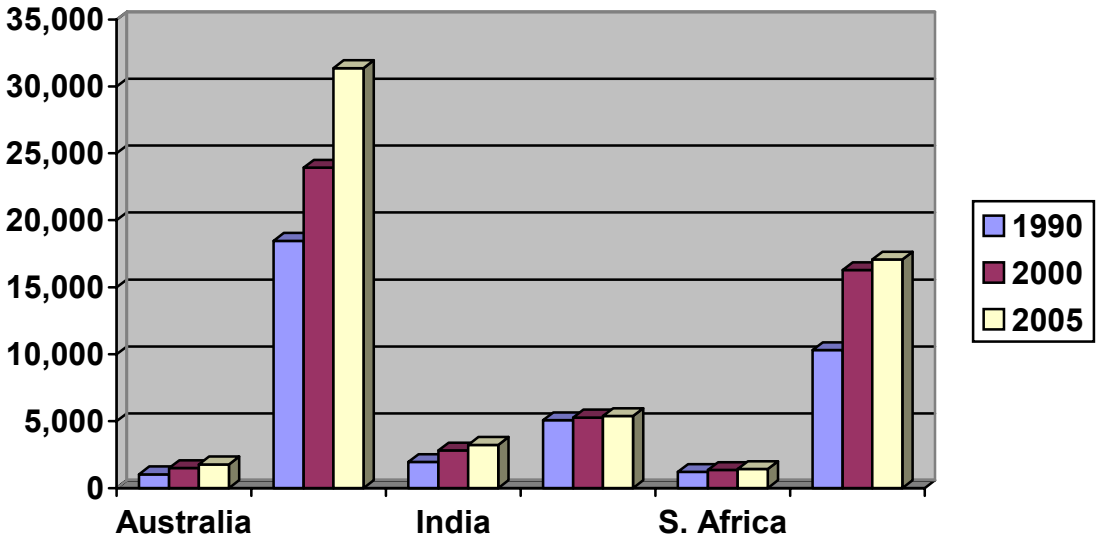

Fig. 2: Area of Forest Plantations (thousand hectares) Source: Earthtrends

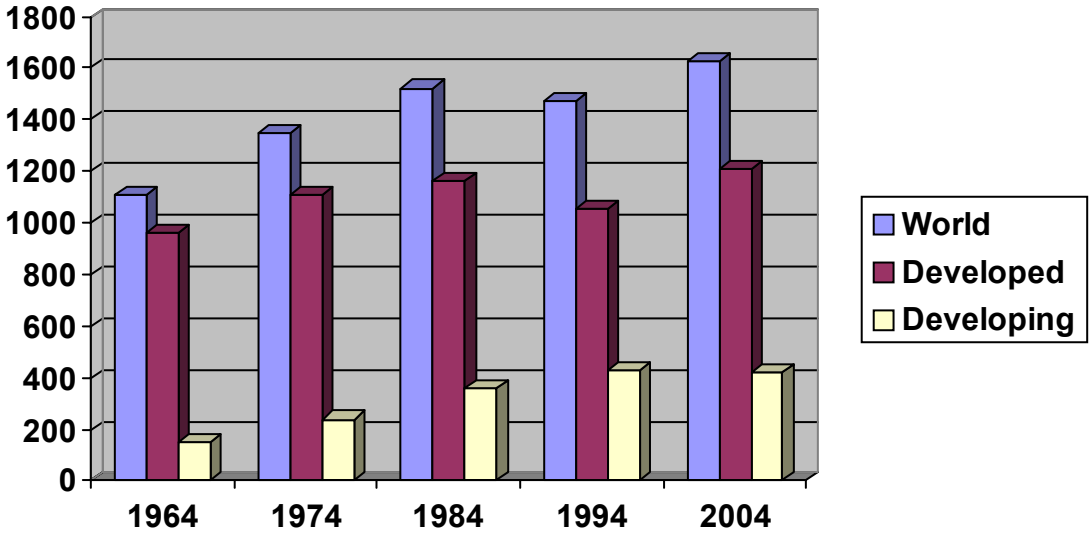

Fig. 3: Industrial Roundwood Production (Million cubic meters). Source: Earthtrends

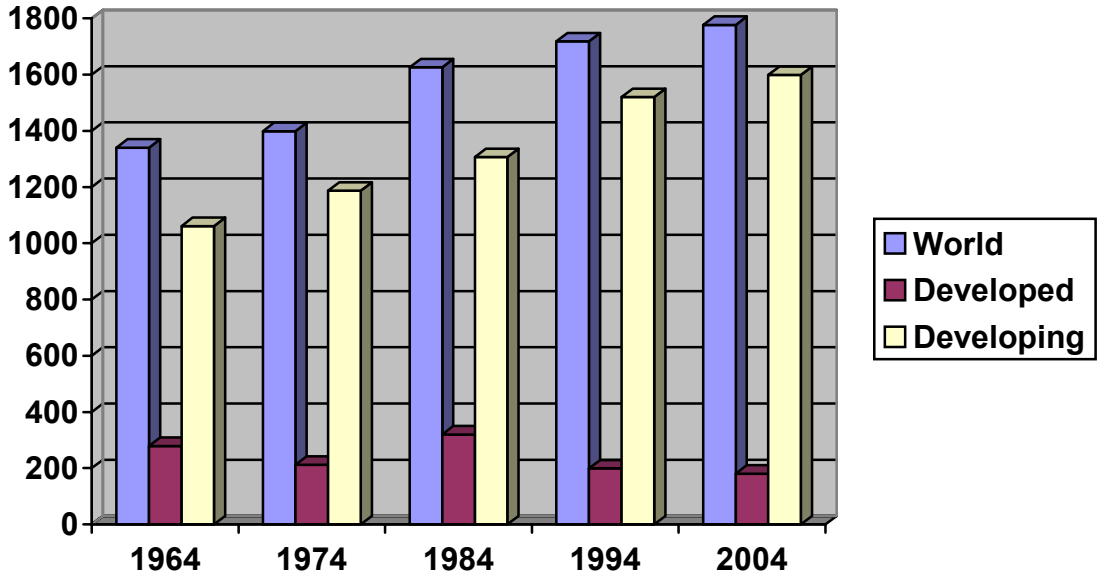

Fig. 4: Fuelwood Production (million cubic meters). Source: Earthtrends

The Situation Today
We will consider the situation today with regard to:

What is the status of global forestry?
What factors are affecting the wood supply?
How can we improve processing?
How do we make it pay – economics and marketing?
What is the status of global forestry?

On a global basis, primary forests (those of native species without human or ecological intervention) account for 36% of forest area, but 15 million acres (0.4%) are being lost or modified each year. Plantation forests are increasing rapidly in both area and production, and, even though they account for less than 5% of forest area, are becoming the major source of industrial wood, producing nearly a quarter of today's industrial wood (FAO 2005). Fig. 5 shows estimates of timber volume in future plantations under different scenarios of planting and timber demand. Predictions are that by 2050, 10 to 15% of the world's forests will be in forests planted and managed for high yields of wood, and these forests will meet more than 80% of the world's needs for industrial wood.

What factors are affecting the wood supply?
Production of both industrial roundwood and fuelwood continues to increase, continuing trends of the 20th century, with fuelwood production exceeding that of industrial roundwood and coming mostly from the developing world. Industrial roundwood still comes primarily from the developed world and products are distributed widely in global trade. However, views of the current global wood supply situation are uncertain, because they are affected by the very changes we are concerned with here. Several factors affect global wood supply predictions. Some of these reduce anticipated supplies: increased consumption in emerging economies, increased fuelwood consumption in many developing countries, increased illegal logging in major supply regions, over harvesting

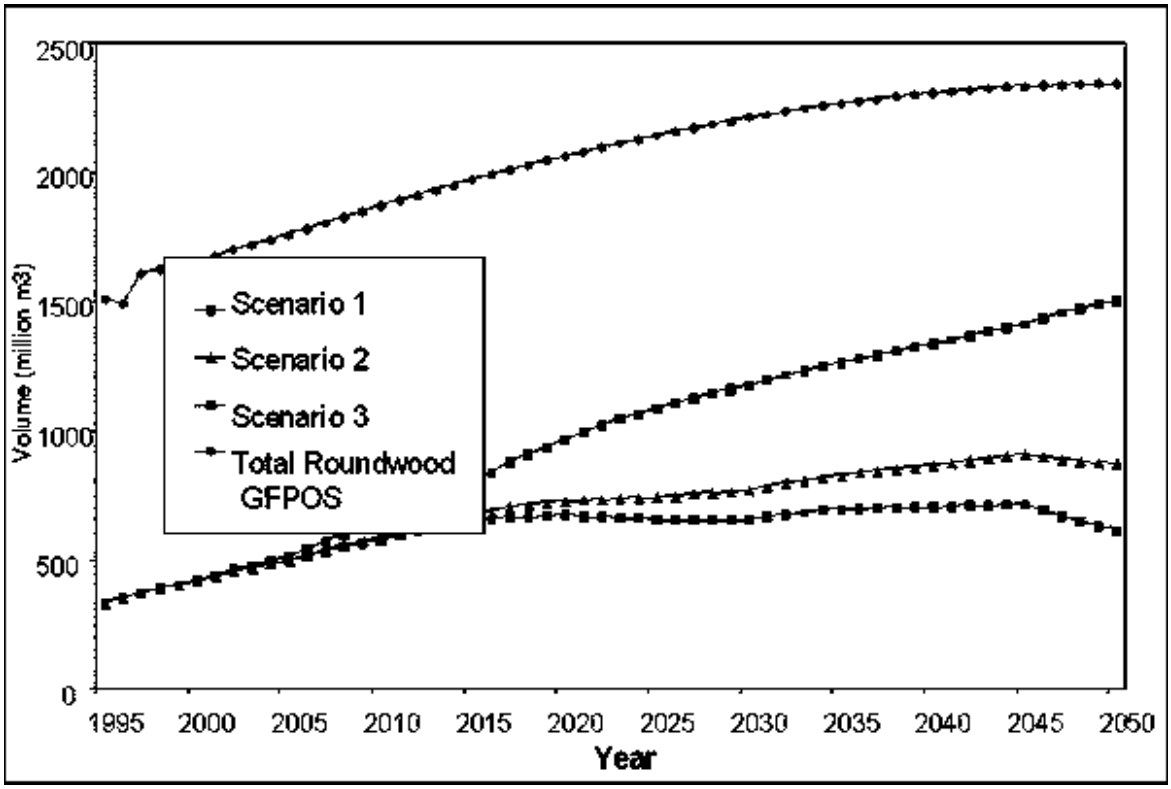

Fig. 5: Estimates of timber volume in plantation forests. (FAO, 2006)

in important supply countries, over enthusiasm for plantation supply -- plantations on the one hand and nature-oriented management and protection on the other, increasing competition for wood fiber between the energy industry and the traditional wood industry, increasing rate of natural disturbances to the forest. On the other hand, some will have positive effects on supply predictions: rapid technological and biotechnological developments, trees with faster growth and improved properties, increased use of recovered paper, extending the supply of paper and paperboard without increasing demand for pulpwood, improved forest policies, Increased substitution for wood by other materials and combinations of wood with plastics and other materials, and more efficient industrial processes that are the product of modern engineering and design. Changes in the global landscape such as: shifts in the number and composition of populations, migration to cities, greater mobility, increased communication and trade, and higher consumption and expectations are behind many of the changes cited above. (Nilsson and Bull, 2005). These are all factors we need to take into account as we consider timber supply in the flat world in which we are now participating.

How can we link wood science and forest science?

Forest science and silviculture are moving ahead to incorporate advanced knowledge and experience into forest practices that both meet needs for adequate supplies of wood for productive uses and provide forests to meet social and environmental needs. Likewise, advances in wood science and engineering are being translated into wood technology for improved wood products and more economical processing. Increased efforts are being made to link advanced composites technology and web-based scientific computing to intensive forest management practices for development of new and innovative products. These efforts have the objective of linking modern forestry with advanced wood technology to assess alternative forest management practices consistent both with future

demand for wood products and with the broader environmental demand on the forest; develop procedures for designing, evaluating, and implementing new composite products based on principles of materials science; and assess the economic viability of new composites and alternative forest management practices (Zink-Sharp, 2006).

The question of commoditization is one that needs increased attention. Engineered products, recent innovations in the trade, are rapidly becoming commodities. In this respect, we see examples from most other industries as the extreme competitiveness of the "flat world" forces the advantage to the low cost producer. Many forest products businesses are beginning to appreciate that they must develop philosophies and operating principles that encourage differentiation, new products to meet consumer needs, expanding markets through export, and continued experimentation and improvement. These are signs of progress, but where can we look to meet the broader challenges to forestry and forest products in an increasingly competitive world?

How do we make it pay – economics and marketing?

As in most aspects of industrial change, economic incentive is an essential factor. The forest industry is essentially a mature industry and must regain its youth by lowering costs, raising its efficiency, and rejuvenating its vision of, and relationship to, the customer. Global business trends call for a greater degree of innovation and an improved awareness of both economics and consumer needs. The above will require substantial investment of both capital and imagination. Quality and responsiveness at all levels will be needed. The increased cost cannot simply be passed to the customer; it must be accommodated as part of the development process. The effort of Toyota to overcome the poor image of Japanese automobiles is a good example. Toyota's goal was to engineer "quality for free" into their product, rather than to simply put a new appearance on an old automobile, by getting brilliant results from average people managing brilliant systems.

An important part of the response to increased demand and competition is managing the supply chain to recognize changes in customers' demands for wood products and being the first to bring those products to market (Winistorfer *et al*., 2005). There have been significant changes in the wood products market structure. Softwood plywood and softwood lumber are increasing in international trade, conventional wood products are being replaced by engineered products, more of each house is being made in the factory, and fewer builders are producing a larger share of houses (Schuler *et al.,* 2005). This calls for "developing a competitive workforce through investment in education at all levels; encouraging innovation; investing in research and development of products, systems, and manufacturing; and responding more fully to the special product and service needs of customers." These are needed to deal effectively with new processing technologies, removal of trade barriers, and innovations in computing, communications, and distribution that accelerate the design, production, and delivery of goods. These lead to the global competition for capital and markets and the competitive pressures that are the theme of Friedman's message.

A Look Ahead

Current trends in research, technology, and new product development could lead forest owners to question the wisdom of investment in forest management for products, especially as management horizons shorten. Most of the world's accessible forests will likely be in some kind of stewardship or management for multiple benefits. A major role will be to protect endangered and at-risk species and ecosystems where some level of

wood production is desired. Biotechnology may help forests to play this role by adding resistance or restoration genes. This is an area that calls for clear leadership that is much broader than forests and wood; it involves resource sustainability, health and safety, communications, performance measurement/benchmarking, and innovations in new products that are creative mixtures of wood with plastics, metal, and other materials that can meet consumer needs. Global business trends call for a greater degree of innovation and an improved awareness of both economics and consumer needs. Overcoming the industry's traditional disaggregation will be a key part of this.

Forests

Future forests are likely to depend heavily on biotechnology and bioengineering to improve both tree growth and wood characteristics. The introduction of biotechnology to forestry has the potential to produce great economic benefits in the form of lower costs and increased availability to consumers of wood and wood products (Sedjo, 2004). Most of the world's industrial wood will eventually come from forests planted specifically for wood production (Salwasser, 2004). There is much potential for applications of biotechnology and genetically modified organisms in wood production forestry. One will be to increase productivity. Equally important are applications that could reduce environmental impacts of intensive management, for example, by reducing the volume and toxicity of fertilizer, pesticide, and other chemical treatments, and perhaps even reducing water requirements, while improving wood quality and consistency. It may be time to start improving wood properties and managing the forest for potential end products, versus harvesting only pulpwood, timber, and veneer logs. The economic benefit associated with the introduction of only one transgene, the herbicide resistance gene, could be as much as $1 billion annually in plantation establishment.

The question arises as to whether, and to what degree, global agreements will affect this trend. Transgenic wood flows will probably not be affected, but global movement of germplasm could well be restricted. This could provide advantage to countries and firms that are willing to work with transgenic trees to increase and improve the characteristics of wood supplies (Sedjo, 2005). Rousseau *et al.* (2006) point out the need for understanding the complex interactions between environmental variables, cultural treatments, and genotypes deployed. New management strategies present challenges and limitations that must be more profitable and ecologically sound than current technologies allow. As clonal plantations become more intensively implemented and new genotypes are deployed, government restrictions and negative public sentiment may impede application of new technologies. Numerous field tests conducted worldwide clearly demonstrate that it is possible to genetically engineer diverse tree species. The main challenge continues to be the development of efficient transformation systems for the most desired genotypes. What is limiting is not the transformation, but the tissue culture system needed to regenerate whole trees from single cells containing inserted genes (Meilan *et al.,* 2004).

Wood Science

Innovative science and technology will be critical drivers of economic growth and development in this century. An example is nanotechnology, manipulation of materials measuring 100 nanometers or less in one dimension (D'Haeze, 2006; Anonymous, 2006). The field of nanotechnology has grown rapidly since the classic invitation of physicist Richard Feynman in 1959 to members of the American Physical Society to join in discovering "a field that might tell us much of great interest about the strange phenomena

that occur in complex situations" and "would have an enormous number of technical applications" (Feynman 1959). Nanoscience and nanotechnology have spread rapidly from a field "of great interest" in physics to a central focus of research and application in basic sciences and engineering. Nanotechnology has the potential for many important applications in such areas as energy storage, instrumentation, sensors, water purification, and others (D'Haeze, 2006). Major efforts in research collaboration and application are called for. The *Nanotechnology for the Forest Products Industry* workshop in October, 2004, summarized research needs in the basic wood sciences and in processing, products, and instrumentation (Anonymous, 2006). Moon *et al.* (2006) review nanotechnology applications in the forest industry and describe work under way on nanoindentation to measure mechanical properties of wood within cell walls. This will be valuable in improving hardening and adhesive bonding of wood. These and other applications are instilling a new sense of change in wood science and technology and opening new possibilities in capturing the advantageous modification of wood properties in genetic manipulation of trees. Another example is near infrared spectroscopy, which offers new opportunities to improve processing efficiency through revealing basic characteristics of wood, both in the forest and in the production facility (So *et al.,* 2004).

Energy

The global energy situation is of special concern, raising the question of threats and opportunities in the developing bio-economy and bio-energy. Liquid fuels may provide a major opportunity, based on the fact that ethanol from wood requires less than 1% of the fossil energy required to produce and deliver gasoline to a vehicle fuel tank (Bowyer, 2006). There is also further opportunity to produce biochemicals and biofeedstocks that could lead, among other options, to biorefineries that produce not only pulp for paper manufacture, but also liquid fuels and chemicals. The problem is to learn how to produce them economically. Strong efforts are underway to optimize the technology to produce biofuels from lignocellulosics efficiently (Schubert 2006). Several companies and government –funded laboratories have engineered enzymes to optimize lignocellulose degradation and funding from both public and private sources is being increased. A strengthened effort in biofuels research and development may well depend on what happens to the price of oil and the political will to change if oil prices do not increase. Biofuel research and production is stimulated by the current high cost of petroleum, but is concerned almost entirely with biofuel from corn and soybeans. Major improvements in understanding the basic science and in technology and economics are needed to realize the greater efficiency of biofuel from lignocellulose.

The Need for Change

This takes us back to change – dismantling of deeply rooted research, education, and business paradigms and replacing them with new ones that are more value stream focused – that create products, solutions, and supporting services that customers want, need, and expect. Change is a difficult and long process, but it can be implemented incrementally and strategically. This could well be the basis for an agenda that would include 1) an honest assessment of our current status in meeting research and education needs for future industry and resource leaders, 2) an ambitious, yet achievable, vision of how we can address current and future needs, and 3) an incremental strategy for working to realize that vision.

A recent report by PricewaterhouseCoopers (2006) highlights the need for innovation among factors that will drive sustainable development. Innovation, especially in core

industries, will respond to changing economic conditions. Changing economic conditions will expand the rate of innovation exponentially to include changes in behavior, product design, supply chains, and geopolitical structure, in addition to technology.

Comments such as these, and reactions of wood industry executives who are deeply into change make it clear that knowledge, science, and technology keyed to wood and the forest resource, while necessary, are currently insufficient to sustain a viable business, research program, or education program in the world around us. Interface and integration between forest-based materials and the world of people, resources, commerce, and innovative products and ideas is an area that requires new leadership. This includes the major considerations of resource sustainability, health and safety, communications, performance measurement/benchmarking, innovations in new products involving creative mixtures of wood, plastics, metals, and composites, and based on chemical and physical processing. The customer has increasingly high concern for product performance, quality, value, and support, with less concern about what it is made of. As this concept is extended to life cycle consideration and chain of custody concerns, it will mean even increased attention to cost, value, and efficiency. We should consider extending that philosophy and develop the science and technology to manage forests for biofuel, natural polymers, paper and paperboard, and engineered wood products, as well as for traditional solid wood products. Further, we must learn, and be willing to implement, ways to do that while managing forests for the many non-product needs consumers are increasingly coming to expect.

Traditionally, we have isolated our focus on production forestry and wood product science and development. Our horizons may be too short. Probably the most productive changes and improvements will come from looking outside the forest and wood industry to learn how to change and compete in an increasingly competitive world. Customers today have high expectations and low patience levels. The Internet has opened channels of information and allowed that information to be considered at a more personal level than ever before. Interface and synchronization between managing the forest resource and use of materials from the forest on a global perspective is an essential factor in meeting customer needs, while operating in an atmosphere that gives increasing attention to the environment, sustainability of the resource, and effective use of human capital. Toffler and Toffler (2006) emphasize the role of knowledge as a key element in the revolution of wealth that has been, and will be more strongly, critical to the world's way of life.

All of this indicates a critical need for partnership of government, academia, and industry in revitalized programs of research and development. It also indicates a critical need to reach out to the basic sciences and engineering to become part of the rapid advances in science and technology. The flat world can work two ways, not only for increasing competition from producers in other parts of the world, but also for enabling us to be aware of what is happening in those areas. Government, academia, and industry are all becoming part of the global picture. International interactions among them are becoming part of our increasingly global world and offer opportunities for global understanding and cooperation that will enable and direct the changes needed to not only stay abreast of world developments but also lead in areas that take advantage of unique abilities and flexibility. A strong beginning in this effort can be provided by foresters and wood scientists working together toward meeting the many economic, social, environmental, and material needs from forests that have become essential in our globalizing world (Brown and Youngs 2004, Youngs et al 2006).

What is the role of IUFRO?
This situation presents a unique opportunity for a union such as IUFRO to demonstrate how it can reach out internationally to bring together researchers in collaborative approaches to meeting the research challenges posed by these rapid changes in global forestry. Without weakening the scientific depth in our Research Groups and Working Parties, we can establish the kind of collaborative programs for which IUFRO was created more than a century ago. We should be thinking of a dialogue and collaboration in which we can address the pragmatic questions of change – change in the paradigms we have been following in education, research, and industry, with willingness to envision a future based on the realities and trends of today and our flexibility to adapt to the "flat" world into which we are moving. Such a program would present us with new challenges, new awareness of what is expected from us, and new vision of how to go about meeting those challenges and expectations. Such a dialogue could be the vehicle for helping forestry, the forest industry, academia, and governments join forces in a collaborative effort to become full participants in the highly competitive world we face.

How do we begin this? I suggest that a major result of this Conference be a small group representing Division 5 going to the IUFRO Board with a plan to join forces with other Divisions in a collaborative program at the next IUFRO Congress aimed at defining the scientific, economic, and social changes we face and how IUFRO could unite in meeting them. Participants from the many parts of the world would then determine how to carry to their home countries the efforts needed to become a part of this global transformation of forestry. By working together, and by maintaining our flexibility for productive change, we can realize the new world of wood in a new concept of forestry in a flattening world. The challenges are great – and becoming greater -- but can be met by dedicated, broadly based effort that builds on the opportunities offered by the same world that presents the challenges. This can provide means to develop and realize the dreams that will provide a basis for meeting the challenges of the changing world we face.

Literature Cited

Anonymous. 2006: Nanotechnology for the forest products industry: Vision and Technology Roadmap. *A report on the Nanotechnology for the Forest Products Industry Workshop, Lansdowne, Virginia, October 17-19, 2004. 92 pp.*

http://www.fpl.fs.fed.us/highlighted-research/nanotechnology/forest-products-nanotechnology.pdf

Accessed June 23, 2006

Bowyer, J. 2006: Global Trends Affecting the Forest Industry. *Dovetail Partners, Inc., workshop "Helping the Wood Products Industry Profit From the Next 10 Years" April 11 and 12, 2006, Princeton, WV.*

Brown, G.N. and Youngs, R.L. 2004: Our vision of forestry: Wood utilization in university programs? *Wood and Fiber Science 36(1)1-2.*

D'Haeze, W. 2006: Nanotechnology to solve global problems. Science *Advisory Board Perspectives*. http://scienceboard.net/community perspectives 168. Accessed 7/17/2006.

FAO. 2005: Assessment of the World's Forest Situation, 2005. *Food and Agriculture Organization of the United Nations.* www.fao.org/forestry. Accessed 6/8/2006.

FAO. 2006: FAOStat.2006.
faostat.fao.org/faostat/collections?version=ext&hasbulk=0&subset=forestry

Accessed 6/15/2006.

Feynman, R.P. 1959: There's plenty of room at the bottom. *American Physical Society, December 29, 1959, California Institute of Technology Engineering and Science, February 1960.* http://www.zyvex.com/nanotech/feynmanWeb.html. Accessed 5/15/2006.

Friedman, T.J. 2005: The World is Flat: A Brief History of the 21st Century. *Farrar, Straus and Giroux, New York, 488pp.*

Meilan, R., D. Ellis, Pilate, G., Brunner, A.M., Skinner, J. 2004: Accomplishments and Challenges in Genetic Engineering of Forest Trees. *Pages 36-51 in Strauss, S.H. and H.D. Bradshaw (Eds.). The Bioengineered Forest: Challenges for Science and Society. Resources for the Future, Washington, DC, 243pp.*

Moon, R.J., Frihart, C.R., Wegner, T. 2006: Nanotechnology applications in the forest products industry. *Forest Products Journal 56(5)4-10.*

Nilsson, S, and Bull, G. 2005: Global wood supply analysis. *Report to the FAO Advisory Committee, Vancouver, BC, May 2005.*

PricewaterhouseCoopers, 2006: Corporate Responsibility: Strategy, Management and Value. (www.pwcglobal.com/servlet/pwcPrintPreview?LNLoc=/extweb/ncpressrelease.nsf/d accessed 4/25/2006

Rousseau, R., Kaczmarek, D., Martin, J. 2006: A review of the biological, social, and regulatory constraints to intensive plantation culture. *Southern Journal of Applied Forestry 29(2)105-109*

Salwasser, H. 2004: Future forests: Environmental and social contexts for survival. *Pages 3-22 in Strauss, S.H. and H.D. Bradshaw (Eds.). The Bioengineered Forest: Challenges for Science and Society. Resources for the Future, Washington, DC, 243pp.*

Schubert, C. 2006: Can biofuels finally take center stage? *Nature Biotechnology, published online July 2006.* www://nature.com. Accessed 7/17/2006.

Schuler, A., Adair, C., Winistorfer, P. 2005: Challenge and Response: Strategies for Survival in a Rapidly Changing Forest Products Industry. *Engineered Wood Journal, 8(2)23-25).*

Sedjo, R.A. 2004: Biotechnology and the global wood supply. *Pages 23-35 in Strauss, S.H. and H.D.Bradshaw (Eds.) The Bioengineered Forest: Challenges for Science and Society. Resources for the Future, Washington, DC, 243pp.*

Sedjo, R.A. 2005: Global agreements and U.S. forestry: Genetically modified trees. *Journal of Forestry 103(3)109-113.*

So, C-L,.Via, B., Groom, L., Schimleck, L., Shupe, T., Kelley, S, Rials, T. 2004: Near infrared spectroscopy in the forest products industry. *Forest Products Journal 54(3)6-16.*

Toffler, A. and Toffler, H. 2006: Revolutionary Wealth. *Knopf, New York, 492 p.*

Winistorfer, P., Becker, C., Kline, D.E. 2005: Will Virginia's Forest Industry Survive Global Competition? *Virginia's Forests, Fall 2005: 10-14.*

World Resources Institute. 2006. Earthtrends. http://www.earthtrends.wri.org/searchable_db/results.php?theme=98years=1965-2004.

Youngs, R.L., McLain, T.E., Brown, G.N. 2006: Wood science and forestry – partners in progress to a new world. *Journal of Forestry 104(4)221.*

Zink-Sharp, A. 2006: Sustainable Engineered Materials from Renewable Resources. http://www.semi.vt.edu,March 2006. Accessed May 20, 2006.

SPECIAL SESSION

IAWS ACADEMY LECTURE

A Scientific Itinerary: Physical Chemistry to Wood Science

Xavier DEGLISE

It is a strange scientific itinerary to start from very simple molecules like hydrogen superoxides (H_2O_3, H_2O_4 synthesized in cold plasma of water and identified by Laser Raman Spectroscopy) to reach a complex macromolecular structure like wood.

With a scientific career in Physical Chemistry (chemical kinetics, IR and Raman spectroscopy, photochemistry…) it is not obvious to understand why solid wood became my main topic of interest. In fact as a teacher I was always interested to look at the professional "output" of the graduates in the industry.

Besides, in the late 70's, appeared in our country a need to develop R/D in Wood Science and Technology. The wood industrial sector was mainly driven by foresters, with a strong expertise in forestry, silviculture, wood anatomy etc. and there was a lack of R/D experts for Wood and Furniture Industries.

In 1978, with the support of the University and the Government, I start a new teaching /research structure which becomes ENSTIB in Epinal. The staff was multidisciplinary (Biology, Chemistry, Physical chemistry, Chemical Engineering, Mechanical Engineering) to fulfill the main industrial needs in Drying, Protection, Gluing, Finishing, Processing and Machining, Construction and Wood for Energy. In parallel with teaching we have developed a research, in this field. For me it was in two main topics, wood pyrolysis, where I have applied my background in Kinetics, and wood surface protection and treatment, where photochemistry and spectroscopy have helped us to understand the mechanisms of weathering.

I will focus my presentation on these two topics where the scientific advances where important and have brought progress in Industry. For pyrolysis/gasification, which was an important topic in 1980, with the peak in crude oil price, we have developed a circulated fluidized bed (CFB) system, starting from the laboratory scale to the pilot, in a chemical pulp mill. Unfortunately we where too far in advance to succeed…and twenty years later the wheel is reinvented in CFB gasification! In wood surface protection, thanks to our background in photochemistry, we have proposed three solutions to increase the durability of Wood/Finishes system: Photo-protection of underlying wood; adjust the Tg (glass or softening temperature) of the finishes; application of a soft undercoat playing the role of shock absorber between the dimensional variation of wood and the hardening of the topcoat.

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WOOD QUALITY

Papers

Acoustic Assessment of Wood Quality of Raw Forest Materials – A Path to Increased Profitability

Xiping WANG*, Peter CARTER, Robert ROSS, and Brian BRASHAW

Assessment of the quality of raw wood materials has become a crucial issue in the operational value chain as forestry and the wood processing industry are increasingly under economic pressure to maximize extracted value. A significant effort has been devoted toward developing robust nondestructive evaluation (NDE) technologies capable of predicting the intrinsic wood properties of individual trees, stems, and logs, and assessing the value of stands and forests. The use of such technologies not only leads to greater profitability for the forest industry, but can also help foresters make wise management decisions and grow higher quality wood.

Acoustic technologies have been well established as material evaluation tools in the past several decades and their use has become widely accepted in the forest products industry for on-line quality control and products grading. Recent research developments on acoustic sensing technology offer further opportunities for wood manufacturers and forest owners to evaluate raw wood materials (standing trees, stems, and logs) for general wood quality and intrinsic wood properties. This provides strategic information that can help make economic and environmental management decisions on treatments for individual trees and forest stands, improve thinning and harvesting operations, and efficiently allocate timber resources for optimal utilization. This paper reviews recent research development in acoustic technologies and discusses their current and potential future applications in forest industry.

Key words: Acoustics, logs, trees, wood properties, wood quality

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Density Profiles of Tension Wood Teak

Mayuree DOUNGPET*

To better understand the wood property in Teak (*Tectona grandis*), especially the wood samples from plantation were presented. Density profiles of the tension wood from a thinning tree were examined in a 15-year-old stand located in the indigenous site of Thailand. Densities of the wood samples are ranged from 592.2 to 664.5 kilogram per cubic meter at 8 percent moisture content. Position effect of the length along the stem was analysed at the 2, 4, and 6 meter above the ground level. Density profiles are discussed in effects of different zones at the same stem level. Comparisons were made between tension wood area and opposite wood area, and between sapwood and heartwood. Mass absorption coefficient of the wood samples are also presented at 8 percent moisture content. Density profiles showed very distinct information which wood at the 2 meter height is better quality than wood at the 6 meter height. Besides, density of teak bark is more than 2 times higher than wood.

Key words: Density profile, teak, tension wood

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Relationship between Growth Rate and Wood Properties in *Populus deltoides* Grown under Stressful Site Conditions

Mayuree DOUNGPET*, Ilona PESZLEN and Richard HALL

Twenty-five trees from eight *Populus deltoides* clones of two families (Family 9105 and Family 9163) were sampled. Trees were six-year-old and grown at 2 x 3 meter spacing. Wood samples were cut at breast height to investigate variation in specific gravity, growth rate, and in fiber length. There were no statistical differences in growth rate between the two families; however, specific gravity was significantly influenced by family and by clone. Significant, negative correlation existed between growth rate and specific gravity. Fiber length was measured in two positions along the radius. Variation in fiber length was not affected by family but only by clone and position. At the first radial position (2nd or 3rd growth rings), no clonal differences were found and fibers were significantly shorter than at the second radial position (4th or 5th growth rings), where clonal averages of fiber length were different suggesting that the earliest selection for fiber length should start after four or five years. A positive correlation was found between stem radius and fiber length. Hence, it should be relatively easy to select within families for both growth rate and longer fibers.

Key words: Poplar clones, specific gravity, growth rate, fiber length, radial variation

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A Multi-parameter Approach to Characterize Wood Quality for Particle Boards

Rupert WIMMER* and Martin WEIGL

This research is about testing various wood quality effects on the performance of particle boards. In a factorial design juvenile and mature wood, as well as ideal and real wood qualities, obtained from two softwood (spruce, pine) and three hardwood species (oak, poplar, beech), were tested in single-layer lab-produced particle boards. A set of 60 different parameters reflected physico-mechanical parameters of the raw material, chemical parameters of the processed particles, as well as structural-mechanical parameters of the panels. Results were showing strong species dependencies, while juvenile-mature and ideal-real effects, respectively, had less predictive strength. It can be shown that raw material indicators strongly determine final board properties; however, the relationships are complex and require a detailed view on the dataset to unravel direct and indirect relationships. Internal bonding showed multiple linkages to mechanical raw material properties as well as chemical parameters such as puffer capacity, pH, holocellulose and organic acids. Other board parameters such as mean density were linked to a few parameters only, including lignin content. In addition, relationships strongly shifted if softwoods and hardwoods are analyzed separately. The outcome of this research suggests that multi-parameter models are needed, and they should be implemented in the processing to control quality and optimize the wood resource utilization.

Key words: Particle board, wood quality, oak, spruce, pine, poplar, beech, wood chemistry, mechanical properties, wood structure, wood panel manufacturing

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Predicting the Quality of Sitka Spruce Sawn Timber from Standing Tree and Log Measurements

Shaun MOCHAN*, Tom CONNOLLY, Barry GARDINER and David LESLIE

In order for the British wood processing industry to stay competitive it is becomingly increasingly important to utilise information on tree and wood characteristics as early as possible in the supply chain. Such measurements can aid in optimizing the flow of timber to ensure that the right material is allocated to a specific processing facility. To do this requires detailed knowledge of the raw material and methods for determining the wood properties of interest in the forest, at the roadside and in the log yard prior to processing, so that decisions on allocation can be made as early in the wood chain as possible.

This paper discusses a number of methods for assessing timber quality in standing trees, including acoustic measurements (in trees and logs). The two acoustic tools used were the FibreGen HT-200 on cross-cut logs and the FibreGen ST-300 on standing trees. These tools measure the velocity of sound in the timber (*V)*, which is a measure of the stiffness of the wood ($MOE = \rho V^2$). The ST-300 measures the velocity of sound in the outer mature wood of a standing tree over approximately a one metre vertical distance. The HT-200 provides a measure of the average acoustic velocity within a log by measuring the resonant frequency of sound produced by hitting the log end with a hammer. Therefore, each method provides a slightly different measurement. Acoustic velocity is primarily dependant on the stiffness of clear wood, with faster speeds indicating stiffer wood. Defects such as knot clusters, large grain angles or rot will tend to reduce the measured velocity. Therefore, slower velocities are indicative of a low *MOE* or the presence of defects, all of which are an indication of timber with poorer mechanical properties or likely visual degrade.

Measurements were made in 6 sample stands of Sitka spruce located in south and west Scotland. Logs cut from sample trees were assessed and then processed in a commercial sawmill. The yield and quality characteristics of the sawn timber (mechanical and visual grading properties) were evaluated. A number of models were then developed based on the measured standing tree and log characteristics to see which gave the best prediction of the final quality of the sawn timber.

Key words: Sitka spruce, standing tree assessment, wood quality

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A Summary of Research Conducted by the Wood Quality Consortium

Laurence SCHIMLECK*, Alexander CLARK, Richard DANIELS and Lewis JORDAN

The Wood Quality Consortium (WQC) was established in late 1999 as a research partnership between the University of Georgia, Warnell School of Forestry and Natural Resources and the USDA Forest Service, Southern Research Station. The initial goals of the WQC were 1) to establish a regionwide baseline for wood properties in loblolly pine plantations, 2) to estimate the effects of intensive silvicultural practices on wood properties, and 3) to develop predictive models to predict wood properties at the tree, stand and regional levels. Forest industry members joined to support the WQC in 2000 and have since funded a wide-range of research projects. The major focus of the consortium has been a baseline wood properties study that has involved sampling 147 loblolly pine (*Pinus taeda*) plantations across the south eastern USA. The baseline data has been used to produce maps showing the regional variation of specific gravity (SG) with age. Models have also been developed for SG, microfibril angle and stiffness variation within-trees. Studies have also been conducted to examine the effects of silvicultural practices (spacing, fertilization, and weed control) on the wood properties of loblolly pine.

Key words: Loblolly pine, wood properties, regional variation, modeling

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5.05 A
USING PLANTATION AND SMALL-DIAMETER TIMBER IN COMPOSITES

Papers

Some of the Mechanical Properties of Cement Bonded Particleboard Manufactured from Alder, Eucalyptus, and Spruce

Mustafa ASLAN, Erhan GOKALP and Salim HIZIROGLU

Influence of species on strengths of cement bonded particleboards is one of the important parameters. The objective of this study was to evaluate modulus of elasticity (MOE), modulus of rupture (MOR) and internal bond strength (IB) of experimentally manufactured cement particleboard panels made from 100 % alder (*Alnus glutinosa ssp.barbata*), eucalyptus (*Eucalyptus camaldulensis Dehn)*, and spruce (*Picea orientalis*) furnishes. Portland cement (PC 42.5) with % 50 of mat weight along with sodium silicate and aluminum sulphate were used as additives for the experimental panels with an average target density of 1.20 g/cm^3 and thickness of 18 mm. A total of nine panels were made for each type of furnish. Initial results of the study showed that all three types of species can be used to manufacture cement bonded panels without adverse effect on mechanical properties of the samples after that they were kept in room with ambient temperature for curing for one month. Panels manufactured using eucalyptus particles had the highest MOE with 4,186 MPa and MOR with 10.2 MPa followed by the panels made with spruce and alder particles. Internal bond strength values also showed similar trend to above findings. Eucalyptus panels met minimum strength requirements stated in European Standards EN 634-2. However, the other two types of panel resulted in 10 % lower values than those of stated above standard.

Key words: Particleboard, cement bonded panels, strength properties

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Fire-retardant-treated Low-formaldehyde-emission Particleboard made from Recycled Wood-waste

Song-Yung WANG*, Te-Hsin YANG, Li-Ting LIN, Cheng-Jung LIN and Ming-Jer TSAI

The objective of this study was to manufacture fire-retardant-treated low-formaldehyde-emission particleboard from recycled wood-waste particles using polymeric 4,4'-methylenediphenyl isocyanate (PMDI) and phenol-formaldehyde (PF) resins. The influence of the PMDI/PF ratio (ratio of particles sprayed with PMDI to particles sprayed with PF, w/w) after fire retardant treatment on formaldehyde emissions, mechanical properties, and surface fire resistant performance of the manufactured particleboard was investigated. The experimental results showed that the formaldehyde emissions linearly decreased with an increasing PMDI/PF ratio. Moreover, the bending strength, internal bond strength, and screw holding strength increased with an increasing PMDI/PF ratio. The thickness swelling of the particleboard was improved by using an increasing PMDI/PF ratio. Furthermore, the fire-retardant-treated low-formaldehyde-emission particleboards fabricated in our study could pass the third grade standard of surface fire resistant performance as specified by CNS 6532.

Key words: Particleboard, fire retardant, recycled wood-waste, quantity of formaldehyde emissions

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Utilization of Non-conventional Tropical Lignocellulosic Resources for the Hardboard Production

SABIHA Salim, ZAIDON Ashaari*, RASMINA Halis, MOHD. NOR Mohd Yusuf and PARIDAH Md.Tahir

A study to determine the potential of utilizing non-conventional lignocellulosic resources such as tropical bamboo *(Gigantochloa scortechinii)*, new clone rubber tree wood *(Hevea brasiliensis),* empty fruit bunch fibers (EFB) from oil palm tree and mixture of rubberwood and EFB (50:50 parts) for refiner mechanical pulping (RMP)-processed hardboard was carried out. Chips of bamboo and rubberwood and EFB loose fibers were pre-treated either by soaking in 2% (w/v) sodium hydroxide (NaOH) solution at 60ºC for 4, 6 and 8 hours or by steaming at 170ºC for 3 hours to soften them. RMP was used to produce fibers before they were fabricated into hardboard. Evaluation of fiber yield, colour and disintegration were made for each treatment process. Both pre-treatments affected fibre morphology and colour of pulp. Pre-treatment of chips with NaOH gave higher fibre yield and produced more undamaged and longer fiber during refining compared to those treated by steaming at high temperatures. Hardboards of 4-mm thick with targeted density of 900 kgm^{-3} were fabricated in wet process using the pre-treated fibers (1:60 pulp consistency) with or without resin (phenol formaldehyde, 1-2%) and additives like wax emulsion, 1-2% and alum $Al_2 (SO_4)_3$, 0.25%. Boards were hot pressed at 180 °C for 20 min. and tempered in a forced circulation oven at 160 °C for 6 h. The performance of the board was evaluated based on their mechanical and physical properties in accordance with Japanese Industrial Standard for Fibreboard (JIS A5305-2003). Properties of commercial hardboard of same thickness were also tested for comparison purposes.

All NaOH-pretreated hardboard with or without resin and additives had superior properties than those produced from steam-pretreated materials. Increasing level of PF resin from 1% to 2% significantly increased the strength of the board by approximately 20% and stiffness by 15%. Among the lignocellulosic materials used to fabricate the hardboards, boards from bamboo fibers had the highest mechanical properties followed by EFB + rubberwood blend, EFB and rubberwood fibers. The percent differences in mechanical properties from the bamboo fibers were respectively 28%, 25% and 24%. Compare to commercial hardboard, majority of the properties tested for these hardboards was comparable except for higher thickness swelling (by 50%).

Key words: Empty fruit bunch fibers, Bamboo, NaOH treatment, Hardboard, wet process

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Oriented Strandboard from Small-diameter Southern Pine Trees

Guangping HAN, Qinglin WU* and Shigehiko SUZUKI

Single- and three-layer oriented strandboard (OSB) from small-diameter southern pine trees were manufactured using phenol formaldehyde (PF) resin. The effects of fines level and panel density on the board properties were investigated. Single-layer boards were made by evenly distributing fines (less than 20 mm long) through the panel thickness at loading levels of 0, 10, 20, 30, and 100% with target panel densities of 0.55, 0.75, and 0.95g/cm^3. For the three-layer boards, fines were only applied in the core layer. The fines content in the core layer varied from 0, 10, 20, 30, and 45% based on the total strand weight in the panel. All three-layer panels were constructed with a face and core strand weight ratio (i.e., shelling ratio) of 55% to 45% (i.e., 1.22).

The results of single-layer OSB showed that increasing fines content reduced parallel bending properties and increased the perpendicular values, leading to a better balance of bending properties in the two directions. Internal bond (IB) strength was enhanced as fines increased. Increasing fines loading level led to inferior panel dimensional stability. The effect of panel density on linear expansion (LE) varied with material directions and fines levels. Regression analysis indicated that bending properties and LE were highly correlated with fines content and panel density.

Statistical analysis of three-layer boards showed that IB and LE varied significantly at different fines contents, while the results of bending and TS properties remained constant for different fines levels. As fines content increased to 10% and 45%, IB values were enhanced to 0.44 MPa and 0.49 MPa from 0.34 MPa at 0% fines content, respectively. Perpendicular LE significantly increased, while the parallel value decreased with the increase of fines in the core layer. When fines increased from 0% to 45%, perpendicular LE increased from 0.39% to 0.93%, while the parallel LE decreased from 0.20% to 0.10%.

Key words: Southern pine, OSB, fines, structural properties

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Effects of PF Resin Impregnation on Mechanical-physical Properties of Poplar LVL

Huanrong LIU, Junliang LIU* and Yubo CHAI

The properties of laminated veneer lumber (LVL) could be improved significantly by impregnating veneers with phenol-formaldehyde resin. The LVL with better mechanical-physical properties could be used in construction and transportation. So in this way, good use can be made of the fast-growing plantation to ease the forest supplying-requirement crisis. This study discusses the effects of different treatments on the veneer resin absorbed amount and LVL mechanical-physical properties.
The poplar veneers (average density of 0.38g/cm3 and normal thickness of 2.0mm) were impregnated with low-molecular-weight water-soluble phenol-formaldehyde resin for 15 min, 30min and 2hours in two conditions: one was in normal temperature and pressure, the other was in 0.8MPa pressure. After different treatments the veneers were produced LVL. Specimens were cut and tested for mechanical properties, including modulus of elasticity (MOE) and modulus of rupture in bending (MOR).Cut specimens were also evaluated for density and thickness swelling after 24-hour water-soak. Untreated LVL specimens were made and tested for reference purpose with PF resin consumption 320 g/cm^2.

The study indicated that at the two conditions, the amount of veneer absorbed resin increased as the impregnated time prolonging. With the absorbed resin amount increased, LVL mechanical properties were improved significantly at first and then decreased, LVL density increased and the thickness swelling after 24-hour decreased. With the same resin consumption, MOE and MOR of treated LVL were 20.2% and 44.7% higher than the untreated. When the veneer were impregnated in pressure for 30min veneer absorbed resin amount was 168%, the MOE and MOR of the LVL got maximum:15.34GPa and 135.31MPa, with the MOE reached Japan JAS SIS-24 standard 140E grade, and MOR exceeded the highest grade 180E. The relationship of the LVL density and 24h thickness swilling with absorbed resin amount fits to 3 multinomial degrees, the R^2 value are 0.9677 and 0.9883 respectively.

Key words: Poplar, laminated veneer lumber (LVL), resin, mechanical properties, impregnation

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Lightweight Wood Composite Boards made of Paulownia

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Paulownia, a naturalized Asiatic hardwood species, has been widely planted recently in the Southeastern United States as a potential crop tree for wood products because of its rapid growth (3-year-old Alabama-grown: 10-15 cm in diameter at breast height [DBH]), short rotation (about 7-15 years), high production per unit area, and high wood and fiber quality (Wood: Excellent acoustics, thermo-insulator, dimensional stability, and workability; Fibers: Excellent short hardwood fibers [Length [0.97–1.21 mm]/Width ratio: 30-60 and vary with species] for soft paper making). Although its multiple-use properties have made it an important commercial wood in Asia, it has not been used commercially as raw materials for making lightweight wood composite panels in USA. In this study, randomly oriented flakeboards, 1.27 cm thick, were fabricated with the flakes cut from the Paulownia wood [density: 0.296 g/cm^3 at OD condition], which was cut from trees [P. tomemtosa] grown in Alabama, USA. Two density groups of flakeboards: (I) PAU-A: 0.312 g/cm^3 and (II) PAU-B: 0.463 g/cm^3 , were laboratory-fabricated with phenol formaldehyde resin. A third density group (III) LBP-PAU: 0.546 g/cm^3 was fabricated with 50% Paulownia flakes as core and 50% Loblolly pine flakes as face layers. Results of static bending tests under ambient room conditions showed that the strength (MOR: Modulus of Rupture)/stiffness (MOE: Modulus of Elasticity) of these 3 groups are, respectively, (I) 8.69 MPa/1.310 GPa; (II) 24.41 MPa/6.757 GPa; (III) 26.13 MPa/4.089 GPa where as the values for commercially produced Southern yellow pine [SYP] and Aspen OSB sidings are about 20.7-27.6 MPa/4.83-8.27 GPa. The specific bending strength [MOR/Density] / stiffness [MOE/Density], considered as indexes of the efficiency and effectiveness of a material in structural application, for these groups are, respectively, (I) 2.79 km/0.42 Mm, (II) 5.27 km/1.46 Mm, and (III) 4.79 km/0.75 Mm where as the values for commercially produced SYP OSB (7/16-in. thick [1.111-cm]; density: 0.676 g/cm^3) are about 5.52 km/1.17Mm and 2.22 km/0.36 Mm, respectively in the parallel and perpendicular direction. These findings suggest that the lightweight Paulownia composite boards with a density of 0.312 g/cm^3 and 0.463 g/cm^3 may have the potential to be developed as the commercial ceiling and sheathing materials for residential house constructions.

Key words: Paulownia, lightweight wood composite boards, SYP OSB, Aspen OSB, static bending strength and stiffness, specific bending MOR and MOE

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5.05 A – Posters

Date Palm (*Phoenix dactylifera L.)* Pruning Residues as a Raw Material in MDF Production

H. HOSSEINKHANI and A. R. KHARAZIPOUR*

In this study, chemical properties of Date Palm Pruning residues including cellulose and hemi cellulose content, lignin content, extractive and ash content were determined, and also its physical properties including fiber dimension were measured. The MDF boards made for this study contained Date Palm fibers as a raw material and employed synthetic resin, urea formaldehyde, as the binder.

Three boards were manufactured for each combination of variables, and samples of all the boards made were tested by the methods of ASTM to obtain mean values of bending strength (MOR), and internal bond (IB). In addition samples of each type of board were tested for thickness swelling and water absorption after soaking in water for 2 hours and 24 hours respectively.

The results of this study show clearly that boards have higher strength than the MDF property requirements, which is recommended by ASTM.

Key words: Date palm, pruning residues, MDF, cellulose, hemi cellulose, lignin, extractives, ash, internal bound, thickness swelling, water absorption

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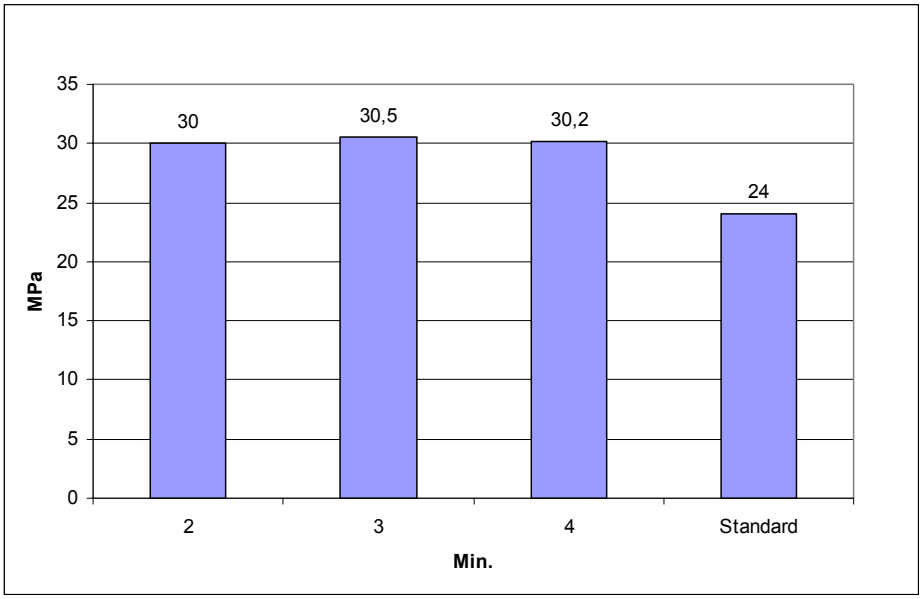
The Effect of Press Time on MOR of Boards



The Use of Waste Banknote Paper in Particleboard Manufacturing

A. ENAYATI* and O. HOSSEINAEE

The effect of partial substitution of/with old waste banknote particles in combination with wood particles in the core layer on particleboard properties was studied. The manufacturing parameters were: an old waste banknote content (0/100, 10/90, 20/80, and 30/70 weight of banknote/wood particle) of 0, 10, 20, and 30 wt.%, a resin content in core layer of 8 and 10 wt.%, a press time of 5 and 7 min, a press temperature of 160 and 180˚C. Urea-Formaldehyde was used as the adhesive in manufacturing of three layers laboratory panels.

The physical and mechanical properties of the panels such as modulus of elasticity, modulus of rupture, internal bond, water absorption and thickness swelling were determined. The results indicated that increasing the amount of old waste banknote decreases the mechanical properties, eg. especially for internal bond significantly. The effect of old waste banknote percentage on water absorption and thickness swelling was negligible still for only 10% UF, maybe for 2h test. The increasing of resin content in core layer, press time and temperature improved all the properties of test panels to some extent (5%, 10% or more). This study addresses options for using 30 % old waste banknote in combination with wood particles in the core layer in order to produce particleboard for interior application.

Key words: Recycling, waste banknote paper, particleboard, board property

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Improvement of Bondability in the Manufacture of Rice Husk Particleboard

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Agricultural residuals, such as rice husk are the renewable resources that can be utilized as raw materials for making particleboard. The objective of this research was to improve bondability by Isocyanate resin in the manufacture of rice husk particleboard glued with urea formaldehyde resin (UF). In this experiment, Polyisocyanate (PMDI) was used to replace 1 and 2 % of UF adhesive. The properties of the resulting mixed adhesive products were then evaluated and compared with particleboard bond with only UF. Properties evaluated were modulus of rupture (MOR), Internal bond (IB),Thickness Swelling (TS) and Water absorption after 24 h. The results showed that a modified resin system with PMDI as minor component significantly improved the board strength properties and dimensional stability (59%). The boards bonded with the 2% PMDI plus 8%UF resin system had higher internal bond strength (0.47mpa) and attained the best dimensional stability and the highest bending strength (14.28mpa).

Please attention that we used only 1 and 2 percent PMDI according to dry solid resin and we used 10 percent resin based on dry solid rice husk particles for each board.

Key words: Rice husk, polyisocyanate, UF, Particleboard properties

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Study on Particleboard made by Using Agricultural Residues

Tien-Tien CHEN*, Wun-Jheng HUANG and Hong-Ding SOONG

The main purpose of this study is to develop composite board from natural fiber-based residues. Six kinds of residues of which particle size ranges from -8+10 mesh(2.0 ~ 1.7mm) to -10+18 mesh(1.7~0.85mm) are moso bamboo (*Phyllostachys heterocycla*), makino bamboo (*Phyllostachys makinoi*), thorny bamboo (*Bambusa stenostachya*), rice straw, maize stalk and peanut husk. The recovery accounts for about 50% of the raw materials used for making board.

The binder to be used is urea formaldehyde, and the resin solid content based on the ovendry weight of particle is 10%. The pressing conditions are temperature (150 °C), pressure (4.2 MPa) and time (8min). The target board density is 700 kg/m^3 and thickness is 10mm. The moisture content, density, thickness swelling, release of formaldehyde, internal bond, bending strength and screw holding strength of all the boards are determined following CNS 2215.

Formaldehyde release of all the boards meets the criteria of CNS 2215-1999, whereas, three of them fails to meet current CNS 2215-2006. All of the boards except makino bamboo board have high thickness swelling after 2hours (8%),because the makino bamboo board had higher portion of bamboo skin. The maize stalk board has the best internal bond (0.28 MPa), whereas the rice straw board has the best bending strength (14.84 MPa). The board made from strand particle and overlaid by woven thorny bamboo has the promising performances, i.e. IB(0.2 MPa) MOR(56.37 MPa), and screw holding force (1004.09 N). Though the peanut husk board has low bending strength, but it can be easily handled and energy saving compared to the other board. Peanut husk mixed with other fiber-based materials or overlaid by veneers will be investigated later.

Key words: Particleboard, residues, bamboo, rice straw, maize stalk, peanut husk

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Study on Application LWA-bamboo Board for Construction Engineering - The Bond and Mechanics Property of LWA-bamboo Board

Yu-Wen LIU, Jin-Cherng HUANG, Yin-Wen CHAN and Sun-Wen JUAN

In this paper, LWA-bamboo board is made up of the *Bambusa stenostachya* and *Phyllostaohys makinoi* Hayata from Taiwan and lightweight aggregate (LWA). The bond property between bamboo material and cement matrix and the flexural strength of LWA board were studied. According to the result of tensile tests, the bond strength between LWA cement matrix and bamboo surface with water-retarding treatments is 1.7 times as high as that without any surface treatment. It is also found that the non-water-retarding bamboo would decade in various degrees when the LWA cement composite was cured in water, of which the bond strength was significantly affected. The epoxy resin treatment helps to prevent water absorption and, therefore, is efficient in enhancing the bond strength with cement matrix. The epoxy resin treatment proves to be a useful treatment for raw materials of bamboo. According to the test result of flexural tests, bamboo mesh and bamboo board may enhance the flexural strength of the composite board. In comparison, the flexural strength of composite board made up of bamboo sections is relatively low due to the uplift effect of bamboo sections in the cement matrix during the processing. In summary, the sequence of flexural strength of various kinds of bamboo LWA cement composite is, from high to low, bamboo board composite board, bamboo mesh composite board., and bamboo section composite board. The incorporation of bamboo in cement composites may increase the flexural strength by 80 % to 3.4 times in comparison with pure matrix

Key words: Lightweight aggregate (LWA), bamboo, cement

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5.07 A
ENERGY FROM BIOMASS

Papers

The Biorefining Story: Progress in the Commercialization of Biomass-to-ethanol

Warren E. MABEE and Jack N. SADDLER*

The Forest Products Biotechnology group at the University of British Columbia focuses its research on the interactions between lignocellulosic substrates and enzymatic activity for the bioconversion of wood-to-ethanol. Continued insecurity around oil supplies has helped to keep oil prices high, and the combination of these factors have driven a rapid expansion in global bioethanol and biodiesel production. While foods such as sugar and corn are still the dominant feedstock for biofuel production, interest in utilizing lignocellulose for the production of a 2nd-generation of biofuels has grown significantly. The agricultural sector has made significant progress in developing bio-based fuels and chemicals. Technologies from the agricultural sector may be combined with recent technical improvements that have made wood-based bioconversion more feasible. The biorefinery concept has been proposed as a means to extract maximum value from lignocellulosics, of which only a portion of the chemical structure is suitable for biofuel production. Within the biorefinery, some components of the lignocellulosic feedstock may be used as the basis for other value-added products. Recent discussions around the lignocellulosic-based biorefinery suggest that two technological platforms may be suitable for biomass-to-ethanol production: the biological platform and the thermochemical platform. The presentation will focus on the current status of this technology, describe the technical hurdles that remain in commercialization, and review the commercialization of this technology around the world.

Key words: Biological conversion, thermochemical conversion, bioethanol

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Biomass Energy Technology in Asia – Issues and Challenges

Why Kong HOI*

Biomass energy is highly emphasized in Asia. There are currently many incentives given to the promotion on the use of renewable energy from biomass in Asia. These biomass technologies ranged from the conversion of biomass into solid fuel such as briquettes and charcoal production to the direct combustion of biomass for use in the palm oil, rubber and brick making industries and the commercial use of biomass energy through the Small Renewable Energy Program. Certain amount of biomass is converted into liquid fuel by pyrolytic process to manufacture bio oil. Part of the paper is also allocated to the development of bio diesel in Asia. For gaseous fuel, some biomass is converted into biogas through fermentation and also through gasification.

This paper reviews the current status of the technologies used in Asia, with special emphasis given to environmentally clean system and economically viable system. A number of environmental issues related to volatile emissions will be highlighted together with numerous industrial applications of biomass energy. A detail techno-economic analysis of the technology will be highlighted. Issues related to labor cost and availability of raw material will also be given prominence.

Cogeneration technologies from biomass energy will also be given special focus in the paper especially towards an environment friendly system that will produce high quality fuel from a number of different types of biomass (with special emphasis to the use of waste from the oil palm industries) as well as producing high grade fuel from low quality waste as feedstock A lot of emphasis will be given a cost efficient preventive pre-treatment of these low-grade solid multi fuels by low temperature pyrolysis in downsized reductive environment for removal of hazardous air pollutants prior burning to improvement of burning efficiency of the revitalized solid fuel power plant-CHP up to 300 MW capacities. This technology has been developed to meet the open – liberalized energy and cogeneration market demands.

The paper concluded with the need for a good commercialization plan that will decrease the risk and maximize the chances for success for biomass energy in Asia. A model framework to develop suitable commercialization programs will also be highlighted

Key words: Biomass energy technology, techno-economic analysis, commercialisation

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Energy from Forest Biomass – Present Challenge for Future Generations of Moldova

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Developing a progressive strategy for the use of energy from forest biomass will become a critical challenge for the future generations of Moldova. Located in the southeaster part of the European continent between Ukraine and Romania (45°28^{I}-48°30^{I} northern latitude and 26°30^{I} - 30° 05^{1} eastern longitude), Moldova has insignificant natural resources compared with other developing countries European (Albania, Bosnia etc.) or African (Sudan, Nigeria, Eritrea etc.). At the same time lack of fossil fuels (natural gas, oil and coal) and mineral ores have resulted in a strong economical and political dependence with regard to supplying countries (Russia and Ukraine). Total preference for agriculture over forestry over the last few centuries has led the country with very rich soil to now have a catastrophically diminished economy. This, in turn, jeopardises the security of Moldova.

Adam Smith mentioned two hundreds years ago that welfare of any country is obtained only by intelligent utilisation of all resources which are in its possession. In Sweden for instance it was the development of mining, forest and hydroelectric industries (indigenous raw materials) that enabled Sweden to become a modern industrial nation. Recently national energy policy of Sweden aims to develop the use of timber biomass for energy production, instead of atomic station. If Denmark becomes the world leader in straw combustion or if Norway develops its wood pellets market, then it is not an amenity but literally a matter of life and death that Moldova, which is 9.6 % forested develops a bio energy strategy. This strategy must encourage farmers to invest money, land and time in commencing commercial forestry practices aimed at developing a bio energy economy. According to the Constitution of Moldova state must ensure rational exploitation of natural resources in conformity with national interests. Hence bio-energy for Moldova becomes a question of economic independence, security, and social health.

Key words: Energy, biomass, natural resources, confidence

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Bio-energy: Conversion and Utilization of Wood as Bio-fuel in Nigeria

Joseph Adeola FUWAPE*

The conversion of wood to different types of bio-energy through direct combustion, pyrolysis, densification and ethanol production in Nigeria was reviewed in this paper.

The trend in wood utilization as bio-fuel has been on the increase with increase in human population and high cost of fossil fuel. Although Nigeria is an oil producing country, it mainly exports the crude oil and imports refined petroleum products since the refineries in the country mostly operate below 10% production capacity. There has therefore been renewed interest in developing technologies for production of bio-energy which are relatively cheap, renewable and environmentally friendly. Examples of mills that are involved in briquette production, co-energy generation and raising of steam from wood waste products are examined in this paper. The research progress in the production of ethanol from plantation grown wood in Nigeria was also outlined.

Biofuel would continue to be the most reliable source of domestic energy in Nigeria in spite of the abundant fossil fuel reserve of the country. It is therefore important to establish energy plantations to meet the growing fuel demand. The combustion characteristics of some fast growing tree species that have been found appropriate for climatic and edaphic conditions in different ecological zones of the country are discussed.

Key words: Bio-energy, briquettes, ethanol, plantation species

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Importance of Woody Biomass Research on Plantation Resources in South East Asia

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This study was conducted by "ASEAN Biomass Research Strategy" project which has been funded by Japan Science and Technology Agency. We carried out the research with National Institute of Advanced Industrial Science and Technology, Japan International Research Center for Agricultural Science, University of Tokyo, and so on for 3 years from 2004. The main aim is to establish a research consortium in Asia for promoting the partnership between industry and academia. And "Biomass-Asia Workshop" has been held 3 times from 2004 to 2006 in Tokyo, Bangkok, and Tokyo. In this report, we describe the utilization of woody biomass in south east Asian countries. Most of the countries face to the shortage of natural forest resources and realize the importance of plantation resources which should be managed with sustainability. Once precious natural forest disappeared, consequently these countries lose not only values of wood resources also values of biodiversity. Reforestation of degraded natural forest is considered to be one of the best ways to afford wood resources. A report estimates almost 50% of total wood resources for wood industries comes from fast growing tree plantations in year 2020. Collaboration programs with Asian countries for better utilization of woody biomass from plantations should be established.

Key words: Biomass, plantation resources, wood

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5.11 A

NON-WOOD FOREST PRODUCTS-ALTERNATIVE FOREST PRODUCTS FOR A SUSTAINABLE FUTURE

Papers

Almaciga (*Agathis philippinensis* Warb.) Resin Production and Market Opportunity for Upland Communities in Karagan Valley, Province of Compostela Valley (COMVAL), Mindanao, Philippines

Arsenio B. ELLA, Moreno L. SANTANDER Jr. and Caroline Marie C. GARCIA

The almaciga tree grows naturally in almost all Philippine forests. Because the Philippine government prohibits felling of the tree, the almaciga's use is limited to its resin, known in world trade as Manila copal. Almaciga resin is used in the manufacture of varnishes, paints, soaps, plastics, printing ink, linoleum, shoe polish, floor wax, etc.

Inventory was conducted of almaciga stands found within two Certificate of Ancestral Domain Title (CADT) areas in COMVAL, i.e., Limparongan and Maragdao covering 5 ha and 20 ha respectively. Stand and stock tables for the two areas were prepared showing the number and volume of almaciga trees per hectare.

Limparongan, which comprises 33% of the total CADT areas in the uplands of Karagan Valley, also served as the experimental site for the initial resin tapping study. The study was carried out following Forest Products Research and Development Institute (FPRDI) procedures. The results showed that resin production was directly proportional to diameter class and number of cuts per tree.

The development of almaciga resin tapping as an alternative source livelihood option for forest settlers, who are all indigenous people called "Mandaya" will rely heavily on the following identified strengths: a) resin from the area has very good quality as per results of the chemical analysis conducted by FPRDI chemists; b) resin supply is plentiful as validated by the resource inventory of almaciga stands and resin yield collected in the initial tapping; and c) concerned upland communities have been trained on proper methods of resin tapping.

Key words: Almaciga resin, Manila copal, resin tapping, marketing

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Effect of Pressing Time on Physical and Mechanical Properties of Phenolic Impregnated Bamboo Strips

MOHD. KHAIRUN Anwar Uyup*, PARIDAH Md. Tahir, HAMDAN Husain, EDI SUHAIMI Bakar and ABD. LATIF Mohmod

Bamboo strips (*Gigantochloa scortechinii*) were impregnated with low molecular weight phenol formaldehyde (LMwPF) resin. The strips were submerged in LMwPF under vacuum (750 mm/Hg) conditions for 1 hour before slowly released within 90 minutes. Treated strips were dried in an oven at 60^{o}C for 9 hours and then pressed (14 kg/m^2, 140^{o}C) for 5, 8, 11, 14 and 17 minutes. The physical and mechanical properties test indicated that the properties of treated strips increased significantly than those of the untreated ones. The mean value of modulus of rupture (MOR) for the untreated strips (177 N/mm^2) showed a significant difference with treated strips after 17 min pressing time (224 N/mm^2). However, no significant different was observed in the cases of modulus of elasticity (MOE) and compression parallel to grain. The MOE of treated strips was found to be about 21777 N/mm^2 while those of the untreated was about 18249 N/mm^2, whereas the compression parallel to grain values for treated and untreated strips were 94 N/mm^2 and at 77 N/mm^2, respectively. Dimensional stability (water absorption, thickness swelling and linear expansion) of phenolic-treated strips were generally decrease by more than 100% after 11 minutes pressing time when compared to the untreated samples.

Key words: Bamboo strips, impregnation, phenolic resin, pressing time, properties

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Targeting the Challenges of Gum-Arabic Agroforestry System Disappearance through Incentives Based System under Rapid Commercialization: Factor Affecting Farmers Land Use Options in Gum Belt of Western Sudan

Tarig GIBREEL*, Siegfried BAUER and Fazli RABBI

Agroforestry is seen as a better farming management strategy for a sustainable farming system to stabilize rural economies in developing countries. Concurrently, some established systems are being lost. Sudanese gum arabic production system is now facing the challenges of the acacia's land conversion into commercial field cropping enterprises, with even more adverse impact on the smallholders' welfare and intimidates the system sustainability. Gum arabic is an important non-wood forest product (NWFP) obtained from *Acacia senegal* tree. Sudan accounts for nearly 80% of the world production and controls 60% of gum arabic world market. Gum arabic is also a significant source of cash income for the peasant communities occupying the gum belt, it accounts for 15% of the gum arabic producers' income and 10 % of other farmers. However, its production has slumped over the last three decades. This paper intended to analyze the determinants of agro-forestry system practice and to asses the impact of commercialization on the farm household resources allocation decision in the gum belt in dry–land agriculture in western Sudan. Results from commercialization index (C1) and Two-Stage Least Square model (2SLS), confirms a positive significant influence of commercialization as well as the investment in livestock on production of food crops, whereas the last negatively influences the commercialization decision. Furthermore, results from the probit model revealed that, adequately attractive price level equivalent to off-farm income is required if the sustainable gum arabic production system is to be conserved. Finally, household decisions to allocate more resources to cash crops, access to market and investment in livestock to ameliorate the risk appear to justify these resources allocation under degraded agricultural production environment. Therefore, increased farm gate prices for gum arabic producers will provide an incentive to use the land in gum arabic agro-forestry system to lead to win-win situation by enhancing cash and food crops productivity and environmental stability.

Key words: Acacia, gum, dry–land, commercialization, sudan

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Non-Wood Forest Products in Poverty Alleviation: A Case Study from the Far-Western Region of Nepal

Swoyambhu Man AMATYA* and Giridhar AMATYA

Nepal, owing to its unique landscape and extreme altitudinal variation, embraces a variety of biological diversity and it has been estimated that 700 to 1,700 species of Non Wood Forest Products (NWFPs) occur in the country. More than 100 species are widely traded and exported. NWFPs have been a source of off-farm employment and an important means of supplementary income for rural communities. Most livelihoods in this region are based on forest resources and subsistence farming with NWFPs being a major product. Almost all NWFPs are annually collected/ harvested from the wild. Non-timber forest products collected and traded, fall roughly into two categories: high-value products from high altitudes, and low-value products from lower altitudes (<2000m). It is estimated that roughly 90 percent of these collections are traded to India without processing.

In order to access the value and potential of Non-Wood Forest Products, in Poverty Alleviation, a detailed study was conducted in the Far-Western Region, which covers all nine districts of the country. International Union for Conservation of Nature (IUCN) and local communities, were involved in the study. The study revealed that there is a rapid depletion of NTFPs in this region. Unscientific harvesting was one of the major causes, followed by the increasing market demand. These factors have adversely affected the availability of various kinds of products in this area. IUCN and local communities have tried to address these issues and help in conserving NWFPs.

Basically, three major strategies - i*n-situ* conservation of NWFPs in government and community forests, promotion of domestication, and training of women harvesters - were adopted. These approaches were found very effective in conserving NWFPs in the communal land and government owned forest land. Consequently, within a period of three years, 153,309 seedlings, mainly of six major NWFPs that have export markets, were planted, covering a total of 312.6 ha of land. It is expected that the monetary benefits would help in alleviating rural poverty of this region.

Key words: Non-wood forest products, sustainable use, harvesting, poverty alleviation

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5.11 A - Posters

Antibacterial Compounds from the Bark of *Cryptomeria japonica* D. Don

Wen-Hsin LI*, Shang-Tzen CHANG, Shan-Chwen CHANG and Hui-Ting CHANG

The ethanolic extract from the bark of *Cryptomeria japonica* D. Don showed good antibacterial activity. The ethanolic extract was separated by liquid-liquid partition to further obtain hexane, ethyl acetate, butanol and water soluble fractions. Among four fractions, hexane-soluble fraction possessed the best antibacterial activity and had minimum inhibitory concentration (MIC) values less than 250 μg/mL against four gram-positive bacteria (*Enterococcus faecalis*, *Staphylococcus aureus*, *Staphylococcus epidermidis,* and Methicillin-resistant *Staphylococcus aureus*). Nine compounds including seven diterpenoids (ferruginol, isopimaric acid, iguestol, isopimarol, phyllocladan-16α-ol, sandaracopimarol and sugiol) and two steroids (β-sitosterol and β-sitostenone) were isolated by HPLC from active subfractions of hexane-soluble fraction and identified by spectral analysis such as NMR(^{1}H NMR, ^{13}C NMR, HSQC, HMBC, COSY, NOESY), IR, UV, and MS. Six compounds exhibited excellent antibacterial activity; their ability in decreasing order was as follows: ferruginol > isopimaric acid > sugiol > sandaracopimarol > iguestol > isopimarol. Ferruginol possessed the strongest antibacterial activity within all the compounds and had MICs ranging from 6.3 to 12.5 μg/mL against all bacteria tested. The MIC of isopimaric acid was less than 50 μg/mL against bacteria tested, except for MRSA.

Key words: *Cryptomeria japonica*, antibacterial, bark, ferruginol, isopimaric acid

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Effect of Heat Treatment on Properties of Cultivated *Bambusa vulgaris* Bamboo

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The suitability of using an eco-friendly heat treatment process was conducted on cultivated *Bambusa vulgaris* bamboo in order to prolong their service life span. *Bambusa vulgaris* was chosen as this species is easy cultivated and has good physical as well as mechanical properties. Matured bamboo culms of four (4) year-old from internodes 5, 6 and 7 in green and air-dried conditions were heat treated. The heat treatment process used palm oil as the heating medium at temperatures of 140°C, 180°C and 220°C for durations of 30, 60 and 90 minutes. The air-dried culms exhibited overall higher physical, strength, and durability properties than the green and untreated culms. The modulus of elasticity (MOE) value of heat treated bamboo in bending was reduced by 13 to 42 % in green and by 3% to 29% in air-dried conditions. The compression strength was reduced by 18% to 33% in green and by 14% to 27% in air-dried ones. The heat treated bamboo lost from 5% to 34% of their initial weight after undergoing 12 months of ground-contact tests for both green and air-dried conditions.

Key words: *Bambusa vulgaris*, heat treatment process, biodegradation, weight loss, durability

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Clarification:

1. Cultivated bamboo gives better properties both in the physical and strength.
2. Bamboo culms at internodes 5, 6 and 7 were heat treated at temperatures of 140°C, 180°C and 220°C for durations of 30, 60 and 90 minutes. Culms were segregated into 3 groups. One group was heat treated at 140°C for durations of 30, 60 and 90 minutes, the second group was heat treated at 180°C and 220°C for durations of 30, 60 and 90 minutes and the third group was heat treated at 220°C for durations of 30, 60 and 90 minutes.

Non Timber Products in West-Iran Forests (Case study: *prstacia mutica* Seed in Chaharmahal & Bakhtiavi Province)

H JAHANBAZI, Y IRANMANESH and M TALEBI

Among trees in the Zagros region of West Iran, *Pistacia mutica* is highly important for its special characteristics, particularly gum and seed production. The seed of *P.mutica* is used to provide oil, tartness, and desserts. This research was performed in Chaharmahal & Bakhtiari provinces, West Iran, with the objective of determining the potential financial contribution of those products. Ten female trees were selected in different diameter classes, all of the seeds of every tree were picked out, and the ripe seeds were weighed. The average number of female trees in the study area was calculated. The results show that average production from one tree was 5.07 Kg. and that the average number of female tress (*pistacia mutica*) was 1561400. Therefore, average production of seed from this species in this province was estimated at about 8 million Kg. With this production, dwellers could obtain an annual income of about 2.24 million euro, which would be a substantial economic benefit.

Key words: *Prstacia mutica*, seed, none timber products, West Iran

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Bamboo-based Income Generating Activity and its Role on Rural Livelihood

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Nepalese rural communities, like those of other developing countries, depend on the forest for their subsistence. Bamboo extracted from the forest plays a significant role in both household use and income generation. The synthetic products (such as plastic tools, bricks, cement, utensils etc) are costly for rural people due to the high material cost and transportation charges. Similarly, high cost of production incurred in timber production makes timber expensive for rural livelihood. Thus, both synthesized and timber products are not affordable to financially poor people of rural communities. The multiple and diversified bamboo products are economically and practically feasible for substituting timber products (on an average, a single culm costs US$ 1, making it affordable to poor people).

Rural communities employ bamboo in multiple uses ranging from poles, furniture, eco-housing, fuel wood, fodder, bedding material for cattle, domestic tool making (vernacular name in nepali - doko, dalo, namlo, chitra, mandro, pitcha, bida, chappani) and food. In the mean time, increasing demand for bamboo and its products has given employment to women and encouraged rural communities to generate income by extending the bamboo based market.

The objective of this research was to determine the contribution of bamboo to the economy of rural communities. The study site Tanahu District was to represent the normal rural population of Nepal. The use of bamboo in rural community ranges from domestic use to use as raw material for cottage industry. Regardless of the farm based or forest based bamboo extraction, the study assessed financial aspect of bamboo based income generating activities that was prevailing in the rural community. To meet the purpose of the study, widely accepted analytical tools as Net Present Value (NPV), Benefit cost ratio and Internal rate of return (IRR) were employed for financial analysis. Gross annual income per household about US$ 75 assumes 9 % share in total household income and 42 % of total farm-based income. Resultant positive NPV and benefit cost ratio greater than unity suggested viability of bamboo based enterprises in the study area. Thus, results drawn from the analysis encourage us to organize and institutionalize bamboo producers for gross economic upliftment of rural communities. However, the development of bamboo based income generating entrepreneurial activities was found to be impeded by various factors. The impeding factors were lack of knowledge and training on scientific method of bamboo propagation, species selection according to site quality, culm and rhizome collection and nursery management. People also lack clear knowledge of market structure. Lack of training in production technology has synchronized the varieties of products and quality of production. Also, there was coordination gap among the stake holders of bamboo based enterprise including bamboo growers, craft makers and trades.

In conclusion, to maximize the foreseen opportunities of rural livelihood upliftment through bamboo based income generating activities, strong financial support should be laid through formulating appropriate policy. One of the major reasons of underdevelopment of bamboo based enterprise is the lack of an institution that unifies bamboo based cottage enterprises into a single stream. The development of organization will help individual producers to discuss on common problems faced and help seek solutions. Besides, the bamboo-based products should be further extended through exploring its use in new areas and to help replace plastic products by eco-friendly bamboo products.

Key words: Bamboo, IGA (Income Generating Activity), rural livelihood

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Antifungal Activity of Essential Oils from *Cryptomeria japonica* and their Constituents

Sen-Sung CHENG and Shang-Tzen CHANG

In this study, antifungal activities of essential oils from *Cryptomeria japonica* D. Don wood, twigs, bark and leaves against four wood decay fungi and six plant pathogenic fungi were investigated. In addition, the yields of essential oils obtained by water distillation were compared and their constituents were determined by gas chromatography-mass spectroscopy (GC-MS) analyses. The yield of essential oils from four parts of *C. japonica* was in the decreasing order of leaf (18.85 mL/kg; 1.42%) > wood (7.59 mL/kg; 0.38%) > twig (2.14 mL/kg; 0.05%) > bark (1.58 mL/kg; 0.03%). From the results of GC-MS analyses, the wood essential oil was found to contain mainly γ-cadinene (22.07%) and δ-cadinene (12.12%); the main constituents of twig essential oil were α-eudesmol (10.87%) and δ-cadinene (10.41%); the bark essential oil has ferruginol (14.70%) and phyllocladanol (12.22%) as main compounds and β-elemol (20.48%) and *ent*-kaur-16-ene (20.23%) were the dominant components of leaf essential oil. Wood essential oil had the strongest antifungal activity against four wood decay fungi and six plant pathogenic fungi. The antifungal activity correlates well with the presence of α-cadinol, β-elemol and β-eudesmol.

Key words: *Cryptomeria japonica*, essential oil, wood decay fungi, plant pathogenic fungi, antifungal activity.

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Sustainable Utilization of Medicinal Plants, a Non-wood Forest Product: A Biotechnological Approach for their Propagation and Cultivation

Shyamal K. ROY* and A.K.M. SAYEED HASSAN

Medicinal plants, which are non-wood forest products, have been playing a very important role in healing diseases. They are still widely used by men and women of the east and the west, not to speak of tribals. Recent developments in plant chemistry and pharmacology have led to an increased interest in the utilization of medicinal plants. In Bangladesh and India there are increasing trends of utilization and industrial uses of medicinal plants. The manufacturing firms exploit the medicinal plants indiscriminately for their raw materials. So, it has become imperative that the exploitation of medicinal plants must be accompanied by cultivation in the forests. In the present investigation we cultivated two medicinal plants, *Rauvolfia serpentina* and *Withania somnifer* in the floor of Dipterocarp forest as a model and found that medicinally important herbs could be cultivated in the forest floor, from which a yearly recurring income is possible for livelihood of the forest people. We utilized a biotechnological method for mass propagation of planting materials of these two medicinal plants. Likewise, several important medicinal plants could be cultivated in the forest floor, which would be feasible from the point of view for medicinally important biomass production for its sustainable uses and consequently poverty reduction of the people dwelling in the forests. The methodology is detailed in this paper.

Key words:

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Beneficial yet Lesser Known Ally of the Forest (Preservation of Bayuko)

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The edible land snail "bayuko" (*Ryssota ovum*) is fast declining in of Mt. Makiling Forest Reserve, Laguna, Philippines. Bayuko is nocturnal. At night time, it can be observed crawling, eating and resting. Ecologically, bayuko helps in the process of decomposition. This explains why these species prefers to stay in places of dead leaves and rotten branches. Bayuko depends on the availability of moisture for survival.

During rainy season, it grows in number. Being so, it serves as a supplementary food for upland communities. In localities where it grows naturally, it is a delicacy. It costs Php 5 to 10 (US$ 0.10) a piece. It is the most sought after snail species as it meat tastes like chicken gizzard.

People who have tasted it claim that bayuko meat has an "aphrodisiac effect" due to its high protein content. To verify this claim, meat samples of bayuko were taken for laboratory analysis. Comparison of food composition per 100g edible portion of bayuko (dry weight basis) with other food source was made. Results reveal the following information:

Food Source	Water	Protein	Fat	Fiber	Ash
Bayuko	6.91	75.59	2.84	0.79	4.59
Pork (suckling belly)	69.20	18.30	11.20	0	0
Chicken (white meat)	75.3	20.6	3.10	0	1.00
Beef (lean meat)	70.60	23.10	4.60	0	1.00
Carabeef	71.00	21.70	6.20	0	0
Milkfish	66.80	23.40	10.40	0	2.00

Sufficient knowledge regarding the breeding of *Ryssota ovum* under captivity can be a potential source of income and it can minimize the practice of extensive harvesting from the wild that could threaten its population. The approach could preserve the species and ensure its contribution in the nutrient cycling of the ecosystem. Based on daily observation, chopped soft stems and leaves of gabi (Taro) will last a day or two for the snails to consume while twigs, branches and other decaying parts of a tree take time to consume.

The Ecosystems Research and Development Bureau particularly its Los Banos Experiment Station is studying how to grow bayuko under controlled condition. A 5m x 5m cage intended for studying the behavior of bayuko and its proper rearing was established at the station. The activities involved in this work specifically in growing the bayuko as undertaken in LBES are shown in this poster presentation.

Key words: Bayuko, nocturnal, decomposition, landsnail, edible

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Non-timber Forest Products and Use of Agroforestry: AKECOP's Collaborative Forest Restoration Research

Don Koo LEE, Monton JAMROENPRUCKSA, Dudung DARUSMAN and Woo Sung KIM*

ASEAN-Korea Environmental Cooperation Project (AKECOP) is a regional initiative founded by ASEAN and the Republic of Korea (ROK) designed to respond to the challenges of restoring degraded tropical forest ecosystems in Southeast Asia. The Project involves 8 ASEAN member countries, namely, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand, and Vietnam. All together, 16 different forestry, environmental research, and educational institutions located throughout the ROK and the ASEAN region are in collaboration. AKECOP's main themes for 2005-2008 are forest restoration for poverty reduction and environmental quality amelioration.

For regional researches, Thailand's non-timber forest products (NTFP) like bamboo and mushroom were cultivated in logged areas. Suitable methods to produce quality planting stocks of bamboo (*Thyrsostachys oliveri* and *Dendrocalamus latiflorus)* using culm age and rooting hormone combinations were studied. Bamboo is considered a greenbelt for fruit orchards. Mushrooms were cultivated for food, medicine and decoration purposes, which provides livelihood for the local community. Ectomycorrhizal mushrooms benefits the trees' growth rate and enhances root disease resistance. In the case of Indonesia, research focused on the introduction of appropriate technologies and the implementation of an agroforestry model to increase biodiversity and productivity in agroforestry systems; including an intensive treatment plan focusing on the fertilization treatment of cassava (*Manihot esculenta*) and coffee (*Coffea robusta*). Increasing the effectiveness of marketing agroforestry products like coffee, cardamom, banana, etc. through participatory strategy is was included in the projects. Collaborative research projects focused on agroforestry and NTFPs continue to strengthen partnerships in the region, thereby helping in the achievement of sustainable forest management.

Key words: Non-timber forest products, agroforestry, restoration

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Pulp & Paper A
CHEMICAL PULPING AND LIGNIN CHEMISTRY

Papers

Estimation of Softwood Pulp Yields in Kraft Cooking with AQ and Polysulfide

Shiho TAKAHASHI*, Akiko NAKAGAWA and Hiroshi OHI

Eighty seven percent of the afforestation area in Japan is coniferous forest. It is required to use more Japanese softwoods, for example, *Larix leptolepis* (karamatsu), *Pinus densiflora* (akamatsu), and *Cryptomeria japonica* (sugi) for the effective production of pulp and bio-energy. On the other hand, the pulp yield in cooking stage is one of the most important factors at a pulp mill. However, it is difficult to know the yield due to a continuous operation of the mill.

Karamatsu, grown in the Agricultural and Forestry Research Center at the University of Tsukuba, was cut and divided into sapwood and heartwood parts. Wood chips were made from each part by chipping equipment into a similar size to a pulp mill. The wood chips were cooked by soda-anthraquinone (AQ), kraft, kraft-AQ, and polysulfide-AQ (PS-AQ) cooking methods in a 300 mL laboratory autoclave at 154-168ºC for 2.5-7.5 h under various conditions with 23-33% active alkali, 0 or 30% sulfidity, 0 or 1% sulfur dose, and 0 or 0.14% AQ dose. Liquor to wood ratio was 5.5 in these cooks. The results of cooks giving kappa numbers 20-40 were chosen for making an equation which could simulate the behaviors of delignification in the four cooking methods. Every pulp was applied to an analysis of carbohydrates composition. Then, other equations were made for simulating the behaviors of carbohydrates (glucose and mannose) as well as lignin-free pulp yield. From these equations, we also simulate the relationship between pulp yields and the ratios of mannose to glucose (M/G ratios) from the karamatsu pulps. Laboratory cooks did not show that a correlation existed between the yields and the ratios of xylose to glucose (X/G ratios) for karamatsu pulps with various kappa numbers, and that it existed between the yields and the M/G ratios for the pulps with kappa number 25 given by kraft, kraft-AQ, and PS-AQ methods. Based on the karamatsu wood cooks, akamatsu and sigi wood chips were also cooked in kraft and kraft-AQ methods under similar conditions to a kraft pulp mill. The softwoods pulp yields with kappa number 25 at the mill using the akamatsu and sugi mixed wood chips were estimated by a method based on the M/G ratios from pulps. It was shown that the M/G ratios of the kraft-AQ pulp and the kraft pulp were 0.0812 and 0.0704, respectively, and that the pulp yield by kraft-AQ cooking was 1.2% higher than that by kraft method.

Key words: Softwood, kraft cooking, lignin, mannose, pulp yield

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Effects of Liquor to Wood Ratio and Sulfide Concentration on Pulp Yields in Polysulfide Cooking of Eucalyptus Woods

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Improvement of pulp yields is economically and ecologically a significant factor for kraft pulp mills. In Japan, most of them depend on using imported hardwood chips as raw materials. The yield improvement can reduce the deforestation rates, the emissions of waste products, and consequently lower wood chip and operating costs. Polysulfide (PS) cooking is one of the most efficient technologies available today to increase pulp yields. However, it has been hard to observe a clear increase of pulp yield in experimentally. In order to evaluate the effects of PS precisely, experimental systems were developed. A system provides cooks at the low ratio of liquor to wood (L/W ratio) with rotating autoclaves, and gives suitable concentrations of chemical agents in autoclaves close to those in an actual continuous digester at a mill. By using the new system, we analyzed results of cooks statistically, and investigated the effects of the L/W ratios: 2.5, 4.0 or 5.5 L/kg as well as the concentrations of sulfide: 5-25 g/L as Na_2O and PS: 0-6 g/L as sulfur.

At a given dosage of active alkali, screened pulp yields (around 51%) in cooks at the low L/W ratio were higher than those (32-48%) at the high L/W ratio, while total pulp yields (50-53%) at the low L/W ratio were a little lower than those (51-55%) at the other. The concentrations of chemical agents are higher at the low L/W ratio. Then, the wood chips could be delignified more rapidly, and consequently the amounts of the rejects in screening are smaller in comparing with the case at the high L/W ratio. In addition, it was observed interestingly that the screened pulp yields of PS cooking were unexpectedly lower than those of kraft cooking at the low L/W ratio, because the PS cooking gave higher amounts of the rejects. The reason of the unexpected results are considered to be the low concentration of active alkali of PS liquors, which are prepared by both the oxidation of white liquor and a dilution of the liquor. Furthermore, kappa numbers and the amount of screen rejects increased rapidly if the initial concentration of sulfide dropped bellow 6g/L. Viscosity also decreased rapidly if it dropped bellow 9g/L. A new PS generation system is desired to satisfy higher concentration of both sulfide and PS.

Key words: Eucalyptus woods, polysulfide cooking, pulp yield, sulfide

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Activation of Kraft Pulps with Nitric Acid Prior to Oxygen Delignification

Evren E. KALYONCU* and Emrah PESMAN

Because of its cheapness and harmless for environment, oxygen has always been attractive oxidant to the pulp and paper industry and used widely for lignin removal before bleaching. It is an important delignification stage in bleaching sequence. But it has lower lignin-cellulose selectivity and the extent of delignification effect is limited to about 50%. Further delignification would lead to occurring severe loss of pulp strength. Kraft pulps can be activated with some reactants for improving the selectivity of oxygen delignification. In this study, changing the structure of lignin with nitric acid prior to oxygen delignification was purposed. Two different kraft pulps which were Eastern spruce (Picea orientalis L.) and the mixture of Calabrian pine (Pinus brutia) and Black pine (Pinus nigra) prepared for this study. Both kraft pulps activated with 1.0%, 2.0% and 3.0% charges of nitric acid prior to oxygen delignification. The selectivity of oxygen delignification increased approximately 18.7% and 21.7% for Eastern spruce (Picea orientalis L.) and mixture of Calabrian pine (Pinus brutia) and Black pine (Pinus nigra) respectively with using 2.0% nitric acid charge. The obtained results indicate that, it is possible to increase viscosity value of kraft pulp by oxygen delignification without significant losses in pulp quality after nitric acid pretreatment.

Key words: Oxygen delignification, pretreatment, nitric acid

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Variety of Lignin Structure in Angiosperms and their Reaction Woods

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By a wide survey of lignin structure of angiosperms, a certain tendency was found among characteristic factors of lignin structure. Generally, lower the lignin content, higher is the proportion of acid soluble lignin, richer in β-O-4 structure, especially of *erythro* type, and also richer in syringyl type of aromatics. The same relationship was found for the difference of the compound middle lamella lignin and the secondary wall lignin. A beautiful linear relationships were observed between *erythro* ratio of β-O-4 structure and syringyl ratio of aromatics ($R^2 = 0.99$). Here the *erythro* ratio is the proportion of *erythro* type among two diastereomers (*erythro* and *threo*) of of β-O-4 structure, and, the syringyl ratio is the proportion of syringyl type aromatics among syringyl and quaiacyl types.

Reaction woods were obtained from leaning wood stems or branches of several tropical wood species and the relationships between the appearance of reaction wood and lignin characteristics were surveyed. Tentatively, the relationships between the appearance of reaction wood and lignin structure could be classified into 4 types, among which angiosperms exhibited 3 types. Some angiosperms exhibited compression wood. In all types, *erythro* ratio changed with clear tendency from the reaction wood part to opposite wood part, but the direction of the change was dependent on the type. In G-S lignin (guaiacyl-syringyl lignin, mostly angiosperms) *erythro* ratio was highly correlated with syringyl ratio, and in G-lignin (guaiacyl lignin, gymnosperms), it was correlated with the content of p-hydroxyphenyl nuclei. In some tension wood, higher *erythro* and syringyl ratio was not always accompanied by lower lignin content.

Key words: Lignin, angiosperms, tension wood, diastereomer

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Structural Changes of Lignin Preparations under the Heat during DSC Analysis

Satoshi KUBO*, Tatsuhiko YAMADA, Koh HASHIDA, and John F. KADLA

In the DSC analysis of lignin preparations, it is found that the observed glass transition temperature, Tg, is gradually increased by repeating of the heating cycle before the DSC run (pre-heating). Tg of softwood lignin preparations were more significantly affected by this pre-heating in comparison with hardwood lignin preparations. Both of softwood and hardwood lignin preparations were well dissolved in several organic solvents, such as DMSO. However, the solubility of softwood lignin preparations gradually decreased with increasing the pre-heat temperature. From our previous study on the low temperature carbonization of softwood lignin preparations, it was found that the some changes in chemical structural were suggested during the heat treatment. The content of hydroxy groups decreased with increasing pre-heat temperature. The same tendency in the hydroxy group contents were also observed for hardwood lignin preparations in this study. GPC analysis showed that the molecular weight of the lignin preparations increased with increasing pre-heat temperature. However, the extent of molecular weight changes were higher in softwood lignin preparations than hardwood one. In the quantitative ^{13}C-NMR measurement, signal intensity of oxygenated benzyl carbons of softwood lignin preparations were decreased by heat treatment. However, such apparent changes were not detected for hardwood lignin preparations. Typical differences in chemical structures between softwood and hardwood lignin preparations were found in aromatic ring structures. (Softwood lignin typically contains guiacyl structure, but hardwood lignin contains both of guiacyl and syringyl structures). Therefore, the chemical structural changes might be related with methoxy group contents in lignin molecules, as well as hydroxy group contents. In this presentation, we will discuss the chemical structural changes of softwood and hardwood lignin preparations to establish the optimum method for the lignin thermal analysis.

Key words: Lignin preparation, heat treatment, chemical structure, DSC

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Effect of α-Carbonyl Group on the Lignin Reaction under Alkaline Conditions

Aiko Imai, Tomoya Yokoyama, Yuji Matsumoto and Gyosuke MESHITSUKA*

The presence of carbonyl group in lignin has a significant effect on its reactivity during various chemical reactions. We examined the effect of α-carbonyl group on reactions occurring at the phenylpropane unit next to a unit possessing the α-carbonyl group. A phenolic dimeric lignin model compound, 2-(2-ethoxy-4-formylphenoxy)-1-(4-hydroxy-3-methoxyphenyl)propane-1,3-diol (guaiacylglycerol-β-ethylvanillin ether), was subjected to oxygen or nitrogen-alkali treatments (0.5 mol/L NaOH, 0.8 MPa O_2 or N_2, 95℃, 100 min) to examine the effect of the α-carbonyl group at the B-ring on the cleavage of β-O-4 linkage.

In anaerobic alkali treatments, 3-ethoxy-4-hydroxybenzaldehyde (ethylvanillin) was detected with about 85 mol% yield. This result indicates that α-carbonyl group at the B-ring significantly promotes the β-O-4 bond cleavage and that oxygen is not required to cleave the β-O-4 bond. Under aerobic alkali condition, on the other hand, 4-hydroxy-3-methoxybenzaldehyde (vanillin) was detected with about 40 mol% yield. When a model compound without a α-carbonyl group at the B-ring, 1-(4-hydroxy-3methoxyphenyl)-2-(2-methoxyphenoxy) propane-1,3-diol (guaiacylglycerol-β-guaiacyl ether) was subjected to the same treatments, quite different results were obtained. In this case, the mol% yield of vanillin was less than 3%. The presence of α-carbonyl group at the B-ring accelerates the oxidative cleavage between α-β positions of side chain at the A ring. As a result, the rate of the α-β bond cleavage exceeds that of aromatic ring scission, which gives relatively large amounts of vanillin. Reaction mechanisms involved will be presented.

Keywords: Lignin, carbonyl, oxygen, bleaching

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Pulp & Paper A – Posters

Preparation of Amphipathic Thermal Moldable Lignin in the Biomass Conversion of Softwood Using Acid-Catalyzed Solvolysis

Tatsuhiko YAMADA*, Satoshi KUBO and Yasumitsu URAKI

Lignin is the second abundant natural polymer existing in plants. Significant amounts of lignin have been produced in the chemical pulping process. However, most of them are burned as solid fuels to recover pulping chemicals and heat. There are some limitations on the lignin utilization as value-added materials, due to its complex poly-aromatic chemical structures. However, it will be important to produce valuable lignin-derived products for the development of future biomass based industrial systems as well as the effective utilization of other biomass components, such as cellulose and hemi-cellulose. Recent development in the biomass conversion has made it possible to convert biomass component into various products, such as fuels, chemicals and other materials. We have also proposed the effective biomass conversion system for the forest biomass using the novel solvolysis reactions (Yamada et al., Japan Patent Pub 2004-83482). In this process using cyclic carbonates and glycols, all biomass components can be converted into chemicals and materials in one step process. Cellulose component is decomposed into formic and levulinic acid by one step process with higher recovery in comparison with two-step acid hydrolysis, which is a promising entry for the bio-based levulinic acid production system. Solubility of the lignin in various solvents was dramatically improved by the introduction of oxyalkyl chains. Introduced oxyalkyl chains also enhanced thermal mobility of lignin molecules and a thermal moldable lignin can be prepared by this one step bioconversion system. Continuous spinning could be achieved with maximum take-up rate of the laboratory scale thermal spinning machine. This biomass conversion will be the first potential system to transform all biomass components into fine chemicals and plastic materials. In this presentation, the recent progress of our biomass conversion system will be introduced.

Key words: Wood components, biomass conversion, thermal molding, solvolysis

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Lignin Structural Changes during EMCC Pulping of the Triploid of Chinese Aspen

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The Triploid of Chinese Aspen was a newly developed fast-growing species by researchers at Beijing University of Forestry with genetic techniques. Within 5 years, the diameter at breast height could reach above 20cm with good chemical and physical properties and high cellulose and low lignin contents, which makes it a good fiber resource for the paper industry. Several paper mills from Shandong and other provinces have started to grow the Triploid of Chinese Aspen in a large scale. Much research work has been done since then for manufacturing mechanical pulps (APMP and CTMP etc). Work for producing chemical pulps with high brightness and quality was also carried out in the Lab of Professor Chen Jiachuan, Shandong Institute of Light Industry. Study on the lignin structure of raw material will help us understand more clear about it and offer more information for the design of the chemical pulping process.

EMCC pulping of the Triploid of Chinese Aspen was carried out. The two-stage method was chosen as the isolation methods for the raw material and residual lignin preparation. The acid-precipitating method was use for the dissolved lignin isolation from the black liquor and the crude lignin was purified by mild-acidic hydrolysis. The lignin samples were tested through GPC, and the changes of molecular weight during EMCC pulping were studied and compared. The lignin ^{31}P-NMR spectra of different lignin samples were obtained and the functional groups within lignin were quantitatively analyzed and compared to discover the disciplines of lignin structures during EMCC pulping.

Key words: The triploid of Chinese Aspen, EMCC, ^{31}P-NMR, lignin structural changes, lignin molecular weight

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5.02 A
RESOURCE CHARACTERISATION A

Papers

Physical and Mechanical Properties of Six Mangium Provenances from South Sumatra and West Java Indonesia

N. HADJIB, A. PRAWIRA and Y.S. HADI

Physical and mechanical properties of six mangium (*Acacia mangium* Willd.) provenances from Martapura Forest Block, South Sumatra, and Parung Panjang, West Java, were carried out at Forest Products Research Institute Bogor Indonesia. The six acacia provenances were Claudia Rivers-QLD, Lake Muray-PNG, Kuru-PNG, Wipin-PNG, Kini-PNG and Kiriwo-PNG. The wood was from plantation forest established in 1991 or 14 years tree. Wood sample representative, size and testing procedures for physical and mechanical properties were referring to ASTM D 143-94 (ASTM, 2002). Tested physical properties were moisture content and specific gravity, and mechanical properties were modulus of rupture, compression strength parallel to grain, shearing strength, impact bending strength, cleavage, hardness, and tensile strength parallel and perpendicular to grain.

The results showed that the highest wet moisture content was Kuru provenance from West Java with 76 % MC and the lowest was Kuru from South Sumatra with 41 % MC. Dry moisture content ranged 10.7-17.4 %, the highest was Lake-Muray from West Java and the lowest was Lake-Muray from South Sumatra. Density was varied 0.39-0.52; the density from West Java was mostly higher than South Sumatra.

Physical and mechanical properties were not affected by the provenance, but they were affected by plantation site. Based on mechanical, the best provenance was Kuru from West Java and Claudia River from South Sumatra. Mechanical properties showed that the six provenances were classified to E11-E10 strength class, and the wood is good for light construction under roof, furniture, door and window.

Key words: Physical and mechanical properties, mangium, provenance, plantation site

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Branch Wood as an Alternative Material Resource. A Comparison of Microscopic Structure and Mechanical Properties of Branch and Stem Wood

Marina CIONCA, Lidia GURAU, Hugh-MANSFIELD WILLIAMS and Gervais SAWYER

A secondary resource, branch wood, could be used in new added value products as an alternative to stem wood, providing its characteristics are known and understood. While there are some photomicrograph records in the literature, there is very little data about the mechanical properties of branch wood. This paper investigates the relationship between the microscopic structure of branch wood and some of its mechanical properties and compares it with similar properties of stem wood. The properties studied were the MOE, MOR and compression strength of maple (*Acer* spp) and Scots pine (*Pinus sylvestris* L.) and the compression strength of beech (*Fagus sylvatica* L.).
SEM and light microscopy images showed that cell diameter, lumen and wall thickness were smaller for branch wood than for stem wood. Branch wood also contained a greater number of vessels and rays than stem wood.

The mechanical tests showed that the MOE and compression strength of maple branch wood were slightly lower than those of the stem wood, while the maple MOR and beech compression strengths were similar for branch and stem wood. However, the MOR and compression strength of Scots pine branch wood were approximately half those of stem wood, while the MOE was around a third.
Maple and beech branch wood had a higher density than their stem wood, while density of Scots pine branch wood was lower than its stem wood. The branch wood density has a clear relationship with the MOR.

Maple branch wood was slightly more resistant to compression than beech and pine. The MOE and MOR of maple branch wood were 2.8 and 2 times higher respectively than those of pine branch wood.

Since maple and beech branch wood have similar strengths to stem wood of the same species, they are alternative raw materials that could be used for manufacturing small furniture panels. If furniture panels were to be manufactured from Scots pine branch wood, they should be used in applications that avoid bending stresses.

Key words: Branch wood, secondary resource, microscopic structure, mechanical properties

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Anatomic and Mechanical Properties of *Schizolobium amazonicum* on Different Ages

Rodrigo Figueiredo TEREZO and Carlos Alberto SZÜCS

The Amazon Forest is one of the greatest hardwood supplier in the global market. The majority of this wood is harvested from the native forest. However, after the great world-wide pressure for the Amazon Forest preservation, the planted forest of native species are growing and becoming economically viable in the north region of Brazil. Amongst the diverse planted species, *Schizolobium Amazonicum* is one of the pioneering species. In this paper, the anatomical, physical and mechanical properties will be presented on trees of different age (six and ten years old). A small difference of mechanical strength observed among those ages. Initials tests show that the parallel compression fibers strength for the 6 years old are of 33,62 Mpa and for 10 years old is of 35,85 Mpa. These modulus of elasticity is of 11.093 Mpa for the 6 years old and of 16.259 Mpa for the 10 years old. Already the wood duramen formation for the 10 years old is 5% larger than the one of 6 years. The density of this wood did not vary significantly among the ages being around 650 kg/m³. These results will be used as a parameter to improve this timber as products for the civil construction area, as well as on laminated timber beams. With a proper knowledge of this planted forest wood, it will be possible to put it in the brazilian and world-wide markets. This research will contribute for the reduction of the native Amazon forest exploitation.

Key words: *Schizolobium amazonicum*, wood properties, planted forest

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Interrelationships among Quality Index for Structural Use of Hardwoods

Masataka TERANISHI, Akio KOIZUMI and Takuro HIRAI

The aim of this study was to discuss the general tendency of the interrelationships among various strength characteristics of hardwoods in order to propose an index property that is easy to measure and exhibits a high correlation with target characteristics necessary for structural use such as connectors used in wood construction, chairs, and sports equipment. Twenty-six species of hardwood included 9 ring-porous and 17 diffuse-porous, and 5 species of softwood were tested. Most of the test methods were followed JIS(Japanese Industrial Standard)-Z2101 which used for testing of small and clear wood specimens. Their strength was considered to represent the strength of the actual size of the structural members because the sizes of the connectors in wood construction or the members of chairs are not as large as the softwood structural timber. Furthermore, defect-free members were used in most of hardwood applications.

Several properties were measured included the cambial age of a small and clear specimen (*CA*), average ring width (*ARW*), specific gravity (*SG*), dynamic modulus of elasticity obtained by the longitudinal vibration method (E_d), static modulus of elasticity obtained by a bending test (E_b), modulus of rupture (*MOR*), absorbed energy in static bending (U_b), energy in an impact bending test (U_s), local bearing strength (*LBS*), hardness (*H*), compressive strength parallel to the grain (*CS*), shear strength parallel to the grain (*SS*), and modulus of rigidity obtained by a torsional test (*G*).

The correlations between E_d and E_b, U_b and U_s, and *LBS* and *H* were found to be considerably high. The results indicated that either of the respective parameters is sufficient to predict the other, and we can select adequate quality indices on a case-by-case basis. Further discussion will be made on the basis of the interrelationships among the characteristics observed in bending fracture tests of both the elastic and plastic characteristics, such as Tetmajer's modulus (*TM*).

Key words: Small clear specimens, strength characteristics, hardwood, quality index

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The Physical and Mechanical Properties of some Fast-growing Secondary Forest Species of Sarawak, Malaysia

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Timber supply from the original sources such as virgin and primary forests is getting scare. There is a need to find other sources of timber for the wood-using industry. Log production has followed a downward trend. Changes in forest polices and conversion of forest lands into other uses are among the causes of the reduction. This paper discusses on options by which timber production can be increased i.e. increasing use of secondary forest trees which have the potentials to become plantation species and provide raw materials for end-products such as furniture, veneer and plywood, poles and piles. The physical and mechanical properties of six (6) species of secondary forest species are presented in this paper. They are Azadirachta excelsa (Jack) Jacobs, Ilex cissoidea Loes, Duabanga moluccana Bl, Endospermum spp…Miq. Anthocephalus (Neolamarkia) cadamba (Roxb) Bosser and Octomeles sumatrana Miq. These six species are part of the few fast-growing secondary trees that are being tested for their physical and mechanical strength properties. More importantly, their economic uses and their possible substitutions for other popular depleting species are being considered. Ease of processing for veneer and plywood, housing materials and timber, and sustainable supply from forest plantations are some of the advantages in utilizing these species. With the present market trend towards light-coloured wood, which is the feature of these five species, should provide wood users the value-added end-products.

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Diverse Strategies of Mechanical Mechanisms of Branches in Several Angiospermous Trees

Chin-Chu TSAI, Yan-San HUANG, Gwo-Shyong HWANG, Shin-Shin CHEN, Shiang-Jiuun CHEN and Ling-Long KUO-HUANG

Growth stress is produced during the maturation of secondary xylem, subsequently accumulated in the timber, and finally released when tree cutting and wood processing. Formation of reaction wood responding to gravity lead to asymmetric distribution of growth stress which would be superimposed on the natural growth stress, and thus aggravate the heterogeneity of wood. In general, compression wood is the typical reaction wood occurred in the lower side of leaning trunks or branches of gymnosperm and tension wood is considered to be the corresponding reaction wood in angiosperm. However, tension wood formation appears to be relatively diverse. Gelatinous fiber is an important character of typical tension wood in many species, but there are still a number of species without gelatinous fibers in their tension wood. Orientation of cellulosic microfibrils in gelatinous layer (G-layer) is believed to be nearly paralleled with fiber orientation. This phenomenon is related to the mechanical property of wood. Researches concerning tree trunks are abundant because of their significant value of wood utilization, but data of tree branches are relatively few. In this study, branches of angiosperm species with different types of tension wood formation were selected. Longitudinal released growth strain (RGS) and eccentricity of wood discs were measured and thusfour branch types were distinguished. Orientation of cellulosic microfibrils in S2 layer and G-layer was observed by iodine deposition method and scanning electron microscopy (SEM). Cell wall ultrastructure is investigated by transmission electron microscopy (TEM). The results are as follows: (1) The upward bending moment produced in angiosperm branches rely on not only high tensile growth stress exerted by tension wood on the upper parts but also extensive growth stress on the lower parts. (2) In species without typical tension wood, growth stress can be normally produced, but formation of gelatinous fibers seems to contribute more tensile stress on the upper parts. Compensation regulations between effects of additional cell growth and those of formation of gelatinous fibers probably exist. (3) A special type of branches performs epinasty- compression stress on the upper side and tensile stress on the lower side of branches result in the downward growth of branches. This is, to our knowledge, the first investigation of epinesty in secondary tissue. Based on these results, the mechanical mechanism of branches is discussed.

Key words: Branch, epinasty, growth stress, microfibril angle, tension wood

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Properties of *Endospermum Malaccense M.A.* and *Azadirachta excelsa* in Peninsular Malaysia

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Endospermum Malaccense M.A. and *Azadirachta excelsa* are currently being promoted and trial planted as the potential species for timber production in Malaysia. This study evaluates the physical and mechanical properties of planted and the natural stand timber. The timber of 12 year-old *E. Malaccense* were collected from the plantation in Bukit Lagong Forest Reserve, (FRIM) and another set obtained from sawmill of unknown age and origin. The result shows that the mean densities are 0.31 g/cm^3 and 0.5 g/cm^3 respectively. The air-dry samples show a shrinkage of 1.71 and 1.45% respectively at tangential direction and; 2.52% and 2.22% respectively at radial direction. The mechanical properties from the plantation grown timber were about half the values from the samples taken from the sawmill. The modulus of elasticity 10,678 N/mm^2 and 5,885 N/mm^2; modulus of rupture 126.36 N/mm^2 and 80.57N/mm^2 respectively while its shear properties were 9.7 and 6.2 N/mm^2.

A study on the wood properties of 10-year-old planted *A. excelsa* and about 20 year-old natural stand obtained from Kelantan State, East Coast of Peninsular Malaysia produced the following average values: air-dry density of 0.53 and 0.60g/cm^3 respectively. The study also shows that the shrinkage is 2.45 and 2.3% at tangential, 1.5 and 1.24% at radial respectively but at 0.5% in both directions for the older samples. Comparative analyses on the modulus of elasticity were 8209.2 N/mm^2 and 8266.23N/mm^2, modulus of rupture 76.07N/mm^2 and 77.57 N/mm^2 while the shear properties were 22.6 and 22.7 N/mm^2. This study shows that there is no distinct difference in mechanical properties for *A. excelsa* between 10 and 20 year-old timber. However in *E. Malaccense*, the differences in mechanical properties are significant and show strong correlation with density. This study would provide an indication on the suitability of using these timbers to its intended usage.

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Bending Properties of Taiwan Red Cypress Plantation Trees grown with Different Thinning Treatments

Cheng-Jung LIN and Chih-Ming CHIU

Conservation ethics and wood resource shortages have stimulated the adaptive development and utilization of plantation trees. Therefore, it is important that intensive management of man-made forests through thinning manipulations for resources of forest product. Taiwan red cypress (*Chamaecyparis formosensis*) is a good endemic species in Taiwan and effective utilization of the species requires an understanding of its wood properties. Thus, basic density, dynamic modulus of elasticity, modulus of elasticity, and modulus of rupture of Taiwan red cypress trees grown with different thinning treatments were investigated. The results showed that the differences among different thinning treatments were not statistically significant. Therefore, the different thinning treatments have not affected basic density, dynamic modulus of elasticity, modulus of elasticity, and modulus of rupture.

The variation of the basic density in the transversal direction remained more or less constant from pith to bark; however, the dynamic modulus of elasticity, modulus of elasticity, and modulus of rupture in the radial direction increased from pith outwardly to bark. Regression analyses gave a reasonably positive correlation between dynamic modulus of elasticity, modulus of elasticity, and modulus of rupture; however, lower correlations between bending properties (dynamic modulus of elasticity, modulus of elasticity, and modulus of rupture) and basic density were found.

Key words: Dynamic modulus of elasticity, Taiwan red cypress (*Chamaecyparis formosensis*), modulus of rupture

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5.04.00
WOOD PROCESSING

Papers

Adaptive and Flexible Production Systems for Woodworking Industry

Arto USENIUS*

Woodworking business in the future has to be more customer oriented than in the present situation. Wood product suppliers are facing big challenges:

- how to convert non-homogenous wood raw material to the products with precise defined properties with maximum yield and minimum waste
- how to shift from bulk products towards value added products
- how to improve considerable flexibility of manufacturing systems
- how to make business and processing adaptive

VTT started 2006 to execute a big national project in close co-operation with leading sawmill companies, machine manufacturers, information and measuring technology suppliers and wood drying system suppliers. Modelling, virtual production and advanced scanning technologies are key methods used in the project. VTT's WoodCIM and InnoSIM simulation and optimization system has been developed covering whole conversion chain – from the forest to flexible manufacturing systems and further to the sawn timber and value added component products. Model system includes precise description of quality features of stems and quality requirements of the solid wood component products individually for all four faces.

In the following some examples of features of future conversion and manufacturing systems:

- Control and optimisation of information and material flows in planning and production supported by integrated information systems covering entire conversion and supply chains
- Flexible and adaptive scanning, production and logistic systems.
- Creation and utilization of the feed back information based on marking and identification of wood pieces in order to make business self learning
- Optimised mechanics and conveyer systems for production facilities and cells.

The results clearly show that it is possible to increase sales value and profit of the conversion considerable by implementing new concepts and technologies in the production.

Key words: Wood processing, manufacturing systems, adaptive scanning, control optimisation

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Oil Palm Trunks – A New Alternative Material for Solid Wood and Veneer-Based Products

Edi Suhaimi BAKAR*, Mohd. Hamami SAHRI, Zaidon ASHAARI and Fauzi FEBRIANTO

Finding the alternative material of wood, especially for solid wood and veneer products, has become a central issue since the last few decades. Productions of wood from the forest are no longer sufficient to meet the demands. Thus, any alternative must be sought, including those from agricultural residues. One alternative from agriculture residues is the wood from the trunks of replanting oil palm plantation. Development of oil palm plantation has been a phenomenal in Malaysia and also in Indonesia since the last two decades. This leads Malaysia become the largest palm oil producing countries in the world with a total planted area of 4.1 million ha in 2006 (Indonesia has become the largest since 2007). This paper discuss about the potentials of wood production from the replanting of oil palm plantations in Malaysia. The efficient sawing pattern for oil palm trunk (OPT), the flaws of oil palm woods, and their effective quality enhancement are discussed. Peeling practices of the OPT into veneers, their problems, and uses of oil palm veneers are also discussed. It is concluded that OPTs from replanting oil palm plantations can be used as a new alternative material for solid wood and veneer productions, so that our the dependency on the wood from the forest can be minimized.

Key words: Oil palm trunk, oil palm wood, oil palm veneer, oil palm sawing, oil palm peeling.

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Online Wood Industries Database

László SZALAI*, Ákos BAUSZ, János BOROS

In our everyday life, we are surrounded by tools that aid us in our work or improve our comfort. A significant proportion of these products are made of wood or some wood based composite. In the past 10 years, the wood products industry was significantly restructured in Hungary. The number of small plants and joineries where domestic and tropical species are used is on the rise. Superior quality and durability became important factors. To achieve this, being able to access the newest research results and innovations in this area, as well as trade information (both as consumers and suppliers), is in the interest of woodworking companies. Some professional journals do publish scientific findings, but there is a lack of comprehensive, widely accessible sources. Not to mention that industry professionals and trade people are often too busy to browse the literature, and find that searching for and processing relevant information is too time-consuming. Wood industry is a strategic trade in our region. Establishing a service to store and, later, publish the professional knowledge accumulated at the Faculty of Wood Sciences, University of West Hungary, as well as the practical experience generated in various plants, could be very helpful in achieving the goals. The creation of a professional database, the goal of which was the assessment of parameters belonging to various specialties, has started.

The goal of the project is creating a database encompassing a wide range of information for the industry, which allows authorized industry professionals to access and extend the content of the database. The extension of the database is aided by special tools as well. The present structure of the database was established based on the advice of many of the experts at the Faculty of Wood Sciences. Since the onset of the project, the configuration of the physical database needed for storing data in the area of wood materials, wood mechanics and wood based panels has been created. This contains parameters defined by the experts. The structure was shaped through multiple consultations, and it may also be extended and modified, according to needs arising later. The connections necessary for use have been defined in the database. This database may be used as a prototype. The web-based user interface for the management of the wood material database is also ready. The newest available web based technology was used in programming the web-based interface. Our further goals include finalizing the structure of the further databases beside that of the wood materials, and extending the functionality of the web interface. Another goal is designing the service content of the knowledge base.

Key words: Online, wood industries, database

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5.04.00 – Posters

Reducing Inventory Cost by using Value Stream Mapping in a Furniture Factory

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In general, order based manufacturing results product flexibility, whereas the time period of responding to customers takes a longer time and their variation increases. The reason for that is, to a more extent, that lead times become longer. Nevertheless, establishing a manufacturing system that is able to prevent inventory decreases lead times and cuts responding time for customers. The purpose of this study is to project and apply a manufacturing system having both high product flexibility and short response time for customers. Therefore, in here, a methodology aiming to reduce inventories is contemplated and this methodology is applied for manufacturing in an office furniture factory.

The first step of the methodology is to determine manufacturing lead times in the system through value stream mapping. A photograph of manufacturing system is taken, in a sense, via value stream map and thus having an idea about inventory accumulation points. To prevent from such a accumulation future state map is planned. At the stage of planning, by considering manufacturing system at hand, the approaches of cellular manufacturing, supplier Kanban and CONWIP (constant work-in-process) are considered. Such approaches have been applied to manufacturing system in an office furniture factory and then the criteria for manufacturing process are analyzed. At the end of application, inventory decrement in manufacturing process and flow manufacturing are obtained. Therefore, a manufacturing system carrying out flexibility, delivery and cost criteria at better points is reached.

Key words: Inventory cost, value stream mapping, Kanban, CONWIP

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5.06 A
PROPERTIES AND UTILIZATION OF PLANTATION WOOD

Papers

Characteristics of *Populus tremula* (L.) and *Populus tremula x tremuloides* Stems in Southern Finland

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Aspen species cover ca. 1.5% (ca. 30 Mill. m^3) of the total growing stock in Finland. Their principal end use currently is for papermaking, however, increasing proportion of logs is expected to be obtained from planted hybrid aspen stands in the future. The purpose of this study was to compare the technical properties of European and hybrid aspen (*Populus tremula* L., *Populus tremula x tremuloides*) stems in Southern Finland. Material consisted of five European aspen stands and seven hybrid aspen stands between 20 and 60 years of age. Routine measurements on the characteristics of the stands were done in 100 m^2 circular sample plots, 6–7 of them per stand. The sample plots were located around one randomly selected, but sawlog-quality aspen that was then more comprehensively measured as a sample tree. 75 of these sample trees were felled, bucked and cut into logs. The logs were graded and their technical quality characteristics were assessed in detail. The most common external quality defects included curves, sweep, and branchiness. European aspen trees showed better quality in terms of branchiness and stem form. Fast growing hybrid aspen trees had even 1.5 metre long clear distances between the whorls, which is an interesting possibility considering wood product manufacture. Both European and hybrid aspen suffered from diverse rot and surface defects. Based on the evaluation of logs, heart rot turned out to be more common than could be expected based on the evaluation of standing trees. Therefore, the overall quality of the logs was relatively poor compared to the impression obtained by pre-harvest measurements of the stands. As a conclusion, it turned out that planted hybrid aspen that is originally meant for pulpwood, has considerable potential to produce saw or veneer logs at significantly shorter rotation age than European aspen.

Key words: European aspen, hybrid aspen, timber grade distribution, branchiness, stem form

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Taper Modeling on Taiwania Plantation in Liukeui Area in Taiwan

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Taper is used to measure the rate of decrease in stem diameter from bottom upwardly. Taper equations express the expected stem diameter over or under bark, as a function of the height above ground level, total tree height, and diameter at breast height. The subject of stem taper curves constitutes one of the bases of forest mensuration and biometrics. Accurate estimates of timber volume and dimensions are two of the most critical pieces of information in timber growing and forest product. As a result of fuller utilization of wood in the stem and of more intensive forest management, the need arose for more accurate taper functions to describe the profile of the stem along its entirety.

In this study five tapering modeling approaches (*i*) sigmoid form, (*ii*) polynomials of order two or greater, (*iii*) Variable-form or variable exponent stem profile models, (*iv*) segmented polynomials with submodels and (*v*) trigonometric taper models were used to estimate the stem diameter at a given height above stump in Taiwania plantations. Comparisons in terms of accuracy and precision using standard error of the estimate, average bias in percentage and mean squared error were made.

The results indicated that based on three criteria considered simultaneously, trigonometric taper modeling approach was the worst in describing the taper of the total tree bole, followed by sigmoid form approach. Three-segmented polynomials, variable-form stem profile and polynomial form with higher order approaches were preferred to describe the taper in the total stem. The mean relative biases for these three models on the validation trees were less than 5% for the whole stem, and were less than 3% over the segments of the trees. The root swell (segment from 0.3 to 1.3 m in height) is a part of stem that is most difficult to predict in tapering modeling. However, the precision and accuracy in the prediction of the butt root swell can be much significantly improved through the three-segmented polynomials or the variable form taper models.

Key words: Stem profile, variable form model, segmented polynomials model

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Eucalyptus Management for Higher Value Utilisation in Europe and South America

Leif NUTTO*

Eucalypts in industrial plantations are mainly planted for pulpwood or general utilisation. Some studies show that the production of eucalypt sawlogs or veneer-logs can be a highly profitable if existing problems in processing the wood can be solved. The present study is based on data collected in Europe and South America, aiming to evaluate the management of eucalypt plantations and the resulting wood quality as well as currently applied processing technologies.

The more prominent defects occurring while processing and drying eucalypt wood are due to high growth stresses, leading to end splitting of logs and sawnwood, and checks on veneer. Another problem, accounts for low lumber recovery rate, is that diameter of sawlog does not match with the applied sawing technology. The study established the relationship between tree growth, wood properties and the impact to lumber quality. Data of individual fast growing trees from several stands in Europe (Spain and Portugal) and South America (Brazil and Chile) were used to develop models for predicting growth and wood properties like growth stresses, wood density and dimensional stability. With these models it was possible to simulate the impact of different management scenarios of several species of the genus *Eucalyptus* (*E. grandis, E. urophylla, E. saligna, E. globules* and *E. nitens*) on high quality sawlog production. Starting from the simulations management regimes can be optimized according to the desired wood properties for solidwood products, as there are low growth stresses, high wood density or high proportion of clearwood. The results showed that applying existing knowledge and technologies plantation grown eucalypts have a great potential in contributing to global hardwood lumber market in the future and meet the demands of wood industry.

Key words: Eucalyptus, wood quality, sawlog, veneer

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Density Variation and Drying Characteristics of Oil Palm (*Elaeis guineensis*) Wood

Kee Seng GAN*, Seng Choon LIM and Heok Choh SIM

Malaysia has 4.05 million hectares of oil palm plantation producing 14.96 million tones of crude palm oil and 1.84 million tones of crude palm kernel oil in 2005. Total export values of crude palm oil and their products was RM 31.8 billion in the year 2006. The economic life of oil palm is between 25 and 30 years. It is estimated that more than 70,000 hectares of oil palm are due for replanting every year resulting in the felling of approximately 9 million palms with an estimate of some 2 million m^3 of oil palm wood for use. However, due to the variations of density and associated shrinkage characteristics of oil palm trunk in the radial and longitudinal directions, it is estimated that only 0.6 million m^3 could potentially be used for wood production. This report highlights the variation in the basic density and drying characteristics of oil palm wood obtained from the first 3 m from basal end of five 30-year-old oil palms. Palm wood could be successfully kiln dried, however, this requires some changes to the sawing practices and more sorting work may be required

Key words: Oil palm wood, plantation, density, drying

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Potential of SilviScan-3 and NIR Technologies in Estimating the Longitudinal Shrinkage of Eucalypt Species

Jun Li YANG, Rob EVANS, Roger MEDER and Nick EBDON

Board distortion during drying is a major cause of downgrade for eucalypt sawn boards. Drying distortion is caused by uneven longitudinal shrinkage and wood grain variation across the boards. The longitudinal shrinkage itself is influenced by wood properties such as cellulose microfibril angle (MFA) and the presence of tension wood. Mean MFA and mean cellulose crystallite width (W_{cryst}, a potential indicator of tension wood) can now be measured rapidly using SilviScan.

A study was undertaken to investigate the potential of SilviScan-3 measurements and near infrared (NIR) spectra in estimating longitudinal shrinkage of eucalypts. The rationale for the study is that if relationships of Silviscan measurements and NIR spectra with the longitudinal shrinkage are successful, foresters and researchers will be able to use SilviScan measurements and NIR spectra to rank trees according to their propensity for producing boards that distort during drying, and to integrate the shrinkage into tree growth and log quality models, from which potential board distortion during drying may be estimated.

A total of 173 shrinkage specimens (3x8x100 mm in green condition, R x T x L) were prepared from four eucalypt discs (*Eucalyptus globulus, E. nitens*, and *E. delegatensis*) cut from trees of 20 to 65 years of age. Two SilviScan specimens that end-matched each shrinkage specimen were also prepared. The tangential and longitudinal dimensions of the specimens were measured in green condition, and at 12% MC before and after steam reconditioning. NIR spectra were obtained on the radial and tangential faces of each shrinkage specimen in green condition and at 12% MC. Density, MFA, W_{cryst} and the longitudinal stiffness of each shrinkage specimen were determined using SilviScan-3.

The strength of the relationships between shrinkage properties and wood properties varied among species. Moderate relationships were found for *E. nitens* and *E. delegatensis* but there were virtually no relationships for *E. globulus*. NIR spectra obtained on the radial faces of the green specimens accounted for 50% of the variation in the longitudinal shrinkage, the R^2 varied among species and it was higher (0.65) for *E. globulus*. Spectra measured on the radial faces were far more useful than those measured on the tangential faces for predicting the longitudinal shrinkage.

Key words: Shrinkage, eucalypts, SilviScan, near infrared spectra

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Comparison of Wood Density and Anatomical Properties between Coppiced Trees and Parent Crop of Six *Eucalyptus* Genotypes

Anton ZBONAK*, Tamara BUSH and Valerie GRZESKOWIAK

Eucalypts are an important source of fibre for the South African pulp and paper industry. The genus is largely propagated by seeds and cuttings but it also has an ability to re-grow from harvested tree stumps in the form of coppiced sprouts. Coppicing is very common practice in South African forestry. It allows the growers to have a second timber rotation without replanting, thus rapidly reducing reestablishment costs. While the large variation in the wood properties among different *Eucalyptus* resources is well documented, little information is available on the quality of wood of the coppice shoots compared to their original trees. In this paper, wood density and anatomical characteristics of coppice and original parent wood were measured using rapid screening tools. The advantage of those tools is that the assessment of average wood characteristics for each tree as well as the within tree variation can be determined.

Six *Eucalyptus* genotypes aged 7 years were harvested from a research trial in Zululand, South Africa in 1997. Cut stumps were allowed to coppice and managed to produce 1 to 2 coppice sprouts. In 2005, the coppiced stems from the same original trees were sampled at the age of 8 years. In total, 54 trees were selected for both types of wood.

The pith-to-bark profile of density and anatomical properties showed the juvenile/mature variation for both wood in parent and coppiced trees. This suggests that wood formation in coppice was similar to wood formation in parent trees. When averaging data at the disc level, paired t-test revealed the significant differences between parent and coppiced wood. These were not consistent across all genotypes. In overall, comparable vessel characteristics and fibre wall thickness were measured for wood of original and coppiced trees. However, the parent trees had significantly smaller fibres with smaller lumen. Fibre properties had also a major influence on wood density, making the wood from coppiced trees lighter. The serious drought which occurred during the growth of parent trees was associated with marked changes in certain wood properties. This could contribute to differences in wood quality between parent and coppiced trees.

Key words: Coppiced wood, wood density, anatomical properties, *Eucalyptus*

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Evaluation of Bending and Compression Strengths of Poplar Plantation Wood using Three Non-destructive Methods

Yafang YIN, Lijuan WANG, Bo LIU* and Xiaomei JIANG

With the rapid establishment of poplar plantation in the northern part of China to supplement diminishing supplies from the natural forests, studies on poplar wood have been focused on contributing processes to value-adding the wood. The objective of this paper was to examine three non-destructive methods for evaluating modulus of elasticity (MOE), modulus of rupture (MOR) and compression strength parallel to grain of I-72 Poplar (*Populus euramericana* cv. 'I-72' 'Sam Martino') plantation wood. A total of 15 standing trees with average diameter of 33.6 cm at breast height were selected as the representative of sample collection region. Each tree was cut into four logs of 2.4 m length each, for which three dynamic modulus of elasticity, i.e. E_{sw} based on stress wave (Fakopp FRS-06/00), E_{fr} longitudinal vibration (FFT Analyser AD-3542) and E_{us} ultrasonic wave (PUNDIT 6), were measured in green condition. After taking log measurements, small clear specimens were cut and air-dried. Static bending and compression tests were then performed to determine MOE and MOR and compression strength in accordance with Chinese Standards (GB 1935, 1991; GB1936, 1991). Significant linear relationships (at 0.001 level) were evident among dynamic MOE of logs by using the three non-destructive methods and static mechanical properties of small samples. The results showed that stress wave, longitudinal vibration and ultrasonic wave technique had obvious advantage to predict MOE and compression strength ($R>0.81$), and also provided good indications of MOR ($R>0.54$). Further assessment on ease of handling of each non-destructive testing method was also discussed.

Key words: *Populus euramericana* cv. 'I-72' 'Sam Martino', Non-destructive method, Modulus of elasticity, Modulus of rupture, Compression strength parallel to grain

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5.06 A – Posters

Effects of Log Grading and Sawing Methods on Yield of Sugi Laminae for Structural Glulam

Hideki MORITA*, Yoshiyasu FUJIMOTO, Takanori ARIMA and Yasuhide MURASE

It is a requirement in the Japanese Agricultural Standards (JAS) that laminae with Young's modulus lower than 4.9 kN mm^{-2} cannot be used for structural glued laminated timber (Glulam). Sugi (*Cryptomeria japonica* D. Don) wood grown in Miyazaki Prefecture is inferior and with low Young's modulus. It is difficult to obtain laminae with Young's modulus more than 4.9 kN mm^{-2} efficiently through conventional manufacturing process. In this study, the effects of log grading and sawing methods on yield of laminae for structural Glulam were investigated. The relationships between the grade of log evaluated by the dynamic modulus of elasticity based on longitudinal vibration ($E_{d,log}$) and the percentage of non-compliance laminae (non-JAS laminae) were examined. The effects of sawing methods and longitudinal position of log on Young's modulus of kiln-dried laminae ($E_{d,lamina}$) were also examined. By grading log based on $E_{d,log}$, the percentage of non-compliance laminae to JAS decreased. For the first log, the effect of cross-cutting (bucking) position in log on $E_{d,lamina}$ were established, by cross-cutting one or two meters above ground, the percentage of higher grade laminae increased. The effect of sawing methods on the first and second logs on $E_{d,lamina}$ were established. An understanding of the combined effects of log grading and sawing methods will enable effective utilization of logs with low Young's modulus for Glulam.

Key words: log grading, sawing method, yield of laminae, sugi laminae.

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5.12 A

EMERGING THEMES FOR SUSTAINABLE UTILIZATION OF FOREST PRODUCTS

Papers

Recycling Wood Waste from Construction Sites into Value-Added Products

MARIA ZURA Mohd. Zain, HAMDAN Husain*, ROZITA Ahmad and ROSAZLIN Abdullah

The utilization of wood waste from construction sites into commercial products is often associated with processing problems. It affects the recycle rate capacity and increases labor cost because foreign materials, such as nails, staples, cement mixture, and aggregates are mixed in the construction wood waste. In this study, the condition of the wood waste was investigated and the factors that inhibit its utilization were evaluated. The potential of this wood waste as commercialized recycled products was also considered. With about 40% of the timber qualifying for recycling; the processed waste timber has been successfully converted into colored wood-chips for landscaping and mulching, briquette, and also as an aggregate in concrete mix.

Bleaching test, fungus and termite test were conducted on the colored wood-chips. A separate study on the characterization of colored wood-chips and its effect on the tree growth as mulch is also being undertaken. Another on-going study is to evaluate the suitability of this wood waste as aggregates in cement mix. The strength properties and absorptive characteristics and behavior were evaluated. The recycling of this construction material is crucial as it can help curb open burning while creating new product and market potential.

Key words: Construction wood waste, coloured wood chips, briquette, cement mix

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Wood-Plastic Composites from Beetle-killed Spruce: An Opportunity for Sustainable Economic Contribution in the Kenai Peninsula, Alaska

Vikram YADAMA, Eini C. LOWELL, David NICHOLLS* and Nels PETERSON

In response to consumer demands for low maintenance and durable timber construction and increased environmental regulation of preservative treated lumber, a natural fiber composite industry has emerged in the last decade. Currently valued at nearly $1 billion (USD) annually, the natural-fiber polymer composite industry has grown over seven-fold since 1997. While primarily focused on residential products such as exterior decking, railing (over a $3 billion annual market in the US), doors, and windows, there is a market potential for other exterior building applications as well, such as playground equipment, landscape timber, and exterior molding and trimming. The wood-plastic composite technology is ideally suited for small forest-based rural communities that can utilize locally available raw material to manufacture products for the local market. With relatively small investment ($3 to $10 million), this emerging technology lends itself well for processing residue streams from other processes such as sawmills and under utilized or low quality wood, such as beetle-killed spruce, to manufacture value-added products.

Over the past 20 years, bark beetles have devastated an estimated 1.5 million acres of spruce trees on the Kenai Peninsula alone, and in many stands, up to 95 percent of the trees have been killed, creating significant fire hazards for many communities. Much of this beetle-killed material is no longer suited for production of lumber and other solid wood products. Manufacture of wood plastic composites (WPC) is less sensitive to the initial condition of wood raw material than other wood products, making them a possible use for beetle-killed material.

In this presentation, results of a study investigating the opportunity of using beetle-killed spruce in wood-plastic composite production will be presented. The objectives of the study were to characterize properties of raw material critical for WPC production, including thermal characterization, chemical composition, particle size analysis, and evaluate physical and mechanical properties of WPC produced with beetle-killed spruce. Results show that properties of wood-plastic composites manufactured from highly deteriorated material are comparable to those of WPC produced using pine wood flour serving as a control material. A brief overview of WPC technology and suitable business models for rural communities, such as in Alaska, will also be presented.

Key words: Wood-plastic composites, beetle-killed spruce, sustainable manufacturing, economic development

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Non-destructive Evaluation of Wood Quality in Standing Douglas-fir Trees and Logs

David BRIGGS*, Eini LOWELL, Eric TURNBLOM and Gonzalo THIENEL

Wood product markets readily segregate into those where aesthetic features, such as grain, color and knottiness, predominate in defining quality and those where mechanical properties, such as stiffness and strength, predominate in defining quality. As harvest age, tree, and log size decrease and use of intensive silviculture increases, quality is becoming more variable creating a dilemma of how to reliably quantify potential mechanical properties of trees and logs so they can be best sorted for markets. It is very expensive for manufacturers to purchase and process timber with low yields of products having the stiffness and strength levels desired by customers. Timber growers desire improved methods for monitoring developing stands to ensure that they will meet desired future property targets and to facilitate marketing timber.

This study is examining non-destructive testing using acoustic velocity, an indicator of wood stiffness, along the tree-to-log-to-product chain to provide a more refined and flexible approach than visual grading for identifying and sorting Douglas-fir (*Pseudostsuga menziesii* [Mirb.] Franco) stands, trees, and logs. Two of the study objectives are (1) to determine the relationships between the average stiffness of lumber or veneer in a log, acoustic velocity of the log, and acoustic velocity of the parent tree, and (2) to assess the effects of silvicultural treatments on these relationships.

This paper presents results on (1) patterns of acoustic velocity between logs within trees, (2) the relationship between acoustic velocity of a tree and that of logs from that tree, and (3) the influence of density and other stand conditions on these relationships. The results of this work enable adoption of non-destructive methods along to tree to product chain to potentially improve value recovered from stands and thereby enhance the sustainability of forests.

Key words: Non-destructive testing, acoustic velocity, wood quality, tree quality, log quality

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Bioenergy from Sustainable Use of Forest Biomass in Atlantic Canada; Benefits and Challenges for the Forest Industry

Rajendra CHAINI*

The forest industry in Atlantic Canada is passing through a difficult phase due to several challenges like global competition, the high value of the Canadian dollar and high energy costs resulting in several closures of production facilities. The Pulp and paper industry is the dominant sector in Atlantic Canada but there has been a growing demand for diversify the industry to ensure a sustained forest economy through sustainable use of the forest products. One possibility for diversification is developing a forest bio-economy through sustainable use of biomass in producing bioenergy products.

Forest biomass has already been used in cogeneration plants in many parts of the world including Canada. The Canadian forest industry meets half of its energy needs from bioenergy. But, the industry is yet to explore value-added opportunities such as energy, bio-fuel, specialty chemicals and polymers. The energy supply problem of Atlantic Canada forest industry can be addressed by sustainable use of its biomass in cogeneration plants and producing cellulose based bio-fuel. However, there are on-going concerns about the possible environmental, economic and social impact of expanding the scope of using the forest biomass into the bioenergy sector. One of the prime concerns is competition with the existing sectors for fiber supply when the price of bio-fuel reaches certain level. This paper will provide a regional socioeconomic impact analysis of sustainable use of forest biomass for producing bioenergy in Atlantic Canada under alternate forest industry scenarios and considering factors like sustainable supply of biomass, future energy costs, carbon neutrality and future industry structure.

Key words: Biomass, bio-energy, socioeconomic impact

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5.12 A – Posters

F-structure A & S – A Tool for Forest Structure Analysis and Simulation

NGUYEN Van Sinh*

Forest planning and management require exact information from a detailed silvicultural analysis, e.g. on local tree species, their percentages, distribution, standing volumes, expected future development, regeneration mechanisms, etc. (Lamprecht, 1989). Such an analysis is based on the forest structure parameters that can be calculated from collected field data. Since complete studies of large areas are almost always impossible, the data for the analysis will be always collected from sample plots.

The data analysis is a long process and some time a challenge. This is especially true for tropical and subtropical zones where the species diversity is very high. By creating *F-Structure A&S* I would like to alleviate the difficulty of the data analysis and hope to make a small contribution to the sustainable forest management practice. Scientific basis for the *F-Structure A&S* is the generally used forest structure parameters and their calculation methods. Table window is where the user inputs the sample plot data and receives results of the analysis.

The most important parameters of forest structure that *F-Structure A&S* calculates are following: (1) the diversity indices (Shannon, Brillouin, McIntosh, Berger-Parker, Berger-Parker, Alpha, Margalef, Menhinick); (2) statistics for individual sample plots and for all together (individual number, average diameter, average height, basal area, volume, species number, cumulative sume of species); (3) other forest structure aspects (mixed ratio, distribution of individuals along height groups, distribution of individuals along diameter groups); (4) statistics for individual species (abundance, relative abundance, frequency, relative frequency, dominance, relative dominance, Curtis and McIntosh' Importance Value Index).

By selecting trees accoding to their attributes we can extract a group of trees from the data table. By doing so we can simulate a logging process, an silvicultural task, or a natural damage. The analysis of the rest data will show us the effect of the logging process, of the sivicultural task or of the natural damage. This function of *F-Structure A&S* allows user to see the expected effect of their decision or their work and might be usefull for sustainable forest menagement.

Key words: Forest structure, analysis, software, computer simulation

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Logging Damage on Forest Regeneration and Soil

F TAVANKAR*, B MADJNOUNIAN and A. E. BONYAD

Future forests depend on regeneration, so the soil is a vital resource for the forest. It is important to minimize damage to the forest ecosystem during logging operations. Knowing the rate of logging damage to residual trees aids forest managers to conserve the forest better. To compile information to support this thesis, Asalem beech forest, which is situated in the north of Iran, has been studied. The forest was harvested by selective cutting and trees extracted using a wheeled skidder model Timberjack C-450. For data collection of regeneration conditions, a systematic randomized design was used by the researchers. The researchers also used a completely randomized design for studying soil condition. For data analyzing, SPSS software was used.

The results showed that after logging operations about 14.5 ± 1.0 % of regeneration (DBH 7.5 cm) was influenced due to logging practices, such that 9.12 ± 0.83 % was destroyed and 5.3 ± 0.6 % was damaged. 15.74 % of the forest soil was compacted with an increase soil density of 0.20 kg/m^3 in harvested areas and 35.61 % of the forest soil was compacted with an increase soil density of with increased 0.45 kg/m^3 in the skid trails. The conclusion was that with careful designing and standard construction of skid trails based on logging maps before felling began and with suitable organization of timber extraction operations, there are definite avenues available for reducing logging damage and soil compaction.

Key words: Logging damage, regeneration, soil compaction, skidding, beech

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IAWA A
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Papers

Ecological Wood Anatomy of *Pinus wallichiana* (Pinaceae) in Central Nepal

Lajmina JOSHI*

Wood anatomical characters of *Pinus wallichiana* growing in central Nepal are evaluated against three non-anatomical characters: tree height, diameter at breast height (DBH) and altitude. Samples were taken from the outermost part of the trunk of three canopy trees at 8 localities between 1800 and 2450 m above sea level. Tree height ranged from 8-70m, and DBH ranged from 15-95 cm. DBH and tree height do not show correlation with one another or with the tracheid characters. Altitude shows strong correlation with most of the wood anatomical characters studied. Multiple regression analysis using non-anatomical factors as independent variables is used for examining significant correlation between wood anatomical and non-wood anatomical characters.

Key words: *Pinus wallichiana,* central Nepal, altitude, DBH, tree height, wood anatomy

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Anatomical and Cellular Characteristics of Secondary Xylem in *Pinus thunbergii* grown under Boron Deficient Conditions

Kwang Ho LEE, Jong Sik KIM and Yoon Soo KIM*

Boron plays an important role in the growth of plants. In particular, cell differentiation and development of cell walls are greatly affected by boron. It has been known that boron deficiency causes many detrimental effects in plant morphology, physiology and biochemical metabolism. However, data on the effect of boron deficiency on secondary cell wall formation are very limited. The present work was undertaken to understand the effect of boron on the development and formation of secondary xylem in woody plants. Seedlings of *Pinus thunbergii* were grown in a hydroponic culture system for 12 weeks. A boron deficient condition in the nutrient solution was produced by addition of Amberlite IRA-743 resin. Boron deficient pine seedlings showed poor development of cambial activity and differentiation of secondary xylem, and the disruption of resin canals. Some tracheids did not develop secondary cell walls. Transmission electron microscopy showed that the pit membrane was extremely thickened and secondary cell wall layers did not maintain compact structures resulting in disintegration of middle lamella and secondary cell wall layers. Uneven staining of secondary cell walls with $KMnO_4$ and Phloglucinol/HCl suggested poor lignification in the tracheids. The effect of boron on the biosynthesis of structural polysaccharides will be also discussed.

Key words: Boron deficiency, *Pinus thunbergii*, secondary xylem development, cell wall formation

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Anatomical Characteristics of Kenaf Grown in Korea

Seon-Hwa LEE, Sung-Min KWON and Nam-Hun KIM*

Anatomical properties of Kenaf (*Hibiscus cannabinus* L.) planted on reclaimed-land in Korea, were examined to understand the growth characteristics using optical and scanning electron microscopy.

The samples of Kenaf were taken from four positions in the stem(3cm, 35cm, 70cm, 105cm) in four growth periods (July, August, September, October) from seedlings planted in the middle of May.

Bast fiber, phloem rays, cortex parenchyma cells and sieve tube members were observed in phloem, and vessel elements, fibers and rays in the xylem. Solitary and multiple radial pores existed in xylem. The cell types of ray parenchyma in radial section were procumbent, upright, and square. The intervessel pitting showed an alternate type. Xylem and phloem proportions increased with increasing growth period. The number of bast fibers and the proportion of rays in phloem increased with increasing growth period. The proportional ratio of vessels in xylem decreased with age, but rays and fibers in xylem increased. Vessel diameters decreased from the base to the top, and the diameter in the radial direction was larger than that in tangential direction. The fiber lengths in phloem and xylem ranged from 2.0 to 4.0mm and from 0.6 to 1.5mm, respectively. The fiber length in phloem increased with increasing growth period, but the length of xylem fiber did not show a systematic pattern.

Consequently, we suggest that the duration from seeding to harvesting of Kenaf in Korea might be three or four months, and then the fibers can be used for industrial materials instead of wood fiber.

Key words: Kenaf, *Hibiscus cannabinus*, SEM, bast fiber, phloem fiber

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Anatomical Properties of *Acacia mangium* x *Acacia auriculiformis* Hybrid Planted in Sarawak, Malaysia

Ismail JUSOH* and Norfaizah MUHAMAD

The *Acacia mangium* x *Acacia auriculiformis* hybrid is a potential timber species for planting in Sarawak due to its stem straightness, pruning ability, better stem circularity and resistance to heart rot. The other criterion for a planted species is the potential utilization as raw material for wood-based industries, which requires knowledge of its wood anatomical properties. This paper presents the results of a study which determined the anatomical properties of seven year-old *Acacia mangium* x *Acacia auriculiformis* hybrid, *Acacia mangium*, and *Acacia auriculiformis*, and compares the anatomical properties of the hybrid to those of its parent species. The anatomical properties studied were fibre length, fibre diameter, fibre wall thickness, fibre lumen diameter, vessel diameter, number of vessel per mm^2, ray height, and ray diameter. Statistical analysis using ANOVA showed significant differences in the overall anatomical properties of the hybrid and the parent species. The average fibre length and fibre wall thickness in the hybrid were 962.03 μm and 2.21 μm, respectively and were found to be greater than in the parent species. However, fibre diameter (17.16 μm), fibre lumen diameter (12.75 μm), vessel diameter (110.95 μm) and vessel density (6.4 vessel/mm^2) were smaller than those of the parent species. Radially, the average fibre lengths and vessel diameters showed an increasing trend whereas vessel densities exhibited a decreasing trend from pith to bark in all *Acacia* species and in the hybrid. However, there were no significant patterns of vertical variation along the trunk for all anatomical properties in the three *Acacia* species and hybrid except for fibre length and vessel diameter which showed increasing and decreasing trends, respectively. It can be concluded that the anatomical properties of the *Acacia mangium* x *Acacia auriculiformis* hybrid differed from those of its parent species and that the values were not intermediate between those of the two parent species.

Key words: *Acacia mangium* x *Acacia auriculiformis* hybrid, anatomical properties, vertical variation, radial variation

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Cell Wall Chemistry and Knotwood Structure of Norway Spruce (*Picea abies* [L.] Karst) Studied by Confocal Raman Microscopy

Riikka PIISPANEN, Notburga GIERLINGER and Pekka SARANPÄÄ*

Norway spruce knotwood contains exceptionally high concentrations of lignans varying between 2 - 24 percent of the wood dry mass and the principal lignan in Norway spruce knotwood is hydroxymatairesinol (two isomers, Holmbom et al. 2004). The concentration of hydroxymatairesinol is highest close to the pith of the knot and decreases sharply towards the stemwood (Willför et al. 2005). So far the lignans have not been located at cell structural level in the knots.

Microspectroscopic techniques (confocal Raman microscopy and FT-IR microscopy) allow chemical investigations in a close-to-native state in context with wood structure and will be used to study lignans in Norway spruce (*Picea abies* [L.] Karst.) knotwood. The confocal Raman microscopy has already proven as a useful tool to follow lignin distribution and cellulose orientations in cross sections of poplar (*Populus nigra* x *Populus deltoides*) wood with a high spatial resolution (Gierlinger and Schwanninger 2006, Gierlinger and Burgert 2006). The cell wall structure of the knots varies from compression to opposite wood and from early- to latewood. The annual rings are very narrow. The samples (cross sections) taken from different zones of the knot were extracted with acetone-water (95:5, v/v) and studied both before and after extraction by Raman and FT-IR spectroscpopy. Samples taken from Norway spruce sapwood were used as reference material. The extracted sections were compared to the intact sections to see differences in the structure of the cell wall layers. The lignan concentration of the native knots can be almost 25 percent of the wood dry mass, thus it can affect the thickness of the cell wall layers and the proportion of phenolic components in the cell wall layers.

Key words: Norway spruce, knotwood, lignans, Raman microscopy

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Development of Improved Methods to Identify Shorea Wood and its Origin

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Timber identification, i.e. of tree species and their origin, is technically essential for monitoring, control and thus enforcement of specific trade regulations. Forestry and Forest Products Research Institute (FFPRI, Tsukuba) is conducting this research project under the collaboration with Forest Research Centre, Sabah (FRC) and Forest Research Institute Malaysia (FRIM).

The genus *Shorea* (Dipertocarpaceae, the most important timber producing group in Southeast Asia, can be divided wood-anatomically into 4 sections which correspond to the characteristics of wood utilization as follows: Sect. Rubroshorea (Red Meranti Group), Sect. Richetioides (Yellow Meranti Group), Sect. Anthoshorea (White Meranti Group) and Sect. Shorea (Balau or Selangan Batu Group).

The colour reaction of hot water extract is developed to identify timbers of Sect. Rubroshorea, especially suitable for plywood, from other sections owing to the distinctive gallic acid content. In addition to common wood anatomical features of the genus *Shorea* such as axial resin canals in continuous concentric bands, vestured pits, heterogeneous size of vessel-ray pits and so on, novel helical thickenings with warts are found in some species. Also it is ascertained that horizontal resin canals are only in restricted species and crystals are contained in idioblasts in some species and in chambered cells in some others.

Specific DNA-sequences, varying among populations or regions or species, are considered as markers. Molecular classification of *Shorea* species based on chloroplast DNA 4 regions (ca.3500bp) have been undertaken using 104 samples, 34 species from Sect. Rubroshorea, 18 samples, 10 species from Sect. Richetioides, 16 samples, 8 species from Sect. Anthoshorea, and 24 samples, 13 species from Sect. Shorea. For DNA analysis, amplification of DNA from wood samples is required using polymerase chain reaction (PCR). Currently, chloroplast and mitochondrial genes are successfully detected from the sapwood of larch (*Larix gmelinii*) and oak (*Quercus crispula*) heated at up to 180 ˚C.

Chemical markers such as extractives and inorganic elements, which have been already in use for the identification of the geographical origin of agricultural products, may have a potential regional or local variation in composition or contents due to genetic or ecological influences. Stable isotope ratios (delta^{18}O and delta ^{13}C) of wood specimens showed significant correlations to latitudes and longitudes of their geographical origins and therefore indicated some possibility to identify the geographical origin.

Key words: *Shorea*, identification, wood anatomy, molecular classification, chemotaxonomy, stable isotopes

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5.03-IRG A
FUNGAL DEGRADATION OF WOOD I

Papers

Control of Moisture Content in Wood Materials for Mould Growth

Dian-Qing YANG*

Mould growth in wood materials is a major concern for house owners, caused by health and aesthetic problems. Moulds present everywhere, usually appear as black or grey patches on wood surfaces in humid environments and are common in houses. Like any living organisms, mould growth needs food, water, temperature and oxygen. To avoid mould growth on wood materials, only two methods can be used in the practice, e.g. poison food with chemicals or control water availability. Chemical treatment of wood materials may also cause negative impact to the living environment. The most suitable method to control mould growth on wood materials in a houses is to utilize design features, construction tools and practices that prevent moisture accumulation and keep wood as dry as possible. For doing this, engineers and home builders have to know the effects of various temperature and moisture conditions on water accumulation in wood materials and the rates of mould growth in such an environment. This presentation will provide information on factors that effect water accumulation and mould growth on various wood and fiber products used for the construction of homes in different environmental conditions in North America.

Key words: Mould, moisture, wood material, wood protection

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White Rot in Eucalypts Wood: Anatomical Changes and Density Variation by X-ray Densitometry

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White rot fungi can occur in wood structures and decayed trees altering the anatomical, physical and mechanical properties of the wood. In the beginning of the biodegradation process there is some difficulty in detecting deleterious changes in these properties. Therefore, the analyses of wood anatomical structure and radiographic images have been used to determinate variations in the cell wall levels and density for decayed and sound wood. In this study, wood samples of the hybrid *Eucalyptus grandis x urophylla* attacked by white rot fungi were analyzed by the techniques of wood anatomy and X-ray densitometry to relate the decaying caused by white rot fungi and the density change in the wood. Macroscopically, white rot was present in the sapwood and heartwood of the samples and the affected wood was on a lightened appearance, indicating a high susceptibility to this fungi. Zone lines were observed as a result of interaction and compartmentalization of the fungi. Microscopically, the colonization of the mycelium was observed initially in the vessels and ray parenchyma; in the sequence the cell wall of the fibers was distinctly affected presenting a series of longitudinal cavities and erosion of secondary wall indicating the depletion of lignin and holocellulose. In the zone lines was characterized the formation of a pseudosclerotial structure, with melanized and branched mycelia into a variety of shapes**.** In a qualitative analyze, was observed a significant loss of density in the wood affected by this fungi in comparison with the sound wood, demonstrating the possibility of this technique to estimate strength loss reduction in the wood. The detailed microscopic wood alterations by white rot fungi and the potentiality of X-ray densitometry to quantify the wood losses were also discussed in this paper.

Key words: White rot, wood anatomy, eucalypts, X-ray densitometry

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Effect of Compatibilizer on the Natural Durability of Wood Flour/high Density Polyethylene Composites against the Rainbow Fungus *(Coriolus versicolor)*

Sara POURABBASI*, A. KARIMI, D. PARSAPAJOUH, M. TAJVIDI and M. SOLEYMANI

To evaluate the effect of compatibilizer on the natural durability of wood flour/high density polyethylene composites against Coriolus versicolor, composites containing 25% and 50% by weight maple wood flour and 1% and 2% compatibilizer (Maleic anhydride polyethylene (MAPE)), respectively, were sampled. Identical specimens of the same composites without the compatibilizer were also prepared. Physical and mechanical properties of all specimens, including water absorption, flexural modulus, flexural strength, impact strength and hardness, were determined prior to and after incubation with the fungus for 14 weeks at 25℃ and 75% relative humidity. Weight losses of the specimens were also determined after incubation. Results indicated that the compatibilizer had significant effects on the natural durability of the studied composite formulations so that all mechanical properties were affected by the fungus to greater extents in the case of uncompatibilized specimens than the compatibilized ones. Weight loss of the uncompatibilized composites was also higher than that of compatibilized ones. Higher water absorption was observed in all cases after incubation. However, the increase in water absorption was considerably higher in the case of uncompatibilized specimens. POLYM. COMPOS., 28:273–277, 2007. © 2007 Society of Plastics Engineers.Considering little weight reduction of the composites, they are very durable material and their recyclability and biodegradability as compared with composites containing inorganic fibers such as glass fiber, these composites present a promising future in terms both mechanical performance and environmental concerns.

Key words: Compatibilizer, natural durability, wood flour, composites, *Coriolus versicolor*

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5.03-IRG A – Posters

Laser Stain Removal of Fungus-induced Stains on Paper-based Cultural Relics

Chyi Shiah TSANG, Han Chien LIN*

Laser techniques has been developed and in commercial use for about 40 years. The purpose of this study is to investigate the potential of paper cleaning by using Nd-YAG laser. Artificial stained paper was made from fungi and were cleaned at different laser cleaning parameters, in order to find out the best treating conditions.

Experimental results showed that 1064 nm of laser wavelength obtained superior cleaning, especial for the results to the black and /or darken fungal stains. It also found no significant difference was detected on the brightness and zero span strength of laser treated papers. The Nd-YAG laser treated specimens exhibited superior brightness improvements in the order of 10Hz, 10pulses, 10Hz, 5pulses, 10Hz, 1pulses. After removal of fungal stains on the surface of paper specimens, the IR absorbance spectra represent the fungi and amino acid on 1550 cm^{-1} and 1650 cm^{-1} ,respectively, and were disappear or decreased obviously. The Nd-YAG laser can be a viable alternative conservation medium for paper-based of artifacts and archives.

Key words: Laser cleaning, Nd-YAG laser, mold stains, paper-based cultural relics.

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Analysis of Pyrolyzed Products from Moso Bamboo Charcoalization and Assessment for its Anti-fugal and Anti-mite Application

Haw-Farn LAN and Ting-Yin HU

The aim of this study was developed antiseptic, lower toxicity, and environmental friendly wood preservative by using the pyrolysis products from Moso Bamboo (*Phyllostachy heterocycla)*. Moreover, the characters of carbonization byproducts can be enhanced utilization for multi-purpose. The results shown that yield of pyrolysed were 16.1 %, 19.0% and 20.2% at carbonization temperature 400 °C, 600 °C and 800°C. The specific gravity (SG) of pyrolysis products were between 1.01 to 1.04. However, the SG was increased with dissolution tar oil content increased. Organic acid content was increased with pH values decreased. The constituent of pyrolzed product was generated depended on the treatment temperature. The aromatics were occurred at temperature over 300 °C and the aliphatic compounds were increased (alkenes, alkenes and carboxylic acid) at 600 °C. The rising treatment temperature caused the lignin degradation and more aromatics formed to larger molecular weights. The molecular weights were occurred under 100 for 400°C and 800 °C pyrolzed products after distilled at 100 °C. However, the more aromatics were detected at 800 °C pyrolyzed products.

The highest anti-fungal (*Leatiporus sulphureu)* affected at 800°C pyrolyzed products with MIC value of dilute 50 times. The second effect was the 25 times at 600°C and the less was the 30 times at 400°C pyrolyzed products. For wood pressurized impregnation treatment, the penetration ability depended on the specific gravity of pyrolyzed product. The 400°C pyrolyzed product shown the better penetration ability than others. However, the 800°C pyrolyzed products shown the best wood decay resistance enhancement. The liquid of pyrolyzed products could kill 100 % mites (*Dermatophagoides farinae)* within 24hours treatment. The 800 °C pyrolyzed products shown the best antimite efficiency than 400°C and 600 °C.

Key words: Moso bamboo (*Phyllostachy heterocycla)*, Pyrolysis products yields, Minimum inhibitory concentration (MIC), Absorbance, Decay resistance. Anti-mite activities.

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Progressive Microscopic Changes in Yellow Meranti Wood Caused by White-rot Fungus of *Phlebia brevispora*

ERWIN*, Won-Joung HWANG, Shuhei TAKEMOTO and Yuji IMAMURA

Yellow meranti (*Shorea gibossa*) trees growing in one area of natural dipterocaprs in East Kalimantan, Indonesia are occasionally inhabited by white-rot decay fungus, *Phlebia brevispora*. This fungus has caused a serious decay on the stem of living *S. gibossa* trees. Through laboratory decay tests and by using light and scanning electron microcopy, various stages of decay of *S. gibossa* wood caused by *P. brevispora* were studied. The samples were exposed for six exposure times of 0, 2, 4, 6, 8, 10 and 12 weeks. In early stages of decay, vessels were more heavily infected than others, and fungal hyphae extended from one cell to another mainly through pits. The presence of cell wall thinning, cell wall erosion, large bore holes, enlarged pit erosion and erosion channels as well as the complete removal of wood cells could be detected in advanced stages of decay.

Key words: *Shorea gibossa*, wood decay, *Phlebia brevispora*, light microcopy, scanning electron microcopy

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Evaluating the Potency of Cinnamaldehyde as a Natural Wood Preservative

Chun-Ya LIN*, Chi-Lin WU and Shang-Tzen CHANG

Since cinnamaldehyde, the major constituent of leaf essential oil from *Cinnamomum osmophloeum*, has significant antifungal and antitermitic activities, it is worthy of investigating whether it has potential to be used as a natural preservative for improving the durability of non-durable timbers. In this study, the fungi and termite resistance of cinnamaldehyde-treated wood were evaluated according to CNS 6717 (2000) and AWPA E1-97 (1997) with slight modifications. The decay resistance of cinnamaldehyde-treated wood after exposure to ambient conditions for 1 year was also evaluated. *Cryptomeria japonica* sapwood was impregnated with cinnamaldehyde at the concentrations of 0.1, 0.6, 1.0 and 5.0% (w/v), respectively. Cinnamaldehyde-treated wood specimens exhibited a concentration-dependant protection after exposure to the brown-rot fungus *Laetiporus sulphureus* and the white-rot fungus *Lenzites betulina* for 90 days and their weight losses were lower than 3.2%. In addition, weight losses of treated wood and mortalities from termite resistance tests were 0.2 and 65.3%, respectively, revealing that wood specimens treated with 1% cinnamaldehyde had excellent action against *Coptotermes formosanus*. Surprisingly, after exposure of cinnamaldehyde-treated wood to ambient conditions for 1 year the weight losses of the treated specimens obtained from the antifungal and antitermitic tests were lower than 4.6% and 1.4%, respectively, indicating that cinnamaldehyde treatment possesses long-term effectiveness. Therefore, cinnamaldehyde has highly potential to be applied as a novel environmental benign wood preservative.

Key words: Cinnamaldehyde, Decay resistance, Long-term effectiveness, Termite resistance, Wood preservation

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From Research Project to Laboratory Accreditation: The Study Case of the Evaluation of Plywood Resistance towards Fungi according to XP ENV 12038

Luc MARTIN, Marie-France THEVENON* and Nicolas LEMENAGER

The quality approach in scientific laboratories is a major goal in order to insure results's fiability and reliability. The Wood Preservation Laboratory of the "Tropical Woods" research unit of the CIRAD has introduced assurance quality in the laboratory testing since 1998 and has got an accreditation delivered by the COFRAC (French Accreditation Committee) since 2006 for 5 laboratory tests on wood preservation products efficacy, including accelerated ageing tests.

The Wood Preservation Laboratory has participated to a European project on "Biological performance testing methodology to evaluate the durability of plywood as a quality indicator for exterior construction purposes" (QLK5-2002-1270 – PLYBIOTEST). On of the tasks was to test the biological resistance towards *Basidiomycete* fungi of many industrial and experimental plywoods according to the guidelines of the experimental standard XP ENV 12038 (May 2003).

During this project, essential quality elements were applied to biological tests performed: organization, staff training, equipment and related metrology, documents and methods, process control (including specimen management). Once all parameters brought under control, internal audits were performed and the quality systems concerning this test was each time substantially improved. Finally, the laboratory accreditation was extended to the biological tests according to XP ENV 12038 in 2007.

From this experience, the gains were numerous:

- quality management was used for a research project improving traceability and viability of the results as the uncertainty of the tests results has been evaluated ;
- accredited tests according to the XP ENV 12038 standard can be offers to industrial partners bringing thus potential resources for the laboratory needs ;
- feedback was given to standardization as means of improvement were detected for this test standard.

Key words: Quality management, XP ENV 12038, Plywoods, *Basidiomycete* biological resistance

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Effect of Fiber Type and Content on the Natural Durability of Wood Flour/high Density Effect of Compatibilizer on the Natural Durability of Wood Flour/high Density Polyethylene Composites against Rainbow Fungus (*Coriolus versicolor*)

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In order to evaluate the effect of fiber type and content on the natural durability of wood flour/high density polyethylene (HDPE) composites against *Coriolus versicolor*, samples containing 25% and 50% by weight of various natural fibers and HDPE were selected. Natural fibers included in the study were wood flour, rice hulls, kenaf fibers and newsprint. Samples containing 25% and 50% natural fiber had 1% and 2% compatibilizer (Maleic anhydride polyethylene (MAPE)), respectively. Physical and mechanical properties of all specimens including water absorption, flexural modulus, flexural strength, impact strength and hardness were determined prior to and after incubation with the fungus for 14 weeks at 25 °C and 75% relative humidity. Weight losses of the specimens were also determined after incubation. Results indicated that samples containing 50% natural fiber were more susceptible to fungal decay as compared with those with 25% fiber. Rice hulls proved to be the most vulnerable natural fibers as nearly all mechanical properties of rice hulls composites significantly declined after contamination by the fungus.

Key words: Composites, natural fibers, high density polyethylene, natural durability

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5.04.06
WOOD DRYING

Papers

Moisture Dependence of Dynamic Viscoelastic Properties for Drying Treated Wood

Jiali JIANG* and Jianxiong LU

Wood material can be schematically described as a two phase composite of elastic fibrils consisting of cellulose and a part of hemicelluloses, and a viscoelastic matrix substance consisting of lignin and the remaining part of hemicelluloses. Moisture has effect on almost all the physical and mechanical properties of wood. Numerous studies have been carried out on the moisture dependence of the dynamic viscoelastic properties of wood, and such dependence was attributed to the effect of absorbed water on the structure of amorphous matrix substances in the cell wall. In this study, Chinese fir [*Cunninghamia lanceolata* (Lamb.) Hook.] plantation wood was treated by high temperature drying (HT), low temperature drying (LT) and freeze vacuum drying (FV), and their dynamic viscoelastic properties along the radial direction were compared to those of the untreated specimens at various humidity environments. The measurement was done in the temperature range of -120 to 40°C at frequencies ranging between 0.5 to 10Hz. The results showed that: 1) With the increase of moisture content, the decrease extent of wood storage modulus extended with temperature increasing. The decrease extent of storage modulus was the lowest for HT-treated wood; 2) Two mechanical relaxation processes were observed for treated wood. The α relaxation process in higher temperature range was due to glass transition of hemicelluloses with low molecular weight, while the β relaxation process occurred in lower temperature range was based on the reorientation of methylol groups in amorphous of wood cell wall and the reorientation of adsorbed water molecules in wood; 3) The loss peak temperature of mechanical relaxation processes moved to lower temperature range with the increase of moisture contents, and moved to higher temperature range with the testing frequency increase; 4) The apparent activation energy of mechanical relaxation processes decreased with the increase of moisture contents. For α relaxation process, HT- and LT- treated wood showed lower value than that for FV-treated and untreated wood.

Key words: Drying treated wood, mechanical relaxation, adsorbed water, activation energy

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Suitability of the Use of Microwave Modification as a Total or Partial Drying Method in the Processing of *Pinus Rradiata* Heartwood. Part 1: Investigations on the Harmful Effects

Lawrence AWOYEMI*

The prospect of overcoming the problem of impermeability in the heartwood of *Pinus radiata* by microwave drying is to some extent limited by the adverse or side effects on some of the end-use properties which are of great importance in the choice of the species for major uses. It is therefore imperative to investigate the best way to use this technology with minimum adverse effects on this species. Twenty-one green quarter-sawn boards (90 x 90 x 1800mm) of *Pinus radiata* heartwood grown in Victoria Australia with average density of 474 kg/m^3 and 34.2% moisture content were divided into three groups A, B and C. Boards in group A were completely microwaved (total drying with microwave) using 36KW microwave power for 2 minutes 30 seconds while the group B boards were given partial microwave drying (pre-drying) using 27KW microwave power for 1minute 54 seconds followed by further drying in a laboratory oven at a temperature of 50^{o}C until the moisture content was around 12%. Boards in group C were used as control experiment (no microwave treatment) and dried in the laboratory oven at 50^{o}C.

The complete microwave drying reduced the moisture content to 11.8% while the partial microwave drying reduced the moisture content to 23.5%. Wood density was reduced by 9.5% and 2.1% in complete microwaved drying and partial microwave drying, respectively. In completely microwaved wood there were 43.3%, 54.4% and 59.9% reductions in modulus of elasticity, modulus of rupture and hardness, respectively while in partially-microwaved wood, the reductions in modulus of elasticity, modulus of rupture and hardness were 28.6%, 24.6% and 16.0%, respectively. It is evident therefore that a mild microwave modification followed by conventional kiln drying will help to maximize the benefits of microwave technology in this species by minimizing strength loss which has been one of the setbacks to the large-scale industrial adoption of this technology in spite of its relatively age-long history.

Key words: Microwave drying, modulus of rupture, modulus of elasticity

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The Influence of Elevated Temperatures on Selected Properties of Rubberwood

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Drying of rubberwood at elevated temperatures is still relatively unknown. In this study, the influence of elevated temperatures on the following properties was investigated: shrinkage, specific gravity, mechanical properties and low molecular sugars (LMS) content. Separate experiments were carried out at 60°C (conventional drying) and elevated temperatures at 100°C, 120°C, 130°C, 140°C and 150°C, with the respective temperature settings maintained throughout each experiment. All test pieces were dried from the green condition to approximately 4-6% moisture content. Generally, drying temperature has markedly affected both thickness and width shrinkage of rubberwood. The incidence of collapse and honeycombing did not occur even in test pieces dried at all elevated temperatures up to 150 °C. Mechanical test showed all strength values of rubberwood sawn dried at elevated temperatures (100 to 130 °C) was higher than the conventionally dried sawn samples at 60 °C. The redistribution of low molecular sugars from the core towards the case (wood surface) is higher as the temperature increases. The ratio of LMS content cumulated in the case (3mm- deep from the surface) to the core was 0.64 for air-dried sawn (control). A significantly higher ratio of 3.61 (case to core ratio of LMS content) was found in sawn rubberwood dried at 130°C. Initial findings showed no visual detection of insects' infestation on planed sawn rubberwood dried at elevated temperatures, after subjected to outdoor exposure for a period of 3-month duration. These findings indicated that appropriate temperature settings could lead to a potential improvement of the durability of rubberwood lumber.

Key words: Rubberwood, temperature, mechanical properties, low molecular sugars, shrinkage

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Potential of High-temperature Drying for the Production of Value-added Products

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High-temperature drying (HTD) in Eastern Canada has been so far mainly applied to softwood lumber used for commodity products. HTD can also be an interesting option for the production of value-added products because of shorter drying times, its energy efficiency, its effect on dimensional stability and its potential to control the quality of warp prone species through the plasticization phenomenon. Its few drawbacks can be minimized through the proper selection of the green material and the development of proper drying strategies. Several studies have been conducted at Laval University during the last decade on the use of HTD for the production of value-added products coming from softwood and hardwood species traditionally used for construction lumber. Various drying program and strategies have been tested in a laboratory kiln and wood quality assessed for final moisture content distribution through thickness and within boards, shrinkage, warp, checking, residual drying stresses, and color change. In general, the results show that high quality value-added products can be obtained from most species dried at low moisture contents by the high-temperature drying process. The drying strategy has, however, to be adapted accordingly. Presteaming, top-load restraint, and a long equalizing period must be part of the drying strategy. Pre-surfacing may also be required if green thickness variation in not properly controlled. Comparisons are made with the conventional drying process in terms of wood quality, production costs, and energy consumption.

Key words: Softwoods, high-temperature drying, value-added products, energy efficiency.

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Mechanical Characteristics of Wood under High Temperature and Pressurized Steam

Wanli CHENG* Yixing LIU, and Toshiro MOROOKA

In this study, Japanese sugi (*Cryptomeria japonica* D. Don) was used as experimental material. The mechanical behavior of wood during drying under high temperatures and pressurized steam was discussed using a specially developed load cell which was capable of measuring stress under high temperature and pressurized steam inside an autoclave. This research work was aimed to build up a database for providing theoretical and scientific proof and to develop a high-temperature fast drying technology with few cracks and less deformation occurring, and little internal stress remaining. The results showed that under 100% RH, the tensile strength of wood samples gradually decreased and the destructive strain increased with increasing temperature. However, it was observed that the increase of destructive strain was more significant as temperature was above 100^{o}C. The curves of tensile strength and compressive stress relaxation with increase of temperature were nearly parallel. The temperature patterns of the maximum tensile stress and shrinkage stress under high relative humidity were similar. Both stresses were dramatically decreased with increasing temperature. In addition, the curve of radial tensile strength-temperature agreed well with the curve of compressive yield stress-temperature when the samples were dried at temperatures ranging from 80^{o}C to 180^{o}C under 100% RH. The maximum shrinkage stress during drying showed the same value with the remaining stress in compression at the same temperature and RH conditions. It was therefore deduced that the reduction of shrinkage stress during drying under high temperatures and pressurized superheated steam could be caused by stress relaxation.

Key words: High temperature and pressurized steam, wood, mechanical characteristics

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Investigation on the Hygroscopic Characteristics for the Collapsed and Non-collapsed Sections of Plantation-grown *Eucalyptus* Wood Subjected to High-temperature Drying

Yiqiang WU*, Yanmei WU, Wanxi PENG and Yuan LIU

Collapse is one of the key factors which limit the utilization served as solid wood products for plantation-grown eucalypt wood. In order to reveal the changing reasons of wood properties caused by collapse, by adopting FTIR spectrum, the hygroscopic characteristics were analyzed for the collapsed and non-collapsed sections of 15-year-old plantation-grown *Eucalyptus* wood subjected to 100°C drying. Results indicated that the equilibrium moisture contents at the state of both desorption and adsorption for the collapse section were less than those of the non-collapsed one, respectively, and the surface free energy for the collapsed section was also less than that of the non-collapsed one. It was the absorbency of the polar groups such as –OH, C = O, C - O, N - H, $-NO_2$ and so on for the non-collapsed section larger than that of the collapsed one that led to the difference of the hygroscopic characteristics between the collapsed and non-collapsed sections.

Key words: Plantation-grown *Eucalyptus grandis* wood, Collapsed wood, Hygroscopic characteristic, FTIR spectrum

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Effect of Temperature on Changes in Physical Properties of Wood below and above the Fiber Saturation Point

Roger E. HERNÁNDEZ* and Zaira SILVA

The effect of the equilibrium moisture content (EMC) on wood properties at two temperatures was studied for yellow birch (*Betula alleghaniensis* Britton) and beech (*Fagus grandifolia* Ehrh.) woods. Two experimental techniques were used to perform moisture sorption tests at 25ºC and 50°C. The first used saturated salt solutions (from 33% to 90% relative humidity) and the second used the pressure membrane method (above 96% relative humidity). Special attention was given to the region near to the fiber saturation point (FSP), where changes in wood properties began to take place. Results showed that at EMC, radial, tangential and volumetric shrinkage, as well as changes in transverse strength, occur above the FSP. This behavior indicates that loss of bound water takes place in the presence of liquid water, which contradicts the concept of FSP. The initial EMC at which bound water starts to be removed was affected by the temperature of test and by wood species.

Key words: Fibre saturation point, temperature, physical changes

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Improving the Dimensional Stability of Different Wood Species by Thermal Modification

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This study investigated the effects of a Moisture-Heat-Pressure-Treatment of wood at three different temperature levels in a new developed thermal dry kiln. Wood samples were taken from European Ash (Fraxinus excelsior L.), White Silver Fir (Abies alba Mill.), Oak (Quercus L.) and European Beech (Fagus sylvatica L.). Shrinkage and swelling behaviour as well as the hygroscopic sorption characteristics of the heat-treated wood as a function of the selected temperatures were analysed using European DIN standards. In addition, the ASE-index over the cross sectional area was computed. The same characteristics and behaviour of untreated wood samples (control samples) were analysed and the results were compared with other kinds of heat-treatments.

As a result of the heat treatment, all the wood samples experienced a loss of substance of wood. The greatest weight loss, which was found in Ash, amounted to about 20.8%. Compared to the not heat-treated wood samples, about 50% decrease in swelling and swelling coefficient in both radial and tangential directions was observed for the treated wood samples – even at the lowest temperature level. The sorption ability of the treated wood samples was investigated also. Depending upon tree species, the reduction of sorption ability was between 30% and 55%. The dimensional stability, evaluated by using the Anti-Swelling-Efficiency-Index, increased between 43% and 52% at lowest temperature level compared with the untreated wood samples. With the higher levels of treatment temperature, only a slight additional increase of the dimensional stability was observed.

Parallel to the improvement of the dimensional stability, it is assumed that the natural durability of the wood species is increasing as well with thermal treatment. This effect is subject to current investigations.

Key words: Thermal modified timber, dimensional stability, heat treatment, sorption ability, Shrinkage and swelling behaviour

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5.05 B
ADVANCES IN WOOD-POLYMER AND MODIFIED-WOOD COMPOSITES

Papers

Selected Properties of Recycled HDPE and Wood/Natural Fiber Composites

Qinglin WU*, Yong LEI, Fei YAO and Yanjun XU

Composites based on recycled high density polyethylene (RHDPE) and wood/natural fibers were made through melt blending and compression molding. The effects of fibers (wood and bagasse) and coupling agent type/concentration on the properties of RHDPE-fiber composites were studied.

The coupling agents, maleated polyethylene (MAPE), carboxylated polyethylene (CAPE), and titanium-derived mixture (TDM) improved the compatibility between bagasse fiber and RHDPE. For the RHDPE/pine system, MAPE acted as an effective coupling agent, but TDM played a lubricant role. Without coupling agents, the bagasse fiber reduced the RHDPE L_{hkl} for the (110) plane, but did not change crystallinity level. The pine fiber increased the L_{hkl} values and crystallinity level. Compared with the neat RHDPE, the composites had lower crystallization peak temperatures and crystallization rates, and wider crystalline temperature range. For the RHDPE/bagasse composite, the L_{hkl} was increased by 1.5% MAPE or CAPE, and the crystallinity level was lowered by coupling agents. For the RHDPE/pine composites, 1.2% MAPE increased crystallinity level, while 0.9% TDM increased the L_{hkl} but lowered the crystallinity level.

Without coupling agents, the RHDPE/bagasse composites had a little higher modulus, but had lower tensile strength and impact strength than the RHDPE/pine system. The modulus, tensile strength, and impact strength of RHDPE/bagasse composites had maxima with MAPE content increase from 0% to 4.5%. Except for tensile strength, there also existed maxima for other mechanical properties of the RHDPE/pine system when the MAPE content increased up to 2.4%. CAPE had little influence on the mechanical properties of RHDPE/bagasse composites with the exception of tensile strength. TDM improved a little the mechanical properties of the RHDPE/bagasse system, but lowered the main mechanical properties of RHDPE/pine. The mechanical properties of the fiber reinforced recycled HDPE compared well with those of virgin HDPE/fiber composites.

There were two thermal degradation stages for the composites. The first, appearing at a much lower temperature, was for the fiber, and the second was for the RHDPE. The coupling agents had little influence on the thermal degradation of the composites.

Key words: Polymer-matrix composites, recycling, natural fiber, high density polyethylene

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Physical and Mechanical Properties of Methyl Methacrylate Impregnated Betung Bamboo (*Dendrocalamus asper*)

Y.S. HADI*, N. HADJIB and M. UTAMA

Betung bamboo (*Dendrocalamus asper*) samples were obtained from Bogor area. The samples were air dried, and then immersed into methyl metacrylate-urea solution for 24 hours prior to irradiation. Urea was added into with concentration of 0%, 1%, 3%, and 5%. The samples were wrapped with aluminum foil and then with polyvinyl sheet, and irradiated with ^{60}Co gamma ray with 40 KGys doses. After opening the wraps, the samples were dried in the oven at 70 ^{o}C for 24 hours. For comparison, the samples of control or original bamboo were also prepared. The all samples were tested for physical and mechanical properties. Weight percent gain without urea added into methyl metacrylate was 10.7%, and 12.8%, 12.7%, and 12.4% for 1%, 3%, and 5% urea concentration respectively. The results indicated that methyl metacrylate impregnated bamboo had better physical and mechanical properties than the original, but urea concentration did not affect significantly the physical and mechanical properties.

Key words: Betung bamboo, methyil methacrylate impregnation, cobalt radiation, properties

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Comparing Nano-mechanical Properties of the Wood Cell Wall by Nanoindentation

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The structural performance of any composite composed of discontinuous fibers is based on three variables: physical and mechanical properties of individual wood fibers, fiber-to-fiber stress transfer, and fiber orientation. The wood fiber itself is a complex composite material with the cellulose fibrils as reinforcing elements in an amorphous matrix of hemicelluloses and lignin. The paper and fiber boards are made of individual wood fiber or fiber bundle. In wood plastic composites, wood is even used as a form of cell wall component. To better design those composites, it will be critical to understand the mechanical properties of wood cell wall or individual fiber. The objective of this study was to measure the mechanical properties of wood cell wall by nanoindentation and then evaluate effects of species and process parameter on cell wall properties. Nanoindentation testing is a technique that determines the mechanical properties of a material in the sub-micron scale. The test involves penetrating a sample material using an indenter, while the penetration depth and load are recorded so that the stiffness and hardness of the indented location can be subsequently calculated. Testing materials included eight hardwood species and five pine fibers refined under steam pressure from 2 to 18 bars. Results show that there were significant effects of steam pressure during fiber refining on cell wall properties. The modulus of wood fiber decreased as the refining pressure increased. The mechanical properties of cell wall were different among species. The modulus of cell wall in the low density hardwood could be higher than one in the high density hardwood.

Key words: Wood, cell wall, nanoindentation

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Property Change of a Rice-hull-PE Composite Exposed to UV Weathering

Weihong WANG, Qingwen WANG and Wenjie DANG

Although wood fillers currently dominate the natural fiber thermoplastic composite industry, fillers based on agricultural residues have become more accepted in recent years. However, little information is available on the degradation of rice hull-flour filled polyethylene (RH/PE) composites. In addition, to enhance appearance and to reduce slipperiness (i.e., improve surface traction), WPC's surfaces are often roughened up in manufacturing by lining, figuring, or brushing those surfaces. All of these processes distrub the original extrusion surface which is rich in polymer. This work studied the durability of rice hull filled polymer composite with different surface quality.

The plane surface generally exhibited greater and faster fading than lined surface. The former experienced significant (at α=0.05) fading after 500 h of UV-weathering and the later experienced significant (at α=0.1) fading after 2000 h. SEM indicated that samples with plane surfaces showed surface cracks after weathered 1500 h，whereas samples with sawn and lined surfaces initially showed cracks after 1000 h and experienced more cracking after 1500 h. Our observations showed that more manufacturing defects distributed on lined surfaces, such as holes, may interrupt the protection from original plastic-rich surface layer. This surface disruption deepens penetration of UV irradiation, which in turn causes earlier surface degradation than in samples with plane (i.e., undisturbed) surfaces.

UV weathering caused surface color changes earlier and takes a longer time to separate the bonding between rice hull and PE matrix; the later affected the mechanical properties of polymer composite reinforced with natural fiber. For sample with sawn surface, both MOR and MOE decreased significantly upon weathering after 1500 h; for sample with lined surface, the MOR decreased to a level that was not significantly different from the initial MOR, however, MOE was significantly decreased after 2000 h of weathering; for sample with plane surface, its flexible properties declined a little during the whole weathering time.

IR analysis indicated that although photodegradation chemically changed both cellulose and PE components after 500 h of weathering, it did not significantly decrease flexural properties.

Key words: Rice-hull-PE, composite, durability, UV, color

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Polymer Materials Prepared from Forest Resources

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Polymer materials from renewable forest resources have attracted an increasing attention recently, predominantly owing to the needs of environmental protection and substitutes of petroleum. Of the various forest resources, cellulose is the richest renewable resource in the world and pine oleoresin is the most important non-wood forest product. So the paper deals with the synthesis of hybrid biodegradable polymer materials from cellulose and pine oleoresin. In the case of cellulose, polymers with good mechanical properties were developed by esterification of cellulose with long chain fatty acid, grafting with acrylic monomers, and blending with synthetic biodegradable polymers such as polylactides. The reaction procedure, compatibilization mechanisms, the structure and properties of the resulted polymers were studied intensively. In the case of pine oleoresin, hybrid latex particles of rosin and polyacrylate were synthesized by miniemulsion polymerization. The influence of introduction of rosin on polymerization was studied by monitoring the evolution of monomer conversion and particle size. The particle morphology was characterized by transmission electron microscopy and scanning electron microscopy. The molecular weight, molecular weight distribution and the glass transition temperature of the resulted hybrid polymers were analyzed by gel permeation chromatography and differential scanning calorimetry. The results in both cases show that the polymer materials prepared from cellulose and pine oleoresin have good properties and could be used in various areas such as plastics, moulding materials, coating, adhesives and etc.

Key words: Polymer materials, renewable forest resources, compatibilisation, morphology

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Study on the Biomorphous Ceramics Derived Wood and Bamboo by Sol-gel

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Biomorphous ceramic materials are based on biological structures have attracted increased attention in recent years related to their perceived advantages of being environmentally benign, energy efficient, and porous. Biomorphous ceramic composites use wood and bamboo as a precursor to develop their shape and structure. Sol-gel technology has been used to prepare the ceramic materials because of its low temperature, homogeneity, and excellent infiltration of the porous wood and bamboo. After first preparing the Sol solution, it is then impregnated into and diffuses into the wood by force through vacuum-pressure equipment. This impregnation insures the sol fully impregnates the inner structure of the wood. The "sol" then forms a "gel" within the wood Finally, the biomorphous ceramic composite is made by controlled thermal decomposition of the woody material to form a monolithic carbon-ceramic template. The kinetics of the thermal decomposition process of woody material and its effective conversion by carbon-ceramic materials were studied. The results showed： The gel was effective in first filling the void spaces of the woody material. It mainly filled in the lumens and porous pit structures of the woody fibres and vessels. The average weight percent gain of the wood increased to 81.3% compared to the former study of 36.1%. When sol entered into the wood, the core reaction was condensation, including the condensation reactions between sol itself and condensation reactions between the sol and the hydroxyls on the cell wall of the wood. This then led to one part of SiO_2 gel bonded with fibrin and another part of SiO_2 Gel consisted in holes of wood in the physical filling way, it realized the goal of composite the inorganic SiO_2 to the inner tissue of wood, thus the performances of the materials were optimized or improved.

Key words: Biomorphous ceramics, sol-gel, pyrolysis treatment

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5.07 B

ENERGY FROM BIOMASS / CHEMICALS FROM WOOD

Posters

Manufacturing Powder Activated Carbon from Moso Bamboo (*Phyllostachys Pubescens*) with Potassium Salts

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The objective of this study is to investigate the feasibility of manufacturing powder activated carbon (PAC), from commercial Moso bamboo (*Phyllostachys Pubescens*) grown in Taiwan. The materials were collected and processed with three potassium salts (KNO_3, K_3PO_4 and K_2CO_3) to examine the effects of three different concentrations 3.0, 4.5 and 6.0%) of the solutions on the final properties. Bamboo specimens were dipped or impregnated into the solutions before being activated at 400, 600, and 800ºC. Two hours retention times were also evaluated to study their effects on the quality of the products. The yields of refined PAC (varied from 28.0 to 21.7 %) decreased with increasing activation temperatures（400~800 ºC）. Potassium nitrate, among the three kinds of salt used, gave the lowest yield. The BET specific surface area of the activated carbon increased with increasing activation temperature and potassium nitrate resulted in the best result. A BET surface area of 1302.4 m^2/g could be reached when the specimens were dipped in a 6.0 % KNO_3 solution and pyrolysed at 800 ºC. PAC's micropore volume increased with increasing salts concentration and K_3PO_4 treatment acquired the highest micropores. After treating with K_2CO_3, our products attained the highest weight percentage of carbon element. It is obvious that Moso bamboo is very suitable for the production of high-value-added activated carbon when optimum activation conditions are applied.

Key words: BET specific surface area, Chemical activation, Moso bamboo (*Phyllostachys Pubescens*), Potassium salts, Powder Activated Carbon (PAC)

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Chemical and Cytotoxic Constituents from the Leaves of *Cinnamomum subavenium*

Soong-Yu KUO*, Wen-Li LO, Chung-Yi CHEN, Jin-Cherng HUANG and Hsien-Tuang HUANG

Two new butanolides, subamolide D (1) and subamolide E (2), a new secobutanolide, secosubamolide A (3), and a new monoterpenoid, subamone (4), along with 21 known compounds were isolated from the leaves of *Cinnamomum subavenium*. The structures of 1–4 were determined by spectroscopic analysis. Propidium iodide staining and cytometry analysis were used to evaluate the cell cycle progression of the treated SW480 cells and it was found that 1 and 2 caused DNA damage in a dose- and time-dependent manners. It is suggested that chemicals present in *C. subavenium* Miq. (e.g. subamolides D (1) and E (2)) may have cancer chemopreventive properties.

Key words: Butanolides, Secobutanolide, Monoterpenoid, *Cinnamomum subavenium*

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Effective and Environmental Friendly Energy Utilization of Forest Biomass

Vitezslav MASA*, Martin PAVLAS, Jiri HAJEK and Alois SKOUPY

Biomass, especially woody biomass is already an important energy carrier contributing significantly to cover energy demands in many parts of the world. Exploitation of forest residues and residues from the wood-processing industry is a promising alternative for future energy supply. Development of advanced technology for biomass utilization is urgently required from the standpoints of global environmental protection measures such as the CO_2-reduction and securing alternatives to fossil fuels. This paper deals with utilizing dendromass as a fuel in utility systems supplying heat covering demand in units of MW.

To successfully spread biomass-based technology, it is necessary to provide investors with long-term profitable solutions. Procedure of optimum choice of the boiler and its duty following the real demand of consumers, safety of energy supply assessment as well as investigation of all the possibilities to extend time of operation (including cogeneration and even trigeneration) have to be involved into sophisticated design of an overall system. Principles of this approach based on made-to-measure solutions are discussed in the paper.

For up to date design of units for biomass utilization computational tools proved to be useful or even necessary. A practical application of using simulation based on energy and mass balances and computational fluid dynamics (CFD) in design phase is presented in the text. The subject is a novel design of full scale experimental unit for utilization of various types of biomass with capacity of 1 MW.

Technology of this unit and its conception are further described. Special attention is paid to progressive features in flue-gas path e.g. flue gas recycling and heat recovery for combustion air preheating. They provide maximum heat utilization and assist in processing wide range of biomass-based fuels in one unit at the same time, which contributes to the reliability and flexibility of energy supply. Operational tests and future development of this unit will enable to obtain novel and original technology with environmental, energetic and economic benefit.

Key words: Biomass combustion, mathematical modelling, trigeneration, boiler

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Carbon Stock and Decreasing of Carbon Dioxide Emissions by using Timber

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The current default approach in the 1996 Revised IPCC Guidelines assumes instantaneous emissions of all carbon removed from site at harvest. This is based on the premise that carbon stocks in wood products are not increasing. There are several arguments for challenging the default assumption. One of them is that since the industrial use of wood is increasing, the amount of carbon fixed in wood products must also be increasing. The default approach accounts for all potential future emissions of carbon dioxide from the harvested wood, but all the carbon is assumed to be emitted earlier than in reality. The carbon in logs is not released at harvest, and the life time of timber structure, wooden house and furniture can be often longer than age of logs. This report is to estimate the amount of carbon stock and emission by utilization of HWP (Harvested Wood Products) in the second commitment period in the Kyoto Protocol. In addition, the amount of energy saved by substituting wood for the other materials and the effect of biomass energy use on carbon dioxide emission reduction are to be quantitatively analyzed. It is assumed that carbon emission would be cut off by substituting wood for non-wood materials used commonly in construction. The life time of harvested wood is major element for estimating carbon stock in use.

Key words: Carbon dioxide emission, carbon stock, log

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Carbon Flow and Stocks from Consumption of Wood Materials and Wood Products in Taiwan

Jiunn-Cheng LIN, Ming Kuang WANG and Yi-Chung WANG*

The total amounts of carbon flows and stocks from consumption of wood commodities in Taiwan remains unknown. This study accounted for carbon flows and stocks based on consumption of wood materials and utilization of forest products using atmospheric-flow and stock-change methods. Based on atmospheric-flow methods, the amount of carbon released into the atmosphere from consumption of wood materials annually was 2.290 Tg C in 1990 and decreased slightly to 2.268 Tg C in 1999. The main proportions of carbon released into atmosphere from consumption of wood commodities and utilization of end-used products in 1999 consisted of 44.96% for wood products in use, 41.31% for waste woods during manufacturing processes, and 12.50% for short-term wood product uses. On the other hand, based on calculations for the second method, changes in carbon stocks of consumption of wood materials and utilization of end products was 0.132 Tg C in 1990 and -0.095 Tg C in 1999. The amount of carbon released into the atmosphere from consumption of wood materials and utilization of end products was about 7.46% of all carbon released from fossil fuel burning in Taiwan. The emitted was about 37.55 to 47.26% of annual carbon sequestered by the forests of Taiwan. From sensitivity analysis, waste wood from production processes of wood-based industries and the service lifetime of wood products influenced the carbon changes. Therefore, extending the service lifetime of wood products, decreasing wood wastes from processing, enhancing waste management, and increasing the proportions of ecological materials (wood commodities) in use may help lower overall carbon emissions.

Key words: Atmospheric-flow method, carbon-flow and stock, stock-change method, wood materials, wood products

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Antibacterial and Antioxidant Activities of Ethanolic Extract from *Michelia formosana* Bark

Lan-Ting GU*, Shang-Tzen CHANG and Hui-Ting CHANG

Michelia formosana (Kanehira) Masamune & Suzuki is one of the five precious hardwood trees in Taiwan. The purpose of present study was to evaluate antibacterial and antioxidant activities of ethanolic extract from the bark of this plant. Additionally, *n*-hexane, ethyl acetate, *n*-butanol and water-soluble fractions obtained from bark extract by liquid-liquid partition were also assessed. Results of antibacterial tests indicated that the bark extract exhibited inhibitory effects on growth of gram-positive bacteria and one gram-negative bacterium (*E. coli*.). Among the four fractions, ethyl acetate-soluble fraction showed better antibacterial performance than the others. Minimum inhibitory concentrations (MICs) of ethyl acetate-soluble fraction were 0.125, 0.1, 0.1, 0.25, 0.5 mg/mL against *E. faecalis, S. aureus, S. epidermidi*, MRSA (Methicillin-resistant *S. aureus*), and *E. coli*, respectively. The antioxidant potential was evaluated using DPPH, reducing power, and TEAC assays. Bark extract exhibited the superior DPPH radical scavenging activity with an EC_{50} value of 13.08 μg/mL. In the total antioxidant assay, bark extract also showed excellent performance with a TEAC value of 0.61 mM. Among the four fractions, ethyl acetate-soluble fraction and *n*-butanol-soluble fraction were the most effective fractions with high DPPH radical scavenging activities (EC_{50} = 14.58 and 11.34 μg/mL), reducing power and TEAC values (0.80 and 0.73 mM). Results indicated that bark extract of *M. formosana* can be utilized as an effective source of antioxidants.

Key words: *Michelia formosana*, extract, bioactivites, antibacterial activity, antioxidant activity.

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Isolation and Identification of Antifungal Constituents from the Heartwood Extracts of Taiwan Hinoki (*Chamaecyparis obtusa* var. *formosana*)

Chi-Lin WU and Shang-Tzen CHANG*

Taiwan hinoki (*Chamaecyparis obtusa* var. *formosana*) is an endemic species in Taiwan and its timbers are well recognized for their natural decay resistance. Isolation and identification of antifungal constituents from the heartwood extracts of Taiwan hinoki were carried out in this study. Results obtained from the bioassay demonstrated that heartwood extract exhibited an excellent antifungal activity against brown-rot fungus *Laetiporus sulphureus* (BCRC 35305) and white-rot fungus *Lenzites betulina* (BCRC 35296). Furthermore, following by column chromatography and HPLC, 16 compounds were isolated from *n*-hexane soluble fraction of Taiwan hinoki heartwood extract. According to Mass, ^{1}H-NMR, ^{13}C-NMR, and 2D-NMR analyses, their structures were identified, namely helioxanthin, α-cadinol, δ-cadinol, T-muurolol, γ-costol, β-sitosterol, stigmasterol, hinokione, hinokinin, palmitic acid, isopimaric acid, sandaracopimaric acid, hinokiol, *trans*-*p*-menthane-1,8-diol, and *trans*-*p*-menthane-1,4-diol. Comparisons of their antifungal activities against wood-rot fungi, it was noted that α-cadinol, δ-cadinol, and T-muurolol efficiently inhibited the growths of wood-rot fungi.

Key words: *Chamaecyparis obtusa* var. *formosana*, antifungal, α-cadinol, δ-cadinol, T-muurolol

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Carbon Sequestration through Different Strategies of Forest Management in Plantation Forests of Japanese Cedar (*Cryptomeria japonica*) in Taiwan

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Research on carbon sequestration in Taiwan has not considered the effects of forestry management strategies, particular for the tree species with the largest population, Japanese cedar (*Cryptomeria japonica*). In this study, we attempted to assess carbon sequestration according to different management strategies for plantation forests of Japanese cedar. Proper forest management can enhance the capability of forests to store carbon and reduce emissions of carbon dioxide into the atmosphere, by converting atmospheric carbon dioxide into organic biomass. This study estimated the growth potential of five forestry strategies using various plantation tree species in the ecosystem management area of the Forest Experimental Station (FES), National Taiwan University (NTU), Chitou, in central Taiwan. Assessment of the carbon sequestration capacities via simulation models were under different management scenarios (i.e., maintaining the present conditions, cutting without reforestation, and cutting with reforestation) as well as by considering the timber utilization rate. The quantity of carbon sequestration in the research area was 27.82 × 103 Mg C. The quantities of total carbon sequestration under different management scenarios were 46.43 × 103 Mg C if the same management strategy of Japanese cedar plantation forests was maintained for the following 20 yr, 29.54 × 103 Mg C if 5 ha of forests was harvested each year without reforestation. At a timber utilization rate of lumber of 65%, the quantity of carbon sequestrated was 48.73 × 103 Mg C if 5 ha harvested annually without reforestation, and 53.13 × 103 Mg C if replanted with Taiwan zelkova. The reforestation of stands after harvesting and promote the timber utilization rate (H-A-W) is best management strategies, suggesting for produce advantages in terms of carbon sequestration in plantation forests.

Key words: Carbon sequestration, ecosystem management, Japanese cedar (*Cryptomeria japonica*)

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Volatile Oil from *Eucalyptus* Species as Novel Bioherbicides

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World over huge economic losses are caused by weeds in different ecosystems and huge amount of synthetic herbicides are used to control them. However, these synthetic chemicals have environmental and toxicological implication linked to their use. In order to maintain sustainability of ecosystems efforts are directed towards exploration of novel herbicides that are environment friendly. *Eucalyptus* species are well-known world over for their volatile / essential oils that possess a wide spectrum of biological activity against insects, nematodes, microbes and fungi. Though volatile oils of *Eucalyptus* have been previously implicated in controlling understorey vegetation in the vicinity of tree, yet this property of volatile oils has not been explored for weed management. We explored the impact of volatile oil extracted from *Eucalyptus* spp. against weeds of arable and wastelands - *Cassia occidentalis, Parthenium hysterophorus,* and *Echinochloa crus-galli*. The volatile oils were observed to have a significant effect on emergence and establishment of weeds. These severely affected the photosynthetic machinery of the weed species and the plants sprayed with oils were wilted. The study concludes that volatile oils from the *Eucalyptus* species possess a good promise for weed management and can be used as a novel bioherbicide under sustainable production systems.

Key words: Eucalypt oils, Weed management, Novel bioherbicide

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Vermicomposting of Litter of *Populus deltoides*: An Excellent Manure for Organic Framing

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In northwestern India, *Populus deltoides* has been planted in plenty under various forestry programmes to supply pulp and timber to the industry besides providing various intangible benefits to the environment. Being deciduous in nature, the tree shed all their leaves during the winter months and these leaves accumulate on the floor. Generally, this enormous organic material decomposes and goes waste. Rather, it emits some foul smell, interferes with native vegetation, makes other operations difficult and releases metabolites into the soil. Alternatively, the burning of litter poses harms to the trees, and produces smoke that has ill-effects on the environment and human health. We explored the possibility of utilizing this huge organic biomass (litter) through *vermicomposting* by using earthworms. It was found that litter is converted into mineral rich natural plant based organic manure. The resultant manure was found to not only environment friendly but also a good source of minerals that can be easily under organic farming practices. This technique of vermicomposting the plant litter holds a good promise and converts litter into non-toxic environment friendly cost-effective organic manure. It is proposed to discuss all the factors and methods involved in making this technique a viable one under small-scale forest plantations.

Key words: Leaf litter, vermicomposting, organic manure

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Anti-inflammation Activities of Essential Oil and its Constituents from Indigenous Cinnamon (*Cinnamomum osmophloeum*) Twigs

Yu-Tang TUNG*, Meng-Thong CHUA, Sheng-Yang WANG and Shang-Tzen CHANG

Cinnamomum osmophloeum Kaneh. is an indigenous tree species in Taiwan. In this study, chemical compositions of hydrodistilled essential oil and anti-inflammatory activities from the twigs of *C. osmophloeum* were investigated for the first time. The chemical constituents of the twig essential oil were analyzed by GC-MS and they were found to be L-bornyl acetate (15.89%), caryophyllene oxide (12.98%), γ-eudesmol (8.03%), β-caryophyllene (6.60%), T-cadinol (5.49%), δ-cadinene (4.79%), *trans*-β-elemenone (4.25%), cadalene (4.19%), and *trans*-cinnamaldehyde (4.07%). The effects of essential oil on nitric oxide (NO) and prostaglandin E2 (PGE2) production in lipopolysaccharide (LPS)-activated RAW 264.7 macrophages were also examined. Results of nitric oxide tests indicated that twig essential oil and its major constituents such as *trans*-cinnamaldehyde, caryophyllene oxide, L-borneol, L-bornyl acetate, eugenol, β-caryophyllene, *E*-nerolidol, and cinnamyl acetate have excellent activities. These findings demonstrated that essential oil of *C. osmophloeum* twigs have excellent anti-inflammation activities and thus have great potential to be used as a source for natural health products.

Key words: *Cinnamomum osmophloeum*, twigs, essential oil, *trans*-Cinnamaldehyde, anti-inflammation

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Mosquito Larvicidal Activity of Ethanolic Extracts of *Cryptomeria japonica*

Hui-Jing GU*, Sen-Sung CHENG, Hui-Ting CHANG and Shang-Tzen CHANG

Mosquito-transmitted disease continues to be a major source of illness and death. It is important to control mosquito vector population for preventing the spread of these diseases. The purpose of this study is to determine the larvicidal activities of ethanolic extracts from leaves, wood and bark of *Cryptomeria japonica* against fourth-instar larvae of the mosquitoes *Aedes aegypti* and *Aedes albopictus*. Among three ethanolic extracts from *C. japonica*, wood extract exhibited the best larvicidal activity against *A. aegypti* and *A. albopictus* with LC_{50} values of 63.2 μg/mL and 93.8 μg/mL, respectively. Comparison of four fractions from wood extract revealed that *n*-hexane fraction exhibited the best larvicidal activity against *A. aegypti* and *A. albopictus* with LC_{50} values of 36.5 μg/mL and 111.8 μg/mL, respectively. Among fourteen subfractions (H1~H14) of *n*-hexane fraction, H5 showed a great inhibitory activity against the mosquito larvae tested. At the concentration of 100 μg/mL, it has a 100% mortality of *A. aegypti* and a 72.5% mortality of *A. albopictus.* Four major compounds, including ferruginol, *epi*-cubebol, cubebol and isopimarol, were isolated from H5 subfraction and it was demonstrated that cubebol exhibited the best activity against *A. aegypti* and *A. albopictus* with LC_{50} values of 60.1 μg/mL and 50.0 μg/mL, respectively. Our findings showed that the wood extract and its main constituents might have good potential as a source for natural larvicides.

Key words: *Aedes aegypti, Aedes albopictus*, *Cryptomeria japonica*, larvicidal activity, mosquito

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Biomass and Bio-based Products Research at the USDA Forest Service

World L.-S. NIEH*

Biomass and bio-based product research at the USDA Forest Service is directed and driven by several congressional actions and presidential initiatives. Among them, the President has set a goal of replacing 75% of imported oil with renewable energy by 2025. The "30X'30" goal requires that renewable energy will displace 30% of our nation's 2004 transportation fuel consumption by the year 2030. Removal of biomass from forests will improve forest health by reducing fire load and logging residues. Forest health will also benefit from removal of dead trees and trees affected by invasive insects. Biomass utilization research aims at developing products and conversion technology. The concept of forest based biorefinery, together with bio-chemical and thermo-chemical pathways to produce energy products and other bio-products, will add value to biomass and will create an incentive for biomass removal from forests. Economical and technological barriers for the deployment of biofuels and other bio-based products still remain. USDA Forest Service scientists, in collaboration with international scientists, are actively researching new technologies to meet the challenges of developing forest biomass-based products including energy products.

Key words: Woody biomass, biorefinery, bioenergy, biomass utilization, USDA Forest Service

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The Antioxidant Activity and Protective Effect of Extracts from the Stem of *Vitis kelungeusis* on Carbon Tetrachloride-induced Acute Liver Injury in Mice

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The object of this study is to investigate and identify the bioactive secondary metabolisms from the stem of *Vitis kelungeusis*. Result demonstrated that the crude extract and its derived soluble fractions showed good antioxidant activities. Among them, the BuOH fraction was the strongest one. The EC_{50} values of DPPH radical and superoxide radical scavenging activities, and ferrous ion-chelating activity of the BuOH fraction were 5.0, 13.6, and 1323.5 μg/mL, respectively. Also, the BuOH fraction showed high phenolic contents (248.3 mg of GAE/g). Moreover, to elucidate the hepatoprotective potential of *V. kelungeusi* extract in mice against CCl_4-induced liver damage, an animal trial of acute liver injury was employed in this study. The results revealed that the ICR mice pretreated with silymarin (positive control) (50 mg/kg/day, ip) and extracts of *V. kelungeusis* (crude extract and BuOH fraction) (10 mg/kg/day, ip) for 3 days, remarkably prevented the elevation of serum AST and ALT activities ($p < 0.05$) on CCl_4 (40 μL/kg of 20% CCl_4 dissolved in olive oil, ip) induced acute liver injury. In addition, mice pretreated with crude extract and BuOH fraction before CCl_4 administration had a significantly lower degree of hepatocyte necrosis than did the mice treated with CCl_4 plus vehicle. These results suggested that the stem extract of *V. kelungeus* showed the hepatoprotective effect under CCl_4-induced oxidative stress. Consequently, ten phytocompounds, including β-sitostenone (1), lupeol (2), β-sitosterol (3), stigmasterol (4), betulinic acid (5), betulin (6), (-)-ε-viniferin (7), 2-(4-hydroxyphenyl)-2,3-dihydrobenzo[*b*]furan-3,4,6-triol (8), 8-(3,5-dihydroxyphenyl)-2,7-di(4-hydroxyphenyl)-2,3,7,8-tetrahydrofuro[2',3':3,4]benzo[*b*]furan-3,4-diol (9), and (+)-balanocarpol (10), were isolated from the stem extract of *V. kelungeusis*. Of these, compounds 8 and 9 were first identified as new natural products. These results concluded that the stem extract of *V. kelungeusis* exhibited excellent bio-activities and thus it had great potential as a source for natural health products.

Key words: *Vitis kelungeusis*, Antioxidant activity, Carbon tetrachloride, Hepatoprotective effect

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Removal of Heavy Metal Ions from Aqueous Solutions by Modified Bamboo Wastes

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Heavy metals, which are not biodegradable and are readily accumulated in living tissues, cause a variety of diseases and disorders. This study aimed to evaluate the ability of chemically and thermally modified bamboo to remove them from aqueous solution.

To determine the effect of chemical modification, bamboo, *Phyllostachys pubescens*, was pulverized, sieved, air-dried, and difibered with 2%/or 8% NaOH and then treated with 0.6M/ or 1.2 M of citric acid, tartaric acid, oxalic acid or malic acid. Around 0.4 grams of treated and untreated powdered bamboo was mixed with 20 mL of each of 10 ppm lead, nickel, copper and cadmium standard solutions. After thoroughly mixing, metal ion concentrations in the filtrate were determined by inductively coupled plasma atomic emission spectroscopy (ICP-AES) and the adsorption capacity was calculated. Results revealed that the heavy metal removal ability of 2% NaOH-treated bamboo was improved due to its defiberation. Approximately 95% copper and 49% cadmium ions were removed by 2%-NaOH treated bamboos, whereas only 30% and 5% corresponding ions were removed by the control bamboos. Tartaric acid and oxalic acid, were the two chemicals having the greatest effect on improving the removal of heavy metals. The heavy metal removal ability of tartaric acid-modified bamboo to remove Pb, around 98%, was almost equal to that of commercial active charcoal (100%). As to nickel, copper, and cadmium removal ability, tartaric acid-modified bamboo was 20 times more effective than untreated bamboo. Tartaric acid-modified bamboo was the candidate material for further follow-up field testing.

To evaluate the effect of thermal modification, powdered bamboo was heated in an oven at 200, 300, 400, 500, 600, 700, 800, 900, or 1000 ºC for 60 min. As the heating temperature increased from 200 to 400 ºC, the heavy metal removal ability of thermally treated bamboo increased. The less adsorptive parts of bamboo-cellulose and hemicellulose have been gradually removed and the most adsorptive part of bamboo-lignin were exposed may, in parts, contribute to the improved ability. Thermally treated bamboo showed the best ability to remove Pb, followed by Cd, Cu and Ni. Moreover, similar results were observed as temperature increased from 500 to 1000 ºC, and the improvement might result from the increase of contact surface through the increasing size of interior mini pores.

Key words: Chemical modification, thermal modification, bamboo, heavy metal removal ability

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5.12 B

INTEGRATING FOREST PRODUCTS WITH ECOSYSTEM SERVICES

Papers

Entrepreneurship and Innovativeness in the Norwegian Nature-based Services Industry

Erlend NYBAK* and Eric HANSEN

This study is an investigation of the nature-based recreation services industry in Norway. A recent study in Forest Policy and Economics identified two main elements of entrepreneurship, the ability to recognize business opportunities and the ability to take calculated risks. Further, that study examined how entrepreneurial attitudes affect the probability for start-ups. It is suggested that entrepreneurial attitudes influence the likelihood for process innovation and increased performance. Entrepreneurship and innovation theory were used and an e-mail survey was conducted. The questionnaire was forwarded to 324 Norwegian micro-enterprises selling forest recreation products and services. The response rate was 55 percent. Respondents that exhibit a stronger entrepreneurial attitude appear more likely to change the way they organize their enterprise and tend to have higher income growth.

Key words: Entrepreneurship, risk taker, opportunity recognition, innovation, performance, nature-based recreations tourism

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Confronting Sustainable Forestry in a Period of Uncertainty and Change: Forest Certification's Role as a Market-based Catalyst

Masami SHIBA* and Naoya OGAWA

Over the past 15 years since UNCED, forest conservation has become an increasingly high-priority issue for both policy makers and the general public throughout the world and a majority of the world's countries have established or updated their national forestry laws and policies and are moving towards integrated approaches that balances environmental, economic and social aspects of forest management. Forest certification verified by independent third-party assessments is voluntary market-based process and has widely accepted a relatively short time, and have solidified its place as integral tool for addressing SFM issues in all types of climate forests around the world.

The demand for forest certification in association with its products in the form of a product label- chain of custody being the term applied to the process of tracking a timber from a specific certified forest to final consumer through various production phases of supply chain, is also growing rapidly in Japan in response to the demand for log imports in the Asia an d Pacific regions, especially in China and India. There are currently three different forest certification schemes in operation in Japan. Two of these are international (FSC, PEFC) and the remainder SGEC (Sustainable Green Ecosystem Council) is national, voluntary initiative with the intention of promoting sustainable forestry practice in Japan. In 2006 around 2.14% (0.533 million ha) of the Japan's forest area is certified by FSC (0.277 million ha, 24 forest lands) and SGEC (0.256 million ha, 29 forestlands) respectively, while 462 timber and paper & pulp companies have been awarded the CoC certification (FSC-CoC: 413, SGEC-CoC: 29, PEFC-Coc: 20).

The primary purpose of this research is to discuss the potential effects of forest certification in association with CoC on management and market strategies of plantation forestry through different certification schemes such as FSC, PEFC and SGEC which parallel or competently emerge on the same products markets in Japan and also partly in the Asia and Pacific regions.

Key words: SFM, forest certification, chain of custody, traceability, marketing strategies

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Forest Products and Ecosystem Services: Using Market Based Approaches to Increase Forest Value

Robert L. DEAL* and Xiaoping ZHOU

There has been increasing interest in the use of incentives and market-based strategies to add value for forest land and to help accomplish conservation goals. These can be in the form of direct payments to landowners, through trading credits or other market-based approaches. While all of the activity around markets for ecosystem services has created considerable interest among stakeholders and shows potential, there is some risk that the lack of a coordinated, integrated approach will simply add to the complexity and cost of these services without generating significant public benefits.

The current trajectory is to develop a separate program, each with its own set of rules and administrative requirements, for each element of the ecosystem. The impact on-the-ground will likely be as fragmented as the programs, resulting in the restoration of many small sites that lack ecological integrity and are unlikely to provide benefits over time. There is a need for a more integrated approach that seeks to achieve broad conservation goals, including fish and wildlife habitat, improved watersheds, carbon sequestration, and other ecosystem services at an ecologically relevant scale.

Forest products will continue to be a major resource product from forest lands and other ecosystem services provided from these lands will be considered additional value. However, carbon credits, water quality and quantity, and conservation values can add substantial economic return from forests. We use an integrated approach to bundle value of different ecosystem services including carbon credits, conservation banking, water quality trading and wetland mitigation banking. We also outline some of the constraints for each of these different ecosystem services and discuss the different regulatory agencies involved and policy issues related to each of these ecosystem services. Our purpose is to establish which ecosystem services can be bundled, understand the process for combining these services on a given land area, and develop an integrated approach for bundling these services. This process can be used to restructure public incentive programs so that multiple resource benefits can be captured.

Key words: Ecosystem services, forest products, conservation value, forest economics

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Carbon Banking: Flexibility for Forest Owners

Hugh BIGSBY*

The focus of forest-based systems for sequestering carbon has largely been on creating permanent stores of carbon on defined areas of land with a one-off payment to the forest owner for the carbon. In terms of forest management, this focus leads to either of two outcomes, continuing production of timber if the forest area is sufficiently large to create an effective permanent carbon pool, or a cessation of harvesting if the forest area is too small. In addition, the payment system for carbon is generally based on matching a specific buyer and seller of carbon using a one-off payment to the forest owner. In combination, both of these factors create a carbon sequestration system that is too inflexible to attract any but the largest land or forest owners.

The paper presents an alternative system for sequestering carbon – carbon banking. Carbon banking treats sequestered carbon in the same way that a financial institution treats capital. In essence, forest owners 'deposit' carbon in exchange for an annual payment, and those who need carbon offsets 'borrow' carbon by making an annual payment. The role of the carbon bank is to aggregate deposits of carbon and use these to meet various demands for carbon. There are a number of benefits of this system. It provides an opportunity for small forest owners with different types, age classes, and management strategies to participate in carbon markets, because payments are based on carbon currently sequestered. It also allows participants in the carbon market to receive current value for carbon, rather than what effectively represents the capitalised value of the future benefits of sequestering carbon, thus removing some uncertainty about locking into the wrong value for carbon.

Key words:

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5.12 B – Posters

Acid Rain Impact in Forest Soil

K. S. PATEL*, B. AMBADE, B. BLAZHEV and R. M. STEFANOVA

Acid rain refers to all types of precipitation such as rain, snow, sleet, hail, fog that is acidic in nature. Acidic means that these forms of water have a pH lower than the 5.6 average of rainwater. Acid rain kills aquatic life, trees, crops and other vegetation, damages buildings and monuments, corrodes copper and lead piping, damages such man-made things as automobiles, reduces soil fertility and can cause toxic metals to leach into underground drinking water sources. The acid rain is halting in the coal-burning site of Indian continent due to huge burning of the fossil fuel for generation of electricity [1]. The most important effects of acid rain on forests result from nutrient leaching, accumulation of toxic metals and the release of toxic aluminum. Nutrient leaching occurs when acid rain adds hydrogen ions to the soil, which interact chemically with existing minerals. This displaces calcium, magnesium and potassium from soil particles and deprives trees of nutrition. Toxic metal such as lead, zinc, copper, chromium and aluminum are deposited in the forest from the atmosphere. The acid rain releases these metals and they stunt the growth of trees and other plants and also that of mosses, algae, nitrogen-fixing bacteria and fungi needed for forest growth. The aim of the proposed work is to investigate the chemical composition of fog water, ground water and surface soil of the forest in the acid rain halt region (Kaorba, Chhattisgarh, central India) to understand the leaching of micronutrients and accumulation of the toxic metals. The impact acid rain in the health of the forest trees is discussed.

Key words: Acid rain, soil quality, Korba, Chhattisgarh, India

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5.01.01
BIOLOGICAL CONTROL OF WOOD QUALITY

Papers

Variation in Growth Strains in Five Clones of *Eucalyptus tereticornis*

Pankaj K. AGGARWAL* and Shakti S. CHAUHAN

Improvement in both breeding and processing of the plantation grown species has taken a paramount importance in forestry research in India as the conventional timber species are becoming scare and expensive. Eucalyptus is one of such species which has been planted widely throughout the country to meet fuelwood, pulp and paper demand with relatively little importance to wood characteristics. The inherent problems associated with this species like growth stresses have distracted both wood industry and consumers in utilizing this wood as the valued sawn timber products.

There is a great deal of natural variation in the propensity for growth stress in eucalypts and the trait has been reported to be heritable. With the clonal forestry gaining significant impetus in breeding trees with the desired traits for specific end-use applications, magnitude of growth stress could also be an important trait for selecting clonal material for the production of solid timber. Selection of appropriate clones provides an opportunity to grow trees with pre-defined wood characteristics for future timber production.

This paper presents variation in growth strains in five clones of *Eucalyptus tereticornis* planted in 1991 by ITC Bhadrachalam. Six logs from each clone were measured for growth strains using wire- strain gauge method. Longitudinal growth strains were measured at approximately mid-length on two opposite sides of each log. All the logs were one meter long and girth at the measuring point was ranging from 30 cm to 50 cm. A large variation in growth strain was observed in the 60 observations (5 clones*6 trees*2 points). Growth strain was found to vary from 160 micro-strain to 1290 micro strains. There was a significant variation in growth strain between the clones. Out of five clones, two clones exhibited very low growth strains (440 micro-strain) while one clone exhibited highest average growth strains of 850 micro-strains. The study revealed the identification of two low strain clones which have potential to be propagated for solid timber production.

Key words: Growth strains, eucalyptus, wire-strain gauge, breeding, genetic

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Investigation of Within-tree and Between-site Resin Canal Variation in Radiata Pine

Jun Li YANG, Geoff DOWNES, Fiona CHEN and Dave COWN*

Resin defects are an increasing problem in value-added processing of radiata pine. Consequently, detection of resin pockets and blemishes is becoming important. It is recognised that within- and between-tree variation in resin canal occurrence has been poorly documented and little is known about the factors that drive the frequency. Climatic, silvicultural, biological and genetic variables are expected to affect resin canal size and frequency.

A study was undertaken to examine the within-tree and between-site variation in resin canal frequency, and the relationship between external resin bleeding scores of standing trees and blemishes in wood samples. A pilot experiment was firstly carried out to examine if the relatively small transverse surface area represented by 2 mm wide radial strips is adequate for describing resin canal occurrence within individual trees. With the results being positive, 150, 2 mm wide radial strips with transverse surface being polished were selected (10 strips for each of 15 sites). Information on the characteristics of resin canals on the transverse surfaces (the number and radial position of resin canals) was obtained using an imaging method. The results indicate that 2 mm wide radial strips are suitable for resin canal occurrence assessment. To detect annual changes in resin canal frequency for a given population, 5-7 strips are required per site, while site differences in resin canal frequency can be assessed using individual strips from a minimum of 6 trees per site.

The numbers and sizes of resin canals increased from pith to the cambium. They also varied between trees and between sites. The within-tree (between-ring) variation was found to be much greater than between-tree and between-site variations. Based on the site means, resin canal frequency appears to be positively related to ring width but not related to resin canal size. Resin canal frequency differed significantly among the 15 sites. It was positively associated with site temperature but inversely associated with site elevation. Resin canal frequency appears to be moderately associated with resin blemishes. Sites with very low resin canal count have low levels of blemishes. Sites with high resin canal count are among the highly-blemished sites. The frequency does not appear to be linked to the external stem resin score, or the occurrence of resin pockets and resinous patches.

These results imply that non-destructive core sampling can be used to gather robust information on the frequency and size of resin canals to assess and compare resin canals in genetics trials. Resin canal information can also be included in growth models for prediction of regional effects, based on site and stand ages.

Key words: Resin canal, defect, radiata pine

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Environmental Control of Wood and Tracheid Properties in Norway Spruce (*Picea abies* (L.) Karst.)

Tuula JYSKE, Harri MÄKINEN and Pekka SARANPÄÄ*

We studied the basic relationships between environmental factors controlled by silvicultural treatments (i.e., thinning and fertilisation), tree growth rate and wood properties of Norway spruce (*Picea abies* (L.) Karst.) throughout stand rotation which often exceeds 80 years in Finland. Furthermore, models were created to predict how wood and tracheid properties of Norway spruce are affected by tree growth rate and stand management.

The material consisted of altogether 109 trees from long-term thinning (Heinola, 61°10'N, 26°01'E; Punkaharju, 61°49'N, 29°19'E) and fertilisation-thinning experiments (Parikkala, 61°36'N, 29°22'E; Suonenjoki, 62°45'N, 27°00'E) in southern, south-eastern and central Finland. Wood properties, i.e., radial increment, wood density, latewood proportion, tracheid length, cell wall thickness and lumen diameter, as well as relative lignin content, were measured in detail from the pith to the bark, as well as from the stem base towards the stem apex.

Intensive thinning and fertilisation treatments of Norway spruce stands significantly enhanced (8%–68%) the radial increment of individual trees. At the same time, a faster growth rate slightly decreased wood density (1%–7%), tracheid length (0%–9%) and cell wall thickness (1%–17%). The faster growth rate only slightly increased lumen diameter (0%–9%) and relative lignin content (1%–2%). However, the random variation in wood properties was large both between and within trees and annual year rings.

The results of this study indicate that the prevailing thinning and fertilisation treatments of Norway spruce stands in Fennoscandia may significantly enhance the radial increment of individual trees but cause only small or no detrimental changes in wood and tracheid properties.

Key words: Fertilisation, thinning, tracheid properties, tree growth rate, wood density

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Impacts of Genetics, Silviculture and Environment on the Physical and Mechanical Properties of Sitka Spruce Structural Timber

John MOORE*, Andrew LYON and Barry GARDINER

Sitka spruce (*Picea sitchensis*) is the most widely planted coniferous tree species in the United Kingdom. It is important for the profitability of the UK forest industry that Sitka spruce can gain increasing acceptance as a structural timber, as the markets for non-structural end uses such as pallets, packaging and fencing are either saturated or likely to become saturated in the future. However, there are concerns about the quality of current and future supplies of locally-grown timber. These are based on largely anecdotal evidence of timber coming onto the market and on trends in stand management (e.g., a move to wider initial planting spacing and no-thin management) which have taken place in the last 50 years. There are also concerns that trees planted on more exposed sites will have inferior stem form and wood properties compared with those planted on more sheltered sites.

There are few datasets to support these assertions. To provide data to answer questions about the extent and sources of variation in key wood properties of interest to the construction sector, a series of studies have been undertaken. In this presentation an overview of three key studies will be given. These have focussed on quantifying the effects of environment, silviculture and genetics on the density, stiffness and strength of solid Sitka spruce timber. Static bending tests were used to determine stiffness (i.e., Modulus of Elasticity) and strength (i.e., Modulus of Rupture) of each piece of timber, while portable acoustic tools were used to estimate the dynamic modulus of elasticity on standing trees, freshly-felled logs and boards. Results show that environment has a large effect on wood properties and that there is considerable amount of variation in the dynamic MOE between sites. Within a site, large decreases in both the strength and stiffness of timber were observed as stand density decreased. While tree breeding has lead to an increase in recoverable volume due to improvements in stem form, there does not appear to be any significant positive or negative effects on wood properties compared with trees grown from unimproved seed. Overall, the current forest resource coupled with present processing options is providing acceptable levels of C16 grade timber, but low levels of C24 material. However, it should be possible to increase the level of C24 grade timber by identifying higher quality stands in the forest and by modifying sawing patterns. A change in breeding strategy to select for trees with low microfibril angle may lead to further improvements in the longer term.

Key words: Sitka spruce, modulus of elasticity, modulus of rupture, wood density

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Growth Stresses and Tension Wood Analysis of *Nothofagus betuloides* (Mirb) Oerst

Maria MANSO MARTIN*, Leif NUTTO and Gero BECKER

The forest of the Chilean Patagonia is dominated by native species of the genus *Nothofagus*. One species with valuable wood for use in flooring and furniture industry is *Nothofagus betuloides* , covering an estimated area of 200,000 ha in this region. Commercial acceptance of *Nothofagus* is rather low due to problems like warp and end split in sawn timber. This can be caused by not adapting wood processing practices such as sawing and drying, but can also be a consequence of high growth stresses caused by the formation of tension wood. With the objective to promote the utilization of this species for high value timber products, the understanding of the relationship between tension wood, growth stresses and final lumber quality is a key factor.

The aim of this study is to analyse and verify the presence of tension wood of this tree species in coherence with growth stresses. The material consists of 30, 150 to 200-year-old trees from unmanaged native forest. Peripheral growth strains were measured at tree heights of 1.3 and 5.5 m. Discs were also taken from these heights for cell structure and tension wood analysis. The results of growth stress measurements show a high variability within and between the trees. To detect and visualize tension wood on stem discs a chemical reagent was applied. The methodology is based on the fact that tension wood contains less lignin and a so called "G-layer" of high cellulose content. The reagent causes the lignin of the wood to turn red, with tension wood zones in the stem discs appearing a lighter colour. The method, previously applied to European Beech (*Fagus sylvatica* L)*,* did not show satisfactory results with the species *Nothofagus betuloides*. A detailed microscopic analysis of cell structure showed that the tension wood in this species has an irregular and scattered distribution in the stem discs, which in many cases can not be recognized by macroscopic analysis. Further research is required to obtain more detailed information about tension wood formation and distribution in the wood of *Nothofagus betuloides*, and also to develop more sophisticated macroscopic detection methods.

Key words: *Nothofagus*, growth stresses, tension wood

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Breeding for Wood Quality and End-products in Radiata Pine: Genetic Relationship and Economic Weights

Harry WU* and Milos IVKOVIC

The quality requirement of the end-products dictates the minimum standard of the wood produced by tree crops. Both silviculture and genetics influence wood quality of tree crops of radiata pine. In this paper, genetic influence of major radiata pine wood quality traits including wood density, microfibril angle, and modulus of elasticity are studied and reviewed from several recent wood quality improvement projects and historical data.

Populations, testing environments, and ages had significant effect on wood density, microfibril angle, modulus of elasticity. Wood density had the highest heritability, followed y microfibril angle, and modulus of elasticity. Higher heritability in wood density, microfibril angle, and modulus of elasticity confirms that selective breeding for the three wood quality traits individually would be very effective, more effective than growth and form traits. However, it was found that growth (DBH) was unfavourably correlated with the three wood quality traits. This indicates that breeding for overcoming the unfavourable genetic correlations is the most challenging issue in the advanced generation breeding for radiata pine.

We developed two strategies to overcoming these unfavourable genetic correlations. One short-term solution is developing economic breeding objective for various end-products of radiata pine. The economic breeding objective (economic weights) has been developed for the production of structural products of radiata pine in Australia. A bio-economic model was constructed to linking radiata pine production system with breeding objective traits. The economic weights for breeding objective traits of wood quality were derived and used for development of selection index. But a better and long term solution is to dissecting the genetic base of the unfavourable relationship between wood quantity and quality traits and developing optimal breeding strategies to overcome or breed out the unfavourable genetic relationship.

Key words: Wood quality, end-product, economic weight, radiata pine, breeding objective

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5.01.01 – Posters

The Effects of the Environmental Stress on the Wood Formation in *Acacia mangium*

Chunhua ZHANG*, Hisashi ABE, Katsushi KURODA and Takeshi FUJIWARA

Acacia mangium is one of the commonest plantation tree species for the tropical region. It grows very fast and forms heartwood at a comparatively early stage of the growth. This makes it an ideal tree species for use in simulation experiments, in other words, it can become a candidate for a model tree for investigating the effects of various stresses to the wood formation, especially heartwood formation. In this study, we planted *Acacia mangium* seeds and raised them for 9 months in an artificial climate chamber by which the tropical climate was reproduced. To investigate their response to environmental stress, young trees were divided into four groups, and then were separately subjected to cold stress, water stress, and light stress for a month. One remaining group was used as the control. After being raised for 7 more months in the artificial climate chamber, all the trees were felled and wood samples were collected from the stems. The specimens sampled from each group were examined by light and electron microscopy.

In spite of having lived only 17 months, the trees which had undergone cold stress had already formed heartwood. Colored heartwood substances were distributed over the whole heartwood, although not homogeneously. Moreover, a greater number of starch grains were detected than in individuals from the other groups, with especially numerous starch-rich living wood fibers being observed on the outer parts of the xylem. Compared with the control, these trees were noticeably shorter. Our results indicate that *Acacia mangium*, a tropical tree species, is very sensitive to cold stress. In this study, the trees which were subjected to water stress formed some narrow vessels, but those which underwent light stress did not show a significant change in wood formation.

Key words: *Acacia mangium*, environmental stress, heartwood, living wood fiber

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5.02 B
RESOURCE CHARACTERISATION B

Papers

Anisotropic Characteristics of Dynamic Viscoelastic Properties of Wood

Jianxiong LU and Jiali JIANG

Wood is an anisotropic material with a complex cellular structure. Because of the orientation of the wood fibers and the manner in which a tree stem increases in diameter as it grows, properties vary along the three principal axes: longitudinal, radial and tangential. In general, although most wood properties differ in each of these three axis directions, differences between the radial and tangential axes are relatively minor when compared to differences between the radial or tangential axes and longitudinal axis.

Some researchers have measured dynamic viscoelastic properties in the radial direction and a few in the longitudinal direction but very little data can be found in the literature on dynamic viscoelastic properties in the tangential direction. The purpose of the work presented in this paper was to investigate the variation of dynamic viscoelastic behaviour in the longitudinal, radial and tangential directions of Chinese fir [*Cunninghamia Lanceolata* (Lamb.) Hook] plantation wood. Testing was done in the temperature range of -120 to 40°C at 1Hz using the Dynamic Mechanical Analysis (DMA). DMA experiments were carried out with different mechanical modes (flexural and tensile). The results showed that the storage modulus was the highest in longitudinal direction and the lowest in the tangential direction. The longitudinal direction showed a lower loss peak temperature than that in the transverse direction, which was opposite to polymer composites where the stiffer direction has a higher loss peak temperature. The rheological properties of wood also showed a dependence upon the mechanical mode used during measurements. The tensile mode presented higher stiffness than the flexural mode. The results obtained in this study could be useful to predict mechanical behaviour in more complex stress fields and to give a better understanding of the damping properties of wood.

Key words: Anisotropic characteristics, dynamic viscoelastic properties, mechanical modes

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Mechanical Properties of *Pinus massoniana* Tracheids

Bo ZHANG, Benhua FEI* and Yan YU

The purpose of the study was to use zero-span tension and nano-indentation technology to determine the tensile strength, modulus of elasticity (MOE) and hardness of *Pinus massoniana* tracheids. It was conclusively shown that the average tensile strength of early wood tracheids was 513 MPa, ranging between 413 MPa and 631MPa. The mean earlywood tracheids strength increased from the pith to the bark. Hardness of the compound middle lamella was found to be almost as high as that of the secondary wall, but the MOE of the compound middle lamella was 50% less than that of the secondary wall. There is about a 40% increase in the average modulus of elasticity (12.91 to 17.89 MPa) and about a 13% increase in the average hardness (0.40 to 0.46 GPa) from early juvenile wood to late mature wood in *Pinus massoniana*.

Key words: *Pinus massoniana*, tracheids, zero-span, nano-indentation

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Mechanical Characteristics of Poplar Wood (*Populus alba* L.) across the Grain

Paola MAZZANTI and Luca UZIELLI

Some mechanical tests are being carried out at DISTAF laboratories, University of Florence, in order to acquire a deeper knowledge about the mechanical and rheological behaviour of Poplar wood (*Populus alba* L.) across the grain.

Mechanical parameters such as strength and elastic, visco-elastic and mechano-sorptive behaviour will be used in modelling the deformations of wooden supports of painted panels belonging to Cultural Heritage, in order to improve their conservation by analyzing their reactions to variations of the environmental thermo-hygrometrical conditions. Indeed in Italy, between XII and XVI century, most of the panel paintings – including those by great Masters such as Giotto, Botticelli and Leonardo da Vinci – were painted on supports made of Poplar wood. The mechanical behaviour of supports in the transversal directions are of the utmost importance, since many conservation problems, including the evaluation of most appropriate restraining devices such as frames and cross-beams, not to mention the evaluation of the environmental parameters, are actually related to cupping deformations and fissures along the grain; also many of the damages which can be observed on the paint layers are related to the behaviour of the wooden support.

In this paper we report about short-term compression and tension tests, which have been carried out on small clear wood samples conditioned at the three following constant climate conditions:

- 85% RH and 30°C (humid climate: wood MC approximately 15,5%)
- 65% RH and 20°C (normal climate: wood MC approximately 12,0%)
- 30% RH and 30°C (dry climate: wood MC approximately 6,0%).

Specimens have been tested along both tangential and radial directions, to obtain the Young's modulus and the modulus of rupture for tension and compression loads. At all three MC conditions the wood showed to be stiffer and stronger in the radial direction than in the tangential direction.
Further tests on creep and on mechano-sorptive parameters are also being carried out.

Key words:

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Effects of Ring Characteristics on the Compressive Strength and Dynamic Modulus of Elasticity of Seven Softwood Species

Ming-Jer TSAI*, Cheng-Jung LIN, Chia-Ju LEE, Song-Yung WANG, Te-Hsin YANG and Lang-Dong LIN

The effects of ring characteristics on the compressive strength and dynamic modulus of elasticity of seven softwood species in Taiwan were examined. The results revealed that there is a good correlation between compressive strength and dynamic modulus of elasticity obtained by using an ultrasonic wave technique (with correlation coefficients r = 0.77–0.86). As a whole, values of compressive strength increased with decreasing ring width parameters; however, they increased with increasing ring density parameters. The ring density related to the compressive strength, but it is not the sole factor affecting strength of wood. According to our statistical analysis, compressive strength was affected by various ring characteristics. The relationships between ring characteristics and compressive strength are influenced by the anatomic directions. Results revealed that earlywood density and minimum density in a ring are equally important variables for evaluating compressive strength of wood.

Key words: Compressive strength, dynamic modulus of elasticity, ring characteristics

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Collapse of the Cellular Structure of Wood induced by Large Compressive Deformation: Experiment on Micro-Samples and Modelling using the MPM (Material Point Method)

Patrick PERRÉ* and Tuan DINH

The collapse of wood cells can occur due to an external mechanical load or by internal loading such as a negative liquid pressure during drying. Depending of the species and the growth conditions, wood is more or less prone to collapse.

Inducing collapse by an external load is a convenient way to investigate the parameters that govern this complex mechanism. Compression with large deformation is used here.

The experiment consists in submitting micro-samples (typically some mm^3) of wood to compression at constant strain-rate up to large deformation. A micro-mechanical machine is used for that purpose. The top surface of the sample is carefully polished before the test using very fine grain. This allows the cross-section of the sample to be observed using a optical microscope. Some tests are also available using an electron microscope (ESEM). In this case, the surface is prepared using a sledge microtome. After some percentage of compression, the cell shapes start to change, followed by a complete collapse of whole cell layers. For different species tested with this device, the collapse is always easier when compression is applied in the tangential direction.

This observation is related to the formation of wood in the cambial zone, which tends to produce aligned radial cell walls and irregularly ordered tangential cell walls. This behaviour is confirmed by computational simulations. In order to be able to attain large deformation, a numerical strategy adapted quite recently to solid mechanics, the MPM (Material Point Method), was successfully used. In order to be as close as possible to the real cellular structure, the grid of material points required by the MPM is directly built from microscopic images of the wood samples.

Key words: Cell collapse, compression, Material Point Method, micro-samples, experiment, modelling

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5.02 B – Posters

Estimation of Weibull Parameters for Fracture Toughness of Spruce

Shih-Hao LEE*

Wood, natural product, is a kind of hygroscopic, porous, discontinuous, inhomogeneous, and anisotropic material. Its physical properties frequently exhibit an unusually wide degree of variability. In order to assess the reliability of wood structures, three distributions, normal, log-normal and Weibull normal, are most often used to describe wood mechanical properties. Weibull has proved to be the most useful and versatile means to represent wood strength among these three distributions. However, proper use of this distribution requires that its parameters be accurately estimated.

The two, (scale, shape), and three parameter, (location, scale, shape), Weibull functions were estimated and compared in this study. Coefficient of determination, r^2, of three parameter Weibull function is closer to 1 than that of two parameter Weibull function. The importance of selection of proper distribution is evident.

Key words: Weibull distribution, Parameter, Coefficient of determination

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Dynamic Viscoelasticity of Young and Mature Bamboo Culm

Yoko INOKUCHI* and Mario TONOSAKI

In this study, dynamic viscoelasticity of 0.5 years-old culm (young culm) and 4 years-old culm (mature culm) of Mousouchiku (*Phyllostachys pubescens* Mazel) was examined. And the cell wall structure of them was observed with a scanning electron microscopy.

The specific gravity (*r*) increased with an increase in volume fraction of bundle sheath (V_f,) , and *r* of mature culm was larger than that of young culm because the cell wall fiber cell and parenchyma cell of young culm was thinner than that of matur culm, both fiber cell and parenchyma cell. Dynamic elastic modulus (*E'*) and the specific dynamic modulus (*E'*/*r*) increased with an increase in V_f , and *E'* of mature culm was larger but *E'*/*r* of one is smaller than young culm. Loss tangent (tanδ) decreased with an increase in V_f . In untreated inner part of culm, tanδ of mature culm was slightly larger than that of young culm. But after water extraction, no significant differences in tanδ between mature culm and young one were found.

The microfibril orientation of fiber cell wall of young culm was about the same as mature culm. *E'*/*r* and tanδ are significantly dependent on microfibril orientation of cell wall. So it is considered that *E'*/*r* and tanδ of young culm was equivalent to mature culm. The microfibril orientation of broad layer of fiber cell was in almost axial alignment, while that of parenchyma cell wall was sloped at large angle with long axis. Therefore, the reason *E'*/*r* and tanδ vary with V_f may be that the features of microfibril orientation of fiber cell is much different from parenchyma cell.

Key words: Bamboo, dynamic viscoelastic properties, volume fraction of bundle sheath, ultrastructure of cell wall

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5.10 A

MARKETING LESSER KNOWN SPECIES, NON-TIMBER FOREST, PRODUCTS & CERTIFICATION

Papers

Marketing of Non-timber Forest Products in India: Opportunities and Challenges

Parag DUBEY*

The ability to support rural livelihoods, including conservation of diversity has led to interest in NTFPs marketing as an instrument for sustainable development. NTFPs marketing in India provides a good example of an imperfect market. Poverty, lack of acquaintance with money exchange system and debt bondage with money lenders forces collectors to sell high value NTFPs for low value food commodities. Under the traditional market network, with a predominant role of intermediaries, unorganised forest dwellers have been receiving low prices for NTFPs. Furthermore, the process of deforestation have increased the distance between village and forest and decreased availability of NTFPs. To fully tap this potential, Government of India established Forest Development Corporations and government-supported co-operatives, to help collectors by eliminating local middlemen and provide benefits in terms of better return and working conditions in NTFPs trade. Some states nationalised few NTFPs, while others acquired monopoly rights. Tribal are required to sell to Forest Department exclusively, however, department then sells it back in the open market through auction to traders after basic processing. Consequently, government revenues from NTFPs have increased substantially, mostly due to inflationary price escalation; total employment and income of collectors have remained stagnant and often fallen. Though collectors have benefited to some extent by realising a fair price, transfer of the real value of the products has not been affected. The collection, grading, and processing of most items is crude and done in a traditional way with little improvements. NTFPs are diverse in nature, quantity collected often uneconomical in size and the prices solely depend upon few buyers. It has been difficult for the government to regulate 'minimum unit price' payment to primary NTFPs collectors; unlike for the agricultural commodities, the official price fixed for nationalised NTFPs also does not get publicity, leaving collectors ignorant. This makes the collectors vulnerable to exploitation by unscrupulous contractors and corrupts collecting agents. There are no incentives for the industries to use NTFPs as raw materials. Policy restrictions exist on transport and sale of forest products, even from private lands. Nationalisation was carried with the objective of setting these imbalances, however, the functioning of this has often been detrimental to the interest of tribal, as institutions have not been cost effective, leads to new forms of exploitation via inefficiencies and apathy. Governmental intervention in the NTFPs industry is a good example of an inappropriate policy and institutional response.

Key words: NTFPs marketing, forest policy, intuitional arrangements, micro-enterprises

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Improving Forest Management Practices through the Development of Markets for lesser known Species (LKS) in Bolivia

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Sustainable forest management depends upon adequate/profitable markets for the products produced from the forest. Forest Certification requires a balanced approach to harvesting of timber. Until recently, only key species such as mahogany and Spanish cedar were harvested for international markets from the tropical forests in Bolivia. With over 2 million hectares currently certified under the Forest Stewardship Council (FSC), other LKS must be harvested to properly manage the forest. Yet, little is known of the physical properties and markets for these underutilized species. Under the leadership of the BOLFOR II project, 20 LKS were identified that needed to be harvested to properly manage the forest to meet FSC requirements. Bolivia has a small domestic market for forest products, which indicates the growth of the forest product sector must be focused in the international market. While increased export opportunities exist for sustainable forest products, there is a lack of understanding and education in the forest products sector and by the government on how to support an export strategy for the forest products sector. This research looked at developing a marketing strategy for 20 LKS from the certified forests of Bolivia. It started by determining the physical properties of these species and identifying potential markets that they may serve. A survey of importers of tropical timber was then conducted to identify the best ways to introduce LKS into the US markets and from this information a marketing strategy was developed for the BOLFOR II project to introduce LKS.

Key words: Bolivia, less-known-species, marketing, forest certification

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Marketing Strategies, Functions, and Benefits of Forest Certification: A Cross-cultural Comparison

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This study compared the strategic importance, marketing functions, and supplier benefits of forest certification between Nordic Europe (Finland and Sweden) and Japan. A nationwide survey with standardized questionnaire scheme was used for each country. In Finland, personal interviews were conducted in late 2004 with 25 companies having had a chain-of-custody certificate from the Programme for the Endorsement of Forest Certification schemes (PEFC). In Sweden, self-administered electronic survey was conducted, and 27 usable responses were received early in 2005. In Japan, a mail survey was sent, and 132 companies responded in late 2005. The majority of respondents from Sweden and Japan adopted certification of the Forest Stewardship Council (FSC).

In Nordic Europe, forest certification was perceived important as a reactive measure against market pressure, and companies from paper business in Japan responded similarly. Conversely, the Japanese wood products companies considered forest certification as a proactive tool to break the deadlock of domestic industry. In all countries, it was unlikely that a price premium is a primary motivator for adopting certification.

Marketing communications did not actively use forest certification in all countries. Respondents used minimal cost and effort in deploying existing channels to demonstrate that their products were indeed certified. Charging a price premium was not possible for most certified companies in Finland and Japan. In Sweden, there was a premium for one third of FSC certified companies, although only part of certified products was sold with a premium.

Certified companies tended to gain positive public reputation in all countries, while certification did not directly improve financial performance of companies.

Key words: Certified forest products, Forest certification, Forest products marketing, Japan, Nordic Europe

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Certification Descriptions as Branding Tools: An Exploratory Analysis of U.S. Homebuilders and Architects

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The diversity of forestry environmental certification schemes can be confusing to consumers and thus, may weaken the clarity of their message. Certified forest product demand is partly contingent on product information. Hence, there is a need to understand how information provided by certifiers is processed by supply chain members. In this study, we develop and test a model that deconstructs certification descriptions into three components: (1) certification drivers, (2) certification principles and (3) pledge of certified products. Four descriptions of forest certification were evaluated based on the weight placed on each of these three components by U.S. homebuilders and architects. A multivariate regression approach was used to determine each certification description's influence on respondent to (1) consider forest certification, (2) deem certification as an effective marketing tool for their company, and (3) perceive that certified products provide advantages over non-certified products. Findings suggest that forest certification descriptions that place a high importance in explaining reasons that justify the use of certified wood products are the most important determinants of architects/builders perceptions about forest certification. Descriptions with a thorough description of the principles that determine how a product is certified also have a significant and positive, but smaller, effect on architects/homebuilders' perceptions of certification.

Keywords: Branding, recall, certification, architects, homebuilders

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Non-tariff Trade Measures: Economic Impacts on New Zealand's Forest Industry

James TURNER*, Frances MAPLESDEN, Andres KATZ and Susan BATES

The export potential of New Zealand value-added wood products will not be realised until technical barriers to exports of these products, including product performance requirements, regulatory standards, product certification, and phytosanitary requirements, are understood. This paper reports on research aimed at understanding potential changes in New Zealand's export market environment, the technical barriers and opportunities likely to arise, and the responses required to enable growth for New Zealand's value-added wood products.

Estimates of the magnitude of the production and transportation cost associated with current technical barriers to New Zealand value-added wood products exports were from exporter surveys. Potential trade barriers were determined from future insight analysis, which identified key trends and drivers influencing technical barriers. An economic model of the global forest sector was then used to simulate the benefits to the New Zealand forest industry of removing current and future technical barriers. The greatest benefit to New Zealand exporters would arise from removal of barriers that account for the greatest proportion of production costs, i.e., higher design values and obtaining engineering certificates for prefabricated house exports to Japan. Additional economic benefit would arise from market development coupled with removal of technical barriers, suggesting that efforts in these areas should be aligned to increase their payoff.

Future research will identify and assess the economic benefit of different strategies for overcoming the most significant technical barriers determined from the first stage of the research.

Key words: Non-tariff measures (NTMs), economic impacts, trade, value-added wood products

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5.10 A – Posters

Chemicals and Wood: Parameters of Acceptability

Karen BAYNE* and Shaun KILLERBY

A key requirement for the adoption of bio-based products such as timber is that they are comparable to alternative inorganic products in terms of performance and cost. Yet they often require some form of modification to increase their longevity, given that they are, by their nature, more susceptible to degradation and deterioration. Such modification (chemical or genetic) can reduce the acceptability of new and novel products. This paper summarises the results of a 3-year programme to investigate the social, ethical and environmental parameters of acceptability for existing and transitional technologies that specifically use chemical modification to enhance performance. The programme has used focussed case studies of outdoor decking products, including life cycle assessments of each product, as prompts to explore stakeholder discourses regarding different types and magnitudes of chemical modification. An "acceptability threshold" model is developed that incorporates environmental, social and ethical concerns impacting on the design of next-generation products and technologies.

Preliminary results show that there are six main dimensions upon which technologies are compared, the 'non-negotiable' value being the ability of the resulting product to deliver adequate physical performance for the intended use. Trade-offs then occur across five other values: cost, health and safety, environmental impact, origin and other aspects of social responsibility. Respondents and stakeholder groups vary in the weightings accorded to each of these 'negotiable' values. The existing technology has an advantage, however, in that performance value includes not only tangible aspects such as strength and longevity, but also the intangible aspects of proven ability, established trust, plus branding and iconic associations. New technologies need to be able to prove their worth against these intangible qualities as well if they are to be accepted into the market in the place of either the existing product or an inorganic competitor.

Key words: Chemicals, wood, acceptability

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IAWA B
INTERNATIONAL ACADEMY OF WOOD ANATOMISTS SESSION B

Papers

The Effects of Site Conditions on Wood Biometric Coefficients in Iranian Beech (*Fagus orientalis*, Lipsky)

Ali VARSHOEE*

In this research, the effect of site conditions such as altitude level, slope and edaphic conditions on wood anatomical characteristics in beech tree *(Fagus orientalis.* Lipsky*)* stands were studied. Ten sample trees were collected in each of five sites, across the southern Caspian forest with three different altitude levels (700, 1000 and 1500 m). From each trunk, one sample was collected at breast height and then biometric coefficients of 30 fibers were estimated using Franklin's (1938) method. The effect of site and altitude level on biometric coefficients and density was significant and the relationships were estimated.

Key words: Site conditions, biometric coefficients, Iranian beech, wall thickness, altitude

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Wood Anatomy of *Haloxylon* Sp. (Sistaan Province, South Eastern Iran)

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There are three species of Saxaul (*Haloxylon* sp.) well known to botanists which are widely planted in the desert regions of Iran. Natural durability of wood from this species is expected to be more than ten years making it possible to use for outside construction.

Although Saxaul afforestation had been a part of the national sand dune stabilization programme there is an urgent need to know its anatomical and physical properties.

This research is a part of Saxaul wood research which started in 1991 all over the country. The results indicate a heavy wood containing abundant crystals within the parenchymatous cells responsible for its high brittleness, very thick fibre walls along with live fibres with elongated nuclei. The vulnerability and mesomorphy indexes show a xeromorphic wood which has fibres resistant to the lack of water. Several interesting images along with the complete description of the wood based on IAWA list of features are included.

Key words: Haloxylon, Saxaul, wood anatomy, wood properties

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Pathways for Symplastic and Apoplastic Flow between Secondary Xylem and Cambium

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Xylem is known for the transport of water and nutrients throughout the plant. In addition, evidence suggests that xylem sap contains information molecules necessary for the coordination of growth processes as well as defence reactions. It has been suggested that xylem and phloem may constitute important parts of the communication and signalling network of the plant. However, the communication paths for lateral exchange of solutes between xylem and phloem have only partially been studied. In the secondary stem of woody plants, besides the pathway of rays, the existence of other lateral pathways for sap movement is undetermined.

We attempted to understand how specific cell types may have a role in the apoplastic and symplastic flow between xylem and cambium. The anatomical structure of the interface between xylem and phloem was studied by confocal microscopy, SEM, and microcasting in the angiosperms *Cercidiphyllum japonicum* and *Kalopanax pictus,* and the gymnosperm *Cryptomeria japonica*. The occurrence of xylem cell type and pitting at the xylem/cambium interface as well as the microstructure of pits between adjacent xylem and cambial cells were characterized. The area fractions of pits in tangential walls of tracheary elements at the xylem/cambium interface varied from 3 to 12 % in different species and were in all cases similar to the tangential area fraction of rays. Therefore, we conclude that tracheid and vessel networks play an important role for direct supply of cambium with water. In addition, living xylem cells with secondary walls and pits facing the cambium were visualized at the xylem boundary adjacent to dormant cambium. This suggests that the symplastic connection between xylem and cambium is not exclusively through rays but is also established via living axial vascular cells (xylem parenchyma, living fibres, over-wintering undifferentiated tracheids and vessel elements). We hypothesize that differentiating xylem cells, as well as over-wintering living xylem cells produce positional xylogenic signals and transmit them to adjacent cambial cells via cell wall pits.

Key words: Cambium, xylem structure and conductive function

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The Different Pattern of Cell Death between Ray Parenchyma Cells and Ray Tracheids in Conifers

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Cell death plays an important role in the functions of secondary xylem cells. The research on cell death in xylem cells has proceeded in tracheary elements such as *Zinnia* system, and a lot of information has been accumulated about cellular and molecular mechanisms of cell death. However, there is less information about mechanisms of cell death in other xylem elements such as long-lived ray cells. In conifers, rays are consisted of two different types of cells, namely ray parenchyma cells and ray tracheids. Ray tracheids lose their organelles in current year's xylem. By contrast, ray parenchyma cells remain alive for several years and more. As a result, they have important roles in storage and transport of materials. In addition, ray parenchyma cells are involved in formation of heartwood that strongly influences wood quality. In this study, we compared the pattern of cell death between ray parenchyma cells and ray tracheids in conifers by microscopy.

The differentiation and cell death of ray tracheids occurred successively at almost the same distance from the cambium as the case of longitudinal tracheids. Thus, the cell death of ray tracheids resembled time-dependent programmed cell death that occurs *in vitro* when single mesophyll cells of *Zinnia elegans* differentiate to tracheary elements. On the other hand, in ray parenchyma cells, no successive cell death occurred even within a same radial cell line of a ray. This pattern of cell death was different from that of ray tracheids. In addition, cell death occurred earlier in ray parenchyma cells that are located in the upper and lower cell lines, and make contact with ray tracheids than the others. In ray parenchyma cells that lose their organelles earlier showed difference in the timing of initiation of cell wall thickening, the orientation of microtubules and the amounts of starch and polyphenols from the others. Our observations indicate that positional information is an important factor in the control of the pattern of differentiation, and, thus, of the function of ray parenchyma cells in conifers.

Key words: Cell death, ray parenchyma cell, ray tracheid, xylem differentiation

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IAWA B – Posters

Variation of Fine Structure within a Stem of some Commercial Softwoods in Korea

Dong-Jin EUN, Sung-Min KWON and Nam-Hun KIM*

Radial and vertical variations of relative crystallinity and crystallite width of cellulose within a stem of three softwoods (*Pinus densiflora* S. et Z., *Pinus koraiensis* S. et Z., *Pinus rigida* Mill.) grown in Korea were examined by an X-ray diffraction method.

The degree of crystallinity in earlywood and latewood increased with increasing growth ring from the pith to about 15 years, and then it remained almost constant. The mean of relative crystallinity was 62% in *P. koraiensis*, 59% in *P. densiflora* and 49% in *P. rigida*. In the sample woods, the relative crystallinities of latewood and adult wood were higher than those of earlywood and juvenile wood. The relative crystallinity in adult wood and juvenile wood was 65% and 58% in *P. koraiensis*, 61% and 56% in *P. densiflora* and 55% and 46%in *P. rigida*, respectively.

The crystallite width was 2.8±0.03nm in *P. densiflora*, 2.8±0.6nm in *P. koraiensis* and 3.0±0.03nm in *P.rigida*; there was no significant difference between adult wood and juvenile wood, or between earlywood and latewood.

From the results, it is considered that the relative crystallinity can be used to evaluate the quality difference between adult wood and juvenile wood of some softwoods in Korea.

Key words: X-ray diffraction, relative crystallinity, crystallite width, cellulose, *Pinus densiflora*, *P. koraiensis*, *P. rigida*

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Radial Changes in Cell Structure of Taiwan Red Cypress Plantation Trees

Chih-Ming CHIU* and Cheng-Jung LIN

Conservation ethics and wood resource shortages have stimulated the adaptive development and utilization of plantation trees. Therefore, it is important that sustainable and intensive management of man-made forests through silvicultural manipulations for resources of forest products. Taiwan red cypress (*Chamaecyparis formosensis*) is a good endemic species in Taiwan and effective utilization of the species requires an understanding of its growth and cell properties. Thus, the cell diameter, cell cavity diameter, cell wall thickness, flattening effect, and thickening effect of Taiwan red cypress plantations were investigated in this study.

The results showed that the transversal variation of the ring width increased from pith outwardly to 3-6-year-old and then decreased gradually outwardly to 26-year-old. Then, it irregularly fluctuated to 36-year-old. Finally, it shows little increase and change to the bark. Variation of radial and tangential cell wall thickness within a ring was irregular; however, little change of tangential tracheid diameter in a ring was found. The transition from earlywood to latewood was gradual in juvenile wood but abrupt in mature wood. The transversal variation in cell cavity diameter of earlywood and cell wall thickness of latewood increased from pith outwardly to 20-25-year-old and then remained much more constant. Change of cell structure from earlywood to latewood was influenced by the flattening effect (30-40%) and thickening effect (15-20%).

Key words: Taiwan red cypress plantation, flattening effect, thickening effect, cell diameter, cell wall thickness

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Variation in Fibre Length Distribution in Scots Pine and Norway Spruce

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The fibre length effect on different wood based products makes it interesting to know how the fibre length varies in and between trees.

From ten Norway spruces and ten Scots pines four discs were taken at 1 %, 1.3 m, 30 % and 60 % of tree height. From each disc three samples were taken at different distance from the pith. The samples were macerated in a 1:1 solution of hydrogen peroxide and acetic acid, thereafter three sub samples from each sample were measured with a optical fibre analyzer (Kajaani FiberLab 3.0, Metso Automation OY). During the analysis, pictures of the measured fibres were saved and classified by length. A sample of the pictures was then checked manually to see if the measured values were correct and represented undamaged fibres.

On an average 54 % of the pictures of spruce fibres had caused an incorrect length value. No corresponding value was registered for pine. A deviation quotient was calculated by dividing mean length of the pictures with correct measured fibres with the mean length of the length class. For both spruce and pine the mean deviation quotient were 0.96. That means that the fibres that were correct measured were on average 4 % shorter than the mean for all measured fibres.

Generally the fibre length increased with height in the tree and with the distance from the pith. On an average for the ten trees, the shortest arithmetic fibre length value was 0.94 mm in spruce. The longest value was 1.60 mm. For pine these values were 0.64 and 1.67 mm. There was no correlation between ring width and fibre length. The standard deviation increased with increasing fibre length and was almost as big as the fibre length. The distribution of tracheids was most skewed and had the sharpest peak at stump height.

Key words: Picea abies, optical fibre analyzer, *Pinus sylvestris,* skewness, tracheid

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Pulp & Paper B
PULPING CHEMISTRY AND SPECIALITY CHEMICALS

Papers

Evaluation of Cooking Processes for *Trema orientalis* (Nalita) Pulping

M. Sarwar Jahan*, A. Rubaiyat and R. Sabina

Trema orientalis is one of the fastest growing species in tropical countries. It's chemical and morphological properties support it as a new source of short fibrous raw materials for pulping. Soda, soda-anthraquinone (AQ), kraft, alkaline-sulfite-anthraquinone-methanol (ASAM), acetic acid and formic acid processes have been evaluated for *T. orientalis* pulping. A good pulp yield (46-52 %), strength and optical properties were obtained in all of these processes. The better pulp yield (51.7 %) and kappa number (13.4) were obtained in ASAM process. ASAM pulp showed excellent initial brightness (53.2 %), which indicated better bleachability in subsequent pulp bleaching. The prebleaching of the produced pulps was evaluated by oxygen, peroxyaid and xylanase treatment. The O_2-prebleaching reduced the kappa number 44-53 % depending on pulping process. The O_2-prebleached pulps are bleached in DED and QPP bleaching sequences. ASAM and kraft pulps exhibited better brightness in both bleaching sequences as compared to soda-AQ pulp. The viscosity of bleached pulp obtained from kraft process was lower than that of soda-AQ and ASAM processes. The strength properties of *T. orientalis* pulps obtained from soda, soda- AQ, kraft, and ASAM processes were acceptable. Pulp obtained by formic acid or acetic acid pulping was a very high pulp yield (56 %), but strength properties were inferior. The bleachability of acid pulp in alkaline peroxide bleaching was admirable. The α-cellulose content in formic acid pulp was >94 %, which suggests to further study for dissolving pulp.

Key words: Fast growing wood, ASAM process, pulp yield, delignification, bleachability

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Kenaf Bast Fiber Kraft Pulp; an Alternative Substitution of Softwood Kraft Pulp for Reinforcing High Yield Hardwood Pulps

Hossein RESALATI*, Nafiseh NASERI and Ali GHASEMIAN

A suggested alternative for production of newsprint, in countries without adequate softwood trees including Iran, is to make chemimechanical pulps from local hardwoods and/or non-wood fibers, as a main fiber furnish, which will be further reinforced by imported softwood kraft pulp. However, deficient foreign currency for importing the required softwood pulp, is a real challenge for pulp and paper industries in most of these countries. The present work is an attempt to introduce an alternative potential from local resources, to make chemical pulp with sufficient strengths which can, at least partially, displace imported softwood kraft pulp for making newsprint. In this respect, the potentials of kenaf bast fiber kraft pulp has been compared with imported softwood kraft pulp, to reinforce local mill made mixed hardwoods CMP pulp , at laboratory scale. Unbleached Kenaf bast fiber kraft pulp samples with kappa number of about 20, 25 and 30 at total digester yields of 54.1, 57.2 and 59.5 %, respectively, have been selected and compared with imported unbleached softwood kraft pulp with kappa number of 30.The initial freeness of softwood pulp was higher than kenaf pulps, but the required refining energy to achieve a particular freeness was much higher in case of softwood pulp. The results of trials to determine the appropriate kappa number and freeness have shown that, kenaf pulp at kappa number of 25 at freeness level of 400, and softwood pulp at freeness of 500 ml, CSF were optimum in case of overall paper properties. At optimum pulp freeness and at similar kappa number, hand sheets of softwood pulp had higher density, slightly higher burst and tensile strengths than kenaf pulp, but at much lower tear strength. However, at lower kappa number of 25, kenaf pulp was much superior than softwood pulp in all of these strength properties. In addition, the results of comparative study to evaluate the relative reinforcing power of kenaf and softwood pulp, indicated that the reinforcing power of unbleached kenaf bast fiber kraft pulp to improve mill made mixed hardwood CMP pulp, was higher than imported unbleached softwood kraft pulp, at similar dosage rate.

Key words: Kenaf bast fiber, kraft pulp, Newsprint, Reinforcing power, Imported softwood pulp

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A Study for Industrial Utilization of Acetic Acid Lignin

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Attempts were made to utilize palm oil residues with acetic acid pulping process under atmospheric pressure. Palm oil residues, such as empty fruit bunches, mesocarp fibers, kernel shells, stems, and fronds, are separated in palm oil production process, and mass of them is huge amount. The residues except stems and fronds can be obtained in the premises of palm oil factories. Usually, they are burned to obtain energy for machinery. Empty fruit bunch, herein after called EFB, of the oil palm was digested into pulp and acetic acid lignin, herein after called AL, through the process, since lignin reacted with and dissolved into acetic acid. Oil palm AL showed heat fusion characteristic and dissolved into organic solvents such as acetone and etc, as same manner as other ALs taken from ordinary woods. Board-shaped moldings were prepared from the pulp and the AL from EFB by proper pressurizing at around 170 degree C. Bending strength of the moldings was easily controlled by varying molding pressure and/or temperature or composition ratio between the pulp and the AL. On the other hand, pulp from EFB after treatment with sodium hydroxide was decomposed to glucose at a high conversion rate, through enzymatic process. It was suggested that acetic acid pulp from EFB could be a good raw material of lactic acid or ethanol. Another attempt was made to prove termites repellent or termiticide of the AL. Cedar chips treated with diluted AL showed certain repellency and termiticide effect to suggest a new usage of the AL.

Key words: Palm oil residues, empty fruit bunch, acetic acid lignin, moldings, termiticide

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Utilization of Woody Biomass Components Separated by the Atmospheric Acetic Acid Pulping

Yasumitsu URAKI, Naoki MIYATA and Makoto UBUKATA

The acetic acid pulping was developed as an alternative with low environmental load and low energy consumption to conventional pulpings. Major components of agricultural waste were quantitatively separated as well as those of softwood and hardwood by the pulping.

The resultant pulp as cellulose component was utilized for papermaking and as a resource for bioethanol. A water-soluble fraction in the waste liquor of the pulping was found to contain antibacterial materials that were probably originated from acid-soluble lignin and extractives. A hemicellulose component was recovered as a mixture of monosaccharides from the water-soluble fraction after removal of the bioactive materials. Those were further converted to carbon source for bacterial cellulose production by chemical and enzymatic modifications.

A lignin component was obtained as a water-insoluble fraction. The isolated lignin showed several unique properties. One of them is fusion property. Therefore, the lignin could be converted to fibers by fusion spinning, and further to carbon fibers and activated carbon fibers. In addition, the property enabled the lignin to be used as a hot-melt type of adhesive for fiber board production.

The other lignins isolated from cedar and oil palm waste after oil extraction by the pulping were found to have weak termite-repellent activity in addition to fusibility. Therefore, a novel type of fiberboard with environmental friend and high durability would be produced by using such the lignin as an adhesive.
Key words: Atmospheric acetic acid pulping, environmentally-friendly fiberboard, Fusiblity, Sepaprtion of woody biomass components

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5.01.02
NATURAL VARIATIONS IN WOOD QUALITY

Papers

Impact of Intensive Forest Management on Wood and Lumber Properties in the S-P-F Species of Eastern Canada

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The potential shortage of sawlogs is emerging as a constraint to the growth and prosperity of the lumber industry in eastern Canada. To sustain quality sawlog supply, the forest industry is intensifying forest management. While intensive forest management (IFM) generally accelerates the diameter growth of individual trees, little research has quantified their effects on wood and end-product quality in major commercial species of eastern Canada. In recent years, a series of studies have been undertaken by Forintek to quantify the impact of IFM on the forest-wood value chain including wood and lumber properties in the three most important commercial species in eastern Canada. In addition, we have also examined the possibility of improving lumber grade and properties through optimal log breakdown.

These studies show that with increasing tree spacing (or decreasing stand density), stem taper, crown size and branch diameter tend to increase, and consequently both wood and lumber properties are negatively affected. The magnitude of the negative effect, however, depends on several factors (e.g., time of density regulation, thinning intensity, species). In general, the earlier stand density regulation starts, the more significant impact on wood and lumber properties it will have. Heavy thinning has significant effects on lumber properties; the negative impact in jack pine is more significant than in black spruce and balsam fir; density regulation at early stages (e.g., initial planting, PCT) has more significant effect than at later stage (e.g. CT). A preliminary study indicates that it is possible to increase lumber bending properties and MSR yield through alternative log breakdown based on internal defects. Further studies with CT technology are under way.

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Fundamental Factors Responsible for the Colour of Radiata Pine Wood

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The colour of the wood in radiata pine has large variations due to natural factors and also wood processing treatments. Few studies have been done on the colour of fresh, green wood. In this study, the specific light absorption coefficient, k, and the specific light scattering coefficient, s, constitute a colour system that is based on Kubelka-Munk's theory which was used to investigate the inherent wood colour caused by wood properties rather than other wood processing or environmental factors.

An experimental design including five experimental factors (sites, discs, heartwood/sapwood, compression wood/normal wood, earlywood/latewood) was designed for investigation of the influence of lignin and wood structural properties on colour. Six wood structural properties (density, specific surface area, cell wall thickness, coarseness, radial and tangential tracheid diameter) were measured using Silviscan analysis. The effects of extractives, moisture, temperature and sample surface texture were measured and kept constant for statistical experiments. Samples were minimized to the microtome level (10 mm x 10 mm x 100 μm) to improve homogeneity. Blue light at 457 nm was selected to be the most suitable wavelength to measure brightness, k and s. Due to the small sample mass of microtomes, lignin was analyzed using acetyl bromide instead of the more standard Klason lignin analytical method. The significance of the effect of each wood property on colour parameters was then analyzed in a statistically designed experiment.

The results of this study were statistically analyzed and were supportive of a significant relationship (1 % level) between k and lignin, and between s and density. A multiple regression model with two variables was established with the dependent variable being brightness and the independent variables being k and density. The correlation between all variables was analyzed. The significance of variance of all variables in the experimental factors also was analyzed using a SAS package. A density-brightness prediction model was established based on the non-significant variance of k between sites. Further work could be done on a colour-wood property prediction model based on the results in this study.

A two-variable model (brightness as a function of specific light absorption and scattering coefficients k and s) can be simplified and applied to predict the colour of radiata pine. This study has shown that the colour of wood can be predicted from knowledge of wood structural properties based on their relationships to k and s as determined. While k can be derived for a wood through its relationship with brightness and s, s itself can be substituted by density, with which it has a very strong correlation. When k is relatively constant, brightness can be substituted by density through s. A second colour criterion, contrast ratio, was defined to quantify the impact of the proportion of latewood on the brightness of wood.

Key words: Colour, radiata pine, light absorption and scattering

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Wood Variation in *Pinus kesiya* of Khasihills in India

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Wood is very variable substance with differences occurring among species and genera, among geographic sources within a species, among trees within a geographic source as well as within each individual tree. Tree to tree variability is especially large with differences within a species often being strongly genetically influenced. Such variability in wood of *Pinus kesiya* is so conspicuous in khasihills of the Meghalaya state that not only local people of the region but forest officials of the state claimed the occurrence of two different species of pine altogether in the region. The more sought after is red pine, which is characterized by red colour of the wood; the other is white pine having white wood.

To investigate the wood variation in the species, samples of wood were collected from so-called red pine and from white pine (khasipine) trees growing in Khasihills and analyzed in Wood Anatomy Laboratory of the Institute. All the wood samples belong to *P. kesiya* (khasipine) and none of them was found to be of red pine (neither *Pinus resinosa* nor *P. densiflora*). However, variation in specific gravity in wood samples was observed- it ranges from 0.42 to 0.55 and 0.55 to 0.68 for so- called white pine and red pine, respectively. Though the age of wood samples is the same but the variation in colour and specific gravity contributes to tree-to-tree variability, ratio of early wood/late wood and deposition of resinous & phenolic compounds in the wood.

The wood variations present in the species provide an advantage to the foresters for developing better wood quality, especially since inheritance patterns of wood properties are usually strong and silvicultural practices can also influence the wood properties. As there is a variation in wood properties within trees of *P. kesiya* in khasihills and some of the trees exhibit to have very good quality wood, hence, efforts should be made to propagate such trees in future plantation programmes for high quality wood production.

Key words: Wood, properties, variation, *Pinus kesiya*

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Intra-tree Variability of Cleavage Resistance of Chinese Fir and I -214 Poplar from Plantation

Haiqing REN and Ming XU

Chinese fir (*Cunninghamia lanceolata*) and I -214 poplar (*populus*×*canadensis* cv.'I -214') are important timber spieces in China, the lumber used mainly for commercial construction. It is also widely used in the furniture, bridge and ship building, and is an important raw material for high quality paper. Many studies have described the mechanical properties of Chinese fir, focusing on density, MOR, MOE, compressive strength, but few have investigated cleavage resistance. This is an important property influencing mechanical properties. This paper reports on the variation of resistance of Chinese fir and I -214 poplar.

Six trees each of Chinese fir (36 years old from Dagangshan, Jiangxi Province), and I-214 poplar (15 years old from Zhangbaotun Woodland of Liaoning Province) were collected by Shanxia Forestry Center. Cleavage resistance properties were measured on 672 samples and 584 samples, respectively. The small clear wood samples were cut according to the National Standards the Testing Methods for Physical and Mechanical Properties of Wood (GB1927 to 1943–1991) to represent sapwood and heartwood from different directions (south and north) and heights (1.3, 3.3, 5.3 and 7.3 m) within the trees.

The result showed that the tangential cleavage resistance values of both species were higher than radial, and that cleavage resistance of sapwood was higher than that of heartwood. In Chinese fir there was no significant difference in cleavage resistance between north and the south directions and there was a little variation in cleavage resistance ration between radial and tangential values from butt to top, which shows a small decrease with height from 1.3 to 5.3 m, then a rise in the top of tree. ANOVA analysis showed that radial cleavage resistance did not differ significantly (at 0.05 level) with height, while there was a statistically significant difference in tangential cleavage resistance with height. In poplar there was a statistically significant variation in cleavage resistance between the radial and tangential from butt to top, which shows a little decrease with tree height from 1.3 to 5.3 m, then similar values in the top of tree. Juvenile wood content, thinning and condition of local growth all affect the cleavage resistance.

Key words: Chinese Fir, I -214 poplar, plantation, variations, cleavage resistance

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The Effect of Different Soil Texture on Wood Properties of *Populus×euramericana cv.'74/76'*

Rongjun ZHAO*, Benhua FEI, Bo ZHANG, Li ZHANG and Jinmei XU

The wood anatomical characteristics, chemical compositions and physical and mechanical properties of the Populus×euramericana cv.'74/76' were measured and analyzed to investigate the influence of different soil texture on the properties of wood. Results showed that different soil texture had significant effects on the cell wall thickness and cell lumen, but wasn't on the fiber length and microfibril angle .The two soil texture had no obvious effect on papermaking, although the lower fiber length and higher cellulose content of sandy soil. Moreover, there are no significant differences between modulus of elasticity in bending and density. The average growth quantities of each year were consistent in two kinds of soil texture. By means of analyzing systematically, the results showed that the Populus×euramericana cv.'74/76' was good papermaking material for fast growth and strong adaptiveness.

Key words: Soil texture, 107 Poplar, anatomical characteristics, Chemical compositions, physical and mechanical properties

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An Investigation on Variations of some of the Physical and Biometrical Properties of Planted *Acer Velutinum* in the Longitudinal Direction in North of Iran

Habibollah KHADEMI-ESLAM*

In the present study, the physical properties of planted Maple wood (*Acer velutinum*) and its variation at three different heights (which were; at breast (1.3m), middle of trunk (5m) and under the crown (10m) was measured and analyzed according to ASTM-D143 specification. To fulfill this study, three planted maple trees from the North of Iran were selected and felled. The specimens were prepared from tree discs at the longitudinal direction in order to measured physical and biometrical properties. The properties such as density, moisture content, porosity, dimensional changes, fiber length etc. were measured.

Results indicate that at first, there would be some increase in the oven dry density (0.54 g/cm3), green moisture content (57%), porosity (64%), dimensional changes like volumetric shrinkage, swelling (15%) and MC (13%) and some decrease accordingly in the longitudinal direction of the trees. With regard to the measured fiber length of 947 microns (781 microns near the pith and 1113 microns near the bark), this could be demonstrated that there are some regular decrease, regular increase and irregular increase in the longitudinal direction of the trees, respectively.

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5.02 C
MEAUREMENT METHODS INCLUDING NDT A

Papers

A Comparison of Three Methods for Determining Young's Modulus of Wood

Chih-Lung CHO*

Young's modulus of China fir, Taiwan red cypress, Taiwan yellow cypress, Japanese cedar, and camphor wood was investigated in this study. These wood species are most typical for wood members of historic buildings in Taiwan. A discussion of apparent and true Young's moduli obtained from the longitudinal and complex vibrations tests and a comparison of these results with tests of the same specimens by the static bending method is presented. A simultaneous determination of the shear modulus (G) of test specimens was obtained by complex vibrations of bending and twisting method.

Results showed that the longitudinal vibration method yielded highest values of apparent Young's modulus and those from static bending method were the lowest. The absolute values of relative percentage differences between E_b (apparent Young's modulus obtained by complex vibrations of bending and twisting) and E_s (apparent Young's modulus obtained by static bending test) increased with the increase in E_b/G values. Based on Timoshenko beam theory and Hearmon approximate solution method, taking rotatory inertia and shear deformation into account, it was observed that a very high correlation (R^2= 0.999) existed between the true Young's modulus obtained from complex vibrations and static bending test respectively. With a tendency for the dynamic measurements were approximately 3% on average higher than static measurements. Both the accuracy of apparent Young's modulus obtained from complex vibrations and static bending tests were improved as the E-to-G ratios decreased and this parameter could be used as guidelines for expected accuracy of apparent Young's modulus corresponding to testing methods.

Key words: Young's modulus, shear modulus, vibration test, static bending test, timoshenko beam theory.

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Estimation of Wood Mechanical Properties by near Infrared (NIR) Spectroscopy

YU Huaqiang, ZHAO Rongjun, FEI Benhua, FU Feng and JIANG Zehui

The visible and near infrared (NIR) (500~2400 nm) spectra, and both the modulus of elasticity (MOE) and modulus of rupture (MOR) of 438 small clear wood samples from 3 species: *Chinese fir (Cunninghamia Lanceolata),* eucalyptus *(E.urophylla×E.grandis*), and poplar 72 (*Populus×euramericana* cv. I - 72/58) were measured. Using partial least-square (PLS) modeling, the NIR spectra could be used to predict MOE and MOR of the clear-wood samples from Chinese fir and Eucalyptus solid wood. For poplar NIR spectra could only be used to predict MOE but not MOR. With the exception of MOR of poplar the correlations between NIR and the mechanical properties were very significant, and the calibration and test correlation coefficients are both above 0.80.

Key words: Chinese fir, Eucalyptus, poplar, MOE, MOR, NIR, Partial least-square

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Bark Measurements with X-ray Technology

Rafael BAUMGARTNER, Udo Hans SAUTER and Jörg STAUDENMAIER

The automatic measurement of log dimensions at the entrance of mid and large scale saw mills in Germany and other countries in Central Europe is successful established since many years. The scanner technology measures the dimensions of the logs at the debarked surface precisely. On this basis the wood volume is calculated without bark as reference for the payment of the resource delivered by the forest owners. The use of this method in saw mills requires to debark the logs right after the logs reach the wood yard of the mill due to the requested payment after short time. For some wood species and during the summer months it can be critical to store debarked logs because of quickly developing discolorations caused by blue stain, cracks and sometimes insect damages. One possibility to deal with these problems of debarking is to measure the logs over bark and subtract a bark estimation from a fixed table afterwards. This does not require a debarking but on the other hand leads to a loss of precision because of the inhomogeneity of bark thickness.

With the use of an automatic detection and measuring of the bark it is possible to control and update the discounts in the bark tables, but more importantly to measure the real volume of the wood at mill site without debarking.
This investigation focuses on the increase of precision of bark measurements for Norway spruce (picea abies) logs with x-ray technology. The used mechanical data was recorded by an industrial scanner with two x-ray sources and algorithms to detect the bark were developed. The manual measurements used for comparison were obtained at four points around the log each at the butt end, the middle, and the top end of the logs.

Key words: Bark, x-ray, Norway spruce

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5.02 C – Posters

Predicting the Hygroscopic Warping of Solid-Wood Plate by Finite Element Analysis

Yiren WANG and Shih-Hao LEE

Warping, defined as the out-of plane deformation of an initially flat plane and caused by built-in force imbalances in hygroscopic material, is a severe issue for wood. The warping of solid wood in response to the moisture gradient, assuming the laminas respond elastically to the developing forces, is modeled by finite element in this study.

A three-dimensional finite element (FE) analysis was applied to predict the hygroscopic warping of orthotropic solid-wood plate. The model and simulation results are presented. The effects of model parameters such as thickness, modulus of elasticity, Poisson's ratio, and shear modulus on the amount of warping were investigated. The results offer a better insight into solid-wood warping.

Key words: Finite element analysis, orthotropy, warp, hygroscopy

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Effect of Hygroscopic Swelling on Push Load of Wood Dowel Joint

Wen-Ching SU and Yiren WANG

Dowel is a popular connector in the wooden furniture but is likely to deform due to moisture change. When a dowel joint is placed in a humid environment, the joint assembly will experience hygroscopic swelling. Due to anisotropic nature of wood, the hygroscopic swelling results in unevenly distributed normal stress on contact surface. Different ring angles of dowel with respect to the grain of wood member would result in different distribution of normal stress after hygroscopic swelling and then affects the withdrawal strength of dowel joint. If the effect of hygroscopic swelling on the withdrawal strength caused by various ring angles could be quantified, the maximum withdrawal strength might be obtained by adjusting the ring angle of dowel.

The push loads of simplified dowel joints which were consisted of dowel and hole member were tested to study the effects of dowel diameter (8, 10 and 12 mm), board type of hole member (flatsawn board and quartersawn board), wood species (maple and oak) and ring angle (0¢X, 45¢X and 90¢X). Besides, finite element method was applied to reveal the stress distribution between dowel and hole member after hygroscopic swelling and to predict the push load. The results were as follows:

1. The push load linearly increased with the increase of dowel diameter, but the push loads per unit area was a constant.
2. The push load was higher after hydroscopic swelling.
3. The push loads of specimens with 90¢X ring angle with respect to the longitudinal direction of hole member were higher than those with 0¢X and 45¢X ring angle.
4. The push loads of maple and oak do not differ significantly.
5. The push load of quartersawn hole member was higher than that of flatsawn hole member.
6. Deformations of wood due to moisture change could be accurately predicated by finite element method in cooperation with orthotropic material properties.
7. The difference between the predicted push loads of simplified dowel joints by finite element method and the measured ones were between -5.29% to 11.72%.

Key words: Dowels, ring angle, push load, push load, dowel joint

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Mechanical Properties of Structural Lumber Produced from Thinned Logs of Japanese Cedar Grown in Taiwan

Chih-Lung CHO, Li-Chwen LIN, Jiunn-Haur CHEN and Huey-Lan WANG

The Japanese cedar (*Cryptomeria japonica*) specimens of this study were from the thinned logs harvested by Luodong forest management district office in 2005. Thinned logs with 3.6m bucking length and with diameter at top end of 15, 20, 25, 30, 35cm were chosen as test materials. Fifteen logs were randomly selected for each diameter class. Test specimens of structural use lumber with dimension of 3.8×8.9× 360cm were produced from each log. The moisture content of lumber was about 19%.

Results indicated that the dynamic modulus of elasticity (DMOE) obtained by longitudinal and flexural vibration method tended to decrease with increasing diameter. The longitudinal DMOE, flatwise DMOE and edgewise DMOE of lumbers from 15cm diameter class logs were respectively 33%, 32%, 46% higher than those from 35cm diameter class logs. There was a significantly linear relationship between longitudinal DMOE and flatwise DMOE or edgewise DMOE. According to this result, longitudinal vibration technique is more suitable used for on-line lumber stress grading operation system.

Machine stress rated lumber of Japanese cedar was established by using linear relationship between dynamic modulus of elasticity and bending strength. The corresponding allowable bending stress of E5, E7, E9, E11, E13 grade were 11.65MPa, 14.26MPa, 17.23MPa, 20.57MPa and 22.08MPa, respectively. The allowable bending stress of structural grade, common grade and utility grade of Japanese cedar visual grade lumber, according to procedure of Chinese National Standard (CNS) 14631, were 15.57MPa, 12.17MPa and 12.13Mpa, respectively.

Key words: Japanese cedar thinned wood, machine stress grade, lumber recovery, vibration test, dynamic modulus of elasticity

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Understanding the Dynamic Viscoelastic Properties of Drying Treated Wood

Jiali JIANG and Jianxiong LU

Wood, as one of the most important biomaterials, is a bio-composite consisting of three structural components: cellulose, hemicellulose and lignin. However, during drying process, wood may undergo changes in mechanical properties, though the speed and cause of these changes vary among drying treatments.

The main goal of this study was to analyze the effect of drying treatments, that is, high temperature drying (HT), low temperature drying (LT) and freeze vacuum drying (FV) on the dynamic viscoelastic properties of Chinese fir [*Cunninghamia Lanceolata* (Lamb.) Hook] plantation wood. Storage modulus (E') and loss modulus (E'') were measured along the radial direction using a Dynamic Mechanical Analysis (DMA). The DMA tests were performed over a temperature range of -120 to 250°C at five different frequencies (0.5, 1, 2, 5, 10Hz) and at a heating rate of 2°C/min. The activation energy of the various drying treated wood was calculated using an Arrhenius relationship. The results indicated that the storage modulus and loss modulus were the highest for HT-treated wood and the lowest for FV-treated wood. Three mechanical relaxation processes were detected in the HT- and LT-treated wood. They were attributed to the micro-Brownian motion of the cell wall polymer in the non-crystalline region, the torsional oscillations of the cell wall polymer, and the motions of the methylol groups of the cell wall polymer in the non-crystalline region in the order of the decreasing temperature at which they occurred. However, for the treatment with freeze vacuum drying, four mechanical relaxation processes were observed. This newly added relaxation was attributed to the micro-Brownian motions of the lignin molecules. This study suggested that both HT and LT drying treatments restricted the micro-Brownian motion of the lignin to some extent by the crosslinking of chains due to the heating history.

Key words: Drying treated wood, dynamic viscoelastic properties, mechanical relaxation, micro-Brownian motion, activation energy

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Effects of Machine Grading Methods on Dimension Lumber

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From felling to grading, there are many factors influence on final grade distribution of dimension lumber. Grade is one of indices in which wood managers are most interested because lumber price is depended on it. Lots of researchers conducted studies on application of bending, ultrasonic wave, and transversal vibration methods on grading of dimension lumber. However, the effects of these methods are still a problem. To solve the above, logs of Chinese fir plantation from Anhui, Hunan, and Sichuan provinces of China were selected. These logs will were cut into the dimension lumbers of 45mm by 90mm required in Chinese wood design codes and dried to the moisture of 12%. Then they were graded by bending, ultrasonic wave, and transversal vibration method respectively. After grading, the dimension lumbers were conducted bending and compression test. Cumulative probabilities of bending and compression strength at each grade were calculated. In accordance with the statistical method, characteristic values of bending and compression strength at each grade were obtained. Compared characteristic value changes at each grade for each method, the effects of their grading methods on the grade distribution of dimension lumber will be discussed. The characteristic value table for grading of Chinese fir dimension lumber will be given.

Key words: Machine grading method, dimension lumber, design code

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Investigation on Sound-Scattering Performance of the Wooden Interior Decoration Materials

F. M. LIN, M. H. SHEN and J. H. FONG

The sound scattering property of decorative material is an important factor for a building acoustics design. An approximately ideal diffuse sound field may be obtained a highly acoustics scattering in the indoor space. In this research all the measurement processes are following ISO1749-1:2004 method.

The research will focus on the sound-scattering properties of the wood based materials. However, the surface properties of the coating conditions and the shape affect the acoustics scattering property of the materials will be studying. Furthermore, the random-incidence scattering coefficient of the materials will be serviceable in room acoustics simulation and prediction.

Key words: Wood based scattering materials, scattering coefficient

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5.03-IRG B
FUNGAL DEGRADATION OF WOOD II

Papers

Antifungal Activity and Synergistic Effect of Cinnamaldehyde Combined with Antioxidants against Wood Decay Fungi

Fu-Lan HSU, Tsair-Bor YEN, Hui- Ting CHANG and Shang-Tzen CHANG*

A major problem of the wood preservatives such as creosote, pentachlorophenol and inorganic arsenicals is that they pose a serious threat to the environment. Because of this, environmentally benign organic preservatives for wood are urgently needed. The objective of this study was to investigate the possibility of using antioxidant alone or with natural biocides such as cinnamaldehyde as a preservative against wood decay fungi. Antifungal activities of six antioxidants, propyl gallate, octyl gallate, butylated hydroxyltoluene (BHT), quercetin, eugenol and catechin were tested against various wood decay fungi. Octyl gallate and eugenol was found to be the only two antioxidants processed antifungal activities. IC_{50} values of octyl gallate were 0.47, 0.16, 0.24 and 0.04 mM against *L. betulina, T. versicolor, G. trabeum and L. sulphureus*, respectively. The IC_{50} values of eugenol were 0.37 and 0.25 mM against *L. betulina* and *L. sulphureus*, respectively. The synergistic effects were also found on the combinations of octyl gallate-cinnamaldehyde and eugenol-cinnamaldehyde. The combination of either using octyl gallate with cinnamaldehyde or eugenol with cinnamaldehyde greatly lowered the concentrations to achieve the inhibitory effect that a higher concentration was needed by octyl gallate, eugenol or cinnamaldehyde alone. The antifungal action of octyl gallate could be attributed to its pyrogallol group functioning as an attached moiety to the hydrophilic portion of the membrane surface and the octyl moiety interfering with the hydrophobic interior surfaces of the membrane. Meanwhile, the synergism of cinnamaldehyde with octyl gallate or eugenol could be due to the interference of fungal cell wall synthesis and destruction on cell wall and membrane plus the additional radical scavenging effect. Results also suggested that antioxidant with fungicidal effect might be a better candidate than pure antioxidant for the system of fungicide/antioxidant.

Key words: Antifungal activity, antioxidants, cinnamaldehyde, synergistic effect, wood decay fungi

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Detection of Anti-Microbial Sapwood Extractives in Non-Durable Scots Pine (*Pinus sylvestris*), Rubberwood (*Hevea brasiliensis*) and Jelutong (*Dyera costulata*)

Andrew H.H. WONG* and Raymond B. PEARCE

A general laboratory bioassay method of Woodward and Pearce (1985) was adopted to detect antifungal activity of sapwood or heartwood extractives of 5 Malaysian hardwoods [dark red meranti heartwood (*Shorea* spp.), red balau heartwood (*Shorea* spp.), kulim heartwood (*Scorodocarpus borneensis*), jelutong sapwood (*Dyera costulata*) and rubberwood sapwood (*Hevea brasiliensis*), including the temperate *Pinus sylvestris* (Scots pine sapwood). The heartwoods of these species are known to be highly resistant to decay by soft-rotting Ascomycetes and Deuteromycetes (about 1% wood mass loss), while the sapwoods of rubberwood, jelutong and Scots pine had much reduced soft rot resistance, respectively 35, 32 and 7% wood mass loss. Crude methanol extracts of woodmeal samples of each wood species were loaded on to thin-layer chromatography plates at between 0.003 and 0.1 g fresh mass equivalent of woodmeal per spot so as to optimize resolution of separated compounds,. and developed with chloroform:methanol solvent (ratio 19:1). The dried plates were sprayed with fresh fungal spores of *Cladosporium cucumerinum* and incubated at >90% RH for 5 days in the dark. Presence of antifungal compounds was revealed by white regions along the solvent transect for each extract of each species where inhibited spore germination and mycelial growth of *C. cucumerinum* occurred. Comparisons of extracts between species and between sapwood and heartwood were noted. Results revealed that several zones of inhibitory activity, indicated by their Rf-values, were clearly visible on chromatographic separations of methanol extracts of these 5 wood species. The inhibitory zones for 2 heartwood extracts (except kulim) did not move from the origin which was also resistant to infection. However inhibition zones were also detected for the sapwoods of rubberwood, jelutong and Scots pine at least against *C. cucumerinum* despite the known soft rot susceptibility of these wood species. The presence of hitherto unidentified antifungal compounds in the sapwoods of these species may elicit some transitory resistance of the wood substrate to fungal infection and onset of decay, though of limited practical significance to its natural wood protection.

Key words: Antifungal bioassay, wood extractives, tropical wood durability, soft rot

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Natural Durability Evaluation of Cypress (*Cupressus sempervirens* L.) Solid Wood and Mixed Heartwood-sapwood Cypress Plywoods

Farshid FARAJI, Marie-France THEVENON*, Nicolas LEMENAGER, Joseph GRIL and Bernard THIBAUT

The goal of this study was to produce plywoods with enhanced natural durability compared to the solid wood from which they were made of in order to upgrade the use of biodiversity. The case of Cypress timber (*Cupressus sempervirens* L) is presented here.

The natural durability of Cypress heartwood and sapwood was determined according to the EN 350-1 towards Basidiomycete fungi (*Coriolus versicolor, Coniophora puteana*) and against termite (*Reticulitermes santonensis*). Different pure and mixed (sapwood-heartwood) Cypress plywoods were laboratory made and their natural durability was also evaluated using the guidelines of XP ENV12038 and EN117.

The biological resistance of both wooden materials are compared. Moreover, for the plywoods, the influence of plies thickness (2.6 mm and 1.3 mm), number of glue lines (melamine-urea-formol resin), percentage of heartwood plies integrated to sapwood plies in the mixed plywood (0%, 40%, 60%, 100%) and finally the way of integration of durable plies (heartwood) into non-durable plies (sapwood) has been evaluated.

Key words: *Cupressus sempervirens* L., Natural durability, Solid wood, Plywood, fungi, termites

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Fire Safety of Wood Floor Assembly: Model and Full-scale Test

Hisa TAKEDA*

A computer model has been developed to estimate fire safety performance of wood floor assembly. The floor assembly considered in this study is 2x8, 2x10 or 2x12 wood joists lined by gypsum board as a ceiling membrane and ply-wood (or OSB) as a sub-floor. The model includes the heat transfer model to calculate the flow of heat in the floor assembly when the ceiling is exposed to fire and the structural model to estimate the mechanical strength of the floor when the floor is loaded. And, the present study demonstrates the data from the full-scale fire endurance tests of floor assembly, comparing to the results from the theoretical model. The study shows that three important factors should be considered for the fire safety of floor assembly: first one is the fire resistance of the gypsum board (ceiling), second is the structural performance of wood joists and third factor is the sub-floor strength. The present paper describes each factor in detail and discusses the total aspect of fire safety performance of wood floor assembly.

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Effect of *Cinnamomum kanehirae* Extractives on the Compositions of the Fermentation Broth of *Antrodia cinnamonea*

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The fruiting body of *Antrodia cinnamomea*, called niu-chang-chih, is well known and highly prized in Taiwan as a folk medicine. This fungus is endemic to Taiwan and is restricted to grow on the inner heartwood cavities of another endemic tree species, *Cinnamomum kanehirae*. The fungal basidiomes have been used for treating food and drug intoxidation, diarrhea, abdominal pain, hypertension, skin itches and cancers. The purpose of this study was to investigate the effect of different *C. kanekirae* extractives on the fungal mycelium production. The heartwood was extracted using 70% ethanol, and then liquid-liquid partitions using n-hexane, ethyl acetate, n-butanol and distilled water were carried out respectively. The effects of treating the fermentation broths with different *C. kanehirae* extractives on the fungal biomass, antioxidant scavenging activity using 1,1-diphyenyl-2-picrylhydrazyl (DPPH) were examined, and the compositions of the fermentation broth were monitored using high-performance liquid chromatography analysis. The results indicate that *C. kanehirae* extractives treated fungal broths had higher growth promotional effect on their biomass then that of the control (0.0313 g). The hexane fraction treated mycelia showed the greatest dry mass (0.0480 g), followed by ethyl acetate fraction (0.0333 g). The *C. kanehirae* extractives were effective DPPH free radical scavengers which masked the antioxidant effect of the fungal broth. The active fungal ingredient, dehydroeburicoic acid was found by HPLC to increase with the addition of *C. kanehirae* extractive fractions.

Key words: *Androdia cinnamomea, Cinnamomum kanehirae,* dehydroeburicoic acid

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Construction of an ITS Sequence Database for the Identification and Classification of Wood Rot Fungi

Sakae HORISAWA*, Yoichi HONDA, Shuji ITAKURA and Shuichi DOI

Developing a database that contains information about wood rot fungi is important in improving technologies about wood preservation as well as advances in understanding wood decay. On the other hand, with rapid spread of the Internet, establishment of a system for the swift precise access to information are required for the computerization of the research information. In the present study, genetic information of the wood rot fungi was analyzed for the construction of the database.

The indoor fungi were selected from the fungal collection which is stored in the Deterioration Organisms Laboratory, The Research Institute for Sustainable Humanosphere (RISH), Kyoto University. Genome DNA was extracted from each isolate, and then the internal transcribed spacer (ITS) region was amplified by PCR using universal primer pair. The amplified DNA fragment was sequenced and was checked on the existing database such as GenBank in order to identify fungal species.

Key words: Wood rot fungi, ITS, database

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Genome-wide Survey of Cellulase Related Gene of White Rot Fungus, *Pleurotus ostreatus*

Tomoyuki TAMENORI and Sakae HORISAWA*

White rot fungus, Pleurotus ostreatus, which is important edible mushroom for cultivation, has been paid much attention from a standpoint of bioremediation and bioconversion because it has both of cellulase and ligninase. In the present study, we attempted to survey of cellulase related genes in *P. ostreatus* genome by Southern hybridization. The draft genome sequence and a large quantity of EST and cDNA information are now available for the white rot fungus, *Phanerochaete crysosporium*. Genome-wide studies of *P. ostreatus* will provide an experimental system to explore molecular mechanisms underlying wood decay.

Key words: Cellulase, genome, *Pleurotus ostreatus*

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Floral Changes of Wood-relating Fungi in the Crawl Space of a New Wooden Japanese House

Aya TOYOUMI*, Sakae HORISAWA, Tsuyoshi YOSHIMURA, Yuji IMAMURA and Shuichi DOI

In order to establish novel preventive measures against damage of wooden houses by decay fungi with less-use or no-use of chemicals, we periodically monitored the fungal flora in the crawl space of a new wooden Japanese house build with recyclable and low-environmental load materials at the Research Institute for Sustainable Humanosphere, Kyoto University.

We employed either a layer of concrete or just soil as the foundation system of the crawl space of the model Japanese house. Moisture content of Sugi foundation timbers and temperature & humidity of the crawl space with different foundation systems were measured as well as the sampling of fungi by the following methods: a) from the crawl space atmosphere with a PDA plate, b) from foundation timbers with a soft transparent plastic tape, and c) from small wood blocks laid on a layer of concrete or on soil.

Numbers of mould colonies grown from the concrete foundation samples were significantly lower than those from the soil foundation samples. Although the identification has not been finished yet, numbers of basidiomycetes isolated from the concrete foundation samples were lower as well. These results clearly indicate the close relationship between the risk from wood decay and the foundation system in wooden Japanese houses.

Key words: Wood-relating fungi, moisture content, crawl space environment, foundation system

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ADHESIVES AND GLUING SESSION

Papers

Study upon the Gluing Shearing Strength of some Adhesive Compounds based on Lignin and Mixed Furan Resin with Furfurylic Alcohol of FC-2 URELIT Type

Valeriu PETROVICI*, Anca Maria VARODI and Emilia-Adela SALCA

Within this paper the authors present the results of their own research studies performed at the laboratory phase, regarding the gluing shearing strength of some adhesive compounds based on lignin and mixed furan resin with furfurylic alcohol of FC-2 URELIT type, which are stipulated to be used for the solid wood gluing at the environment temperature. They are prevalently used just as binder for the mixtures preparation in foundries and constructions as well.

This resin is manufactured nowadays in Romania and it is exclusively used for the abrasive materials fixation on different supports by cure at 40ºC temperature. In this case the lignin is used as filling-plasticizing material.

The study was performed by using a 5% constant addition part of IR catalyst and the ammonium chloride, both in solid state and aqueous solution with the concentrations of about 20 and 25%. The optimal 5% addition part of catalyst was practically resulted after some preliminary cure experiments of the mixed furan resins with the furfurylic alcohol of URELIT FC-2 type at 20ºC temperature. This led through a gelation time of about 45 minutes.

Within the framework of this paper the authors present the components of some adhesive compositions as well as their physical-chemical characteristics in comparison with the ones of a control sample adhesive based on the urea-formaldehyde resin of URELIT R type. This is the only urea resin used nowadays in Romania for gluing the solid wood at the environment temperature.

The study results regarding the use of these adhesive compositions for gluing some beech samples, under the same pressing schedule parameters highlighted that, in this case, the values of the gluing shearing strength in dry state were over 50% higher when they were calculated for the same specific consumption of the oven-dry applied adhesive. After their water immersion for 24 hours long at 20ºC temperature these values were over 25% higher. It was noticed in the mean time the possibility of achieving the adhesive specific consumption less 35-45% as well as the working specific pressure less 40%.

Key words: Furan resin, furfurylic alcohol, lignin, gluing shearing strength

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Bonding Performance of Tropical Fast-growing Wood Species - Bondability of Six Indonesian Wood Species in Relation with Density and Wettability

Eka Mulya ALAMSYAH*, Masaaki YAMADA and Kinji TAKI

To estimate the potential bonding performance of bonded wood products from the tropical fast-growing wood species, a study on the bondability of six Indonesian wood species has been conducted. The former were *Paraserianthes falcataria* (0.34g/cm^3), *Pinus merkusii* (0.59g/cm^3) and *Acacia mangium* (0.64g/cm^3), and the later were *Lesianthus pruverulens* (0.30g/cm^3), *Toona sinensis* (0.52g/cm^3) and *Gmelina arborea* (0.51g/cm^3). Two-ply laminations were produced using PVAc, UF, RF and API adhesives. In order to determine the bonding performance, the block-shear test was applied according to the JAS for structural glued-laminated timber under normal and after accelerated-aging treatments. The bonding performances were classified into four categories of excellent (if bond strength and wood failure were 80 to 100% of its original wood strength and wood failure), good (60 to 79%), bad (40 to 59%), and worst (0 to 39%). Specimens with excellent and good bonding performances are indications of better adhesive penetration and easier bonding. The nature wettability of the wood was performed through the contact-angle measurement on the surface of the wood. The results showed that the bonding performance of *L. pruverulens*, *P. falcataria*, *T. sinensis* and *P. merkusii* was almost distributed in excellent and good categories while the bonding performance of *G. arborea* and *A. mangium* was almost distributed in good, bad and worst categories. As wood density increases, consistent high bond strength with high wood failure percentages were more difficult to achieved particularly in *G. arborea* and *A. mangium*. The smaller contact-angles for *L.pruverulens*, *P. falcataria*, *T. sinensis* and *P. merkusii* suggested that the surfaces were easier to be wetted than that of *G. arborea* and *A. mangium*. It seemed that the good wettablity for *L.pruverulens*, *P. falcataria*, *T. sinensis* and *P. merkusii* allowed adhesives to spread well and make intimate contact with the wood surface. Wood components, probably extracts, appeared to affect the curing of both adhesives for *G. arborea* and *A. mangium*.

Key words: Bondability, Indonesian wood species, density, wettability

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Toluene Emission from Epoxy Resin Adhesive Contained a Slight Amount of Toluene

Junpei HIDA*, Masaaki YAMADA, Kinji TAKI and Masao INOUE

Volatile organic compounds (VOCs) such as toluene emitted from construction adhesives is one of causes on sick building syndrome in Japan. Now, using material safety data sheet (MSDS) information, non-toluene adhesives have widely used, generally. However, MSDS information cannot detect the substances with the concentration less than one percent. In this study, we make two-type specimens which are floor specimens and glass plate specimens using epoxy resin adhesive contained toluene contents of 0.03 and 0.05 percent (EP-0.03 and EP-0.05), and conducted emission test by using small chamber method according to JIS A1901. The results showed that for floor specimens, toluene emission factor of EP-0.05 and EP-0.03 were 1423g/m^{2}h and 662g/m^{2}h in the first day. A large amount of toluene was emitted even if toluene content was a slight amount. Then, toluene emission factor of both EP-0.05 and EP-0.03 has been decreased sharply, and in a seventh day was about a quarter of that in a first day. In a 28th day, they decreased 1/10 of that in a first day. Total amount of toluene emitted from floor specimens by a 28th day were 43 percent of total contents of toluene in EP-0.05 and 29 percent of that in EP-0.03, the ratio of toluene emission increased with the increasing toluene contents. For glass plate specimens, toluene emission factor of EP-0.05 and EP-0.03 were 514g/m^{2}h and 327g/m^{2}h in a first day. Although it was lower than that of floor specimens, toluene emission factor was high. It decreased more sharply than that of floor specimens, and toluene emission factor of both EP-0.03 and EP-0.05 were less than 30g/m^{2}h in a seventh day. Total amount of toluene emitted from glass plate specimens by seventh day were 13 percent of total contents of toluene in EP-0.05 and 16 percent of that in EP-0.03. Although toluene content was increased, the ratio of toluene emission was similar. Therefore, it is considered that there is the persistence for the emission in floor specimens, and large amount of toluene emitted by a first day in glass plate specimens.

Key words: VOCs, toluene, floor, epoxy resin

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Ultrasonic Atomization of Wood Resin-Adhesives

Xuelian ZHANG*, Douglas J. GARDNER and Lech MUSZYNSKI

A novel, patent pending approach to the application of wood resin-adhesives based on the ultrasonic principle was developed in this study. Liquid polymeric diphenylmethane diisocyanate (pMDI) resin-adhesive was successfully atomized using a bench-scale 25 kHz Sono-Tek ultrasonic atomizer. The average droplet sizes of the resin-adhesive droplets generated were around 60 μm to 100 μm and few fine droplets smaller than 50 μm were produced. In addition to a more uniform droplet size distribution than that produced by a conventional spinning disk atomizer, the droplets of pMDI resin-adhesive atomized by the ultrasonic atomizer were more easily and accurately controlled. These results indicate the potential advantages of implementing ultrasonic atomization in OSB production, which would include: 1) elimination of the hazardous fraction of fine resin-adhesive droplets, 2) potentially decreasing ventilation system load, and 3) contributing to potential production cost savings from improved resin efficiency. The ultrasonic atomization of resin-adhesives seems a very promising alternative to the spinning disk atomizer.

Key words: Ultrasonic atomization, pMDI resin-adhesive, droplet size and distribution

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Strength and Long Term Durability of Glued European Beech Timber

Denny OHNESORGE* and Gero BECKER

Over the past years several investigations have been conducted to determine structural properties of European Beech timber. Using European Beech as raw material for glued products for constructions, the glueability is the most relevant aspect one has to be aware of. Melamine-Urea-Formaldehyde (MUF) resin is a very common adhesive for softwood glulam products. Various tests on short term strength of the bonding line showed a good glueability of Beech timber stored under normal climate conditions. However, when varying the wood moisture content, the results are not satisfying anymore. Similar results have been obtained by using delamination tests according to European standards, which are a regular assessment procedure testing structural glues for softwoods. High shrinking and swelling rates of European Beech wood are supposed to cause high strains on the glue line, while wood moisture content changes. This leads to delamination, which does not fulfil required limits. The results are even worse, if the Beech timber contains red heartwood.

This paper presents results of an investigation, which analysed the bonding performance of European Beech glued with a Melamine-Urea-Formaldehyde (MUF). Adhesion tests to assess the bond line performance have been carried out to address relevant differences between “white” (uncoloured) and Beech wood containing red heartwood. In addition delamination tests using different bonding variations have been carried out, with the aim of improving the bond line performance.

Key words: European Beech, glueability, adhesive, delamination, bonding

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Novolak PF Resins Prepared from Liquefied *Cryptomeria Japonica* and used in the Manufacturing of Moldings

Wen-Jau LEE and Yi-Chun CHEN*

The wood of *Cryptomeria Japonica* was liquefied in phenol with sulfuric acid (H_2SO_4) and hydrochloric acid (HCl) as catalysts. The liquefied wood was reacted with formalin to prepare the Novolak type PF resins. The resins were then mixed with wood powder, hexamine and zinc stearate to formulate the glue powder those used for the manufacturing of moldings by hot-pressing. The result from FT-IR showed that the chemical composition of wood was decomposed after liquefaction, and formed the derivative with phenol by the ether bond. The GPC analysis showed that the phenolated wood that liquefied with H_2SO_4 and HCl as catalysts had the weight-average molecular weight of 1298 and 1101, respectively. As the liquefied phonolated wood was mixed with formalin, the exothermic reaction happened, and the gel-like Novolak resins would be form. After dehydration, two kinds of Novolak resin powder i.e. SF and CF had the weight-average molecular weight of 3638 and 3941 respectively and the melt point of 149.4°C and 127.5°C respectively. The DSC thermosetting analysis showed that SF and CF Novolak resins mixing with hexamine as the cross-linking hardener was an exothermic reaction, the temperature at the maximum of exothermic peak was 157.7°C and 143.4°C, respectively. The boards of molding could be made form the glue powder that containing Novolak resins, wood powder, hexamine, and zinc stearate by hot-pressing, their weight retention after acetone dissolve test were over 89.6%. Comparison among the various conditions, using the glue powder of CF had higher weight retention than SF, otherwise increasing the resin rate, prolonging the hot-pressing time or elevating the hot-pressing temperature could all increase the weight retention. The highest internal bonding strength of these molding boards was 15.9 kgf/cm^2, among which using SF were superior to CF, and hot-pressing with 200°C were superior to 180°C. After 36 hours of water immersing, the molding boards had approximately 7.6% of water absorption and 1.3% of thickness swelling.

Key words: *Cryptomeria Japonica*, Liquefied Phenolated wood, Novolak PF resin

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5.04.07 – Posters

The Use of Various Formaldehyde Scavengers in Urea Formaldehyde Resin for Medium Density Fiberboard

Sevda BORAN*, Mustafa USTA and Sedat ONDARAL

Amino resins have been used to bond composite wood products that have a very important role in the wood processing industry, such as in the medium density fiberboard, particleboard and plywood. Urea-formaldehyde (UF) resins are the most well-known amino resins, although they are limited to interior applications because of their poor water stability. In addition, urea formaldehyde resins have many advantages including low cost, ease of use under a wide variety of curing conditions, water solubility, low cure temperatures, resistance to microorganisms and to abrasion, excellent thermal properties, and lack of color, especially of the cured resin when compared with other resins. On the other hand, the main drawback of urea formaldehyde resin is the release formaldehyde into the environment during cure when urea formaldehyde resins are used as a binder component. Formaldehyde emission can constitute a health hazard in enclosed environments, because formaldehyde is a suspected carcinogen and an irritant to the respiratory system. The formaldehyde is malodorous and is thought to cause to human and animal illness. Therefore, the regulatory pressures have existed to reduce or eliminate formaldehyde emissions from wood products, recently. The industry still faces the possibility of more restrictive regulations on formaldehyde in dwellings. The most acceptable method for the industry has been the use of chemical additives called formaldehyde scavengers to reduce formaldehyde emission from urea formaldehyde resins. In this studythe applicability of various formaldehyde scavengers at reducing the levels of released formaldehyde for urea formaldehyde resins will be reported..

Key words: Formaldehyde scavenger, urea formaldehyde resin, adhesive, medium density fiberboard.

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Analysis of Change in ROS Free Radical of *Pinus kesiya* var. *langbianensis* Heartwood Treated with Laccase

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Enzymatic oxidation of lignin phenolic hydroxyl groups can enhance the level of auto adhesion between wood fibers or particles depending upon the bonding mechanism of wood-based materials without synthetic adhesives such as urea- and phenol formaldehyde. Adhesion effect is caused by increased number of reactive oxygen groups at the fiber surface. The parameter of laccase treated wood fibers plays vital roles in generating reactive oxygen species (ROS) free radicals.

Laccase I (extracted from *White-rot fungi*) and laccase II (extracted from *Aspergillus*) are used to catalyzed oxidation of heartwood powder of *Pinus kesiya var. langbianensis* in suspension under the following conditions of pH value is 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5 and 6.0, respectively; temperature is 30°C, 40°C, 50°C, 60°C, 70°C and 80 °C, respectively; treatment time is 1h, 2h, 3h, respectively, and laccase dosages is 10U/g wood power, 20U/g wood powder and 30U/g wood powder, respectively.

Electron spin resonance (ESR) spectroscopy of laccase treated heartwood powder shows that a considerable amount of reactive oxygen species free radicals is yielded more than that of the control. ANOVA analysis indicates there is significant difference between ROS concentration values of laccase treated heartwood powder and the parameters including pH value, treatment temperature, treatment time and laccase dosage for both laccase I and laccase II, respectively. Furthermore, the effects of laccase I is better than that of laccase II except for section of confirmed the optimum pH value. As a result, the optimum parameters of laccase treated heartwood powder for two kinds of laccase are pH value 3.0, 50 °C, 2h and 20U/g wood powder. The use of laccase in processing and manufacturing of fiberboard may produce new and more environmentally safe products.

Key words: Heartwood, laccase, *Pinus kesiya* var. *langbianensis*, reaction conditions, ROS concentration

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Study on Plywood Production with the Thermoplastics Film

Ho-Chin CHEN*, Po-Chih YANG, Tsai-Yung CHEN and Chun-Hsiung HSU

The objective of this study is to replace commonly used urea formaldehyde resin (UF) and phenol formaldehyde resin (PF) with thermoplastic film from Low Density Polyethylene (LDPE) and Ethylene-Vinyl Acetate (EVA), as the adhesive in plywood production. In this research, the veneer choices are *Shorea spp*. (Lauan) and *Pinus radiata* (Radiata pine, Monterey pine). The hot pressure is 10 kgf/cm^2 by the temperature 150℃ and 180℃, the pressing time as 2 min, 3 min and 5 min. Final, the plywood properties were tested according to CNS 1349 standards, such as the density, moisture content, tensile shearing strength . The best factors found in the result can be used in search for best producing conditions. This research expects to use thermoplastic film to the development of new plywood production technology, which can be produced without formaldehyde release. The goal is to replace commonly used synthetic resin as glue and extensively apply this innovative technology on home living or interior spaces; which well bring safe and comfortable living environment.

Key words:

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R& D and Application of Bio-Based Phenol Formaldehyde Resin as a Wood Adhesive

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In order to reduce global dependency on scarce petro-chemical resources, this paper evaluates the industrial feasibility of producing and using bio-based phenol formaldehyde resin (BPF) for wood adhesion.

Results from both the laboratory and industrial research, development, preliminary production and application, according to the study understanding of biology and chemical properties of such biomasses as walnut shell and their resinifying mechanics, showing that : 1) the various type of BPF with substitution of the biomass for 25 ~ 40% phenol, whose properties are similar with those of traditional pure phenol formaldehyde resin (PF), can be produced on the industrial co-polymerizing technology without any residue and pollution; 2) On almost the same technical conditions for PF, the overall performances of BPF are similar with those of PF; 3) Proper controlling of co-polymerization conditions and final viscosity of BPF may raise the gluing efficiency; 4) Proper solid content of different type of BPF is one of the critical factors to reduce the cost of both production and using of BPF; 5) Emission of free formaldehyde and phenol of BPF is much lower than that of PF due to the natural capability of biomass to absorb free substances, as indicates a good environmental potential of BPF; 6) Both the production and using costs of BPF are 5 ~ 15% lower than those of PF owing to both the low price of the biomass than that of phenol and no residue and no pollution technology of BPF, which declares a sound economic benefit.

All of the above achievements point out that both the industrial technology and economy are feasible for the raw material from the inexhaustible biomass to replace the non-renewable, non-sustainable petro-chemicals for resin. Since then, more R & D work is needed for a wide potential of BPF, and more favourite policies, esp. the favourite tax policy, should be given by governments to both the researchers and manufacturers of BPF to encourage their further efforts.

Keywords: Bio-based phenol formaldehyde resin, wood adhesive

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Investigation on Adhesion of the Resins used for Coating Layer on Yankee Dryer Surface

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In the manufacturing process of crepe paper products, the use of creping aids on the Yankee dryer surface is important to improve creping process and the adherence of paper to the Yankee surface. In this research that was performed on a laboratory scale, the adhesion of a liquid adhesive creping aid, compound polymer, was investigated. A compound polymer was prepared based on mixing ratio of Poly (Amid-o-amin)-Epichlorohydrin resin (PAE) as an adhesive agent, Poly (Vinyl Alcohol) (PVA) as a modifier agent, Cationic Fatty Acid (CFA) and Ethylene Glycol (EG) as release agents. The adherence of paper to the substrate that was coated by compound polymer solution was measured using peel strength test. Increasing the percent of total solid content of compound polymer would increase peel strength of paper. Peel strength of paper would increase if EG as a release agent was being used. The amount of PVA/PAE resin in formulation of creping aid was critical for building a flexible and tough coating layer on to the substrate and an adequate adhesion of paper in peel strength test.

Key words: Wet strength resin, coating layer, peel strength, and epoxy resin

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Properties of the Polyblends Prepared from Polyhydric Alcohol Liquefied Japanese Fir with Epoxy Resin

Chiou-Chang WU and Wen-Jau LEE*

In this study, Japanese fir (*Cryptomeria japonica*) was liquefied in polyethylene glycol (PEG)-glycerol co-solvent with H_2SO_4 as catalyst. The epoxy resin of diglycidyl ether of bisphenol A type was synthesized from epichlorohydrin and bisphenol A with the molar ratio of 5/1. The polyblend resins were prepared by blending the liquefied wood and epoxy resin, and the triethylene tetramine (TETA) was used as a cross-linking harder. The effects of liquefied wood on the reactivity of polyblend resins, and the feasibility of using the polyblend resins as the wood adhesives were investigated. The results showed that polyblend resins could be cross-linked at room temperature as TETA added, and it was an exothermic reaction at the period of curing. But the released heat would diminish as the ratio of liquefied wood in the polyblend resins increased, and the gel time would be prolonged. DSC thermoanalysis showed that normal temperature cured resins could be further cross-linked with heating. As the polyblend resin was used in the wood gluing, cured by heating with 90°C for 3 h could have the best bonding strength, even at the rate of 60 parts of liquefied wood added, the bonding strength was superior to the traditional epoxy resins.

Key words: Adhesive, Epoxy resins, Liquefied wood, Polyblend resins

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Method of Extracting Tannin from Bark of *Acacia mangium* Trees for Bio-Based Adhesive

YEOH Beng Hoong*, PARIDAH Md. Tahir, KOH Mok Poh , MOHD. HAMAMI Sahri, LUQMAN Chuah Abdullah

High oil price and recent concern about the availability of crude oil and natural gas have led to a renewed interest in the R&D of non petroleum based phenol. Tannin or flavanoid is the best natural substitute for the petroleum-based phenol. Condensed tannin constitutes more than 90% of the world's production of commercial tannins (*ca.* 200,000 tons per year), that can potentially be used in adhesive formulation for bonding wood-based materials. The method used to extract tannin from tree bark differs according to tree species. *Acacia mangium* tree contains 10% bark (v/v) which can produce between 10-20% of tannins material (dry weight). In this study, several methods of extraction have been studied and two methods have been identified to produce acceptable high yields of tannin. The effect of particle sizes, extraction medium, solvent concentrations and tree site were examined. The hot water extraction was carried out using a mixture of water and bark (6:1 w/w based on the over dried weight) and Sulfite tannin using a water:bark:sodium sulfite:sodium carbonate (600:100:1:0.25 w/w) at 70˚C for 3 hours. The Sulfite method improves the yield by 38% and 44% for trees taken from Peninsular and Sabah respectively. The formaldehyde–reactive polyflavanoids, Stiasny value were respectively 90 % and 87 %. Based on the high yield and Stiasny Number, this tannin has potential as to be used in adhesive formulation for bonding wood material.

Key words: Tannin, Acacia mangium, tree bark, bio-based adhesive, sulfited tannin, Stiasny value

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5.14-SWST

EDUCATION AND THE PROFESSIONAL FUTURE OF 21ST CENTURY WOOD SCIENCE

Papers

Considering Changes in Wood Utilization – as seen from Europe

Helmuth RESCH*

Worldwide, continuous change is evident. What impact does it have on the utilization of wood? What should be considered when educating professionals in Wood Science and Technology (WST)? Where did we come from and where do we need to go?

Throughout history, forests provided important social, ecological, and economic values. Early, it was recognized that trees had to be managed to assure sustainability of forests. Wood utilization advanced along with an unprecedented and exciting industrial evolution and Wood Science and Technology became an interdisciplinary field. Recently, stronger environmental concerns and "globalization" impacted societies in major ways. They influence timber availability, processing, and trade.

Environmental concerns are imbedded in the European "Vision for 2030", which calls for "a competitive, knowledge-based industry that fosters the extended use of renewable forest resources. It should strive for societal contribution in the context of a bio-based, customer-driven and globally competitive European economy." Demand is growing for engagement in the bio-energy field with "green" chemicals and composites. CO_2 savings are to be made by using timber in construction. The "Kyoto Protocol" led to a market, trading monetary value of carbon sequestration that is consequential to afforestation programs. Harvesting and trade of timber became restricted, particularly in tropical areas.

Globalization created entirely new business, social, and political patterns. People communicate worldwide, organizations and business network. Companies can create, transmit, and analyse data for manufacturing, inventories, marketing, sales, and billing. Manufacturing processes can be taken apart and individual tasks sent around to whoever can do it best or cheapest or both. Quality assurance for products and their manufacturing is increasing in importance.

Globalisation progresses in education. The "Bologna Declaration" led to reforms desired to "make European Higher Education more compatible and comparable, more competitive and more attractive". Interdisciplinary education in WST will be needed. While recognized as a material science, it must retain its identity and association with its related industries and traditional support groups. Undergraduate education may require three phases: First, a broad knowledge base, then specialized topics, and finally, integration of the provided information. Options should become available during the second and third phase. Graduate programs are ideally tailored to the background and professional needs or aspirations of students. Flexibility is necessary because faculty members need to select thesis topics related to their research and funding. Bodies for accreditation of curricula may be wise to require a standardized core of subjects, but show flexibility when recognizing related, optional course work.

Key words: Wood science and technology, education, global change
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Bachelor of Wood Science and Technology: Curricullum Developed for Future Challenges in Wood-based Industry

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The environment of forestry education is dynamic. It is characterized by global, societal, structural and technological changes. With the increasing interest in wood-based products, which contribute significantly to the Malaysia economy, the current forestry education in Malaysia has become less relevant. A drastic restructuring of the program is required to face future challenges in this sector. The future decision-makers, the students of today, need skills adequate to meet future challenges to the relevance and sustainability of the wood-based industry.

Therefore, the Faculty of Forestry, Universiti Putra Malaysia, has restructured the existing Bachelor of Forestry Science (B.For.Sc.) program with seven minors into a more focused structure comprising three programs: Bachelor Wood Science and Technology (BWST), Bachelor Forest Management (BFM), and Bachelor Park and Recreation Science (BPRS). BWST is the first to be approved by the government and is offered for the first time in the July session 2006/2007. It offers two options: Biocomposite Technology and Wood Industry Management. Objectives are to produce graduates who are able to manage the forest resources efficiently, who are skilled in the manufacturing and processing technology for wood and other lignocellulosic materials with emphasis on environmental impact, and who are capable managers in the field of forest production and products.

After completing the program, the BWST graduates will know technical aspects of wood science and technology, have high professional ethics, have high social accountability and good communication skills, be able to think critically, and be skilled in techno-business and entrepreneurship. A market survey indicates that structure of the program is relatied to the need for dynamic change in forestry education and BWST graduates should be competitive with those of similar programs elsewhere.

Key words: Bachelor of wood acience and technology, forestry education, bio - composite technology, entrepreneurship

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Forest Products Education and Training in Austria: Changes and Challenges

Alfred TEISCHINGER* and Rupert WIMMER

Austria´s educational system is structured into three levels: primary school, secondary school, post secondary and tertiary education. Starting with the upper secondary level (9th year of school, age 14), different vocational school systems provide education with general and vocational training at various levels for specific industry sectors such as mechanical engineering, civil engineering and construction, chemistry, electrical engineering, electronics, communication technologies, business engineering, agriculture or forestry. Successful graduates from upper secondary technical and vocational schools may enter regulated professions and are entitled to practise their profession after two years of experience.

As the forest products industries play a major role in Austria´s economy the vocational schools together with the Universities as well as "Fachhochschulen" (Universities of Applied Science) provide an extensive educational system. They split into forestry, wood technology, pulp and paper technology, timber in construction, interior design, and furniture manufacturing. As the wood industry in Austria is widely based on small-medium sized enterprises as well as vocational trades, the educational system is addressing this diverse structure.

Current transformations in the structure of the wood industry, in conjunction with adaptation processes towards a common European educational system (so-called Bologna process) have facilitated major challenges that need to be addressed. This presentation is about some of these changes, to develop new structures in the forest products educational system. It is also seen as a chance to draw young people to a mature industry in transition, highlighting the attractiveness of the forest-based industry as a career opportunity for the next generation.

Key words: Forest products education, vocational training, future challenges

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Wood Science & Technology: Its Future as a Profession and its Education in the United States

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This paper tracks the development of education in wood science & technology (WST) in the United States and it discusses the critical issues and trends in WST as a profession. Special consideration is given as to the future of WST education in the USA and WST as a profession. The current state-of-the-art in teaching and the future standards for WST education is reviewed as is the potential and need for strategic alliances with other disciplines and professions. Comparison with educational systems in other professions is made and the role of the professional society is examined. Increasing the visibility and acceptance of WST as a profession is discussed. Alternatives for making graduates as attractive as engineering, chemistry or biology graduates are presented. Strategic alliances, partnerships, and networking opportunities with non-WST fields with a goal of becoming more inclusive of all lignocellulosic fiber materials are analyzed. Finally, the promotion of wood/lignocellulosics into expanding international markets and the need for renewing a focus on non-residential/commercial construction markets, in addition to retaining wood's dominant place in North American residential construction, is addressed.

Key words: Wood science, profession, education

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The Extension Education of Forest Products in the Experimental Forest of National Taiwan University

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The forest management in Taiwan has changed its mission toward to the sustainable management of forest ecosystem because of the depletion the wood resource and the arising of the forest conservation issues. Thus, the development of forest product utilization should also toward to sustainable, delicate, and high value-added applications. The major goals of The Experimental Forest of National Taiwan University are education, research, forest management models, and environmental conservation. In order to response the change of forest management, to promote the delicate utilization of forest product and environment education which were combined with the recreation industry, four activities were held in forest recreation area and wood utilization center regularly. There were:

1. Do-it-yourself of wood working was the making of wooden stool or bookshelves by using plantation or thinned logs.
2. Utilization of bamboo charcoal was the carbonization of bamboo and the painting of carbonized bamboo cups.
3. Hand made paper was the making of bamboo paper by traditional procedures.
4. Extraction of essential oil from the wood chips, leaves, or aromatic plants.

Through above recreational and educational activities, several important conservation concepts and forest policies were introduced to publics such as the utilization of plantation wood, carbon sequestration, reduction of carbon dioxide emission, delicate utilization of bamboo, and medical utilization of wood extraction. These programs have gained their reputation and people also learn much about update information and know the efforts of forest authorities.

Key words: Extension education, do-it-yourself, plantation wood, bamboo charcoal, essential oil

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Current Changes in Higher Education for the European Wood Industry

Heiko THOEMEN* and Arno FRUEHWALD

Higher education and research in Europe currently undergoes the most dramatic changes since the emergence of modern universities. Driving forces are the increasing rate of technical development, globalization and social changes. Clearly, the wood sector is not excluded from this development. There is an increasing demand on higher education in the wood sector, including livelong learning programs. Further challenges are the internationalization of education and research, competition among universities and colleges, and the reorganization of knowledge. Above, the wood sector is facing an image problem, which is not completely new, but is becoming more severe in times where competition on students and excellent scientists is increasing. This presentation will summarize the most important changes in the European system of higher education, analyse the current situation in the wood sector, and will derive some recommendations for stimulating future developments.

Key words: Education, Europe, wood industry, globalization

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5.14-SWST – Posters

Outlook on the Forest Products Vocational Education in Taiwan—Honeybee Cultivation and the Manufacturing of Related Products

Jan Shou HSIEH, Wen Chen LEE and Li Yu LEE

Under the Taiwan Forestry Management Act, the principles of forest management were revised to emphasize multiple use. The additional value from forests is significant. Under the current policy, we teach "Honeybee Keeping", which is a new course in Taiwan forestry vocational education. We cooperate with the beekeepers and integrate their experiences and knowledge in class teaching In this 3 hr./week course, students learn different topics of beekeeping and they also practice beekeeping techniques under the guidance of school teachers and professional beekeepers.

We teach students the biology and life history of honeybee (*Apis mellifera*); how to use beekeeping equipment; beehive manufacture and maintenance; gathering and collecting honey; and manufacturing the byproducts (beeswax, royal jelly, pollen, candle wax). Since the course started in 1999, we have bred 10 beehives (about 200,000 honeybees) every year. The annual production of honey is 300 kilograms from longantree (*Dimocarpus longans*) and about 50 kilograms from wild flowers (especially from *Bidens pilosa*).

In addition to their importance, honeybees are valuable in tree pollination. On the other hand, forested areas provide both forage and protection from excessive sun or wind for bees. Forest flowers and bees can provide mutual help.. On the basis of recent experience, we believe raising honeybees can be a newly developing direction in forestry vocational education.

Key words: Honeybee keeping, forestry vocational education, bee honey, byproducts

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Society of Wood Science and Technology – A Bridge Linking Academia, Community, Industry and Government

Victoria HERIAN*

SWST is an internationally-recognized professional organization of wood scientists, engineers, marketing specialists and other professionals concerned with wood and lignocellulosic materials. Members are dedicated to the wise use of many types of our most environmentally-responsible resources. SWST is committed to conserving our forests through the development of new ideas, procedures, policies and products for the wood industry. This organization establishes a forum for the exchange of ideas; the communication of knowledge; and the development of high standards, policies, and ethics for wood and lignocellulosic materials research and the wood industry. One mechanism we utilize to bridge education to ultimate practice is our quarterly journal, Wood and Fiber Science which is not only in printed format but has also recently become available in an electronic format. Only by supporting the high principles of conservation-minded use of our resources, can we reduce the impact on our environment. Quality education in our field is a fundamental first step in taking wood science and industry into the 21st century. By fostering educational programs at all levels of the field--undergraduate, graduate and post-graduate and by fostering the professional ethics and standards within this science--SWST aids universities and colleges in providing a quality educational foundation through accreditation of wood science and technology programs. In a continuing effort to expand awareness of problems and solutions concerning the wise use of our overall wood and lignocellulosic resources, SWST provides funding to assist qualified people to participate in national and international visits for increased awareness of progress within the wood industry field.

Key words: Education, accreditation, wood Science, professional, ethics

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Wood Science Education Reform in Slovakia

Marian BABIAK and Igor ČUNDERLÍK

Wood Science education in Slovak republic is undergoing a reform following the Boulogna process. The aim of the process is to create European Education Area with the following goals:

- accept a system of comparable academic degrees
- accept a two degree system – pre-graduate and graduate
- build up a common credit system (ECTS)
- to improve mobility
- to improve European co-operation in quality evaluation
- to improve European higher education dimension.

Faculty of Wood Sciences and Technology of the Technical University in Zvolen is the only institution providing higher education in Wood Science and Technology in Slovak republic. It has more than 50 years tradition. Nowadays the process of the creation of new curricula and their accreditation is going on. The poster displays experience with the creation of new curricula, especially for pre-graduate studies and their implementation. Slovak republic had a long tradition with strong apprentice and industrial schools and to find balanced mutual interrelations is difficult. Form and content of pre-graduate thesis creates another problem.

Special attention is paid to the third degree – PhD education. Faculty of Wood Sciences and Technology is a partner in the project submitted to European union by West Hungarian University in Sopron. The aim of the project is to create European Wood Research School that would educate PhD students. The school should take the advantage of mobility to give the students the best at each partners university according to their specialization.

Key words: Wood science education, educational reform, European Education Area

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Raising Interest for Forest Products among Students

Michaël RIVOIRE*

This short poster gives general ideas about education in the forestry field, by a student. Generally, working in the forest products field does not raise much interest among students. New jobs dealing with environment and ecology in general are more attractive, and a lot of people still do not understand why trees are harvested.

Even in forestry schools, a lot of forest products courses do not have the influence they could have. The way of teaching is a key point: useful tools exist but foresters are often timorous with new technologies. Yet, a student crafting different wood boards on a computer will learn much more by errors and trials than by listening to a magisterial course.

From an original point of view, it is possible to tell that some widely accepted ideas about teaching lead to students' disinterestedness. For example, (1) teaching before allowing students to manipulate products or data, (2) assuming that learning from a website wastes time and is less efficient, or (3) thinking that learning games are only suitable for young children, or even (4) assuming that field trips are the most efficient way to teach forestry. All these assumptions, if reversed, might be the key of more interest for the forestry field.

Surprised students (or general public) could be the future people interested in forest products.

Key words: Students, education, opinion

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Turkish Forest Products Industry and Forest Products Engineering Education

Ahmet KURTOGLU, Ercan TANRITANIR and Seda ERDINLER

It is indispensable fact that wood is a basic product of life. However, many countries such as Turkey have difficulties meeting consumer needs because they have limited forest resources. Meeting consumer needs for wood products in a sustainable manner becomes a much more important issue in a country such as Turkey that still uses more than half of the basic product wood as firewood.

For this reason, need for a new engineering branch occurred in increasing efficiency in the companies, bringing products to a modern quality level, developing, projecting, manufacturing and marketing the wood based products that the population needs like furniture, paper, etc., with optimum evaluation of wood raw material obtained from insufficient forest resources. That is "Forest Products Engineering".

With a glance at the jobs of Forest Products Engineering, it seems like a very difficult engineering branch. The basic reason of this difficulty is; Forest Products Engineers should imbibe the business information aiming recognizing various features of wood raw material, technical knowledge devoted to formation of industrial engineering, administration and indispensability to apply the appropriate combination of these.

In our country, first academic education of Forest Products Engineering begun in Karadeniz Tecnical University, in 1972-1973 academic year who gave the first graduates at the end of 1974-1975 academic year. In 1982-1983 academic year Forest Products Engineering Department was established in Istanbul University, Faculty of Forestry and gave the first graduates an 1986.

It would be useful to update Forest Products Engineering Department structure, major department names and numbers due to the developments in our country and in the world.

Another important problem in the education of Forest Products Engineering is the decrease in the demand of students to this Engineering branch recently in the world. If this problem continues, it is clear that Forest Industry will be effected in a negative way. In our country, student quota in some Forest Products Engineering sections failed for the 2006-2007 academic year. It is determined that only 5-10 students have applied. This shows that it would be very useful to overview.

Key words: Forest products, education, Turkey

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Society of Wood Science and Technology 2008 Annual Convention
Cosponsored by IUFRO Division 5-Forest Products and Universidad del Bio Bio

Victoria HERIAN*

Society of Wood Science and Technology (SWST) is an internationally-recognized professional organization of wood scientists, engineers, marketing specialists and other professionals concerned with wood and lignocellulosic materials. Because of this international status, the Society decided to follow through on this status and begin hosting its Annual Convention in a non-North American venue in 2008. It will alternate locations in even years around the globe and in odd years will host with the Forest Products Society in North America. The first international meeting will be held on November 10-12, 2008 in Concepcion, Chile at the Universidad del Bio Bio, a cosponsor of the meeting. IUFRO Division 5-Forest Products is also an official sponsor of the meeting. There will be four sessions during the first two days dealing with (1) International Wood Supply Issues, (2) Global Trade in Forest Products, (3) Wood Quality: Challenges in the 21st Century, and (4) Secondary Processing of Timber in the 21st Century. Each session has a North American and South American Co-Chair. The Society will also hold it's Annual Business Meeting at this time. The last day of the Convention will be a day-long tour of the area and the forest products industry. The 4th International Meeting of Forestry, Wood Products, Pulp and Paper will follow the SWST meeting in Concepcion.

Key words: International, professional organization, convention, chile

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5.01.06
WOOD QUALITY FROM INTENSIVE MANAGEMENT

Papers

Growth Performance of Certain Tree Species planted with Crop Plants on Coal Mine Spoil in a Dry Tropical Environment: An Implication for Soil Redevelopment

A. N. SINGH*

The rapid acceleration of human population growth has resulted in enhanced industrialization. The increasing human needs for energy resources have accelerated the degradation of natural habitats. Coal mining industry is next to the agriculture in the world which causes a serious sign in the area of forests where such industries take place. Presents study conducted in the east section of Jayant coal mine (North eastern part of Singrauli coal fields, Madhya Pradesh, India) between latitudes 24º6'45"-24º11'15" N and longitudes 82º36'40"-82º41'15" situated in the tropical region where deciduous forest species are densely vegetated. There is no doubt on the importance of such forests cover which are more important for carbon sequestrations and global warming effect in the current scenario of environmental condition.

Crop plants (*Cajanus cajan*: a leguminous crop; *Pennisetum typhoides*: a non-legume crop) were grown within rows of trees to rapidly increase the organic matter inputs and soil fertility of mine spoils. Results indicated that *Cajanus cajan* not only fixes the nitrogen, it increases total phosphorus availability due to the presence of VAM fungi in the roots. Cajanus cajan was sown in the plots of non-leguminous trees: *Azadirachta indica, Gmelina arborea, Terminalia bellirica and Tectona grandis.* Whereas non-leguminous crop (*P. typhoides*) was combined with leguminous trees: *Albizia procera, Acacia catechu, Dalbergia sissoo, Leucaena leucocephala and Pongamia pinnata*, respectively. Greatest height was attained by *L. leucocephala* and the least height by *T. bellirica*. Diameter was highest for *G. arborea* and lowest for *A. indica*. Reclamation efforts to provide acceptable long term cover with low maintenance requirements need more knowledge of species for revegetation and soil redevelopment.

Key words: Coal mine spoil, native species, growth, height, diameter

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Plantation Density and Thinning Effects on the Tracheid Length and Maturing Age of Japanese-cedar Grown in Taiwan

Pei-Yu KUO*, Jin-Hau CHEN and Song-Yung WANG

This research explored the influences of 36-year-old *Cryptomeria japonica* which is planted with different plantation densities and thinning. The plantation density B (3000 trees / ha) had average longer tracheid length than that of the plantation density A (2200 trees / ha). But the tracheid length of juvenile wood didn't have such a significant difference between different plantation densities.

In this research, using the tracheid length and ring width is the way to distinguish mature wood and juvenile wood. The method 1 used two regress lines to determine the mature year among 15-22. The method 2 used the tracheid length increased less than 1% to determine the mature year among 16-22. The method 3 used the ring width increased less than 3% to determine the mature year. And the mature year was about 19 years in the results of the three methods above.

Neither the tracheid length of juvenile wood nor the first thinning at the same plantation had significant differences among each sample site. And this research discovered that before the thinning of 2001, every sample site at the same plantation was homogeneous. If the plantation densities were different after first thinning, the plantation density B had longer average tracheid length than the plantation density A. After second thinning in 2001, the plantation density B had a significant difference between each simple site. Therefore, the plantation densities and thinning treatment significantly affected the tracheid length.

Key words: Tracheid, mature wood, juvenile wood, plantation density, thinning

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Effects of Strip Thinning Practice on the Properties of Japanese Cedar grown in North-Eastern Taiwan

Jin-Hau CHEN*, Song-Yung WANG and Cheng-Jung LIN

This study explores the influence of strip thinning on the quality of trees. Strip thinning followed by planting practices was carried out in a Japanese cedar forest located at Compartment No. 20, Taipingshan Working Circle of Chilanshan. There were five thinning treatments of strip cutting of 2 rows (Type1), 3 rows (Type2), 4 rows (Type3), 5 rows (Type4), and the control area (Type5). Every treatment had three replications. Using the ultrasonic technique, Pilodyn, and the Fractometer were used to test wood properties.

The more strip thinning strengthened, the smaller vertical ultrasonic was. There was an obvious difference between type4 and type5. In strength properties, the highest of the Fractometer compression strength was 399.6 kgf/ cm^2 of type5, and the lowest was 295.7 kgf/cm^2 of type4. This result was the same as the supposition of vertical ultrasonic, that is to say, the more strip thinning strengthened, and the lower compression strength was. By the compression strength, it presented that if strip thinning was up to 4 rows (type3), the strength decreased significantly.

Key words: Japanese cedar, strip thinning, ultrasonic technique, compression strength, Pilodyn.

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Non-Destructive Wood Quality Estimation from Standing Tree in Relation to End Products Characteristics of Fast Growth Plantation Eucalypts in Uruguay (*Eucalyptus grandis* M.)

Sadaaki OHTA*, Hugo O'NEILL, Felipe TARIGO and Sebastian QUAGLIOTTI

Eucalyptus grandis logs were taken from different sites (Northern, Centre and Southern region, Uruguay) and tree ages ranging from 10 to 26 years. Twenty to thirty sample trees were selected from each site and taken from 2 or 3 logs by each tree in 4m long. Non-destructive test in standing tree was carried out by FAKOPP (propagation velocity) at 1m to 2m from the ground of each tree. Dimension boards were taken from near the pith, intermediate and outer part of each log. Modulus of elasticity (MOE) was obtained by FAKOPP (both standing tree stems and logs), FFT-Analyser (logs and real size boards), and MOE of sawn boards (50mm x 150mm x 2800mm) both green and air condition (13% moisture content) were tested. Modulus of rupture (MOR) of kiln dry boards was obtained by destructive test. Standing tree of MOE in each location, Northern, Centre and Southern, was ranged from 8865-15221 MPa (average 11990 MPa), 8800-13928 MPa (average 1185 MPa) and 9392-15611 MPa (average 11510 Mpa), respectively. Relationships between standing tree stem's and log's MOE could be seen high correlation, standing tree stem and log R=0.78-0.90, especially standing tree and dry boards taken from around the bark could be seen higher correlation. Variations of mean MOE and MOR from pith to outer location in the stem were 10354 MPa, 37 MPa (around the pith), 11443 MP, 44 MPa (intermediate location) and 12564 MPa, 56.5 MPa (outer part in the stem). It can be considered that juvenile wood effects, especially MOE, are not greater than that of *Pinus taeda* and percentage of increasing in MOE from pith to bark ranges from 20 to 25%. Mechanical properties (MOE) in the stem have an increasing tendency according to tree height (up to 12 m analysed). Tree to tree variation among the heights in a stem, we can say that the first log has higher MOE than the other tree, the second log (4-8m) and the third log (8-12m) have possibility the greater MOE. The results are applicable to thinning tree selection and early stage selection for genetic improvement studies. From the point of view on MSR-lumber, it can be said that a standing tree stem MOE has greater than 9000 MPa, the dry end products from higher positions of logs can surpass the E-110 (equivalence to 9800-11770 MPa) according to Japanese Agricultural Standard (JAS) for structural uses. It is important studies for quality improvement combination with a forest management and wood quality improvements by genetics for aiming at the value added end products as a commercial timber, that is, high yield of clear cutting surface for example, of the fast growth plantation eucalypts wood.

Key words: *Eucalyptus grandis* M., Non-destructive, MOE, MOR, MSR-limber

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Spiral Grain Development in Plantation Grown White Spruce (*Picea glauca* (Moench) Voss)

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Spiral grain is a wood anatomical feature: the grain of the tree is formed in a helical arrangement about a tree's axis, as opposed to developing parallel to the tree's axis. For many years wood users have been aware of this wood quality defect, and its negative impact upon both mechanical properties and dimensional stability of sawn wood products. Literature review reveals that there is substantial variation in spiral grain development, both in pattern of development and in spiral grain angles achieved. Reports in the literature indicate the greatest consistency of spiral grain development in plantation grown conifers, though with considerable variance in spiral grain development between trees in mature plantations, between different plantations of the same species, and between tree species. Wood quality properties of plantation grown trees have shown that log diameter/ growth ring orientation and spiral grain are key to development of twist in lumber, and are a major cause of reject boards sawn from small diameter logs. With increasing dependence upon second growth and plantation timber, grown on shorter rotations and producing smaller logs, the influence of spiral grain upon the wood quality attributes of sawn lumber is of increasing importance.

This paper presents the results of an investigation of spiral grain characteristics of trees harvested from a 40 year old white spruce (*Picea glauca* (Moench) Voss) plantation at Mill Lake, Petawawa Research Forest (Canadian Forest Service), Ontario, Canada. The Mill Lake installation is a replicated plantation establishment density trial, with a range of commercial and non-commercial tree spacings. Twelve trees were harvested from one replicate of the 1.8 x 1.8 m establishment density. Three trees were selected for harvest from each respective crown class: dominant; co-dominant; sub-dominant (intermediate); and suppressed. The trees were sectioned and intensively sampled to capture the density profile (obtained using X-ray densitometry), growth ring data (obtained using WinDENDRO) and spiral grain angle of each section. Spiral grain angle of each year of growth was assessed at multiple points, using laser equipment developed by SP/Trätek; grain angle being assessed by use of tracheid effect. Data was analysed to assess spiral grain development from uniform establishment condition through development into the four crown classes, with respect to ring age, diameter, location and relative location in tree, and wood density profile.

Key words: Wood quality, spiral grain, conifer plantation, crown class, tracheid effect

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Wood Properties of Sawn Timber of Norway Spruce (*Picea abies* (L.) Karst.) grown under Wide Spacing

Franka BRÜCHERT*, Florian M. FRISCH, Stefan PELZ and Udo H. SAUTER

The silvicultural management of Norway spruce has been discussed repeatedly in the past with respect to volume production, stand stability, and financial outturn. In the last decades, the discussion put more emphasis on the question of how silvicultural management also affects the quality of the wood. This investigation deals with material of spruce which has been grown under extreme wide spacing and originates from the Spruce solitary program initiated by Abetz in 1987. This project aims to investigate the effect of these silvicultural treatments on the development of branch structure, ring width and technological properties on Norway spruce.

The test plots represent a stocking density of 350 trees (plot A), 700 trees (plot B) and 1600 trees (plot "regular management" FA) per hectare. The test material was small-dimensioned thinning material (27-37 years old, ca. 16-18 m tree height, app. 19-29 cm dbh), two trees for each plot and a total of 6 logs. The logs were sawn into 44 cants (50x100 mm²) and 78 laths (30/60 mm²). The evaluation of the round wood was carried out according to the German standard HKS and the European standard ENV 1927-1:1998, the sawn timber was evaluated according to the standard DIN 4074-1:2003. For sawn timber, particularly the criteria ring width, knotiness and twist led to downgrading. Solely material from plot A and B (wide spacings) was rejected due too large ring width. Knotiness and knot size had a strong negative effect in particular with the small-dimensioned boards and in timber from the wide spacing treatment. In general boards showed greater twist than cants. Timber sawn close to the pith or with boxed pith tended to warp more due to the presence of juvenile wood than timber sawn at a distance from the pith. The relationship between ring width, wood density, MOE and bending strength found showed similar trends as known from the literature. Wide spacing led to a larger ring width in plots A and B in comparison to plot "regular management" of a narrow spacing. This resulted in a lower wood density, lower MOE and lower bending strength. MOE and bending strength found were in the range of the lowest figures for Norway spruce cited in the literature.

As the test material represents young thinning material, the future prospectus for the wood quality with increasing age and tree dimension will be discussed. The prognosis for the quality of the timber is regarded more positive for the narrow spacing alternative "regular management" in terms of quality criteria knotiness and ring width than for the wide spacing alternatives. However, there is a lack of data on such spacing experiment for older tree age so far.

Key words: Wood quality, silviculture, sawn timber

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Investigating the Effect of Tree Breeding on the Timber Properties of Sitka Spruce

J.Paul MCLEAN*, Shaun MOCHAN and John MOORE

Sitka spruce (*Picea sitchensis*) of Canadian origin is the most commercially important plantation tree species in the United Kingdom. Traditionally, timber from Sitka spruce has been used in non-structural applications such as pallets and fencing. Growing environmental awareness and a desire to reduce the UK's carbon emissions have resulted in increased interest in the use of locally sourced timber for construction. However, there are concerns about the quality of timber from UK-grown Sitka spruce, particularly when compared with timber from other softwood species grown in continental Europe.

Early tree breeding efforts in the United Kingdom attempted to increase the volume of timber produced without lowering the quality. Trees were selected on the basis of vigour and stem form (straightness and branching) and a series of progeny trials were established throughout the UK in the 1960's. A recent sawmill study, conducted using trees from one of these trials in Northumberland, showed that selecting for improved straightness and reduced branch size resulted in a significant and substantial increase in the yield of timber meeting the requirements for the C16 grade. However, little is known about the impact of these genetic selections on the anatomical, physical and mechanical properties of wood. A study was therefore carried out using small clear specimens of timber from the same progeny to obtain information on Modulus of Elasticity (MoE), Modulus of Rupture (MoR) and wood density. In addition, microfibril angle (MfA) measurements were made on a sub-sample of these trees using Silviscan. Significant differences in MoE and MoR were observed between progeny and corresponded to differences in wood density and microfibril angle. However, the variation in these properties between progeny, whilst statistically significant, was small compared to the variation within progeny and even within a tree.

Key words: Genetics, strength, stiffness, wood density, microfibril angle

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5.01.06 - Posters

Effect of Stem Form Factor on Wood Properties of Sugi (*Cryptomeria japonica*) Plantation Trees - Stem Stiffness, Anatomical Wood Properties and Knot Distribution

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The woods from sugi plantations in Japan display large intra and inter tree variations of wood properties even in the mono-cultivar stands. These variations have inhibited increasing the use of sugi woods. To promote the use of sugi woods, the variation of wood properties should be controlled by silvicultural practices. However, there was less information for effective silvicutural practices to control the wood properties. The purpose of this study is to examine the effects of stem form factor (SFF: height to diameter ratio), which is closely related to the silvicaltural practices, on stem stiffness, anatomical wood properties and knot distribution in sugi plantation trees.

Sample sugi trees were collected from a 19-year-old, mono-cultivar stand with tree density of 2219 tree /ha, which has experienced no thinning and pruning. Tree height, DBH, crown length and stem stiffness of standing trees at 1.2m above ground were measured for all 92 trees of the stand. Among them, nine sample trees were selected to cover the range of the SFF and stem stiffness, and subjected to stem analysis and measurements of anatomical wood properties. Two sample trees (a dominant and a suppressed tree) were also selected for analysis of knot distribution within the stem.

The SFF was correlated with the other parameters for 92 sugi trees ($p<0.01$): suppressed trees of the larger SFF had the smaller crown length ratios (CLR: the ratio of crown length to tree height) and the stiffer stems than dominant trees of smaller SFF. Stem analysis of 9 trees revealed that aging of trees from 5 to 18 years old resulted in an increase of stem slenderness (tree height /ground-line tree diameter) from about 30 to 60. This was associated with a decrease in microfibril angle at S2 layer of latewood tracheid and an increase in tracheid length from cambial age 3 to 16 at 1.2m above ground. The knot analysis demonstrated a high knot density of the suppressed tree of larger SFF than the dominant tree, suggesting that high knot density of the suppressed tree would partially offset the positive effects of its high SFF on the strength of woods. These results suggested that 1) maintaining appropriately high tree density could produce the woods with higher mechanical properties through the high SFF and low CLR, and 2) pruning may improve the positive effect of the high SFF on mechanical properties by reducing the density of dead knot within the stem.

Key words: Stem form factor, stem stiffness, anatomical wood properties, knot

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5.03-IRG C
WOOD PROTECTION AND DURABILITY

Papers

The Role of Global Cooperation in Wood Protection for Conserving Forest Resources

Gerard DEROUBAIX* and Jeffrey J. MORRELL

Humans have long made efforts to protect wood from degradation, but it has only been in the last 2 centuries that these efforts have proven to be effective. Wood protection has become an important world wide industrial segment, but it the chemcials used, the processes by which they are delivered and the potential impacts of these processes on the environment remain works in progress. In this presentation, we will discuss the current state of the industry in terms of the systems used and the steps being taken to minimize the environmental effects of wood treatments. A central focus of this talk will be the International Research Group on Wood Preservation and how this group can serve as a focal point for international collaboration to address these issues.

Key words: Durability, biodeterioration, wood protection, environmental impact

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Recent Developments in Treatment with Borates for Decay and Termite Resistant Framing

Jieying WANG*, Paul I. MORRIS and Shane MCFARLING

The recent interest in boron treatment of wood is mainly due to its environmental acceptability, good penetration in wood, and its efficacy against decay and termites. Based on Forintek's research, the required penetration of borate for various national standards can be achieved using a combination of pressure treatment schedules and a diffusion period. These standards may also be achieved by a new non-pressure process, developed by Kop-Coat, demonstrated by Forintek with mountain pine beetle-affected lodgepole pine.

In protected above-ground field tests simulating sill plate use (collaborative research between Forintek, the University of Hawaii and the University of Kyoto), the eight years' results in Hawaii and ten years' in Japan have confirmed that borate treatment provides structural lumber with long-term protection from decay and subterranean termites, including *Coptotermes formosanus* Shiraki. Results from a 10-year painted L-joint test by Forintek have demonstrated the decay resistance of borate-treated wood with borate-diffusion treated hem-fir using a low retention of 0.2 % boric acid equivalent. Since the biggest disadvantage of boron-treated wood is the chemical loss when in contact with liquid water, research has been carried out on boron fixation, but the most successful method could be application of proper coatings on borate-treated wood. This has been in practice for exterior uses in New Zealand and the UK for decades. The colourless nature of borates also allows improved durability while maintaining the natural appearance of wood. Forintek's accelerated testing has shown that boron leaching retardation can be achieved using certain water-based transparent coatings. Long-term field tests are now underway.

Key words: Boron, disodium octaborate tetrahydrate (DOT), termite resistance, decay resistance, wood preservative treatment

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Durability of some Alternatives to Preservative-treated Wood
Progress Report 2: Results from Field Tests after 5 Years' Exposure

Marie-Louise EDLUND and Jöran JERMER

A number of alternatives to preservative-treated wood have been tested according to EN 252 (stake test) and a specially designed ground-proximity field test, the latter in Sweden as well as in Hawaii, USA. Seven untreated wood species and four alternative wood treatments labelled as environmentally friendly (acetylation, linseed oil, heat treatment, vinyl polymer) were included in the study. Four copper-based wood preservatives and CCA were used as references and untreated *Pinus sylvestris* sapwood as control.

Results after five years' exposure showed that

- Preservative-treated wood, with some exceptions, in general had far better performance than any of the untreated wood species and alternatives tested.
- Amongst the alternatives, acetylated wood had a performance comparable to preservative-treated wood.
- Heat-treated wood performed well above ground but poorly in ground and should therefore not be used in direct contact with the ground.
- Linseed oil-treated wood with a high retention of linseed oil performed well, but because of poor appearance it seems difficult to use successfully in practice.
- Larch heartwood performed better than any other untreated wood species tested.
- The ground-proximity test method was considered to be of doubtful value for evaluating the performance of wood above ground.

Key words: Durability, natural durability, acetylation, heat-treatment, linseed oil, decay, above-ground testing

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Non Pressure Rural Wood Preservation for the Tropics

A.A. OTENG-AMOAKO*

The eminent shortage of timber in many tropical countries calls for concerted efforts from home governments to device means of sustaining what is left. One of the options for sustainable forest management practice used in Ghana is creating awareness of people on how to increase service life of wood and other forest products in service. The process dubbed "Rural Wood Preservation" was demonstrated on national television through a series on Technology for Rural Livelihood promoted by the Council for Scientific & Industrial Research, the umbrella organization for all research institutions in Ghana. The success of this television programme led to the writing of this handbook titled: "Non-Pressure Rural Wood Preservation for the Tropics".

The 77-page book deals with description of the basic components of wood, bio-deterioration organisms, factors that affect service life of wood in service, a comparison between water-borne, oil-borne and new generation preservatives, and a guide to choice of a preservative. The thrust of the book, which is of particular interest to wood preservation practitioners, is the step by step approach with illustrations, for using any of the eight selected non-pressure wood preservation treatment methods. The handbook briefly discusses remedial treatment of wood products in service and concludes with safety and environmental precautions needed to ensure that human life is not compromised when wood is being treated.

The handbook brings simple but an effective and affordable methods of chemical protection to the level and doorstep of grassroots, rural people, sawmillers, builders, forestry students and lecturers, and all stakeholders interested in extending the service life of forest products through non- pressure preservation methods.

Copies of the book will be on demonstration and for sale.

Key words: Sustainable, forest, rural, wood, preservation

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Effect of Cinnamon Oil and Clove Oil against major Fungi Identified from Surface of Rubberwood (*Hevea brasiliensis*)

Narumol MATAN* and Nirundorn MATAN

Antifungal activities of cinnamon and clove oils at ratio 5:1 against major fungi found on surface of rubberwood (*Aspergillus niger*, *Penicillium chrysogenum,* and *Penicillium* sp) were investigated using the agar dilution method. The minimum inhibitory concentration (MIC) of the combined cinnamon and clove oils was determined to be 50 µg/mL for *Aspergillus niger*, *Penicillium chrysogenum* and *Penicillium* sp. Antifungal activity of the combined cinnamon and clove oils at the concentration 50 µg/mL was further examined on surface of rubberwood under the storage condition at 30 °C and 80 %RH. It was found that all fungi on rubberwood were completely inhibited for at least 40 days under the storage condition examined.

Key words: Rubberwood, cinnamon oil, clove oil, antifungal

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5.03-IRG C – Posters

Development of Preservative Treatment Method using Sub and Super Critical Carbon Dioxide

Myeung-Won CHO*, Sung-Mo KANG and Gyu-Hyeok KIM

Significant efforts have been devoted for developing biocide impregnation method into wood materials using supercritical fluid. Developing better understandings of fluid phase and its effect on treatment results would facilitate a more rational development of supercritical fluid (SCF) impregnation. In this project, the preservative treatabilities under super- and sub-critical fluid conditions were evaluated using radiata pine sapwood. Treating characteristics are discussed in relation to different fluid phases and treatabilities (biocide penetration, distribution, and retention).

Key words: Supercritical, sub-critical, fluid phase, treatabilities

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5.04.08
SAWING, MILLING AND MACHINING

Papers

Minimizing Fuzziness in the Planing Operation of Rubberwood (*Hevea brasiliensis*)

Jegatheswaran RATNASINGAM* and Edward FRANCIS

Rubberwood (*Hevea brasiliensis*) has emerged as the most important wood raw material for the South East Asian furniture-manufacturing sector, but its use is plagued with low processing yield, attributed to the high incidence of machining defects, especially fuzziness. Although previous researches have explained the fuzziness in Rubberwood to the presence of tension wood in the material, research reports of attempts to minimize fuzziness in Rubberwood are sparse. Hence, a series of experiments were carried out in a Rubberwood processing mill to establish a guideline for minimizing fuzziness during the planing operation.

A total of 1,800 linear-metres of Rubberwood, 50 x 100 x 1000 mm, were processed through a single-head planer molder at a constant feed speed of 14 m/min. The cutter head had four knives, which rotated at 6000 RPM. Three levels of moisture contents of the sample boards (12%, 10% and 8%) and three levels of rake angles of the cutting knives (20°, 25° and 30°) were used in this study. All other parameters were kept constant in accordance with industrial practice.

The results were that fuzziness is the predominant wood-machining defect, followed by torn grain in the planning operation of Rubberwood. Only 23% of the total machined surface was free of any defects. Further, the occurrence of fuzziness was significantly reduced on samples with 8% moisture content and when using the 30° knife rake angle. Microscopical examination and surface roughness measurements shows that the average roughness (Ra) for fuzziness is in the range of 200μm, which is will adversely affect the final quality of the finished surface. Therefore, minimizing fuzziness during the planning operation of Rubberwood will have a far-reaching economic implication on the Rubberwood furniture industry.

Key words: Planing, Rubberwood, fuzziness, roughness, yield

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Different Approach for Wear in Wood Cutting

P.J. MEAUSOONE*, M. GAUVENT, P. MARTIN and P. TRIBOULOT

The research of metallic materials for wood cutting tool is principally oriented in research of maximum hardness, without thinking of effects of wood material. According to the tree species and the type of metallic materials, the wear of the wood cutting tools is very different. The metallic nature of cutting tools, the water and water soluble components in the wood result in an electrochemical mechanism of corrosion. Of course, both a mechanical wear and an electrochemical action are responsible of the total wear of the metallic tools.

In a first time, the objective of this study is to characterise the electrochemical action of the wood medium on the corrosion of the materials which constitute the woodcutting tool. We have elaborated a corrosive juice of wood by infusing oak shavings into water. After, we have selected several metallic materials used in woodcutting and the oak specie. For that, the stationary electrochemical measurements (Rp, Ecor, and i=f(E) curve) were carried out during 24 hours in a medium containing the water soluble extract of oak. The electrochemical behaviour of each metallic material was characterised and the morphology of the corroded surface was observed. Thus, the electrochemical corrosion is not negligible and can be very important for some cutting materials.
In a second time, further experiments are in progress to characterise the effect of the mechanical wear by friction. An experimental machine tool, TEEMO, is made with the object of measuring the real effect. We want to verify the relationship between corrosion and abrasion. So we tested the same materials as corrosion using. We can , actually, approve or not the choice of manufacturers on cutting materials for wood tooling.

Keywords: Wood, wear, corrosion, tool, electrochemical, friction

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A Characterization of the Small-scale Sawmilling Industry in Nigeria

Abel. O. OLORUNNISOLA*

Sawmilling is one of the oldest and most important wood processing industries in Nigeria. The industry in Nigeria is dominated by small-scale sawmills. This paper traces the history and reviews current practices in the small-scale sawmilling industry in the country. Items of information were collected from secondary sources on historical antecedents of the industry, ownership pattern, sawing facilities; sawmilling practices; wood residue management, and the major challenges facing the industry. Findings showed that the origin of the sawmilling industry origin dates back to the eighteenth century. Today, there are over one thousand, three hundred small-scale sawmills in the country. Sole proprietorship and partnership, the two forms of ownership prevalent in the mills, delimit owners' access to investment funds. Horizontal bandmills and circular saws are generally used for log conversion. Visual lumber grading is largely practiced and economic utilization of wood waste is minimal with the traditional methods of usage as land-fillers and fuel still prevalent. Raising capital to effect mill modernization and employee training/re-training were the two major challenges facing the industry.

Key words: Sawmilling industry, structure, practices, Nigeria

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Inventory Analysis of Particleboard made by Japanese Mills

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Wooden based boards are believed to be environmentally-friendly materials. However, there is little reliable quantitative background data of wooden boards when life cycle assessment (abbr. to LCA) is tried to conduct. Therefore, inventory analysis of particle boards (abbr. to PB) was conducted for six mills among four manufacturers in Japan whose production share is over 50 %. The functional unit was set to one ton of U and M type PB whose scope covers from arrival of particles to production of PB. Time frame was one year from April 2004. Basic background data were mainly referred from database in JEMAI-LCA Pro which was recently developed by Research Center for Life Cycle Assessment, National Institute of Advanced Industrial Science and Technology (AIST) and references if necessary. Impact assessment was conducted by Life cycle Impact assessment Method based on Endpoint modeling (abbr. to LIME) developed by Research Center for Life Cycle Assessment in Tsukuba.

Ratio of crude oil consumption was about 70 and 30 % for adhesives used in mills investigated and PB production, respectively. The CO_2 emission derived from fossil resources by boiler, electricity and adhesives were about 50, 30 and 20 %, respectively.

The expected damage costs of one ton of U-type and M-type PB were 1,552 and 1,585 yen (12.9 and 13.2 US$), respectively. This means that there is little difference between urea resin and melamine-urea cocondensed resin. It became clear that the damage cost goes up about 30% if CO_2 emission from biomass resources was taken into account. It also became clear that suspended dust (abbr. to SPM) generate and cause air pollution if woodchip was used as fuel for a boiler.

Key words: Particleboards, Life cycle assessment, Impact assessment, JEMAI-LCA Pro, LIME

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Check Detection and Characterization in Veneer qualifying with Use of Digital Image Analysis

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The checks of veneers are one of the most essential attribute of their quality - they define resin usage in panel production and the strength of the veneer as a semi-product. They may also influence the quality of end-product – panel. For many years researches are conducted in order to adjust peeling parameters to avoid checks, but there is still lack of convenient, fast and precise method for complementary check characterization. In order to fill this gap evaluation of a novel veneer checks measurement and description method based on digital image analysis has been undertaken. The base of the method is that the camera is located sideways to veneer what allows to view checks geometry in the one cross-section of veneer. Checks are being opened by bending the veneer on the roller of a specific diameter. In this manner it is possible to obtain results without any special sample preparation. Images of the veneer checks are processed and analyzed to obtain the possible borders of check. Then the algorithm developed for this purpose reproduces the check by finding its area and discarding false borders (noise). In this way check occurrence density as well as checks' depth and inclination may be found. The method is automatic and delivers the most important information on checks of veneer: distances between checks, their depth and inclination. Further data e.g. on check shape are easy to acquire.

Key words: Check detection, veneer, image analysis

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5.04.08 – Posters

Tool Wear Characteristics of Particleboard made from Empty-Fruit Bunch (EFB) of Oil Palm

Jegatheswaran RATNASINGAM* and Chew Tek TEE

Oil palm (*Elaeis guineensis* Jacq.) is the most important plantation crop in Malaysia, and the resulting biomass is finding wide application in many sectors. One of the promising composite products produced from the biomass, particularly the empty-fruit-bunch (EFB), is particleboard. Although this composite material possesses acceptable mechanical properties, its machining properties remain doubtful. The high silica content in the biomass is thought to accelerate tool wear during the machining operation, but reports on this subject are limited. Hence, a series of machining experiments were carried out using a CNC router, to evaluate the tool wearing properties of the composite in comparison with a standard wood-material particleboard.

A single-fluted tungsten-carbide router bit (12 mm ϕ, 22 000 RPM), with a rake angle of 15° was used in this experiment, with a depth of cut of 2.0 mm and feed speed of 1 m/min. The router bit machined the edge of the board, moving along the full length before returning to repeat the cycle. The tool was examined for the extent of wear after a cutting length of 5,000 m. The result was that the wear pattern was similar in both oil-palm based and the wood-based particleboards, but the rate of wear in the former was 80% higher at the initial stage, but gradually reduced to 50% throughout the cutting length. Microscopical examination of the cutter edge revealed a greater incidence of micro-fracture when cutting the oil-palm based particleboard, indicating the presence of hard impurities in the composite. From an economic perspective, the tooling cost for machining oil-palm based particleboard is estimated to be US 1.15 per meter, as opposed to US 0.35 per meter for the wood-based particleboard. This study shows that the machining properties of oil-palm based particleboard will be a primary concern, if it is to find widespread application in the furniture industry.

Key words: Oil palm, particleboard, tool wear, micro-fracture, cost

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Environmental Friendly Fine Machining Process of Wood

Wen-Ching SU*, Yiren WANG and Huoh-Jong SHIAU

Wood dust could cause serious pollution in the wood-working environment. Machining processing, without sanding, to obtain a fine surface of flat furniture parts is an environmental friendly process. A self-designed two-step surface planner with oblique angles of 15° and 20° was used to machine China-fir, hard maple and red oak. Machined surface quality was investigated. The machined surfaces were compared to those resulting from sanding and planning.

Results from this experiment showed that the chip thickness of three solid woods were always thicker than pre-set cutting depth by about 0.03mm~0.1mm for oblique angle of 15° and 20°. The chip formation of China fir was flat and the others were spiral. The surface quality of three solid woods machined by oblique angles of 15° and 20° were similar to that machined by sanding. The surface quality obtained by the two-step oblique cutting was better than that of sanding surface. Furthermore, it was found that the damage surface caused by planning was removed by the two-step oblique cutting according to the observation of roughness profile and SEM photo. The tactile impression of oblique cutting surface was smoother than that of sanding.

Key words: Oblique cutting, roughness, chip, wood machining

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Maximizing Economic Benefits from Curve Sawing in Southern Pine Dimension Lumber Manufacturing

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This paper discusses how softwood sawmills like southern pine dimension mills can maximize the incremental economic benefits from curve sawing using a systems approach based on an advanced linear programming (LP) technique with an external reconstruction algorithm. In a case study involving a southern pine dimension mill with an average production of 274 mbf (or thousand board feet) per 8-hour workshift, it was observed that with this systems approach the study mill could enhance the expected incremental net revenue (INR) from curve sawing by about 40.8 percent (from $6,663 under non-optimal operating conditions to $9382 under optimal operating conditions), on average. As shown by the results of the advanced LP analysis, such potential increases in net revenue could be realized by the study mill if it changes its current log input mix to include proportionately larger-sized logs with greater sweep severity. Also, the mill could further enhance its economic benefits from curve sawing by operating at a higher production level. Through regression analysis it was determined that the study mill could realize an average incremental net revenue of $32.24 per mbf of additional lumber production.

Key words: Curve sawing, linear programming, sawmilling

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Machinability of Fifteen Major Nigerian Indigenous Hardwoods

AWOYEMI, L*, OLUJOBI, O. J and FABOYE, O. O

The machinability of fifteen major Nigerian indigenous hardwoods of commercial importance was determined. Two logs were machined from each species using horizontal band saw. The time taken by the machine to cut through each log was taken and machinability evaluated as a fraction of the normal speed of the machine when not cutting and the working speed of the machine during cutting for each species.

The machinability of the species investigated are as follows; *Milicia excelsa* (0.43); *Mansonia altissima* (0.45); *Ficus exasperata* (0.43); *Nesogordonia* sp (0.24); *Ceiba pentandra* (0.69); *Terminalia superba* (0.35); *Antiaris toxicaria* (0.64); *Albizzia zygia* (0.30); *Khaya ivorensis* (0.35); *Celtis mildbraedii* (0.32); *Funtumia elastica* (0.29); *Pterygota macrocarpa* (0.35); *Afzelia Africana* (0.32); *Alstonia boonei* (0.64) and *Lophira alata* (0.28).

Species with relatively low degree of machinability such as *Milicia excelsa*, *Mansonia altissima*, *Ficus exasperata*, *Nesogordonia* sp, *Terminalia superba*, *Albizzia zygia*, *Khaya ivorensis*, *Celtis mildbraedii*, *Funtumia elastica*, *Pterygota macrocarpa*, *Afzelia Africana* and *Lophira alata* are usually preferred by the users especially where durability and strength are highly essential. However, the local furniture industries always try to avoid some of these species especially when producing items where much of cutting and nailing is involved and consequently settle for highly machinable species such as *Ceiba pentandra*, *Antiaris toxicaria* (0.64) and *Alstonia boonei* (0.64).

Key words:

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Surface Structure induces Quality of Laminated Particleboard Edge during Machining

Piotr BEER*, Bartosz PALUBICKI, Grzegorz KOWALUK and Waldemar SZYMANSKI

Particleboards are very considerable material for furniture fabrication. Edge appearance is one of the most important quality factors of furniture elements made out of laminated particleboards. Many methods for edge quality improvement are still not efficient enough to cover all requirement coming from industry.

Basing on our study and experiments the most important point deciding of cutting quality is placed just under laminates. It means, a way of laminates support determines quality of laminated particle boards. The aim of this study was to quantify and qualify structure of particleboard supporting a laminate to express best results in machining even for not perfect sharp tools.

In this paper the relationship between surface structure of laminated particleboards and machining are presented. Quality of machining was measured as a field of damaged laminate on the wide surface of the board. Examples of laminated particleboards structures are presented together with their quality analysis.

Key words: Quality, structure, particleboard, machining

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State of Lumber Manufacturing Industry in Japan

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Japanese wood demand was 85.8 million m^3 (log equivalent volume) in 2005 and 32.9 million m^3 (38%) for sawn lumber, 12.6 million m^3 (15%) for plywood, 37.6 million m^3 (44%) for pulp and paper, and 2.8 million m^3 (3%) for others. The lumber manufacturing industry consumes about one fourth of the total wood supply and it is one of the main wood industries in Japan. In this paper, the state of Japanese lumber manufacturing industry is reported.

Number of sawmills decreased from 14,565 in 1995 to 9,011 in 2005. Number of employees also decreased from 104,197 in 1995 to 49,159 in 2005. Recently, many small and middle sawmills closed with decreasing the share of lumber sawn in Japan. On the other hand, some large sawmills increased their production. The amount of log consumption was 20.5 million m^3 (11.6 million m^3 of domestic log and 8.9 million m^3 of imported log) in 2005 and the amount of log consumption per sawmill was 2,280 m^3. Sawn lumber of 12.8 million m^3 shipped from the domestic sawmills and 82% of total sawn lumber shipment was for construction use. The amount of imported sawn lumber was 8.4 million m^3 (3.3 million m^3 from North America, 2.9 million m^3 from Europe, and 1.1 million m^3 from Russia) in 2005.

Key words: Lumber manufacturing, sawmill, sawn lumber

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Evaluating the Impacts of Skill Improvement in Small-scale On-farm Timber Processing in Kenya

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A variety of tree species for timber are planted on the farms in different parts of Kenya. Following the ban on timber harvesting in the government plantations, majority of sawmills were closed due to lack of materials to sustain their operations. This promoted the use of less preferred sawing methods: chain saws, pit saws and mobile saw benches. These methods are wasteful due to large saw kerfs, especially power saws and circular saws in addition to poor sawing skills. Kenya Forestry Research Institute initiated a programme in 2002, to improve sawyers' skills through seminars. Over 200 sawyers have so far benefited. An evaluation study, two years after the first training showed that timber recovery increased by over 6% and 5% for chain saws and mobile saw benches respectively. Timber size uniformity and surface quality also improved. It is recommended that such training seminars be conducted in all parts of the country where trees on farm are sawn. Other recovery reducing factors like saw kerfs, associated with small-scale timber processing methods should be researched with the view of making thinner saws for the mobile benches and thinner chains for the power saws.

Key words: Timber, chain saw, mobile saw bench, recovery

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Automatic Deep Wood Boring System to control Axial Deviation of Holes

Takeshi OHUCHI*, Hiroko HAMASAKI, Han Chien LIN and Yasuhide MURASE

Many deep holes for bolt joints are often required in construction using heavy structural glulam timber. In deep boring of these timbers, an axial deviation in a hole occurs frequently and causes difficulty in bolt joints operations. Therefore, the development of a deep boring system for wood which prevents axial deviations in holes is important. The authors have previously paid attention to the axial deviation of holes and examined the effect of various processing conditions on this issue. From these results, they pointed out that the axial deviation of holes occurs because of the annual rings and also that the amount of the axial deviation corresponds to the acoustic emission (AE) generated in boring.

The objective of this study was to examine the effect of annual rings on the axial deviation in detail. In addition, based on the experimental data, an automatic deep boring system of wood for controlling the axial deviation of holes was developed, and verification experiments for this system were carried out. The main results obtained are as follows:

The axial deviation of holes is affected by the annual rings. Within the range from 15 to 25 degrees in the angle between the boring direction and the annual rings, the amount of axial deviation of a hole showed the maximum value (2.7mm). A correspondence between the axial deviation of hole and the average signal of the AE generated in boring was recognized.

From these results, an automatic deep boring system which adopted step-backing control using the average signal of the AE as a signal to monitor the axial deviation of a hole was developed. That is, when the axial deviation of a hole occurs in boring, the material fed to the bit is temporarily returned, and deep boring is automatically performed again. This system was composed of a monitoring part, a boring system, and a personal computer (PC) for control of the entire system. From the result of the verification experiment, it was found that this system could decrease the amount of axial deviation of holes compared with non-control system.

Key words: Deep boring, axial deviation, AE, step-backing control

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5.07 C
CHEMICALS FROM WOOD

Papers

Ethanol from Wood Cellulose: Economic Realities

Howard ROSEN*, Ted WEGNER and Peter INCE

Cellulose ethanol was produced commercially in the United States over 100 years ago, but other methods of producing ethanol have become more economically viable. Thus ethanol is no longer produced today in significant quantities from wood cellulose feedstocks. As issues such as global climate change, over crowded public forests, and US energy self sufficiency become of greater concern; the use of wood as a feedstock to make ethanol for a transportation fuel may again become viable.

In 2005, 4 billion gallons of fuel ethanol were produced in the US mainly from corn. This was equivalent to 2.8% of the total volume of US gasoline consumption, 140 billion gallons in 2005, but only 1.9% of the gasoline's energy content, because of the lower energy value of ethanol compared to gasoline. In 2006, US ethanol production reached nearly 5 billion gallons, and production was increasing, but at present only a relatively insignificant amount is cellulosic ethanol. US petroleum energy imports are expected to increase over the next 20 years, unless in-country alternative energy sources can be found. Cellulosic ethanol and other biofuels (biodiesel, butanol, etc.) are among leading candidates for alternative liquid transportation fuels.

This talk will discuss the factors involved in the future economic opportunity and risk for the development of fuel ethanol from woody feedstock. We will discuss fuel pricing and economic trends, competing biomass conversion processes, corn feedstock competition, wood costs, competing wood uses, and technological advances. The need for alternative renewable resources clearly exists, but without an economically viable path for production, no commercial processing plants will be built.

Our conclusion is that production of ethanol from wood in the near term will most likely be feasible in a biorefinery type processing plant, where other products are produced besides ethanol. Certainly economic risks and uncertainties must be carefully monitored.

Key words: Biofuels, biorefinery, woody biomass, energy, gasoline

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Determination of Chemical Components of Benzene/Ethanol Extractives of Castanopsis Fissa Leaf by GC/MS

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The chemical components of Benzene/Ethanol extractives of fresh Castanopsis fissa leaf were separated and identified by GC/ MS after enriching and dissolving in Benzene/Ethanol. Relative content of each component was determined by area normalization. 30 compounds representing 98.31 % of the extractives were identified. The most abundant constituents were 2-furancarboxaldehyde,5-(hydroxymethyl)- (cas) (22.07%), à-D-glucopyranoside, o-à-d-glucopyranosyl-(1.fwdarw.3)-á-d-fructofuranosyl (10.53%), D-allose(6.84 %), D-mannose(5.72%), 1,2,3-benzenetriol(5.20%), 9-á-d-arabinofuranosylguanine(4.48 %), 4H-pyran-4-one,3-hydroxy-2-methyl- (cas) (4.13%), quercetin 7,3',4'-trimethoxy(4.08%), 4H-pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl-(3.97%), 9,12,15-octadecatrienoic acid, 2,3-dihydroxypropyl ester, (z,z,z)- (3.76%), 2-myristynoyl pantetheine(2.64%), 2-furanone, 3,4-dihydroxytetrahydro (2.60 %), cyclopenta[1,3]cyclopropa[1,2]cyclohepten-3(3ah)-one, 1,2,3b,6,7,8-hexahydro-6,6-dimethyl-(2.25%), hexadecanoic acid, 2,3-dihydroxypropyl ester (cas) (2.09%), acetamide, N-methyl-N-[4-[2-acetoxymethyl-1-pyrrolidyl]-2-butynyl]- (1.88%), 1,4-diacetyl-3-acetoxymethyl-2,5-monomethylene-l-rhamnitol(1.84%), (3r*,4s*)-3-(2-nitro-4-methoxyphenyl)-4-(4-hydroxyphenyl)hexane(1.79 %), 1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester (cas) (1.43%), 2,3-dihydro-benzofuran(1.11%), and so on.

Key words: Gas chromatography, mass spectrometry, benzene/ethanol extractives, castanopsis fissa leaf

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Possibilities of using Dendromass for Energy in the Czech Republic

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The paper dwells on the assessment of timber reserve development in Czech forests in the last fifty years and on the estimated share of timber commercially not utilized so far. It evaluates biomass exploitable for energy purposes with respect to ecological bearing capacity of its withdrawal from the forest. An assessment is made of possibilities for increasing production, e.g. on plantations. A calculation is made of the approximate energy content of annual timber production in the Czech Republic and an assessment is made of some technologies for biomass harvesting, processing and enhancement, and of burning technologies. These are evaluated with respect to their total energy efficiency, total balance of greenhouse gases and other pollutants. The paper also presents a list of valid emission limits concerning the operation of boilers used for biomass combustion – from small up to very high outputs. Total annual balance of utilizable energy is estimated by using energy audit and LCA and an assessment is made of possible environmental impacts.

Key words: Energy, forest biomass, emission limits, Czech Republic

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Fast Pyrolysis of Waste Plastics with Woody Biomass

Moon KIM*, Philip STEEL, Priyanka BHATTACHARYA, Leonard INGRAM and Charles U. PITTMAN, Jr

Researchers continue to investigate the thermochemical pathway to production of fuels and chemicals from renewable biomass. Fast pyrolysis is a known method to produce bio-oils that have shown promise as fuels and chemicals. Waste plastic copyrolysis with wood in batch processes have previously employed rather long residence times. Our research investigated rapid copyrolysis of pine and oak wood with three plastics: polystyrene, polyethylene and polypropylene. Py-GC/MS analyses were performed with wood feed stocks to determine the relationship of py-GC/MS temperature and heating rate to fast pyrolysis treatments. Pyrolyses were conducted at 450, 500, 600 and 700^0 C. Residence times tested were 1, 5, 10, 20 and 30 s. Two heating rates were applied and were varied depending on the applied temperature level. Products differed markedly with both temperature and residence time. The py-GC/MS temperature and residence time that best simulated fast pyrolysis product types and distributions were determined to be 450^0 C with 10 s residence time. These conditions were applied to co-pyrolyze 0:100, 25:75, 50:50, 75:25, 100:0 (wt:wt) wood to plastic mixtures to determine the influence on chemical product evolution and distribution. Chemical species were generally produced relative to the proportions of wood and plastic ratios. Researchers have previously observed that co-pyolysis produced an upgraded raw bio-oil and this observation was tested in the present research.

Key words: Pyrolysis, wood, plastic, py-GC/MS

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Pulp & Paper C
MECHANICAL NON-WOOD PULPING

Papers

Viscoelastic and Microstructural Properties of Novel Cellulosic Gels

Reza KORHEI and John KADLA*

Changes in viscoelastic and microstructural properties are examined in a ternary cellulose acetate (CA) system. With increasing nonsolvent content an increase in steady shear viscosity is observed and at a critical concentration phase separation occurs and structures exhibiting “gel-like” behaviour are produced. Phase behaviour is dependent on method of sample preparation and the makeup of the cosolvents. Increasing the hydrogen-bonding component of the cosolvent system dramatically affects the viscoelastic behaviour of the gels, as does changes in cosolvent hydrophobicity. Increasing CA concentration and cosolvent hydrophobicity leads to enhanced steady shear viscosity and dynamic viscoelastic properties. Enhanced dynamic viscoelastic properties and gelation are due to intensification of inter- and intramolecular hydrogen bonding interactions as well as hydrophobic polymer-polymer interactions. Steady state and dynamic rheology are used to evaluate the effect of cosolvents with varying hydroxyl groups and alkyl chain lengths on phase separation and gelation. Rheological and microscopic (LSCF) confirm the formation of strong linked gel networks that are fractal in nature and possess varying microstructures depending on the cosolvent structure and composition.

Key words: Cellulose acetate, rheology, gel

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Wood and Fibre Properties of Norway Spruce (*Picea abies*) and Scots Pine (*Pinus sylvestris*) and their Impact on the Quality of Stone Groundwood Pulp

Götz MARTIN*, Heiner GRUSSENMEYER and Gero BECKER

The European pulp and paper industry is facing an increased worldwide competition. Therefore the challenge is to manufacture products with higher and uniform quality in a more cost efficient way. One possibility to improve paper quality and production efficiency is a more selective utilization of the most important European fibre resources which are Norway spruce and Scots pine.

Mill-scale grinding and lab-scale bleaching trials were performed to investigate the influence of different wood and fibre properties of Norway spruce and Scots pine on stone groundwood pulp and paper quality. The results show, that fibres of Norway spruce are more suitable for the production of high quality stone groundwood pulp than fibres of Scots pine. Especially the larger fibre width and the higher extractives content of Scots pine have a negative impact on paper strength properties like tensile index and tear strength. At a freeness of 80 ml with Norway spruce pulpwood a tensile index of 37.8 Nm/g and a tear strength of 0.75 mNm/m was achieved while it was 25.1 Nm/g and 0.52 mNm/m with Scots pine pulpwood. The higher extractives content of Scots pine has also a negative impact on pulp brightness which is roughly 5 % lower than the pulp brightness of Norway spruce.

Advantages in the utilization of Scots pine in stone groundwood pulping are the high paper porosity which could be beneficial for LWC paper, the higher yield per m³, and also the lower purchasing price.

Key words: Norway spruce, scots pine, wood and fibre properties, pulp and paper properties, bleaching

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Refiner Mechanical Pulping of Oil Palm Fronds for Newsprint

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Application of oil palm frond (OPF) as raw materials for mechanical pulp and newsprint paper is extremely promising due to its availability. Moreover, the demand of newsprint paper in Malaysia is expected to be enormous in the future. This paper reveals the effects of pre-treatment before refining and blending OPF mechanical pulp with old newspaper (ONP) on the properties of paper. The OPF was pulped by refiner mechanical pulping process and chemically pre-treated with differing in retention time and soda (NaOH) concentration of OPF dry weight. The pulp was brightening by acidifying and hydrogen peroxide stages. Blending was made between OPF pulp with ONP at ratios of 20%, 40 %, 60% and 80% to produce laboratory papers. The properties of these papers were measured and compared to unblended ONP. After pulping, their total yield of pulps, freeness, fibre length and fines content are in the range of 83 to 97%, 579 to 155 mL, 0.97 to 1.62 mm, and 6 to 25%, respectively. Their apparent density, opacity, brightness and tensile index are in the range of 0.28 to 0.48 g.cm^3, 93 to 98%, 26 to 39% and 0 to 52 kNm/g, respectively. The retention time and soda (NaOH) concentration had an effect on pulp and paper properties. Soda concentration has the higher impact on pulp properties compared to retention time. The blended of OPF and ONP paper properties were affected by incorporation of the OPF pulp. The changes on the properties varied, depending on the particular property and level of OPF pulp incorporation.

Keywords: Blending, oil palm frond (OPF), old newspaper (ONP), paper properties, refiner mechanical pulping

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Application of Two Chelating Agents on Bagasse APMP Pulping

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Pulp and paper industry depends on wood as its prime and suitable raw material, even though it had enjoyed dependable supply of wood resource, but this source of fiber is diminishing and paper industry is not only faced with shortage of suitable wood but it is also must satisfy the expectation of environmental protection groups, who are increasingly demanding the reduction in wood harvesting. Consequently the industry is searching other means to fulfill its fiber requirements. Nonwood fibers such as agricultural residues has showed excellent potential for the supply of cellulosic fibers and pulping agricultural residues especially bagasse appears available alternative of wood pulping. Bagasse is unique and promising because it is only worth a fuel.

Bagasse soda pulping is well established in sugarcane growing countries. However, other pulping processes must be investigated. Even though BCMP pulping has been implemented in two mills, pulp application of APMP pulping is required. APMP process requires utilization alkaline hydrogen peroxide as delignification and brightening agent. However, presence of transition metal ions in raw material causes decomposition of hydrogen peroxide and decreases the brightness of pulp due to alkaline darkening. Therefore, chelating agents such as DTPA or EDTA is used for transition metal management prior to peroxide addition.

Pulp were produced using two stages: in first stage bagasse was treated with DTPA, EDTA at 0.25, 0.5, 0.75 % (o.d. basis) at 70°C for 20 and 40 minutes and PH was adjusted 5 using H2SO4, and in second stage, pretreated bagasse was impregnated with 3% H2O2 4%NAOH at 80°c for 30 minutes. After defibration, the pulp was washed and pulp pads were prepared for measuring optical properties.

Transition metals were also measured in untreated bagasse according to Tappi standard no. T266om- 94 as it was found that Cu=64, Fe= 145.5 and Mn=6.6ppm. Application of 0.25 % DTPA for 20 minutes increased the brightness by 7 unites but yellowness was decreased 2.5 units. But a (greenness), b (blueness), L (whiteness) properties was improved by increasing chelating content and time.

Key words: APMP, Chelating, DTPA, EDTA

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Effects of Acetylation on the Physical Properties of Paper made from Bagasse

Mojtaba SOLTANI*

The objective of this study was to investigate the influence of the acetylation on properties of paper made from bagasse solphate pulp. The paper were acetylated (to 9 - 13 and 22 WPG- weight percent gains) without catalyst and with acetic anhydride. Effect of refining also tested.

Physical properties of paper were measured and investigated between treated samples and the control according to TAPPI standard.

The results indicated; water absorpbtion; tear resistance and double folding were reduced by acetylation and Brightness; burst; breaking length and porosity increasing trend as function of the degree of acetylation.Refining improved acetylation; D-folding and decreased porosity.

In the end, results indicated that most of important factors significantly influenced and improved due to acetylation.

Key words: Acetylation, physical properties, bagasse, paper

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5.02 D

MEAUREMENT METHODS INCLUDING NDT / WOOD COMPOSITES AND WOOD PRODUCTS

Papers

Optimal Constitution of Composite LVL Column with Crack-free Surface

Ping YANG, Hidefumi YAMAUCHI and Hikaru SASAKI

To meet the demand for large scale wooden column with drying crack-free surface, a composite column by filling a spiral winding cylindrical laminated veneer lumber (LVL) with a green round timber core was proposed in this study. The basic concept is to block drying crack of timber core from extending to the surface of the column by restraint induced by the external dried cylindrical LVL with interlocked grain. To clarify the adequacy of this proposal, computer simulations incorporated with Hoffman failure criterion were conducted to analyze the deformation behavior and stresses distribution in different constitutions of sugi (*Cryptomeria japonica* D. Don) composite LVL columns during seasoning. For simplicity, the analysis of an axisymmetric modeling in plane strain state was adopted on some assumptions; such as the distributions of initial and final moisture content, the variation of moisture content in the composite LVL column during seasoning, etc. The mechanical properties of materials were taken to be the moisture-dependent variables which were only active at moisture content below the fiber saturation point of 28%. However, the stress relaxation was not taken into account for the evaluation of the drying cracks distributed in the composite LVL columns in this study. Based on the analytical results convinced by the experimental observation, the cylindrical LVL requires a thickness of greater than 15% the timber core radius (T_{LVL}>0.15R_c); otherwise there would be a high risk of the drying cracks appearing in LVL layer or even on the surface of the composite column, as the critical radius (R_{crit}) would exceed the timber core radius (R_c). The findings will be useful in designing the appropriate constitution for composite LVL column hence upgrading its quality and cost performance.

Key words: Optimal constitution, laminated veneer lumber (LVL), cylindrical LVL, finite element method (FEM), Hoffman failure criterion

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Evaluation of Bending Properties of China Fir Laminae by Nondestructive Testing Method

Te-Hsin YANG, Far-Ching LIN, Cheng-Jung LIN and Song-Yung WANG

It is a matter of considerable importance for the timber industry by applying the nondestructive evaluation techniques to predict the material properties of wood. The nondestructive evaluation is the science of identifying physical and mechanical properties of a piece of material without altering its final application capabilities, and such evaluations are achieved by nondestructive testing (NDT) techniques.
In this experiment, 2- by 6-inch and 2- by 8-inch China fir (*Cunninghamia lanceolata*) laminae were tested by visual inspection, the DMOEv which was dynamic MOE from ultrasonic wave method, DMOEf which was dynamic MOE from tap tone method) and MOE which was from static bending test were calculated, respectively. The interrelationships among visual grading, machine stress grading, and strength properties (NDT parameters) were also examined. The experimental results shown that the MOE values of 2- by 6-inch and 2- by 8-inch laminaes has the tendency of Class1 **>** Class2 **>** Class3 according to CNS14630, the visual grading method. But there was significant difference between Class1 and Class 3. However, there was no significant difference among the MOE values of the four laminaes grades by CNS 14631, the visual grading method. Most of criteria in the visual grading of the lumber were not closely correlated with specified properties. Visual grading was not as precise as machine grading.
In addition, the dynamic MOE of lumber was greater than that the static MOE of lumber. And the DMOEf was very close to the MOE. There were high correlations among the DMOEv, DMOEf and MOE, especially between the DMOEf and MOE. It was a better approach to determine the static MOE of lumbers. The bending properties of sawn lumber can be successfully evaluated by ultrasonic wave and tap tone techniques. DMOEf was found to be the best single predictor of MOE.

Key words: Nondestructive evaluation, lamina, visual grading, ultrasonic wave, tap tone

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Analysis of MOE and MOR of Bamboo-wood Composite LVL

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The MOE and MOR of composite laminated veneer lumber which were produced with Moso-bamboo and poplar veneers by PF resin impregnation can be improved significantly. In order to find the proper hot-pressing process, this paper discussed the effect of the position of bamboo curtain in the board mat and the hot-pressing parameters on mechanical properties of the composite.

The experiment was designed in single factor method. Assemble patterns, compressing ratio, hot-pressing temperature and hot-pressing temperature four factors were studied, and each factor had four levels. The poplar veneer and Moso-bamboo curtain were impregnated with low-molecular-weight water-soluble PF resin. Specimens were cut from the board and evaluated for mechanical properties, including modulus of elasticity (MOE) and modulus of rupture in bending (MOR).

The study found that the four factors all have significant effect on the mechanical properties of Bamboo-wood composite LVL. The Bamboo/Wood composite LVL which surface was one layer bamboo curtain had better mechanical properties, MOE and MOR are 13.43GPa and 148.13MPa separately which increased 18% and 45.5% compared with poplar LVL. As compression ratio increased, LVL mechanical properties were improved significantly at first and then decreased, the relationship of the LVL MOR and compression fits to 3 multinomial degrees: $y = -7.6736x^2 + 56x + 62.317$, the R^2 value are 0.9839. The LVL MOE and MOR were all increased at first and then decreased as hot-pressing time and temperature increased. The optimized hot-pressing process parameters were gained in this study: the assemble pattern was bamboo curtain laying on surface, compressing ratio was 15~20%, the hot-pressing temperature was 150℃ and the hot-pressing time was 1.2~1.6min/mm (board thickness).

Key words: Moso-bamboo, bamboo-wood composite LVL, impregnation, modulus of elasticity, modulus of rupture

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Measurement of Wood Properties using Digital Cross-cut Images

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In the forest based industry as well as in the forest research the quality of wood is the key information required. The measurement of quality properties has turned out to be challenging and there exists rather few quality measurements devices in use in the forest based industry. Most of the quality measurements are based on x-ray tomography and are highly expensive. Obviously more inexpensive and simpler measurements are needed. If the quality of sawn timber products can be determined or measured more accurately, automated quality classification of the products become feasible. At present, most saw mills produce bulk products having rather high variability in quality. Without quality classification the price of the product is according to the lower quality fraction. Naturally after classification the high quality product is much more valuable than lower quality, and thus single tree can be utilized better.

We have researched digital image analysis methods for measuring quality of wood by using digital images taken from cross-cut surface of a single log or board. Our quality characterization is based on texture analysis methods and thus they are not so sensitive to the quality of the cross-cut surface. The methods work well despite of slight defects e.g. rot, crack or knots. The methods work well for surfaces sawn with sharp chainsaw. We will present a set of quality measurement methods based on digital images: methods for measuring annual ring width and orientation, for locating the pith and for counting and tracking annual rings. With our methods we are able to recognize the defective areas within the cross-cut surface, and thus we can omit measurement results originating from defected areas, e.g. rotten, knotty or cracked wood.

We find the quality measurements discussed above to be of high industrial relevance, but the methods may offer assistance and efficiency as well in forestry research.

Key words: Wood quality, annual rings, Image analysis

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Determination of Moisture Content and Specific Gravity of Merchantable Loblolly Pine Logs by near Infrared Spectroscopy

Christian MORA, Laurence SCHIMLECK, Alexander CLARK and Richard DANIELS

The application of near infrared (NIR) spectroscopy for the estimation of the moisture content and specific gravity of loblolly pine (*Pinus taeda* L.) logs is described. A total of 243 wood discs representing 162 merchantable logs of 16-foot length, ranging in age from 13 to 19 years were analyzed. NIR spectra were obtained from the transverse face of the discs when the wood was green using a FOSS XDS NIR System coupled with a SmartProbe Analyzer.

The relationship between measured and NIR estimates were good, with coefficients of determination (R^2) of 0.84 for specific gravity and 0.93 for moisture content, using 7 and 10 factors, respectively. The calibration models were applied to a validation set giving R^2 of 0.78 for specific gravity and 0.73 for moisture content, with acceptable standard errors (SEP) in both cases.

These results were further analyzed by bootstrapping, revealing no differences between the true mean parameters and those predicted by NIR. The bootstrapped population mean specific gravity and moisture content obtained from the reference values was 0.431 with a 95% confidence interval of [0.416, 0.445] and 1.32 with a 95% confidence interval of [1.25, 1.39], respectively. The analysis based on the NIR predicted values resulted in a bootstrapped population mean specific gravity of 0.426 with a 95% confidence interval of [0.412, 0.441] and a population moisture content of 1.35 with a 95% confidence interval of [1.29, 1.40].

The calibrations presented in this study demonstrate that NIR spectroscopy has real potential to predict specific gravity and moisture content of green *P. taeda* logs. Considering that both properties are highly variable among trees, it is suggested that for this kind of applications, the most important factor is the number of samples measured rather than the precision of single measurements.

Key words: Loblolly pine, NIR spectroscopy, specific gravity, moisture content, resampling.

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NIR Spectroscopy for Prediction of Radial Variation of Mechanical Properties in Scots Pine

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Near-infra red (NIR) spectroscopy has been shown to be a fast and non-destructive method to predict wood properties. In Scots pine, the largest variation of mechanical properties is found in the radial direction from pith to bark. The aim of this study was to develop a NIR model for prediction of radial variation of mechanical properties in Scots pine wood. Three Scots pine trees from different height classes (supressed, co-dominant and dominant) were chosen from each of two stands. One stand was thinned from above and one stand thinned from below. Stem discs were taken from 1.3 m and 4 m of tree height. From each stem disc clear wood samples were taken from 7 radial positions; 6, 11, 15, 20, 26, 33, and 42 rings from pith for mechanical testing and NIR analyses. Standard analyses of MOE and bending strength were made on three growth rings wide samples (ca 6.3 x 120.5 mm TxL direction) in the radial direction. NIR analyses were performed using a NIR spectrometer with a fibre optic probe. The wood samples were centred over the measurement area of the probe and and plced on a thin glass covering the probe. NIR measurements were collected in the radial direction on the plane perpendicular to the longitudinal direction. Reflectance spectra were recorded at every second wave length between 780 and 2380 nm at room temperature.

At present no final results are available. If the NIR spectroscopy analyses show good correlation with the mechanical properties tested, the results will be used to develop the characterisation methods of wood properties and to link these with wood product performances.

Key words: NIR Pinus Sylvestris wood properties thinning radial variation

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5.02 D – Posters

Abstract #395

Measuring Thermo-physical Characteristics of Wood and Wood Based Materials

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Basic thermo-physical characteristics of wood (specific heat, thermal conductivity and thermal diffusivity) form an important set of characteristics of wood and wood based materials from the viewpoint of processing technology as well as their final use.

The poster deals with the methods of the experimental determination of these characteristics. The methods can be generally divided into two groups – steady-state and non steady-state methods. The former are usually considered as more precise but provide only one of the characteristics – thermal conductivity. Another disadvantage of these methods is a long time of measurement. Non steady-state methods are more effective as they can measure all the characteristics but only on condition that the power of the heating source is known. If not, they also provide only one characteristic – thermal diffusivity. The specific heat of wood can be also measured by calorimetric method. As wood and wood based materials belong to insulators, special requirements must be fulfilled at the measurements.

At the Department of Wood Science of the Faculty of wood Sciences of the Technical University in Zvolen a quasi steady state method was developed and it has been used for the measurements for a long time. In addition to it we have a special device "ISOMET" produced in Slovakia. The results of both methods are compared in the poster.

A large group of methods is based on the solution of indirect task, where the appropriate solution of the thermal conductivity equation is fitted to the experimentally obtained relationship between temperature and time in a selected point. The advantages and disadvantages of these methods are discussed.

Key words: Specific heat, thermal conductivity, thermal diffusivity of wood

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Influence of Heat Treatment on Shrinkage / Moisture Content Behaviour of Eucalyptus Woods

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This work presents some physical modifications caused by heat treatment of Eucalyptus woods (*E. grandis*, *E. saligna* and *C. citriodora*). Five heat treatment of 5 hours were tested: 180°C and 220°C with air; 220°C, 250°C and 280°C with nitrogen (oxygen level lower than 1%).

The physical properties were measured using an experimental device specially designed for the accurate determination of wood/water relations on micro-samples. In this device, the moisture content of the samples is determined with a highly sensitive electronic microbalance and two dimensions of the sample are collected continuously without contact by means of two high-speed laser scan micrometers. A climatic chamber with a water bath maintained at the dew point temperature allows the air conditions to be accurately controlled over long periods of time. Thanks to a computer control of the climatic conditions, the dynamic measurement of weight and radial-tangential dimensions are collected during a desorption / adsorption cycle (relative humidity values between 85% and 32% at a constant temperature value of 30°C). Untreated and treated samples were analysed.

Our results point out a progressive decrease of the equilibrium moisture content and the shrinkage values with the increase of treatment temperature. For example, the average reduction of tangential shrinkage was 16% (180°C, air environment) and 46% (220°C, inert environment). Even though the decrease of wood hygroscopicity is a well-known benefit of the heat treatment, this work presents complementary information provided by the accurate and simultaneous determination of sorption and dimensional properties during variation of relative humidity. These results are of great importance in the use of heat-treated wood and in the choice of the heat treatment conditions.

Key words: Heat treatment, Eucalyptus, Shrinkage, Moisture content

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5.03-IRG D
ENVIRONMENTAL ASPECTS IN WOOD PROTECTION

Papers

A Complete Closed-loop CCA-treated Wood Recycling System

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This paper summarizes a complete closed-loop CCA-treated wood recycling system based on liquefied wood technology with a multi-products approach to enhance economic viability. Liquefaction converts wood to a viscous liquid by using organic reagents and low temperatures. This CCA removal technology can liquefy CCA-treated wood in the presence of organic solvents at a mild temperature (120-150 °C) with an acidic catalyst. The liquefied wood is then dissolved in a mixed solvent followed by separation of the CCA components with the addition of coagulants and precipitants. The remaining liquefied wood solution is concentrated and used to prepare biomass-based materials, such as polyurethane foams and phenolic resins or bio-energy. The CCA-containing solid residues can then be reused and recycled for future preservative treating or purified into other products that have value to a wide range of industries. The results demonstrated that the technique is technically feasible and is successful in removing more than 98% of heavy metals (i.e., 100% chromium, 100% arsenic, and 98% copper) from decommissioned CCA-treated wood. Since this process uses relatively low temperatures, short reaction times, and small amounts of organic reagents, it can be highly effective.

The significant advantages of the wood liquefaction technology are its ability to put all the wastes from the system into solution, thus eliminating generation of wood waste, achieving zero discharge of CCA into the waste stream, and the methodology is environmentally friendly. We believe such a recycling system can be built as a model in a municipality with a population of approximately 100,000 to protect natural resources and facilitate sound environmental stewardship.

Key words: Liquefied wood, CCA-treated wood, recycling, acid catalyst, environmental stewardship

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Comparative Laboratory Leaching Tests of Post-treatment Storage Period Impacts on CCA Leachability and Fixation in Treated Kempas Heartwood

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Three laboratory leaching test methods were compared to determine the effects of different post-treatment storage fixation periods on leachability/fixation of CCA components from treated kempas (=Menggris, *Koompassia malaccensis*) heartwood. Freshly CCA-treated kempas wood blocks were subjected to different storage (fixation) periods of up to 4 weeks, before undergoing one of 3 leaching tests: the methods of EN84 (consisting of initial vacuum impregnation of wood in water), modified EN84 (initial immersion of wood in water) and a new, and least severe, test (daily routine of soaking wood for 5 hours in water followed by drip drying for 19 hours), all over a 2 weeks leaching period. End-sealed test wood blocks of permeable were treated with CCA to target retention of 5.6 kg/m^3, immediately stored to fix at ambient conditions for 0 and 48 hours, 1, 2 and 4 weeks, followed by a 2 weeks leaching tests to determine cumulative leaching losses of copper (Cu), chromium (Cr) and arsenic (As). Overall, leached CCA elements ranged from 0.37 – 5.61µg/ml Cu, 0.82 – 8.52 µg/ml Cr and 0.76 – 6.08 µg/ml As. There are significant variations in leaching losses ($P<0.05$) between unfixed and stored fixed blocks among the 3 laboratory leaching test methods. Significant variations of Cu levels existed between the least severe method and the other two methods that used prolonged immersion of wood in water. However, there were no significant differences in CCA leaching losses between EN84 method and the variant of the EN84 method, implying that initial vacuum impregnation of wood in water may not be mandatory for EN84.

Key words: Leaching test, EN84 method, CCA fixation, tropical timbers, Kempas

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K_d Values of Cu, Cr, as in different Soil Matrix in Korea

Sung-Mo Kang*, Seung-Hun Shin and Ja-Oon Koo

Chromated copper arsenate (CCA), a long history of successful preservative, have raised environmental concerns. Adsorption characteristics of domestic soils for chromium, copper, and arsenic were assessed by measuring distribution coefficient (K_d) values of these metal components. The results revealed that K_d values were higher in chromium, followed by arsenic and copper in soil matrix. Different soil matrixes resulted in varying mobilities of CCA components. The values of K_d for all three metals increased with organic matter contents. The results suggest that the mobility of metal components may be very limited to the surface area adjacent to CCA-treated wood due to their fairly large distribution coefficient (K_d). However, the metal components would be persistent and accumulated in the soil, resulting in high chemical concentration in service area of treated wood.

Key words: Copper, chromium, arsenic, soil, distribution coefficient

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Supercritical Water Treatment of Creosote-treated Wood Waste

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Two of the three most commonly used wood preservatives in the U.S. are chromated copper arsentate (CCA) and oil-borne pentachlorophenol (penta). Both are excellent preservatives for extending the service life of exterior wood. Both also pose environmental problems associated with their disposal. This paper describes the treatment of two different groups of preservative-treated wood (CCA type C and oil-borne penta) in anaerobic supercritical water (SC) under acidic and basic conditions, respectively. A decommissioned (ca. 13 yr.) southern pine (*Pinus* sp.) guard rail impregnated with CCA and a freshly-treated penta impregnated pole were examined. During SC treatments, wood particles were transformed (approx. 98% efficiency) into liquid and gaseous hydrocarbon mixtures irrespective of pH conditions and preservative. In the case of CCA wood, the metals were recovered primarily in the aqueous (AQ) phase with some metal residues adsorbed to the reactor walls and very minor amounts dispersed in the hydrocarbon (HC) phase. The metals recovered in the two liquid phases vs. total concentration in the wood were as follows: copper: 91% AQ; <1% HC, chromium: 28% AQ; 1.3% HC, and arsenic: 69% AQ; <1% HC. The penta wood yielded a similar hydrocarbon mixture, with the chlorinated phenols undergoing dechlorination and further reactions. The findings indicated that decommissioned CCA- and penta-treated wood can be chemically converted, using environmentally-benign chemical processes, into a mixture of hydrocarbons that can be used or sold. Thus, the hazardous waste (preservatives) was recovered (CCA) or degraded (penta), and the solid waste (wood) was transformed into a complimentary product mixture in a single pass. The major advantage of these findings is that there is no substantial solid or water soluble residue from this process. In any case, the process water can be recycled. Based on these results, it would seem that the waste problem associated with decommissioned CCA- and penta- treated wood products can be addressed in environmentally-friendly ways. This approach has attainable end points: 1) recovery and/or transformation of chemical wastes, 2) significant reduction of the volume of decommissioned treated wood targeted for landfills or other treatment systems (e.g., incineration), and 3) the generation of a value-added hydrocarbon mixture for utilization as bio-based fuels and chemicals.

Key words: CCA, hazardous and solid wastes, supercritical water, PAHs, penta, preservative-treated wood, transformation/recovery/recycling

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Run-off Quality from Sprinkling Debarked Logs and Logs with Bark of Picea Abies

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Storage of round wood is necessary for efficient industrial production at sawmills and pulpmills. The need for wood storage becomes even more stressed when large storm fellings create huge volumes of wood that risks deterioration. In Scandinavia sprinkling of round wood is used to protect stored wood from fungal and insect infestation and drying during summer. Depending on sprinkling regime, the amounts of log yard run-off might be considerable. Log yard run-off can be harmful for a water recipient due to eutrophication and oxygen depletion. It is therefore desirable to find solutions for minimising the pollutants, i.a. organic material and phosphorus, in the run-off. A large part of these pollutants probably originates from the bark. In Scandinavia the majority of all logs are debarked after storage and sprinkling. Debarking the logs before storage instead might help reducing the amounts of pollutants. In this study two storage experiments were conducted to investigate the importance of bark during sprinkled storage. Experimental piles with debarked logs and logs with bark of Norway spruce (Picea abies) were sprinkled for 10 to 12 weeks during summertime at two locations in northern Sweden. Run-off was collected below the piles. Concentrations of pH, total organic carbon (TOC) and total phosphorus in the log yard run-offs were analysed and compared. The possibilities for reduced eutrophication and oxygen depletion are discussed as well as the suitability of the method in Sweden.

Key words: Wood storage, sprinkling, debarking, TOC, phosphorus

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5.03-IRG D – Posters

The Possibility of Timber Plantation Treated with Plastic and CCB for Marine Construction

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Recently, timber plantation plays an important role on wooden based industries. However, the plantation timber quality is relatively low. Some treatments have been developed to improve its quality such as preservation with CCB and impregnation with plastic compound. This study is compared the durability of timber treated with plastic and CCB, with non-treated timber as well as non-treated timber from natural forest. The plantation timber studied are jeungjing (*Paraseriathes falcataria*), damar (*Agathis* sp.), pinus (*Pinus merkusii*), and rubberwood (*Hevea brasiliensis*). Non-treated timber that usually need for marine construction are ulin (*Eusideroxylon zwageri*), jati/teak (*Tectona grandis*), laban (*Vitex pubescens*) and merbau (*Instia bijuga*). After 6 and 12 months, the results show that CCB impregnated timber was more durable than plastic treated and non-treated timber. Wood samples were mostly attacked by organisms from the family of Pholadidae and Teredinidae.

Key words: Timber plantation, CCB, plastic, marine wood construction

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Evaluating the Process of ACQ-treated Woods with TGA and CEM Analysis

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To provide an understanding of the fundamental thermal behavior and the disposal-end products of ACQ-treated woods, this study is comprised of two categories of examination. The first is related to the use of TGA under different thermal decomposition conditions (nitrogen or air, and 5 or 40 ^{o}C/min), and the use of EDX to examine certain residual elements of the char. The second applies the CEM techniques to evaluate the emission gas concentrations of O_2 and CO_2 concentration, the emission content (CO, SO_2, NOx), and the emission gases temperature were measured. The results of the TGA showed that the char at an air atmosphere were less than that at a nitrogen one, and the pyrolysis temperature for the heating rate of 5 ^{o}C/min was lower than that of 40 ^{o}C/min, but both them were with the same amount of char. The results of the EDX obtained that the main element is C (77.89 %), and that the relative proportion of Cu was 2.67 %. The results of CEM indicated that the emission gas temperature rise rapidly up to about 250 ^{o}C and then slowed down in the temperature range of 200 ^{o}C shown as a Plateau curve. The concentration of O_2 decreased from 20.7 % to about 17 % linearly, and on the contrary the concentration of CO_2 increased from 0.2 % to about 2.5%. Both O_2 and CO_2 then approached the shape of a Plateau curve until the end of the combustion time, as well as had a close relationship during combustion. For the maximum value of the emission content during the combustion, the emission quantity of CO was about 160 ppm. The NO_x emitted gas was about 25 ppm. The SO_2 was not found in the emission, suggesting that ACQ-treated woods was not the origin of the SO_2 in environment when it was concerned with final disposal (combustion).

Key words: ACQ (Ammonical Copper Quats, ACQ-1)-Treated Woods, Char, TGA (Thermalgravimetric Analysis), EDX (Energy Dispersive X-ray Spectrometer), CEM (Continuous Emission Monitoring)

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Influence of Methanol Soluble Extractives on CCA Fixation and Leaching on Malaysian Hardwoods

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As the heartwood of Malaysian timbers is usually the utilizable form of wood material, the ability of CCA preservatives to fix well in treated Malaysian hardwoods may be influenced by the presence of heartwood extractives. A study on the influence of methanol soluble extractives on CCA fixation and leaching of CCA treated permeable and refractory Malaysian hardwoods subjected to different post-treatment storage (fixation) periods of up to 4 weeks, using EN84 laboratory leaching test, was carried out. End-sealed test wood blocks (20 x 20 x 20mm) of permeable Perah (*Elateriospermum tapos*) heartwood and refractory *Acacia mangium* heartwood were soxhlet-extracted in methanol solvent before CCA treatment to target retention of 5.6kg/m^3. Test blocks were immediately stored fixed at ambient conditions for 0 and 48 hours, 1, 2 & 4 weeks before subjected to 2 weeks laboratory leaching test to determine the leaching of copper (Cu), chromium (Cr) and arsenic (As). Overall, for all leachate elements, there was significant variation between fixed and unfixed methanol extracted test blocks but no distinct variation between 4 storage periods (48 hours, 1, 2 & 4 weeks). Methanol-extracted heartwood blocks, improved the treatability (based on CCA retention and penetration) compared with unextracted woods. While there was significant difference ($P<0.05$) in CCA leaching rates between methanol-extracted and un-extracted test blocks of both Malaysian species, there was a tendency that such extractive removal may able to reduce the leaching of Cr and As from the heartwoods of these tropical species, indicative of the role of wood extractives *in situ*, on preservative fixation/leaching behaviour.

Key words: Leaching test, EN84 method, CCA fixation, Malaysian hardwoods, Methanol soluble heartwood extractives.

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5.05 C

ENVIRONMENTAL IMPACTS AND BENEFITSOF WOOD-BASED COMPOSITES

Papers

Modeling the Formation and Bonding of Wood Composites

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Wood composites have been traditionally studied using experimental methods. While providing general understanding and short-term solutions, the trial-and-error approaches are often limited by equipment conditions and material variations. Analytical approaches are needed to fundamentally understand and technically advance the wood composite materials. This presentation summarizes recent progress in developing mathematical and computer simulation models for wood composite formation and product bonding performance. Based on fundamental principles, the models characterize and predict: 1) the random formation of particulate mats, 2) the consolidation of the porous mat structure, 3) the heat and mass transfer during hot pressing, 4) the resin distribution, and 5) the bonding performance of the products. The models have constituted a theoretical basis and an analytical methodology, which can be applied to investigate other facets of wood composites.

Key words: Wood composites, modeling, simulation, formation, consolidation and bonding.

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The Detection of Volatile Organic Compounds (eg Formaldehyde) Emissions in Wood Based Materials using Photoacoustic Infrared Spectroscopy

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Wood is a porous material that has the ability to modulate moisture and thermal performance. Therefore, wood based materials are often used as constructive and decorative materials in buildings. However, the effects of volatile organic compounds (VOCs) from wood based materials have importance for indoor air quality. This study used photoacoustic analysis to monitor and detect the formaldehyde levels from wood based materials in order to understand how to prevent the formaldehyde emissions and the related impacts of formaldehyde concentrations on the indoor environment.

For the real time detection of ambient formaldehyde concentrations with high sensitivity and selectivity, the optical parametric oscillation (OPO) laser was developed. The multipass acoustically open photoacoustic detector (MOPAD) combined with OPO lasers and the desiccator as the test cell for VOC gas sensing in ambient air. The photoacoustic spectrum of formaldehyde was measured from 2796 to 2806 cm^{-1} and an absorption line at 2805 cm^{-1} was selected for detection. The 2805 cm^{-1} absorption line of the ν_1 vibrational mode was chosen because of the absence of interference from gas-phase water and carbon dioxide bands. HITRAN spectra for different water and formaldehyde concentrations were diconvoluted?convolved with the IR lineshape function and were compared with the measured photoacoustic spectrum. This allowed the direct detection of formaldehyde in laboratory air without filtering or treatment. Such a device will be an ideal tool for monitoring concentration changes of wood based materials. Additionally, the concentrations of formaldehyde, recorded by the photoacoustic method,.in laminated venner lumber were 671 mg/m^3 (537 ppmV) and MDF 10.6 mg/m^3 (8 ppmV).

Key words: Volatile organic compounds, formaldehyde, photoacoustic infrared spectrsocpy, wood based material, indoor air quality

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Properties of Multi-layered Kenaf

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Kenaf (*Hibiscus cannabinus* L.) has been recently introduced to the Malaysian biocomposite industry. Based on their basic properties, both bast fibres and core material of kenaf are distinctly apart. While bast fibres are stiffer and low in wettability, the core material of kenaf is relatively weaker and has excellent absorbing properties. This study evaluates the properties of Multi-Layered Kenaf Board (MLKB) made from a combination of bast fibres and core material. Both materials were separated first by pretreating the fibres with NaOH then combed until the fibres became loose. The study shows Kenaf bast fibres that have been treated with higher alkali concentration (5% NaOH) are lower in holocellulose, hemicellulose, α-cellulose, and lignin respectively than when treated with water alone. Both kenaf core and rubberwood behaved similarly towards acid and alkali. Due to its morphology properties, kenaf core inner surface exhibited higher wettability than the outer surface. The properties of kenaf board were tested using MS standards 1737: 2005. An Analysis of Variance (ANOVA) was carried out and the effects were further analysed by means separation using Least Significant Difference (LSD) at $p \leq 0.05$. Kenaf board comprising bast materials in the middle layer was found to be stiffer than that of homogeneous (100% rubberwood). The incorporation of low molecular weight phenol formaldehyde (LPF) resin and melamine urea formaldehyde (MUF) in board comprising of 70% kenaf core on the surface and 30% bast in the middle layer produced boards of reasonably good strength and dimensional stability, modulus of elasticity (MOE) 873 MPa, modulus of rupture (MOR) 8.9 MPa, internal bonding (IB) 0.32 MPa, thickness swelling (TS) 12.6%, and water absorption (WA) 118.9%. The presence of bast long fibres had improved the linear expansion (LE) length-wise. Even though the MOR values of MLKB obtained in this study were below the minimum value (13.0 MPa) for use in dry condition (PG1), they are much superior than the control 100% rubberwood board.

Key words: Kenaf, bast fibre, multi-layerd kenaf board

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Recycling Economic Development of Wood-based Panel Industry in China

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This article briefly reviews the evolution of recycling economy in China, and then characterizes how a recycling wood-based panel industry could co-exist and provide biomass feedstocks for the traditional wood-based panel industry. In response to worldwide environment concerns, as well as the shortage of wood resources in China, it is concluded that by developing and promoting a recycling-based economic system the Chinese wood-based panel industry would not only save energy, natural resources and protect environment, but also increase its innovations and product quality. This would also enhance its competitiveness in the global market.

In recent years, bearing in mind the limited natural resources and the ever increasing environment concerns, the Chinese government has initiated a recycling economic development model. This has lead to a series of new regulations such as "the clean production code", "the solid residues recycling regulations", and "regulations for making efficient use of wood resources." As the biggest producer of wood–based panel products in the world, the China's wood-based panel industry is also a major consumer of wood resources. The industry shall proactively abide by the theory of recycling economy and implement the principle in the wood-based panel production. The corresponding measures shall include using more renewable, alternative natural resources, and developing environmentally-friendly technologies and products while simultaneously enhancing its efficiency in using of wood resources. In this way, the wood-based panel industry will play an important role in protecting ecosystems and stimulating the sustainable development of economy in China. The authors highlighted the importance of the sustainable development of the wood-based panel industry, investigated the current status and potential difficulties of the recycling development in wood-based panel industry, and finally proposed solutions to overcoming the barriers.

Key words: Recycling economy, wood-based panel industry, sustainable development, environment protection

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VOCs of Wood Based Panels in Europe

Marius C. BARBU*

People usually spend approximately 90% of their lifetime indoors'. The indoor environmental quality (IEQ) has therefore a major impact on health and comfort. It is generally influenced by various factors, including the indoor air concentration of volatile organic compounds (VOC).

Beside formaldehyde, which originates mainly in the used resins, a variety of other organic compounds are released from wood products and can be found in the indoor air. Basically, level and composition of such VOCs are determined by wood species and type of wood-based material, respectively. As adverse health effects are associated with elevated indoor air concentrations, several international activities have been launched, including the European Collaborative Action or the German "Committee for Health-related Evaluation of Building Products". Their main task is the evaluation and limitation of building products' emissions. Concerning the release of formaldehyde, standardised emission classes additionally determine and restrict the usage of wood-based composites in Europe and Japan.

Aim of the work is to characterise analytical methods and approaches to evaluate building products regarding their impact on the indoor air quality. Important factors possibly influencing the result are exemplified on basis of emission test chamber measurements of relevant products. In this context a focus is set on the course of emissions as well as characteristics of individual compounds. Furthermore, general measures to lower emissions from wood-based products are presented.

In order to offer sustainably competitive wood based products and to address possible claims from customers in the future, knowledge about the described results and interrelationships is of great importance for any manufacturer of wood products and of course for the end users.

Furthermore, it shall be generally discussed how the mentioned public activities could affect utilization of wood composites. As one consequence, appreciated advantages of some wood products might be eclipsed – e. g. the processability or price competitiveness to other non wood materials.

Key words: Wood based panels, VOC, wood products emissions, IEQ

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Overlaying Properties of Particleboard Panels made from Eastern Redcedar and Osage Orange

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In this study, surface characteristics of overlaid particleboard panels manufactured from whole-tree chipped furnish of eastern redcedar and Osage orange were determined. 7.5 cm by 12.5 cm samples of single- and three-layer panels were overlaid with melamine impregnated paper. Roughness measurements were randomly taken from the surface of overlaid samples using a fine stylus profilometer. Three roughness parameters, average roughness (R_a), mean peak-to-valley height (R_z) and, maximum roughness (R_{max}) were used to evaluate surface characteristics of overlaid samples conditioned at 55% and 92% relative humidity exposures. Statistical analysis revealed that no significant difference in roughness values of single-layer panels made from two types of furnishes was found at 55% relative humidity levels. However, single-layer samples had significantly higher roughness values than those of three-layer at the same relative humidity exposure. When the samples were exposed to 92% relative humidity both types of specimens had significantly higher values of R_a, R_z, and, $R_{m,ax}$ than those of measurements taken at 55% relative humidity. The stylus method is able to detect differences in surface roughness of overlaid panels that can occur due to particle size changes. The manufacturing process of such panel incorporates the low quality whole-tree in Oklahoma. Therefore, a manufacturing operation and overlaying process would be able to utilize more volume of input per delivered tree and generate less processing waste than a traditional particleboard plant.

Key words: Eastern redcedar, Osage orange, surface roughness, overlays, melamine paper

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Low Weight Panels: A New Development in Europe

Heiko THOEMEN* and Marius BARBU

In the last five decades, the usage of conventional particleboard and MDF has not been questioned for furniture and other interior applications. Its relatively low price, flexibility for multiple applications due to the type variety and good machinability, were the major advantageous characteristics of these panels.

However, light weight panels (< 400 kg/m³) have gained considerable interest in recent years all over Europe, as well as in other parts of the world. Clearly, the general mega-trend towards light weight structures, which is evident in many industries, does not exclude the furniture and panelling sector. In today's world, people are moving more often than they used to do. In Central Europe, half of the sales of furniture is already in take-away and DIY furniture. The current furniture design requires thick panels as components, which can be economically achieved only using light weight boards, if one wants to avoid problems in the handling of furniture. A weight reduction would have a positive effect on transportation and packaging costs.

The paper describes and explains the current trend towards light weight panels in Europe and Asia. The state of the art of different product types with reduced weight is discussed, such as honeycomb panels, ultra-light particleboard or MDF, and sandwich panels with the core made of synthetic foams. The possible applications of each of these products depends mainly on two factors, namely their performance in use and their production costs. A comparison of the mechanical product properties and economical aspects will therefore be given. The paper focuses also on the technological aspects, implementation in existing lines and requirements for further users. Other products using these new panel types include insulation boards, with densities below 200 kg/m³, which have direct application in the ecological building industry. Last but not least a focus on the prospects and limits of light weight panels for different types of application is presented.

Key words: Low weight panels, low density boards, light furniture, MDF, honeycomb, foams

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5.05 C – Posters

Producing Composite Articleboard from Peanut Husk and Wood-based Materials

Wun-Jheng HUANG, Hong-Ding SOONG, Li-Jen HOU and Tien-Tien CHEN

The purpose of this study was to strengthen the particleboard made from agricultural residues such as peanut husk by using different wood-based materials. The board size, target density and types are 450mm × 450mm × 10mm, 0.65g/cm^3, 15 respectively. The binder to be used is phenolic formaldehyde resin (PF). The resin content of PF is lower (i.e.6%) than commonly used in UF (i.e.10%) . Pressing temperature, pressure and time are 190℃, 2.74MPa, 8min respectively. As the low bending strength of particleboard made from peanut husk, we used different kinds of wood-based materials such as radiata pine particle, red lauan veneer, bamboo veneer etc. to increase the mechanical properties. Free formaldehyde release of the boards ranged from 0.71 to 1.41ppm (meets F_3 of CNS 2215-95). Board density, moisture content and thickness swelling were 0.60~0.63g/cm^3, 3.35~4.71%, 12.74~42.30% respectively. In mechanical properties, board internal bond strength, screw holding strength, modulus of rupture, modulus of elasticity and wet bending strength were 0.075~0.64 MPa,198.51~526.42 N,3.05~34.08MPa, 277.91~3212.61MPa, and1.33~21.45MPa respectively.

Key words: Peanut husk particleboard, phenolic formaldehyde resin, radiata pine particle, red lanan veneer, bamboo veneer, woven bamboo veneer

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Multiple Advanced Reuse of Agroforest Waste from the Used Mushroom Growing Sawdust: Extractive and Lignocellulosic Residue Utilizations

Yong-Long CHEN, Ho-Chin CHEN, Tsai-Yung CHEN and Jyh-Horng WU*

The purpose of this study is to evaluate the potential health benefits and to recycle the lignocellulosic waste from the used mushroom growing sawdust. In the present study, column chromatography (CC) and high performance liquid chromatography (HPLC) were employed to separate and purify the methanolic extracts from the used mushroom growing sawdust, and their antioxidant activities were further evaluated by various assays, including DPPH radical screening assay, superoxide radical screening assay, and ferrous ion-chelating ability assay. In addition, total phenolic contents were also determined. Accordingly, among various soluble fractions, the EtOAc fraction from the used mushroom growing sawdust exhibited the best performance in DPPH radical screening assay and superoxide radical screening assay. Also, the EtOAc fraction showed the highest phenolic contents (65.3 mg of GAE/g). Consequently, 4-hydroxyl-3-methoxyl benzoic acid was further isolated from the antioxidative EtOAc fraction and its activity was also confirmed. On the other hand, the bio-based composites were manufactured by different mixing ratios (50:50, 60:40, 70:30) of the extractive-free lignocellulosic waste and high density polyethylene (HDPE). Results revealed that mechanical properties of composites were decreased by increasing the ratio of lignocellulosic waste, but all of composites conformed to the commercial standard of JIS A5908. Even the ratio of lignocellulosic waste to HDPE up to 70:30, the modulus of rupture (MOR), internal bond (IB) and wood screw holding strength still got up to 7.5 MPa, 0.9 MPa and 49.1 kgf, respectively. Furthermore, the thickness swelling (TS) of all of composites was less than 8% after 24 hr water immersion. These results demonstrated that it would benefit the development of the potential application of agroforest waste from the used mushroom growing sawdust in different areas.

Key words: Mushroom growing sawdust, agroforest waste, antioxidant, bio-based composites, high density polyethylene (HDPE).

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Enzymatic Modification of Wood Fibres for Activation their Ability of Self Bonding

Cora MÜLLER*, M. EURING and A. KHARAZIPOUR

The incubation of wood fibres with a phenoloxidase results in the oxidation of lignin crust on fibre surface. During this reaction, lignin is highly oxidized, as can be seen from its high carboxyl content. A problem is that Laccase can only oxidize the phenolic constituents of lignin, due to its lower oxidation potential. Therefore the use of appropriate low molecular-mass compounds (so-called mediators), in combination with Laccase, makes this enzyme competent for the oxidation of nonphenolic substrates. The oxidized mediator can rely on an oxidation mechanism that is not available to the enzyme.

The focus in the present work was the application of the mediator 4-hydroxybenzoic acid (HBA) for incubation of wood fibres with laccase for the production of medium density fiberboards. In the first step the wood fibres are sprayed with laccase mediator solution (LMS) for the production of MDF-boards on the pilot-scale. Afterwards the fibres incubate at room temperature for 1 up to 2 hours. In the second step the incubated fibres are dried at 70 °C to a final water content of 10-12 % and than they are formed to a mat. The mat is pressed for 4 up to 5 minutes at a temperature of 210 °C and 22 MPa pressure to 10 mm thick fibre boards. Afterwards the boards are tested for their mechanical properties.

Key words: MDF, laccase, mediator, enzymatic activation

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Development of Innovative Medium Density Fibreboards (MDF) with Decreased Formaldehyde Emissions

Christian SCHÖPPER* and Alireza KHARAZIPOUR

One of our research objectives is to develop wood based panels by use of pure natural binders or mixed adhesives to analyse the substitution potential of conventional resins by natural bonding agents in laboratory and pilot scale. Another important aspect of our research and development activities on wood based panels is to develop Medium Density Fibreboards, three-layered particleboards and insulating materials without or with low formaldehyde emissions compared to nowadays produced composite materials. To achieve these objectives one possibility is the utilisation of natural binder systems based on renewable resources.

In line with this project the applicability of a natural binder system based on wheat protein should be analysed as bonding agent for a later industrial production of Medium Density Fibreboards (MDF). The Medium Density Fibreboards produced with this natural binder should feature the same mechanical-technological properties than urea formaldehyde resin bonded MDF. Therefore the actual German (DIN) and European norms (EN) for Medium Density Fibreboards are taken as a basis to estimate the achieved properties of the protein bonded MDF. To determine the substitution potential of conventional resins by this protein binder for the production of MDF the wheat protein suspension is used on the one hand as pure binder system and on the other hand combined with conventional resins like urea formaldehyde and phenol formaldehyde in different ratios (so called “mixed adhesives”). By modifying the amount of the natural binder in the mixed adhesives the formaldehyde emissions of the boards should be decreased. Another important aspect that should be determined in line with this project is to verify the thesis that proteins can react as formaldehyde catching substance.

Key words: Medium Density Fibreboards, natural binders, wheat protein, wood based panels, formaldehyde emissions

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Manufacturing of Wood Particle Oyster-shell Bonded Cement Composites

De-Tsai LIN*, Chi-Lung CHIANG, You-Lin CHEN, Ru-Jiun LUO, Bei-Shan LIN and Pei-Ling LIU

We investigated the manufacturing conditions, forming properties of wood particle oyster-shell bonded cement composites (WOCCs).Variables were hydration temperature, chemical additive, material, and amount of filler on composite. Aquiculture wastes, cement, and wood particles were mixed in five ratios: 0/80/20, 4/76/20, 8/72/20, 12/68/20 and 16/64/20based on dry weight. The water-cement ratio was 0.45 and 0.35.Calcium chloride and sodium silicate were added at a level of 3 %(based on cement weight). Boards were conditioned for 1 week. According to CNS 2215 method, we investigated density, moisture content, modulus of rupture, water absorption and thickness swelling. Results of physical, mechanical, and sound insulation tests indicated: Compatibility of materials is related to hydration temperature. 10% replacement of cement with oyster-shell to manufacture composites showed its strength performance was slightly lower than those without adding oyster-shell. Mass loss decreased oyster-shell amount with increased, and boards properties at 60°C was better than 100°C by conventional processed. 10% replacement of cement with oyster-shell to manufacture composites showed it can decrease noise at 250-1K(Hz).

Key words: Hydration temperature, oyster-shell, strength properties, wood particle oyster-shell bonded cement composites

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5.06 B
PROPERTIES AND UTILIZATION OF PLANTATION WOOD

Papers

Improving Utilization and Value Adding of Plantation Timber from Sustainable Forest Management

Yu Eng TAN*, Nigel LIM, James JOSUE and Kee Seng GAN

This ITTO-funded project attempts to improve utilisation and value-adding of selected plantation-grown timbers in Peninsular Malaysia (PM), Sarawak and Sabah. The overall development objective is to improve end-uses of Malaysian forest plantation resources through systematic evaluation of their basic material properties. The timber species selected are: *Acacia mangium* and/ or Acacia hybrid from Peninsular Malaysia, Engkabang (*Shorea macrophylla*) from Sarawak, and teak (*Tectona grandis*) from Sabah. The choice of species was made taking into consideration primarily availability of adequate test materials from different age groups in the above three regions.

Before proper evaluation could be carried out, a set of harmonised testing techniques for assessment of various basic properties including physical and mechanical characteristics, wood anatomical structures, processing and drying behaviour, as well as durability and wood chemistry will be established. Such unification of testing methods, once adopted by the tropical timber producing countries, will facilitate comparison of wood properties of plantation species from different countries. The findings will also enable the establishment of other effects such as silvicultural treatment, soil type, stand density etc. on wood properties.

Based on the basic data obtained, selected value-added products will be developed using appropriate processing and manufacturing techniques. The project will assist in the formulation of suitable plantation forest management strategy, among others, to supplement the deficit in timber supply in Malaysia.

This paper summarises the progress and challenges encountered so far. It further invites inputs from the participants to enhance the objectivity, practicality and universality of the harmonised techniques to be developed.

Keywords: Plantation timber, harmonised testing techniques, wood properties

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Effects of Moisture Availability on Wood Properties of South African-grown *E. grandis*

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The productivity of *Eucalyptus grandis*, planted extensively in South Africa, is highly dependant on soil moisture availability. However, soil moisture availability is often limited and evaporative demand is high resulting in reduced productivity and significant changes in wood properties. This study explored the use of rapid screening tools to characterize the properties of wood in stands of *Eucalyptus grandis* grown in the sub-tropical and warm temperate regions of South Africa.

Gamma-ray densitometry, image analysis techniques and NIR-spectroscopy were used to assess wood density, and vessel and fibre characteristics of breast-height core samples from stands representing varying levels of moisture availability. Combinations of mean annual precipitation (MAP) and estimated soil water storage (SWS) were used to achieve a range moisture availability levels. Growth data, radial maps illustrating pith to bark variation in wood properties, and weighted mean values of material aged 8 – 10 years are discussed for each region in terms of responses to soil characteristics, individual environmental factors that influence moisture availability, and their interactive effects on wood quality.

In the sub-tropical region, higher levels of water availability resulted in lower density wood with larger vessel and fibre diameters, thinner cell walls, lower vessel frequencies, higher NIR-predicted cellulose content and lower NIR-predicted lignin. The patterns of response of wood properties to varying water availability in the warm temperate region were similar to that of the sub-tropical region; however, results were often less clear. The response of wood properties to water availability in the sub-tropical region was thought to have been amplified by higher temperatures.

This data could be used in future planning strategies by assisting growers to factor in objectives for wood quality and quantity, and predict the value of increased volumes of wood. Wood property data could also lead to much greater raw material and energy efficiencies in the pulp and paper mills.

Key words: *Eucalyptus grandis*, moisture availability, wood properties

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Alternative Timbers to Iroko (*Milicia excelsa*) for Various End-uses: Ghana's Offer

Samuel AMARTEY* and Alhassan ATTAH

Timber is a key commodity in Ghana for internal use and for export and this makes its efficient management and utilisation very important. The Timber industry has been a good source of foreign exchange for the country for decades and timber traditionally ranks fourth to minerals, cocoa and tourism in foreign exchange earnings for the country. There are about 680 tree species growing in the High forest zone. In addition to the natural forest, plantation forests cover about 760,000 ha with species such as *Tectona grandis* (*Teak*), *Cedrella odorata* (*Cedrella*), *Gmelina arborea* (*Gmelina*). About 140 of the timbers in the forests have commercial usefulness but regular harvesting has been limited so far to only 40 or so species as a result of lack of market acceptance for the other timbers. The older established commercial species such as *Triplochiton scleroxylon* (*Obeche*), *Milicia excelsia* (*Iroko/Odum*) and *Khaya ivorensis* (*Mahogany*) have been heavily extracted and are currently facing extinction. This will eventually have a negative impact on biodiversity and the environment. However, promotion and utilisation of the many lesser used species in the forests as alternative sources of wood for various end uses should ensure sustainable forestry. The key to increase utilisation of the LUS is to have a sound knowledge of their location, quantities, size, form distribution, biological, mechanical and physical properties relative to specific end-use and knowledge of industrial and end use markets (domestic and international) for these species. This paper compares various properties (mechanical, biological) and volumes of lesser used timber species such as Dahoma (*Piptadanistrum africanus*), Ekki (*Lophira elata)*, Kusia (*Nauclea diderrichii)* and Papao (*Afzelia bella*) which are being promoted as good alternatives to *Iroko/Odum* for various end uses.

Key words: Primary timbers, lesser-used timbers, sustainable forestry

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Wood Properties of *Eucalyptus* as Indicators to Silviculture and Forest Improvement for Saw Log

Jose Nivaldo GARCIA*

Many reports on different *Eucalyptus* species were summarized, discussed and compared. Seven important defects which are associated to *Eucalyptus* sawn wood production are presented and some methodologies to evaluate these defects quantitatively were proposed. Theories which help to explain the defects in terms of their origin, interactions, dependencies and errors associated to how and when the measurements were taken, in the sawing process, were also presented. Theories were proposed in such a way to transform the defects into reliable and comprehensive technological indicators which silvicultural practices and forest improvement programs can be based on.

The studied indicators were evaluated for different forest practices and also according to their genetic parameters in clonal and/or progeny trials. Most of the defects evaluated showed under strong genetic influence. Significant genetic gains to the wood quality can be obtained and predicted if the indicators may explain, as a number, the real expression of the defects they are related with.

Some common lumber defects related indicators were shown to be not reliable, so they were considered as non-relevant for use in saw logs improvement programs. Others were a little more significant, so they need to be confirmed through a more comprehensive experimental design which permits individual variable to be analyzed in defining the overall lumber quality.

Key words: Eucalyptus, sawmill, sawn wood, wood defects, wood improvement, mechanical properties

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Strength Performance of Glulam made from Obi-sugi Laminae with low Young's Modulus of Elasticity

A. MATSUMOTO*, H. MORITA, Y. FUJIMOTO, A. SHIIBA and Y. IIMURA

Obi-sugi is a type of Japanese cedar (*Cryptomeria japonica* D. Don) grown mostly in Miyazaki prefecture. It grows faster in warmer and wetter southern prefecture of Japan. Obi-sugi is reportedly inferior in strength performance and thus has low Young's modulus of elasticity (MOE). Japanese Agricultural Standards (JAS) requires laminae used for structural glued laminated timber (Glulam) to be higher than 4.9 kN mm^{-2}. Based on this, the yield of laminae cut from obi-sugi log for structural glulam is extremely low and the production cost unattractive. In this study the bending, compression and tensile tests on finger jointed obi-sugi laminae and on the symmetric-structured glulam composed of different grade of laminae including those with lower Young's modulus were conducted. It was confirmed that the strength performances of laminae with lower Young's modulus such as L30 and L40 were nearly equal to that of sugi wood with Young's modulus of 4.9 kN mm^{-2}, and these lower Young's modulus laminae could be used for structural glulam. As for the glulam made with composition of these lower Young's modulus laminae, such as E65 (using L40 laminae for inner layer), E55 (L40 for inner layer) and E55 (L30 for inner layer), the glulam performed well in bending and compression tests but were slightly low in tensile strength.

Key words: Obi-sugi, laminae, structural glulam

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Physical and Mechanical Properties of *Eucalyptus grandis x E. tereticornis* Hybrid grown in Argentina

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The *Eucalyptus grandis* is of very high growth (it overcomes the 40 m^3/yr) but one of the limitations is its low density and hardness, especially for solid products as the case of floors. The red eucalyptus, *Eucalyptus tereticornis* and *Eucalyptus camaldulensis* are of very high density and hardness, but their problem is their slow growth (less than 20 m^3/ha/yr). Therefore, INTA started to study a series of hybrids looking for acceptable growth rates and wood with more density.

The present work is the first report that it is published at national level, and in great measure at international level, about the main physical-mechanical properties determinated of the promissory hybrid of *E. grandis* x *E. tereticornis* (other determinations exist mainly in South Africa). The companies that market these clones usually only offer data of the density, but this research shows more complete data: density, hardness Janka, static bending (module of elasticity & rupture, tension in the limit, parallel cut, parallel compression to the grain, perpendicular compression to the grain, shrinkage, nails and screw withdrawl.
Trees were used to the cut age (about 10 years) and with average dimensions of 34 cm diameter DBH (Diameter Breast Height) and 30 m height, planted in the sandy soils of the INTA Experiment Station of Concordia, Entre Ríos, Argentina.

The tests were carried out in the laboratory of the National Technological University UTN, with a Shimatsu universal machine. For the obtaining of samples and tests the ASTM and IRAM (Argentina) standards were used the according to the test.

The results, compared with other determinations of *E. grandis* and *E. tereticornis*, show intermediate values among the mentioned species.

Key words: Physical and mechanical wood properties, *Eucalyptus grandis*, *Eucalyptus tereticornis*, Argentine, fast grown lumber

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Physical and Mechanical Properties of Multiple-leader *Acacia crassicarpa* A.Cunn.Ex.Benth and *Acacia mangium* Willd

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Evaluation on selected physical and mechanical properties of *Acacia crassicarpa* A. Cunn. Ex. Benth and *Acacia ma*ngium Willd multiple-leader trees were carried out to determine their potential utilization. The study involved two classes of multiple-leader namely: ML2 (trees with two leaders) and ML3 (trees with more than two leaders), and four and three provenances for *A. crassicarpa* and *A. mangium* respectively. Analysis of variance on the physical properties (specific gravity, radial and tangential shrinkages) for the former species showed that the ML classes were significantly different at $P<0.05$, but not between provenances. ML2 produced higher mean values in terms of specific gravity, radial and tangential shrinkages with 0.48, 2.48% and 4.36%, respectively, compared to ML3 which gave values of 0.47, 2.89%, and 5.83%, for the respective parameters. Similarly, the ML classes differed significantly at $P<0.05$, in terms of mechanical properties, i.e. modulus of elasticity and modulus of rupture. ML2 produced mean values of 8708.05 MPa and 74.01 MPa while ML3 produced values of 7557.7 MPa and 60.4 MPa, for modulus of elasticity and modulus of rupture respectively. On the contrary, the latter species showed opposite effects by exhibiting significant differences of both the physical and mechanical properties between provenances but not between ML classes. Provenance from Bensbach WP (PNG) produced the highest mean value (0.46 for specific gravity, 4.43% for radial and 3.69% for tangential shrinkages, 10164.70 MPa for modulus of elasticity and 83.02 MPa for modulus of rupture). On the other hand, provenance from SW of Boset WP recorded the lowest values of 0.44, 3.25%, 2.71%, 7197.00 MPa and 52.38 MPa respectively. It can be concluded that growth habit in terms of multiple-leader formation and genotype do affect the physical and mechanical properties of these species.

Key words: physical and mechanical properties, multiple leaders, *Acacia crassicarpa*, *Acacia ma*ngium

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5.10 B
MARKETING STRATEGIES & FORCES

Papers

Forest Products Markets in Western European Urbanized Society

Nico A. LEEK*

Forestry and forest products have become an international political issue. Especially in consumer countries such as UK and The Netherlands, the NGO's have strongly influenced public opinion and their impact is increasing quickly e.g. in Denmark, Germany and Belgium. These countries have developed, or will develop, national standards for sustainably produced timber, which can be used for the introduction of public procurement policies for forest products. At the same time, in the more urbanized societies in Western Europe forestry is more and more oriented towards nature development. In the Dutch government policy f.e. 30 % of the total forest area will be managed exclusively for nature development (excluding wood harvesting) and 70% of the area for multiple use forestry. Harvesting rates have also been influenced by the rather low wood prices, the relative high harvesting costs and the fragmented ownership. In most western European countries the wood harvesting volume nowadays has been reduced to a level of 50-70% of the mean annual increment.

Since 2004, consumption of wood products has been increasing again in the EU, which trend is even stronger in the USA and seems to be exploding in China. The growing demand for timber coupled to a decreased harvest in European forests results in serious problems in wood procurement. Wood prices are rising e.g. in the Dutch packaging industry sawn wood prices were already 30 % higher in June 2006. Another development is the expected strong increase in the demand for energy wood in the EU. Looking at the forest based industry in Europe; we see international pulp & paper companies with production plants all over Europe. There is a very strong up scaling in the sawmill industry, especially in Germany. Globalisation is resulting in larger companies with increased production capacity. The new sawmills prefer relatively small diameter round wood. Ironically, the general trend in European forest management is to produce an increasing share of large dimensioned timber, which is due to implementation more nature oriented forest management and the public demand for older and more attractive forests. How to solve these dilemmas?

Key words: Certification, nature development, wood harvesting, urbanized society.

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Value-Focused Forestry in British Columbia: Competitiveness and Sustainability Issues in the Secondary Wood Products Industry

Wellington SPETIC*, Robert KOZAK and Thomas MANESS

The Canadian forest sector has historically been, and unquestionably continues to be, one of the country's major economic powerhouses. British Columbia's forest sector, with its large endowment of unique wood resources and access to strong markets, is Canada's frontrunner, and remains a market leader in today's increasingly global forest industry. In recent years, however, market forces, such as shifting demand for traditional commodities, changes in export markets, trade disputes, appreciation of the Canadian dollar, and competition from lower-cost regions have had an impact on BC's primary forest products industry.

Strengthening the secondary wood products industry is suggested as a transitioning strategy from today's orientation of maximizing volume throughput to a more value-based approach, by diversifying the industry and reducing communities' nearly exclusive dependence on the primary sector. Consisting almost entirely of small and medium enterprises (SMEs) operating in a variety of product markets, the secondary wood products industry is becoming increasingly important to BC's economy. Yet, there are enormous opportunities for improvements.

By focusing on the secondary wood products sector, this study will assess concepts of firms' competitiveness in British Columbia. Also, the concept of sustainability, its implications to SMEs, and its impacts on competitiveness and value-focused forestry will be addressed. Findings from this study will serve to assist in the development of policies and recommendations for a more diversified, differentiated, and value-focused forest sector in British Columbia.

Key words: Competitiveness, sustainability, SMEs

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Model of Export Marketing Strategies in Transition Countries – the Case of Slovakia

Yvonne BRODRECHTOVA*, Michel BECKER and Heiner SCHANZ

Many countries around the world are more closely integrating their economies into the global trade. Selecting an appropriate export marketing strategy by recognizing its main influences might improve establishment of companies in the new international markets and strengthening their competitive advantage. Determinants of export performance have been extensively studied and although marketing strategy is considered as one of the major determinants of export performance surprisingly little is known about export marketing strategies (EMS), and even less has been done on their influencing determinants in the forest products industries.

The model we present with special attention to transition countries addresses these theoretical and empirical gaps by using four theoretical perspectives including: a resource-based view of the firm, market-as networks and institutional theory connected by transaction characteristics of the transaction costs theory. The model was arrived at empirically by qualitative and quantitative methods. In a first qualitative step, in-depth personal interviews with randomly-selected exporting forest products companies in Slovakia were carried out. Content analysis, thematic coding and contingency tables have been applied to determine the relevant determinants. In the subsequent step a complete inventory of all exporting forest products companies has been carried out based on structured phone interviews. Cluster analyses revealed the different EMS types and multinomial regression analysis provided the different probability of influence of the most significant determinants on EMS types.

The model allows for deriving a distinction between various types of EMS and their significant influencing determinants. The main differences appear between foreign and locally owned companies. Overall, not only resources and networks, but also institutions, have a bearing on the EMS. The way in which the company was established is the single significant influencing determinant that suggests that the past 17 years of the transition process are still having an effect.

Key words: Marketing strategy, export, international trade, forest products, transition economy

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The Relationships among Marketing Forces, Industrial Brand Equity, Industrial Trust and Customer Loyalty: An Empirical Study of Taiwan Lumber Import Market

Tse-Wen HSIEH, Tsui-Ying HUANG and Jun-Yen LEE*

Companies, normally, maintain customer loyalty with their marketing forces in order to achieve goals for sustainable management. In addition, the satisfaction, value, brand equity, company size, and total quality are also the factors that could affect the customer loyalty (Taylor, 2004; Lilien and Wong, 1984; Altan, 2002). As a matter of fact, only trust and brand equity excluding marketing forces are the main factors (Taylor, 2004). The objective of this research is to explore the relationships among the factors of marketing forces, industrial brand equity instead of product brand equity, industrial trust, and customer loyalty in B2B market.

In this research, a questionnaire was designed and sent to eighty-nine Taiwanese lumber importers to collect information. Structure equation model was introduced to evaluate the data and the concept model. The estimates are statistically significant. As results, the constructs of industrial brand equity and industrial trust are the mediating variables between marketing forces and customer loyalty. The effect of industrial brand equity on customer loyalty is the strongest among these constructs. Thus, to increase Taiwanese lumber purchasers' loyalty, the lumber suppliers should establish and maintain their brand equity.

Key words: Marketing forces, industrial trust, industrial brand equity, customer loyalty

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5.10 B – Posters

Development of a Joined Marketing Concept for Silver Fir in Central Europe

Thorsten BEIMGRABEN* and Udo Hans SAUTER

Silver fir plays an important role in the forests of Southwest Germany, Switzerland, Austria and Northern Italy. Silver fir has a stabilising function in the forests and under ecological aspects the area covered with fir should be enlarged. Saw millers complain, that the timber of Silver fir is difficult to dry and shows heart shakes which lead to yield losses. Most end users are unaware of the fact that there are large differences in terms of wood quality between Silver fir and Norway spruce. Over the intervening years the knowledge on the positive properties of Silver fir got lost and rumours about bad quality arose, mostly caused by the problems generated by mixing up the timber of fir and spruce.

The most important positive characteristics of Silver fir identified are resin free timber with its appealing surface and colour. In addition to this, Silver fir features a positive life cycle assessment and short transport distances, when using it in the area of its natural ecological presence. A fact that has not to be proved by a certification of its origin, because Silver fir is limited to Central Europe.

The aim of the project presented was to develop a public interest in Silver fir, to sharpen its profile as an unique timber species and to recify and improve the public image of Silver fir. In the frame of the project a marketing concept for Silver fir has been developed and established in praxis. Marketing material (information, brochures and examples) has been prepared for different target groups. The range of products made from Silver fir was documented and extended.

Contacts between different Silver fir marketing groups in Germany, Austria and Italy have been established and in consequence a joined image brochure has been developed and published. Therefore a joined logo has been created, which from now on will be used for all marketing activities concerning Silver fir. In a second step a joined website (www.weisstanne.info) for Silver fir has been created in close cooperation with our partners. This instrument is used as a central communication platform between forest owners, saw millers and end users. It includes a list of suppliers and experts dealing with Silver fir products.

The whole project was characterised by a coordination of different marketing activities in Central Europe. The result was a tremendous progress for the marketing of Silver fir in Europe. The arrangement of a joined logo, website and image brochure strengthened the market position of Silver fir and gave motivation to all participants in the marketing activities. Silver fir escaped from the shadow of Norway spruce and is nowadays noticed as a different wood for many high valued products. Several small and medium sized companies took the chance to establish new product lines based on Silver fir. (www.weisstanne.info)

Keywords: Silver fir, marketing, website, product development

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Types of Export Marketing Strategies - the Case of Forest Products Industries in Slovakia

Yvonne BRODRECHTOVA*, Michel BECKER and Heiner SCHANZ

Export marketing strategies (EMS) are a relevant topic in the globalization of the markets. Better knowledge of their types can lead to the strengthening of competitive advantage and create value. However, in the last decade, research on international standardization and adaptation, barriers to exporting and particularly the intensively studied link between export performance and export marketing strategy, has neglected the issue of the various types of export marketing strategies and their main differences. Additionally, even less is known about the transition countries of Europe in general and in the forest products industries in particular.

A conceptual framework based on various schools of thought about marketing strategies has been designed to fill these theoretical and empirical voids. The deductive approach in the form of case study with qualitative and quantitative methodology has been chosen to test the framework in the context of the exporting forest products industries in the Slovakia. In a first qualitative step, in-depth personal interviews with 30 randomly selected companies have been carried out in order to deductively identify determinants modeling export marketing strategies. In the subsequent quantitative step a complete inventory of all exporting forest products companies based on 138 structured phone interviews, has been completed. Using these determinants, performed hierarchical cluster analysis revealed taxonomy of the export marketing strategy types.

The presented results distinguish four export marketing strategies which are dynamic in nature. In most companies export seems to dominate and the main differences lie among local firms and foreign entrants, as well as among finalization of exported products. The insights of each EMS as well as further discussion about the dependency and independency of the determinants in the export marketing strategy research will round out the poster presentation.

Key words: Marketing strategy, export, typologies, forest products, transition economy

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5.01.07
TREE RING ANALYSIS

Papers

Metal Deposition in Baldcypress Tree Rings: Nickel, Copper, Chromium, Manganese and Iron

Margaret S. DEVALL*, Leonard B. THIEN and George C. FLOWERS

A baldcypress (*Taxodium distichum*) tree-ring chronology was constructed along a polluted bayou (Bayou Trepagnier) near New Orleans in Louisiana, USA. The levels of nickel (Ni), copper (Cu), chromium (Cr), manganese (Mn) and iron (Fe) in annual rings were analyzed using x-ray fluorescent spectrometry. High levels of Ni, similar to Pb, could be correlated with the establishment of a refinery and dredging which created spoil banks containing elevated levels of metals. Cu and Fe varied little over time, while Cr and Mn gradually increased. Mean concentration of Ni was higher closer to the refinery. Cu and Fe concentrations were similar along upper and lower portions of the bayou, and Cr and Mn concentrations increased in the lower portion. The levels were different for metals in baldcypress trees along transects perpendicular to the bayou. Waterlogged soil, circumneutral to basic pH of the bayou and presence of acid volatile sulfides from the brackish lake water are likely the explanation for relatively low levels of metals in the tree rings in spite of their proximity to the spoil banks.

Key words: Dendrochemistry, baldcypress, Taxodium distichum, Bayou Trepagnier, pollution

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Identification of Iranian Timber via Cross Sectional Characteristics and with Help of a Computer Program

Vahid Reza SAFDARI*

In spite of Iranian climate diversity, the number of commercial timber species is very low, but wood identification is nevertheless very complicated. In this research, cross sections of the most important of Iranian timbers have been studied. First of all, species have been divided into three groups (ring porous wood – diffuse porous wood – and semi-ring porous wood), then species which were similar have been treated in same group. The most important characteristics in identifying the ring porous wood (1.*Quercus castaneifolia 2. Ulmus glabra- Zelkova carpinifolia - Ulmus campestris- Celtis australis* 3. *Gleditschia caspica- Mours alba- Robinia pesudoacasia 4. Fraxinus excelsior- Albzzia julibrissin*) are latewood vessel arrangements, presence or absence of tyloses in spring wood, and distinctiveness of rays and ulmiform rays. On the other hand, the most important characteristics in identifying diffuse porous wood (1. *Fagus orientalis* and *Platanus orientalis* 2. *Carpinus betulus* and *Alnus glutinosa* 3. *Pterocarya fraxinifolia*, *Diospyros lotus*, and *Juglans regia* 4. *Betula alba* and *Populus spp* 5. *Parrotia persica* and *Buxus hyrcana*) are clarity of tree rings, types of rays and the presence and visibility of axial parenchyma.

Key words: Wood identification, cross section, Iranian timber

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Potentiality and Application of Dendrochronology in Brazil

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The science of dendrochronology experienced its former development with temperate forest trees where a characteristic seasonality occurs. However, the general assumption was that tropical trees lack periodic growth marks in their xylem. In Brazil, earlier contributions to tree-ring analysis were made by wood anatomists devoted to the analysis of the distinctiveness of growth rings of diverse tree species. A few decades later, tropical dendrochronology was recognized as a result of strong efforts of researchers studying tree species in the representative tropical forest ecosystems. More recently, basic research on seasonal phenological behavior of tropical and subtropical trees and their link with climate and cambial activity provide more evidence that several tree species form annual growth rings. Many tree species can now be dated and cross-dated, and consequently used in studies of growth rates and sustainable management, ecological modeling and responses to climate and other environment- limiting influences. Tropical ecosystems are a key piece of the Earth´s global equilibrium, with strong interference in carbon exchange with the atmosphere and in the global water cycle. This makes it even more necessary to expand tree-ring studies in the Neotropics. In this contribution we present a retrospective view of earlier knowledge, and address progress in Brazil, focusing on new challenges in tropical dendrochronology.

Key words: Tropical dendrochronology; tree-rings; wood anatomy

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5.01.07 – Posters

Ring Structures of Chinese Fir and Poplar Plantation Wood

Youke ZHAO* and Jianxiong LU

The ring structures of 35-year-old Chinese fir and 12-year-old poplar plantation wood were measured with the X-ray microdensitometer. The radial variation of ring density and ring width, the variation of ring structure in different tree heights and the relationship among ring structure indices were discussed. The results showed, for Chinese fir, the ring density decreased for the first 3 or 4 years and then increased, and after 13 or 14 years, it became steady. The ring width increased for the first 3 or 4 years, and then decreased, after 13 or 14 years, it became steadily. As the tree height increased, the Chinese fir's ring density first decreased and then increased, while the ring width first increased and then decreased. There was high correlation between the ring density and ring width (coefficient was -0.84), ring density and latewood percentage (coefficient was 0.92). For poplar, the ring density variation was small, the ring width increased from pith to 5 years and then decreased afterwards. As the tree height increased, the poplar's ring density increased and the ring width first increased and then decreased. The correlation coefficient of poplar between the ring density and latewood percentage, and that between the ring density and earlywood density were 0.98 and 0.95 respectively, suggesting that the earlywood density plays a dominant roll in ring density. The ring density and ring width showed no correlation.

Key words: Poplar, Chinese fir, ring structure

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Climate-tree-growth Relationships of *Quercus cerris* and *Q. pubescens* growing in Sympatry in the National Park of Pollino (Basilicata Region, Southern Italy)

Luigi TODARO*, Laia ANDREU, Paolo CHERUBINI and Antonio SARACINO

In order to improve the ecological understanding of *Quercus cerris* and *Q. pubescens*, a comparative dendroecological investigation was carried out. In addition a master chronology (1497-2004) of *Quercus* spp. was developed using some old beams. The study site is located in a mesic area at 3 km from the village of Terranova di Pollino (PZ) in southern Italy (Basilicata Region) and contains one of the oldest and largest oak stands growing in Italy (> 250 years, wider than 2 m at breast height). The influence of climate was assessed comparing total ring width indices with monthly mean temperature (Tmean) and Precipitation (P) registered at Teana (PZ) and Campotense (CS) meteorological stations, respectively, from 1924 to 2000. Response functions were performed for two periods: (1925-1972) and (1953-2000) to analyse how the growth-climate relationships changed throughout time and to detect these changes in the climatic response of *Quercus* spp.

A negative relationship with Tmean (during winter and summer) and a positive one with summer precipitation were detected. These results clearly indicate that summer drought is one of the main limiting factors in *Quercus spp.* growth in the study site.

Key words: Mediterranean region, dendroecology, radial growth, response function

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5.04.12
SURFACING AND FINISHING

Papers

Changes in Anatomical, Physical, and Chemical Characteristics of Bamboo during Natural Weathering.

Jong Sik Kim*, Nam Young Kim and Yoon Soo Kim

Weathering is described as the degradation of materials exposed to outdoor condition. Although a large amount of information is available on wood weathering, information on the weathering of bamboo is limited. Present work was investigated the effect of weathering on anatomical, physical and chemical properties of bamboo. One to three year old bamboo culms (*Phyllostachys pubescens*) were exposed to natural weathering condition for 1 year in Gwangju, Korea and examined every 3 months.
Main changes in bamboo by weathering after 3 months were discoloration and slightly peeling off the outermost layer. After 6 months, silica materials were exposed on the surface and numerous fine V-shaped cracks occurred. After 1 year, silica materials were disappeared and all the tissues close to vascular bundle were degraded. Surface cracks were primarily confined to the parenchyma tissues between vascular bundles. Some fungal hyphae and spores (of molds) were also observed on the surface. The compression and tensile strength of bamboo showed the similar values when compared to bamboo after one year. The FT-IR spectra showed that the bands assigned to lignins were decreased. In particular, absorption band a 1645cm^{-1} assigned to *para*-phenolic hydroxyl group is significantly decreased. Absorption band assigned to polysaccharides (mainly hemicellulose) was also slightly decreased. The present work indicated that the degradation of bamboo under weathering intensified after 6 months and lignin on the surface was mostly damaged by weathering.

Key words: Anatomy, bamboo, FT-IR, lignin, natural weathering

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Weathering Trials of Tropical Timbers finished with several Exterior Coatings in Japan and Sarawak, Malaysia

Makoto KIGUCHI*, Yutaka KATAOKA and Kandau JENANG

Four Sarawak and Japanese timber species were finished with four commercial exterior coatings, and then the specimens were exposed at outdoors in Tsukuba (Japan) and Kuching (Sarawak, Malaysia) for two years. The weatherability was examined by difference of exposure cites, exposure directions and exposure angles.

Timbers species used in this study were Bajan (*Kokoona reflexa*), Mersawa (*Anisoptera costata*), Selangan Batu (*Shorea crassa*) and Sugi (*Cryptomeria Japonica* D. Don). Densities of the species were about 1.03, 0.99, 0.64 and 0.36, respectively. Exterior coatings used were Xyladecor, Cetol HLS, Cetol Novateck and Wood Guard. The three coatings except for Wood Guard were penetrating or semi-film forming types with brown colour. Wood Guard was a film-forming type of fluorine resin with transparent. Finished surfaces of the timbers were radial section and tangential section. Colour change, water repellency and glossiness were measured in periodically.

Results of colour change in Kuching showed that Bajan was observed at the biggest coluor change followed by Batu and Mersawa. However, Sugi showed the best colour stability among the four species. It seemed that the amount of coatings on the surfaces of Sugi was the richest in the specimens because of the lowest density in that species. We considered the influence of exposure directions to the weatherability in Kuching and the results of colour changes showed that colour change at East face was the biggest, and then the West face and the North face were almost same. That of South face was the smallest. The colour change at different exposure angles showed that the horizontal exposure caused the biggest colour change.

The results of colour change and surface failure in Kuching were bigger than those in Tsukuba. However, the difference of the results between Kuching and Tsukuba was not so big rather than the difference of climate index calculated by mass loss of thin wood veneers exposed at the test cites (21.1 of Kuching and 11.4 of Tsukuba).

Key words: Weathering, exterior coatings, exposure conditions, climate index

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Service Life of Finishes on Smooth-Planed and Saw-Textured Western Redcedar Bevel and Saw Textured Douglas-fir Siding

R. Sam WILLIAMS* and William C. FEIST

35 finish systems (clear water-repellent preservatives; lightly pigmented water-repellent preservatives; semitransparent stains; solid-color stains; and paints), applied to newly planed vertical-grained; factory-planed flat-grained; or saw-textured vertical-grained western redcedar bevel siding, were evaluated for cracking, erosion, and general appearance over 14 years of outdoor exposure. Service life was dependent on the wood surface and increased in the following order: clear water-repellent preservatives; lightly pigmented water-repellent preservatives; semitransparent stains; solid-color stains; and paints. The performance was about the same for both the flat-grained and vertical-grained planed bevel siding, but was greatly improved for almost all finish systems on the saw-textured western redcedar bevel siding.

In a similar study, one-coat latex solid-color stain and two-coat latex paint systems, applied to saw-textured Douglas-fir T1-11 siding using several finish application methods, were evaluated over 11 years of outdoor exposure on 5 unheated buildings. Finishes were applied using brush, roller, and airless spray. Roller-application included back-brushing for some of the panels and no back-brushing for others. As expected, two-coat paint systems were vastly superior to one-coat solid-color stain systems. In some cases, the brush-applied finish-systems were slightly better than the roller- and airless spray-applied finishes, however in general the application method made little difference in overall performance. The most important factors were the saw-textured surface, the amount of finish applied, and the care taken in application.

Key words: Water–repellent preservative, solid-color stain, semitransparent stain, paint, western redcedar, douglas-fir, saw texture

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Use of near Infra-red Spectroscopy to Characterize Weathered Wooden Surfaces

Martino NEGRI* and Anna SANDAK

Surface properties are a relevant parameter to characterize the wood quality. Recent developments in the field of optics opened completely new tools for measurements. One of such tools is near-infrared spectroscopy (NIR). The method allows to asses the chemical composition of the surface as the non-visible infrared light interacts with the surface chemical composition. IVALSA/CNR started recently a new line of research involving the FT-NIR spectro-photometry into evaluating of the surface chemical composition and estimating surface (whole piece) properties. Some of the research directions are:

- estimation of the chemical composition of the wood sample
- detection and estimation of the fungi infection
- identification of specific chemical components (heavy metals, etc)
- estimation of the chemical changes due to weathering

The FT-NIR technique has many advantages:
- relatively fast measurement
- no need for special sample preparation/non-destructive testing
- no residues/solvent to waste
- possibility for determination of many components simultaneously
- high degree of precision and accuracy
- direct measurement with very low cost

Unfortunately FT-NIR possesses also some disadvantages; it is percept as rather difficult method, and needs very intensive calibration before “routine testing”.

A massive campaign of measurements of the absorbance spectra on finished and non finished specimens in field test, shows the differences between weathered and non-weathered wood providing the parameters to use NIR as a tool for estimating the surface degrade.

Key words: Near Infra-red, surface characterization, weathering, wood surface

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Dyeability of Chemically Treated Wood and Discoloration by Xenon-light Irradiation

Yu ZHOU, Ikuho IIDA*, Kazuya MINATO*, JinLin WANG and Jianxiong LV

Discoloration of wood directly influences the decorative performance of wood products or wood-based materials, therefore the degree of color change is a crucial factor that determines the utilization area of dyed wood. Discoloration has been occurred because the wood components and dye molecules were degraded by UV-ray irradiation. UV-ray is one of the main reasons for color changes of wood and dyed wood. But it is not clear, which one reacts with the reagent molecules in treated wood, the cellulose, hemicellulose or lignin. Which one is main body.

This paper studied the color changes of Poplar I-214 veneers and that dyed by dyestuff, the color of dyed veneer treated by chemical reagents and that of treated veneers exposed to xenon-light by color measurement. Poplar I-214 veneers were treated by 4 kinds of chemical reagents, and then them were dyed by disperse light scarlet GS 200, and all of treated veneers were exposed to xenon-light for 3 days. The color of these veneers were mensurated by the color and color difference meter. It is pointed that in Poplar I-214 dyeing and xenon-light attenuation of each chemically treated veneer color, the dyeability and discoloration of veneers by acetylation and maleic anhydride treatment are better than those of treated by formaldehyde and glyoxal resin. The capabilities of dyeing and discoloration of veneers is improved by the control of dyeing technology, especially chemical treat methods. The results indicate that there is the chemical reaction occurred between the veneer surface cellulose or Lignin and dye molecules when they meet with. Being treated by acetylation and maleic anhydride makes use of keeping from of discoloration of dyed wood.

Key words: Poplar veneer, chemical treatment, dye, xenon-light irradiation, discoloration

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5.04.12 – Posters

A Novel Method for High Resolution Imaging of Coating Distribution within a Rough-textured Plywood Surface

Bernard S.W. DAWSON*, Adya P. SINGH, Anni RATZ, Geoffrey DANIEL and Anamika SINGH

Texture, substrate and coatings technology are defining factors in achieving a suitably protected wooden surface. The texture of wooden surfaces to be coated is a fundamental part of the finish. Texture can refer to the natural anatomical characteristics of a surface due to its being either a hardwood or a softwood. For a hardwood the texture or coarseness of a wooden surface is open, referring primarily to the vessels while for softwood, fibres are longer and thinner resulting in a much finer degree of coarseness.

Texture and coating type to a large extent determine the nature of the wood-coating interface on a particular wood species. The texture and wood characteristics of a wooden surface define the substrate surface to which a coating is applied. The nature of a wooden substrate surface has direct consequences in terms of coverage and dry film thickness of coating and therefore on how well the coating can effectively coat the surface. The coverage has economic implications but this may be offset be performance when in service. The production of wooden surfaces, for example, the rotary veneer peeled surface of plywood exhibits the effects of lathe check creation. Band-sawing of these surfaces is a worthwhile operation since it can negate the impact of the checks.

The use of digital photography, light microscopy and profileometry has facilitated a clear understanding of the complex interactions at the wood-coating interface and highlighted characteristics that may later impact on performance. Light microscopy has revealed the integrity of the various coatings on textured surfaces showing whether equitable coating distribution resulted on application.

In this paper, microscopic examination of coated wooden substrate is used to show many facets underpinning the substrate-coating interface and the characterisation of coated wooden surfaces. This information is crucial to understanding the macro-performance.

Key words: Texture, coatings, radiata pine, roughness

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In situ Deposition of Copper Metal in Radiata Pine

Bernard SW DAWSON*, Tatjana SMOLIC and Adya SINGH

We explored the possibility of wood to be used as new generation material as applications of such materials would depend on creating new properties. Such properties could include increased conductance which would improve efficiency of powder coating, or provide selective shielding from electromagnetic radiation in living environments, or anti-electrostatic properties much desirable property in various industrial environments.

The aim of this work was to bring about an intimate deposition of metals in wood and in particular Cu deposition *in-situ*. This was achieved by reduction of Fehling's reagent with the help of glucose followed by disproportionation reaction with 5% H_2SO_4.

Experimentally, a Bethel (vacuum/pressure) process was used in solution treatments of wooden stakes. Wooden stakes were impregnated three times; first with glucose solution - reducing agent, second with Fehlings reagent - source of copper ions, and lastly with H_2SO_4 - disproportionation medium. Solutions concentrations and uptakes, were used to calculate Copper amount in wood. Analytical methods (ICP-MS, AAS, and SEM-EDAX) were used to determine actual amount of copper in wood and leachate. Mechanical properties, like strength stiffness and hardness, were tested on treated not leached wood stake samples

Cu concentrations of 1.2 to 2.2 weight percent were found in the treated samples. Equal molar ratios of both Cu (0) and Cu (II) predicted on reduction and disproportionation. XPS analysis of unleached treated samples showed both oxidation states of copper were present. On the basis of SEM analysis, copper species covered interior lumen surfaces but not cell walls.

Densities of all treated samples increased from 434 kg/m^3 in control samples to 524kg/ m^3 in the treated samples. Stiffness was reduced from 8.9GPa in control samples to 6.9GPa in treated samples while strength was considerably reduced from 86 MPa in control samples to 52 Mpa.
Hardness remained unchanged on treatment (~ 2990 N) and electrical conductivity was unchanged over untreated wood.
It was not possible to control the mass balance in terms of copper, in these multi-step treatments. Overall, sample treatments lead to some decrease in strength and stiffness, but hardness and electrical conductivity remained unchanged compared with untreated samples.

Key words: Radiata pine, *in-situ* metal reduction

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Stabilizing Effect of Extractives in the Photodegradation of Wood

Tzu-Cheng CHANG, Hui-Ting CHANG, Chi-Lin WU and Shang-Tzen CHANG*

The influence of extractives in the photodegradation of wood has not been fully clarified. The aim of this study is to understand the role of extractives during wood photodegradation process. FTIR and X-ray photoelectron spectroscopy (XPS) were used to analyze the variations in chemical characteristics on the wood surfaces of non-extracted and extracted *Cryptomeria japonica* heartwood after lightfastness test. FTIR analysis showed that lignin on the extracted wood surface degraded significantly after lightfastness test. Consequently, the contents of quinones, carbonyl groups and water-soluble derivatives from lignin increased markedly. However, degradation of lignin occurred to a lesser extend on the non-extracted heartwood surface. On the other hand, XPS analysis revealed that non-extracted heartwood exhibited a higher O/C ratio than the extracted one and the relative area of C_1 peak decreased obviously on the non-extracted heartwood after irradiation. These findings suggested that extractives are susceptible to photooxidation and their photooxidation rate is higher than lignin. Besides, after leaching photo-degraded specimens with water, the O/C ratio and C_{1s} peak of extracted heartwood remained nearly the same as non-irradiated specimen, whereas those of non-extracted heartwood varied significantly. It is likely that wood extractives would interact with other components on wood surface during photooxidation process, which leads to less water-soluble derivatives on the non-extracted wood surface. In conclusion, extractives play an essential role in retarding the photodegradation of wood and the rate of wood degradation was decreased by the presence of extractives.

Key words: *Wood extractives, Lignin, Photodegradation, FTIR, XPS*

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Surface Hardening and Evaluation on the Plantation Softwood

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The compression treatment of wood is useful to improve the properties of plantation poplar wood and considered to be a good process for the efficient utilization of it. Poplar wood was impregnated with improvement phenol-formaldehyde (PF) resin and compressively cured by hot pressing. The PF resin treated wood (PFW) was improved on surface hardness, dimensional stability and mechanical properties, Furthermore chemical characteristics of PFW was analyzed by ESCA. Results show that WPG and ASE are increased markedly with the increase of PF resin concentration; the density and strength are clearly raised with the increase of compression ratio. ESCA spectra of PFW were different from those of wood and PF resin according to the wave analysis method. With the increase of weight percent gain (WPG) of PFW, peak area of CI decreased gradually while that of CII and CIII increased gradually. These results would be due to the changes in chemical structure and component of wood with the compressive curing of impregnated PF resin.

Key words: Poplar wood, Compressive curing, PF resin, Impregnation, Density, strength, ESCA

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Formation of Conducting Polymers on Wooden Surfaces

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Conducting polymers (or synthetic metals) are typically formed by doping conjugated organic polymers to increase their electrical conductivity by several orders of magnitude up to that of semiconductors or metals. These unique materials can possess the electrical, electronic, magnetic and optical properties of a metal while retaining the mechanical and to some extent the processing properties of a conventional organic polymer. In addition, they exhibit interesting chemical properties, particularly oxidation-reduction. Collectively these attributes provide many opportunities for the development of a wide range of new materials and applications based on conducting polymers.

The development of polyacetylene and other conducting polymers has been based predominately or polyaniline, polypyrrole and polythiophene. We report results for the treatment of cellulose and wood paper with both aniline and pyrrole, confirming the formation of conducting polymers by measurement of conductivity and by visualised with scanning electron microscopy.

The use of innovative delivery systems for monomers, dopants and oxidants for completely penetrating treatments of solid wood samples is our immediate goal. We hope to present the results of this work and to provide data characterising the polymerisation, by microscopic and spectroscopic examination of the wood cell walls, *in situ* deposition of the conducting polymers.

Key words: Conducting polymers, polyaniline, polypyrrole, wood

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Primer Adherence on Radiata Pine Wood (Pinus radiata D. Don)

Sandra FICA, José NAVARRETEY and Ana M. FERNÁNDEZ*

Handling and environmental conditions can have a negative effect on the surface quality of finished remanufactured wood products. Different primers have been used to reduce this problem. New primer developments require permanent efforts to reduce cost and increased production output. In this study a currently used wood primer and a new formulation are compared using a general factorial design. Five factors were investigated: primer type, initial wood surface quality, primer film thickness, and the presence of finger joints in the wood sample. The response variable measured was the adherence between the substrate and the primer, an indirect measurement of the primer durability. Radiata pine wood samples were prepared and painted in accordance with the factorial design. Painted samples were tested according to ASTM D 3359-87 Standard and evaluated by image analysis.

The results demonstrated no significant adherence improvement for the new primer formulation.

Key words: Primer, adherence, image analysis

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Tropical Hardwood in outdoor Conditions: Behaviour toward the Colour Durability

Martino NEGRI*, Barbara TESSADRI and Ignazia CUCCUI

For building façades and outdoor artefacts the colour changes in wood affect and limit the use of wood. In the framework of a large project on wooden houses, IVALSA is studying the behaviour of colour changes on different tropical wood species either without any surface protection, either with various finishing and/or protecting products.

The main goal is to provide the behaviour of the different wood species, according to the protecting methodology adopted, due to the ageing effect deriving from the outdoor environmental conditions; the colour changes are recorded as pictures (digital colour calibrated), as CIE-Lab coordinates, as gloss values and finally as Near Infra-Red spectra; also contact angle and reflectance to visible and to structured light has been measured on a sub-sample. The contribution of visible and UV-A spectra, such as RH and temperatures are logged in field experimental set up. The tests here reported have been carried out for nine months. The finishing products tested are both water and organic solvent based.

The colour changes differs according the cardinal orientation, being the north oriented specimens frequently the most degraded.

Key words: Wood colour, colour durability, wood outdoor, surface finishing products, surface properties

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Three Dimensional Gloss Measurment on outdoor Weathered Wood

Jakub SANDAK and Martino NEGRI*

Surface properties influence the quality of wood in outdoor uses. This paper presents a peculiar measurement techniques developed for the surfaces characterization, such as a full sphere light reflectance goniometer on finished and non-finished wood.

One of the most important properties of the surface is the light reflectance or gloss. In general there are three types of interactions when light hits a surface, i.e reflection, absorption and transmittance The light interaction with wood is especially complex thus the standard techniques of the reflectance measurement with gloss-meter are very limited. Instead of measuring only one direction of the light reflection, we measured the whole sphere. The degree to which light is reflected depends on the viewer and light position relative to the surface normal and tangent. It is known from literature as Bi-Directional Reflectance Function (BDRF). BDRF is a function of incoming light direction and outgoing direction relative to a local orientation at the light interaction point. When light interacts with a surface, different wavelengths of light may be absorbed, reflected, and transmitted to varying degrees depending upon the physical properties of the material itself, this means that a BDRF is also a function of wavelength. Light interacts differently with different regions of the surface, this is known as positional variance, especially noticeable in materials such as wood, marble, etc. For estimation of the BDRF we have developed a 3D reflectometer. The quantity and quality of information is superior to the standard gloss-meters, but in the same time the algorithm for data processing is much more complex; a simple and intuitive algorithm for computation of the numerical indicators calculated on the base of BDRF has been developed.

Key words: 3D gloss, wood surface, weathering

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5.10 C

CORPORATE RESPONSIBILITY, INNOVATION & PRODUCT DEVELOPMENT

Papers

Using Consumer Research for Product Development in the Wood Processing Industries

Anders Q. NYRUD* and Anders ROOS

The purpose of this study is to expand the knowledge about consumers' attitudes towards wood products. The attitudes of private end users and key industrial decision makers, such as architects and building contractors, are investigated. Better understanding of consumers' motives when making their purchasing decision will improve marketing of existing wood products and enhance development of new products and technologies in the wood processing industries.

The presentation provides an overview of methods to evaluate consumer preferences and attitudes towards products. In the study, several methods have been applied to explore consumers' attitudes and applications of consumer analysis about wood products will be demonstrated. This includes results from focus group analysis, free elicitation studies, sensory analysis and preference mapping, conjoint analysis and structural equation modeling. Finally, practical implementation of the results in product development is discussed.

The results provide insights in consumer perceptions of wood products, on factors forming overall satisfaction with this type of products and the factors forming intention to consume wood products.

Key words: Consumer research, consumer attitudes, attitude formation, wood products

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A Proposed Framework for the Diffusion of Corporate Responsibility Practices in the Forestry Sector

Natalia VIDAL* and Robert KOZAK

Sustainability is particularly important for resource-based industries whose operations have a direct impact on the natural environment. Forestry, mining, and fisheries depend on the sustained extraction of natural resources, and because of these direct links to environmental disturbances, are easy targets of public criticism. Adoption of Corporate Responsibility (CR) practices helps to legitimize forest companies by demonstrating their commitment to sustainability.

This study examined the diffusion of Corporate Responsibility practices through forest companies in the Canadian and Brazilian contexts in order to understand how and why diffusion takes place. Specific objectives of this research were: (1) to identify how forest companies understand CR; (2) to identify the process by which CR practices are diffused within forest companies; (3) to propose a framework for furthering the diffusion of CR within the forestry sector; and (4) to understand how CR practices diffuse between developed and developing nations.

This study was conducted in three phases. A content analysis of the top 100 forest and paper companies was conducted in *Phase 1* to identify how forest companies worldwide understand CR. In *Phase 2*, grounded theory methodology was used to develop hypotheses and suggest a theoretical framework for the diffusion of CR strategies. Case studies were then developed in *Phase 3* to validate the theoretical framework. It is expected that a framework explaining the diffusion of CR practices will serve as: (1) a map showing how CR information flows within and between forest companies, how it is processed, and how decision-making occurs as a result of it; and (2) a means of identifying opportunities to enhance the reputation and public image of individual companies and the forestry sector as a whole.

Key words: Corporate responsibility, sustainability, forestry, diffusion

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Measuring Innovativeness in the North American Softwood Sawmilling Industry

Chris KNOWLES and Eric HANSEN*

Firm innovativeness is the propensity of firms to create and/or adopt new products, processes, and business systems. Previous research has consistently shown firm innovativeness to be a driver of firm growth and critical for maintaining competitiveness. While previous research has acknowledged the importance of innovativeness, a valid and reliable scale for measuring firm innovativeness does not exist. The purpose of this study was to develop a new scale for measuring innovativeness, specific to the forest products industry through a systematic and structured scale development process. A new innovativeness scale will provide researchers with a systematic way of evaluating the connection between innovativeness and firm performance. This presentation will cover all stages of the scale development process including: the theoretical development of the scale, initial item generation, and an overview of the two-stage study in the North American softwood sawmilling used to refine the scale. Finally, the scale will be used to examine the relationship between firm innovativeness and financial performance in the North American forest products industry.

Key words: Innovativeness, scale development

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Wood in the Interior Environment: Subjective Meaning Revealed Using a Non-prescriptive Sorting Methodology

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The significance of materials used in the built environment extends well beyond their concrete reality. Functioning as a form on non-verbal communication, materials connote meaning about the identity of people and organisations. With this in mind, our study explored the connotations about companies that arise from variation in corporate interiors. In particular, our interest was to understand the distinguishing attributes connoted by wood in the interior office environment.

Participants (28 students representing a broad cross-section from a major Japanese national university) were asked to sort photographs of 20 office interiors into groups according to their own personal categorization scheme. Referring to each group, the participants were each asked (by a native Japanese speaker) “What do you think it would be like to work at these companies?” and “What gives you that impression?”

Multidimensional scaling (MDS) analysis was then used to assess the relationships between the offices, representing them as points in a geometric space with the distance between points proportional to the frequency that offices were grouped together. The first two MDS variables explained 78% of the variation in the data. The interviews generated 544 units of text describing the companies, which were assigned to one of 20 classification schemes. The 5 most commonly used classification schemes (representing 60% of this data) were coded and correlation analysis was used to relate this coded data to the MDS variables.

The first MDS variable separated companies seen to be friendly, calm and of small/medium size from companies seen to be busy, large and formal. The second MDS variable separated companies of traditional nature with average capability workers from companies thought to be pioneering and with a positive workplace atmosphere. Interiors featuring wood products were clustered together (indicating that this was an important attribute used in sorting) and tended to be associated with friendly, calm, small/medium and pioneering firms.

These findings highlight the important intangible qualities of wood products, which our industry would do well to understand and exploit in the course of product and market development.

Keywords: Environmental psychology, social attributions, marketing

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5.10 C – Posters

Innovation in the Global Forest Sector

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Innovation research within the forest sector has experienced rejuvenation in recent years as global competitiveness of manufacturing industries has become a critical policy issue at national and regional levels. Five innovation-oriented studies have recently been completed at Oregon State University. These studies were designed to 1) assess the current state-of-the-art in new product development and innovation in the industry, 2) develop a better measure of firm innovativeness, and 3) relate organizational climate to firm innovativeness and performance. This presentation will highlight the most important findings from these studies. For example, managers perceive innovation to be of three types: process, product, and business systems; firms tend to emphasize process innovation rather than product or business systems; firms do not commonly implement structured new product development processes; innovation knowledge is inadequately shared across divisions within large companies; and measuring innovativeness is often not highly prioritized. Finally, the presentation will outline important innovation-related research opportunities.

Key words: Innovation, innovativeness, forest industry

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CSR and the US Forest Products Industry: Issues and Stakeholder Views

Rajat PANWAR and Eric HANSEN*

This study examines corporate social responsibility (CSR) in the US forest products industry from the issue management perspective. Issue management approach helps companies better understand the society's evolving perception in the realm of social and environmental domains. Such expectations might be very useful for companies in order to formulate their CSR plans and programs. Thus, issue management approach provides a farther reaching scope to CSR concept in that the issues currently falling outside the relevant stakeholders' demands are captured as well. Such issues could form the future public opinion and surprise the companies. The presentation outlines different issues that select key informants consider are relevant for the US forest products companies along with the frequency associated with each issue.

Results indicate that several issues fall outside the immediate control of forest products companies. A considerable number of issues seem to typically belong to either forestry or policy arena, indicating at increased necessity for forest products companies of backward linking and participating in public policy formulation.

Key words: Corporate social responsibility, issues management, stakeholders

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5.12 C
SUSTAINABLE FOREST-BASED NON-TIMBER INDUSTRIES

Papers

A Synthesis of Biomass Utilization for Bioenergy Production in the Western United States

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We examine the use of woody residues, primarily from forest harvesting or wood products manufacturing operations (and to a limited degree from urban wood wastes), as a feedstock for direct-combustion bioenergy systems for electrical and/or thermal power applications. We examine opportunities for utilizing biomass for energy at several different scales, with an emphasis on larger-scale electrical power generation at stand-alone facilities, and on smaller-scale facilities (thermal heating only) such as governmental, educational, or other institutional facilities. We then identify west-wide barriers that tend to inhibit bioenergy applications, including accessibility, terrain, harvesting costs, and capital costs. Finally, we evaluate the role of government as a catalyst in stimulating new technologies and new uses of biomass material.

Key words: Biomass, bioenergy, fuel hazard reduction, harvesting, forest products

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Indonesian Ecotourism: A Prospect of the Non-wood Forest Products

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Ecotourism as "tourism that involves traveling to relatively undisturbed or uncontaminated areas with the specific objectively studying, admiring and enjoying the scenery and its wild plants and animals, as well as cultural manifestations (both of past and present) found in these area. Tourism is the largest industry in the world and ecotourism is the largest growing sector of the tourism industry.

Forest as one of the ecosystem produces some qualitative resources to develop ecotourism. Most of the biodiversity is found in the forest particularly in conservation area. Indonesia has a mega biodiversity that encourage the increase ecotourism project rapidly. In Indonesia according to Direktorat Bina Kawasan Pelestarian Alam (1994) total Indonesia's conservation area is 23, 05 million hectares. So that sees how big the potential area in forest should be well conserves for ecotourism program. In Indonesia's tropical forest, we can observe a numerous endemic flora and fauna. Species of mammals, butterflies, amphibians, flowering plants are one of the components of the forest that attract some tourist to come. Photography and movie making, rafting, paddle along the river by long boat or rubber raft while enjoying the beauty of forest, canopy trail are amazing icon that we can get it in the forest ecotourism activities.

Beside that, local communities surrounding the forest also have a role to attract tourist to come in ecotourism area. Indonesia has the cultural diversity also. It separated in each beautiful island. There area about thousand of the unique culture that will entertain the visitors during in the Indonesia's ecotourism area. Some religious attraction, ritual ceremony, traditional clothes, traditional musical instrument performance, providing traditional and modern accommodation, local transportation, traditional dishes, guide services and all of the service required will be conducted by local communities. Local communities have some indigenous knowledge because their daily life is very close with the forest. The development of the ecotourism will be towards sustainability. From ecological aspect, ecotourism will produce low of impacts to environment; keep the genetic of the biodiversity; educational value. From Economical aspect, local communities and the country will be advantaged through the money that the visitor spend during in the area. And for the social aspect will maintain local culture and raise the awareness to save the forest.

Key words: Ecotourism, non wood forest product, sustainability

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Distrust in Private Forests – Main Gap in Sustainable Forest Management of Moldova

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This study point out that distrust in private forests is the main gap in sustainable forest management of Moldova. To argument this statement we completed historical analysis, reviewed documents and literature and then qualitative and quantitative data were linked. Hence under Roman domination (106-271) the majority of the forests were stated legally as public assets. While during next centuries was much expanded monastery property, but also secular one of the big forest owners, obtained through donations, abuses, and other means. Thus, in the beginning of XIX century the majority of the forests were owned by monasteries, boyars, and free peasants while state was practically absent in the forest property statistics. Only after annexation of Basarabia to the Russian Empire in 1812 year state became forests holder. Actual pattern of forest ownership in Moldova comprise state forest authority (90.25 %), mayoralties (6.22), agricultural unites (2.39 %), cities and other localities (0,61%), industry and transport (0.4%), territory of aquatic fund (0,1), other holders (0.035). We are conscious that after entire land expropriation in the middle of last century rural people lost the confidence in the land property rights and state representatives. The actions, which created this breach were expropriations, chronic changing of the states, governments, moneys, with no compensation for the society. This paper first describes the dynamic of forest cover and the management of forest estate, secondly evolution of forest ownership, and thirdly European and world conferences concerning private forests. Finally the main recommendations are made in order to improve the confidence of local (rural) people in private forests.

Keywords: Distrust, ownership, afforestation, people, pasturing

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5.12 C – Posters

Ecological Classification System of Forest Landscape in Eastern Mountainous Region of Liaoning Province

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Ecological Classification System is a multifactor hierachical classification system which uses the interrelationships among ecosystem components including vegetation, soils, and physiographical factors as the basis in classifying sites across the forest landscape. In this study, basing on Digital Elevation Models (DEM) and satellite SPOT-5 data, a hierachical Ecological Classification System of forest landscape was developed for the eastern mountainous region of Liaoning province by using the spatial analysis function in ArcMap. Ecological Land Types (ELTs) and Ecological Land Type Phases (ELTPs), the two lowest layers in the hierachical framework, were mapped. The boundaries of ELTs were determined by geomorphic conditions quantified by Digital Elevation Models; ELTPs were classified by overlaying ELTs with forest vegetation data layers which were obtained with remotely sensed data, forest inventory data, and ground data. The ELTPs represented the divisions of land in terms of both natural and human-induced forest conditions, and therefore were reliable units for forest inventories and management. ELTPs could function as conventional forest inventory sub-compartments. By this means, forestry departments could adjust forest management planning and forest management methods from the point of view of the forest landscape scale to realize the forest ecosystem management. Most importantly, Ecological Classification System of forest landscape, together with geospatial information technologies and computer techniques, would be a feasible way to realize the digital forestry.

Key words: Ecological Classification System (ECS) of forest landscape, Ecological Land Type (ELT), Ecological Land Type Phase (ELTP), forest inventory unit, eastern mountainous region

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Pulp & Paper D

PAPERMAKING

Papers

Structure Analyzing and Predicting the Consumption of Fluting Paper Rate in Iran

Ajang TAJDINI*, Mehran ROOHNIA and Ahmad JAHAN LATIBARI

In this paper, using data and information from production, import and export in last decades: 1. The total consumption and consumption per capita of fluting paper, and 2. Because of prevailing opinion (Various types of consumption of paper products is a function of related products per capita and population in different years), the quantity of internal production and import were determined in consumption balance. We used linear regression analyses for trend survey of population and consumption per capita in the past 10 years (1994-2005), then estimated total consumption through 2006-2011and 2021. Finally on the basis of consumption quantity calculation (demand) of each types of paper products in predicting periods as well as the observation of the most important pulp and paper future projects, the shortage quantity for demand satisfaction has been presented (Which should be provided by the import).

Results showed that the rate of fluting paper consumption by the year 2021, will reach to the amount of 290,000 tons per year that cause 200,000 tons of shortage per year. This result causes the increase almost 70% of import ratio in consumption balance.

Key words: fluting paper, consumption, import, export, consumption balance.

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Thermal Paper Recycling

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The purpose of this study was to resolve the recycling problems associated with thermal paper. When the paper web containing pulp from thermal paper enters the dryer section, low brightness or dark spots will often develop. The cause of the problem is incomplete removal of the coating materials during repulping that leads to color rendering later on. Thus, determining how to remove these substances and improve the brightness and brightness stability of the paper products has become a crucial issue for expanding the proportion of mixed office wastepaper in paper products and extending its range of application. We collected mixed office waste, particularly those containing thermal paper and investigated their treatment conditions during recycling. A gas chromatograph-mass spectrometer (GC-MS) was used to analyze various functional additives in the thermal paper. The results suggested that when in acidic and highly alkaline recycling conditions, the residual coating materials from the wastepaper were markedly reduced compared with the control. The acidic treatment was particularly effective, and produced marked brightness and brightness stability improvement. The color-rendering compounds were absent when in acidic repulping, while dibutyl phthalate (a degradation product of the leuco dye) content was 90% less than that of the control. Thus, the problem of thermal paper recycling can be mitigated by using acidic repulping conditions. Moreover, paper from acidic treatment showed a slight decrease in tensile strength and an increase in tearing strength, while no significance changes were observed in the bursting strength or the total strength index. Among the extractives, GC-MS analyses identified 4,4'-(1-methylethylidene)-phenol (color developer), 1-(phenylmethoxy)-naphthalene and hexadecanamide (color sensitizers), and dibutyl phthalate (a degradation product of the leuco dye).

Key words: Thermal paper, color developer, color sensitizer, leuco dye.

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Biopulping & Pitch Removal: Studies of Fungal Inoculated Wood in Pulp and Paper Operations

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Biopulping is defined as treatment of wood with fungi prior to pulping. With the biopulping results published so far, there has been little lignin loss in the treated wood prior to pulping but good extractives decrease measured and substantial modification of cell walls observed. Two questions concerning biopulping wait to be answered: What is the rate-limiting step and what is the mechanism? The small amount of lignin loss has not been explained though the literature still suggests that biopulping can only be done by lignin degrading fungi.

Colorless, albino *Ophiostoma* fungal products were made by natural mating techniques – neither mutation nor genetic engineering was used, and though not lignin degraders, these fungi can affect rapid decreases in extractives content when applied to wood. Though the total percentage in wood of extractives, low molecular weight oleophilic materials extracted from wood chips by neutral, nonpolar, organic solvents, is less than 3.5% for most wood species, this represents a major problem for most pulp mills, particularly TMP, CTMP, and sulfite pulp mills, in several aspects including impacts on strength, brightness, and effluent toxicity, and deposition, alone or with fibers, filler, defoamers, coating binders and insoluble inorganic salts.

Use of the albino *Ophiostoma piliferum* fungi, commercialised as Cartapip® , for degradation of resins and as a biocontrol agent, demonstrate commercial production of a brighter pulp with resin extractives significantly decreased and improved strength properties analogous to biopulps. Efficacy of the albino *Ophiostoma* technology has been demonstrated on *Pinus taeda*, *Pinus resinosa*, *Pinus radiata* D. Don. and *Populus tremuloides*.

Besides the original published results, *Eucalyptus* species have recently been the focus of extended studies in a collaborative project between Taiwan Forest Research Institute and New Zealand, in order to develop more efficient pitch reducing *Ophiostoma* fungal products that can also improve the brightness of unbleached *Eucalyptus* pulp. Taiwanese isolated *Ophiostoma* strains, New Zealand albino *Ophiostoma* isolates, and the original marketed Cartapip 97 were screened and after 2 weeks of fungal treatment, 70% of the lipophiles were destroyed and nearly all extractives showed high amplitudes of reduction, including sterols which had 63% degradation by the fungi.

Key words: Extractives, TMP, sulfite, fungi, biopulping

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Effect of BCTMP Content in Pulp on the Performance of Fluorescent Optical Brightening Agents

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Increasing bulk and opacity of paper has become an important topic in papermaking as grammage keep decreasing. Thus, high-yield BCTMP has been used to increase bulk and opacity of paper. However, the practice has a downside of poorer brightness and apparent whiteness. We studied the application of various types of fluorescent optical brightening agents (OBAs) to stocks mixed with different proportions of BCTMP on the optical properties (brightness, apparent whiteness, and CIE L*a*b*) of the handsheets so that the best dosage might be found for higher brightness or lower costs. Pulps with varying BCTMP at blend ratios of 0, 10, 15, 20 and 30% were added with 0, 0.25, 0.5, 1.0, 1.5, 2.0 and 4.0% to dry pulp of di- and tetra-sulpho-OBAs, respectively, with a total of 70 sets of experiments. The results indicate that when BCTMP ratio was 15%, adding 1.5% of the di- and tetra-sulpho OBAs yielded the highest brightness (90.58% and 89.83% GE, respectively), and apparent whiteness (113.85 and 106.40% GE, respectively) of the handsheets. The CIE L*a*b* values showed increases in a* and b* when BCTMP ratio and OBA dosages increased; whereas at 1.5% dosage of the OBA addition, an inflection point was observed. Aging tests indicated that along with increased UV irradiation, the calculated scattering coefficients (k) based on the Kubelka-Munk theory showed an inverse proportional relationship with the brightness or apparent whiteness of the handsheets. The overall results suggest that disulpho-OBA was more suitable for wet-end applications, and dosage limit of 1.5% was appropriate. The brightest pulp mix entailed a blend of 20% BSKP, 65% BHKP and 15% BCTMP

Key words: Fluorescent optical brightening agent, bleached chemithermo-mechanical pulp (BCTMP), yellowing, brightness, apparent whiteness

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Application of Talc to Calcium Carbonate-containing Paper Coating Formulations

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Talc has a platy structure with hydrophobic surfaces. There are weak cohesions between the crystal lattices within the talc particles; hence it possesses very low frictional coefficient, softness, and low abrasiveness. Talc has been applied to paper coating mainly for low weight coated (LWC) gravure grade and matted art paper for offset printing mostly in Europe. We applied 2 types of talc in place of kaolin clay in calcium carbonate-based coating formulations and investigation of their effects on coating color and coated paper properties. The experimental design entailed keeping the ground calcium carbonate (GCC) in a typical art paper color formulation at 70 parts while varying the amounts of no. 1 clay by substituting with the talc at 0, 25, 50, 75 and 100% levels. The results indicate that technically talc could totally replace no. 1 clay, and the slightly finer talc grade had better performances. Among the color properties, talc decreased low-shear viscosity but at the cost of sacrificing water retention value to some extent. Among the coated paper properties, talc helped to improve printed gloss, smoothness, coarseness, IGT picking resistance, RI wet ink absorption, dry picking, and wet picking, but tended to decrease gloss and prolong ink drying time. Talc use showed no effects on the brightness and opacity of the coated paper and it is suitable for matte grade coated papers.

Key words: Talc, water retention, matte grade coated paper, printed gloss

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Pulp & Paper D – Posters

Recycling of Carbonless Paper and Laser-printed Paper

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In this study, we attempted to treat the causes of low brightness and the tendency of black spots to appear on the recycled pulp of carbonless paper. The difficult problem of de-inking laser-printed paper was also included in this study. Our experimental results indicated that in the recycling of carbonless paper, a color rendering pretreatment before the de-inking process effectively removed colored particles and resolved the low brightness problem. As for colored carbonless paper, such as yellow sheets, a 2-stage bleaching entailing adding 2% H_2O_2 before washing and a further 2~6% H_2O_2 bleaching after flotation produced pulp with a brightness of 80% ISO or better, and the pulp showed good brightness stability. Red-colored waste carbonless paper could be subjected to a 2-stage bleaching consisting of 3~5% NaOCl and 2~4% H_2O_2, to achieve the best results of brightness values of 75% ISO or better and also relatively good brightness stability. In the de-inking of laser-printed paper, residual ink specks were an often-encountered problem. Our experiments suggested that by adding various long-chain aliphatic alcohols, de-inking efficiency could be improved. Such additives reduced the capability of aggregating ink particles, hence forming large-diameter ink dots that could effectively be removed. Among the alcohols, n-octadecanol and a mixture of n-octadecanol and n-butanol showed the best results. In our de-inking scheme, we modified the traditional washing and flotation process by washing and centri-cleaning. The 2 types of alcohols could lower the dirt count values of de-inked pulp to 5 ppm and produce pulp brightness values of 95% ISO or better. Furthermore, by going from washing directly to centri-cleaning, the flotation stage was bypassed and nearly all of the ink specks were removed as well; hence, we deemed that the process should reduce process costs and also lessen water consumption.

Key words: Earbonless paper, bleaching, laser-printed paper, n-octadecanol

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Pulping Characterictics of Blue Stain Fungi and Fungicide Treated Woods

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This study was performed to evaluate the changes in wood extractives, mainly acetone extracts, in pine woods (*Pinus densiflora* and *Pinus rigida*) treated by three blue stain fungi (BSF) such as native BSF in Korea, *Leptographium* sp., screened Albino strain(BSFcs-1) and commercial Cartapip and fungicide, Wood guard. In addition their pulping and bleaching properties were investigated.

BSF treatment has significantly reduced acetone extracts, 25.1-30.4% decreasing in red pine and 22.9-28.1% in pitch pine. Three week aging treatment showed about 20% decreasing in red pine and 19.3% in pitch pine. There were not so significant differences in acetone extracts among native BSF and Albino-type strains (Albino strain, BSFcs-1, and commercial Cartapip). But fungicide, Wood guard, treated wood showed relatively lower decreasing rates of extractives, 14% in red pine and 10.1% in pitch pine. Therefore it is understandable that the fungicide could protect the wood from blue stain fungi attack, but has no effect on its extractive reduction.

Concerned to pulping properties of BSF and fungicide treated woods, red pine and pitch pine, optimum pulping conditions were 20% active alkali, wood to liquor ratio 1 to 6, 170℃, and 2.5 hr. In the case of BSF-treated woods, optimum pulping condition was same as the sound wood, 43.5-45% of pulp yields and 1.3-1.45% of rejects. Screened pulp yield of fungicide treated wood was lower than those of BSF-treated woods. Rejects in pulps were higher in fungicide-treated woods than BSF treated woods. Bleached pulp yields were ranged of 92 to 93.5%. BSF, Cartapip and fungicide treated woods resulted in lower brightness of 55-58%, but Albino-type strain (BSFcs-1) 61.3-62.3%, very similar to untreated one. Therefore bleaching chemicals could be saved in the processing of chemical pulping.

Keywords: Blue stain fungi, Cartapip, extractives, fungicide, kraft pulp, bleaching

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5.02 E
WOOD COMPOSITES AND WOOD PRODUCTS

Papers

Characteristics of Bamboo as Fiber Reinforced Material

YU Wen-ji* and YU Yang-lun

The differences of bamboo (*Phgllochys heterocycla var. pubscense*) with different ages and positions in shear strength, bending strength and modulus of elastic were analyzed emphatically. And the ultra-structural characteristics of failure surface of bamboo specimens were inspected by scanning electron microscopy (SEM). Results showed that bamboo has an evident characteristic of fiber reinforcement, so it is feasible to test bamboo by the criterion for fiber reinforced materials. The changes of bamboo mechanical properties with various ages are owing to the fiber maturity. The mechanical properties of bamboo are positively correlated to the distribution of vascular bundles. The differences of longitudinal mechanical properties are owing to the amount of vascular bundles per unit area. The differences of radial mechanical properties are owing to the distribution of vascular bundles and the different conformations. Bending failure mainly appears in intercell and intrawall characterized by the pulled out single vascular bundle. Shear failure of specimens mainly occurs in transwall and intrawall characterized by a cluster of pulled out vascular bundles and the markedly destructive surface of the vascular bundles.

Key words: Bamboo, fiber reinforced material, mechanical properties, failure characteristics

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The Properties of Mild Steam and Chitosan Treated Ramie and Pineapple Plant Fiber Bundles

Sasa Sofyan MUNAWAR, Shuichi KAWAI and Kenji UMEMURA

The morphological, texture, physical, and tensile properties of ramie and pineapple plant fiber bundles were investigated to get the high performance on mechanical properties and to find the appropriate natural fibers which can be used for the composite products. The fibers were treated with mild steam (0.1 MPa) and chitosan solution 4%. The properties of these treated fibers were characterized and compared with the untreated fibers. Field Emission Scanning Electron Microscope (FE-SEM) was used to observe the surface morphology of those fibers. X-ray diffraction (XRD) was used to observe those fiber textures. Tensile properties of the treated and untreated fibers were also recorded. SEM photographs showed that the surface of the mild steam treated fibers was lighter than that of untreated fibers. The chitosan 4% was covered on the fibers surface. The steam treated fibers had higher values of degree of crystallinity, crystallite orientation factor and crystallite size than those of the untreated fibers. Ramie fiber shows a great mechanical property than pineapple fibers. The values of tensile strength, Young's modulus and toughness of the steam treated fibers similar with the chitosan 4% coated fibers, were higher than untreated fibers. The tensile properties of fibers showed a decreasing tendency with increasing fiber diameter.

Key words: Plant fiber, fiber treatments, morphology, fiber texture, tensile properties

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The Influences of Undercuts on the Vibrational Characteristics of Wooden Bars

Chih-Lung CHO, Shih-Yin WU, Sheau-Yun YEH and Yeang-Her HWANG

Wooden bars used in marimba or xylophone with definite pitch are undercut in order to bring the frequencies of the first few overtones into a harmonic relationship with the fundamental frequency. This study using flexural vibration method to investigate the influences of different undercuts with parabolic shaped arch on the eigenfrequencies and internal frictions of wooden bars during their tuning process. These parabolic outlines were characterized by the length and depth of the undercut which from 0.2L to 0.8L and from 0.2h to 0.8h, respectively. L and h refer to the total length and depth of the wooden bar, respectively. Padauk, Selangan batu, Borneo ironwood, Taiwan acacia, and Taiwan zelkova were used in this study.

With regard to the fundamental frequency (f_1), this revealed a decrease with respect to the gradual undercut. By contrast, the second mode and third mode frequencies (f_2 and f_3, respectively) had less pronounced decreases and this allows one to broaden the relationship between the first three natural frequencies. Both the relationship of the values for f_2:f_1 and f_3:f_1 vs. the length and depth of the undercut showed parabolic behavior. The optimal dimensions of the undercut for these five wood species can be determined from the parabolic relationship so that the frequencies of mode 2 and 3 of flexural vibration are harmonically related with that of the fundamental frequency. It may be worth using Selangan batu as wooden bars for marimba or xylophone according to high Young's modulus and low internal friction.

Key words: Wooden bar, undercut, natural frequency, Young's modulus, internal friction

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Frictional Coefficients between Timber and Other Structural Materials

Qingjun MENG, Takuro HIRAI and Akio KOIZUMI

In most of design codes or standards of timber constructions, frictional resistance is not regarded as contributing to structural resistance. This comes from consideration for stress relaxation or reduction of effective vertical loads under vertical components of earthquake forces. Friction between timber and timber or other structural materials, however, plays quite an important role in actual mechanical behavior of timber constructions. If we accept this actual behavior, the consideration above seems not always reasonable but too conservative in some conditions.

In this study, we conducted experimental measurement of frictional coefficients between structural timber and other structural materials, which are of lack of information, as the first step toward the development of structural design considering frictional resistance. We prepared planed softwood timber specimens whose air-dry specific gravities ranged from 0.30 to 0.56 and typical wood based panels; hardwood plywood, softwood plywood, OSB and MDF. We also prepared an inorganic structural panel and steel plates. Static and dynamic frictional coefficients between timber and these materials were measured for every combination of principal axes of timber or wood based panels.

The obtained average static and dynamic frictional coefficients ranged from 0.25 to 0.37 and from 0.18 to 0.28, respectively, among all combinations of materials and slip directions. The dynamic/static ratios ranged from 0.68 to 0.84. Test results showed negative correlations between air-dry specific gravities of timber and static/dynamic frictional coefficients against that ordinary characteristics of other mechanical properties of timber have positive correlations with specific gravities.

Key words: Wood based panel, frictional coefficient, specific gravity

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Shrinkage/ Swelling Coefficients in Norway Spruce (*Picea abies* L. Karst) Tissue Types after Impregnation with Linseed Oil

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There is a need for methods to improve the dimensional stability of wood during its passage through production chains. One possibility that is thought to have good potential is to impregnate the wood with hydrophobic oil. The main objective of the pilot study presented here was to quantify the effects of impregnation with Linogard (a linseed oil derivative), following three different pre-treatments, on specimens of Norway spruce (*Picea abies* L. Karst.) wood representing four types of tissue. Mean shrinkage/swelling coefficients (S-coefficients) following the impregnation process were between -12.1 and -13.7 % for pre-treated and green specimens, and +1.4 % for dried specimens. Values of S-coefficients after water procedure (subsequent to impregnation) in impregnated specimens varied between 13.6 and 9.8 % and in dried control specimens between 15.6 and 13.2 %. S-coefficients within tissue types were not significantly different in impregnated specimens; however S-coefficients in control specimens differed significantly between heartwood and sapwood tissue types. Since impregnation had positive effects on the dimensional stability of all examined tissues subjected to the pre-impregnation treatments and furthermore diminished much of the variation within tissue types, there appears to be scope to develop wood materials with tailored dimensional stability characteristics if relevant material properties are assessed throughout the total production process.

Key words: Shrinkage, swelling, Norway spruce, impregantion, linseed oil

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5.03-IRG E
INSECT FACTOR IN WOOD PROTECTION

Papers

Treatment of Green Logs infested by Exotic Pest: Case Study of the Emerald Ash Borer: *Agrilus planipennis* Fairmaire

Pascal NZOKOu and D. Pascal KAMDEM*

Invasive alien insect species periodically infest forests in the United States causing the destruction of plant species and decimating populations, resulting in significant economic and ecological losses for areas involved. The Emerald Ash Borer (EAB) was first discovered on North American soil in the summer of 2002 near Detroit, Michigan and has since spread to several other Midwestern states and Ontario, Canada, causing the destruction of ash populations. Limitations posed on the circulation of green ash logs and lumber has seriously affected the economic value of ash logs and lumber in affected regions. This study investigated over bark chemicals and non-chemical treatments for sanitization of infested logs to allow free circulation and trade for value added products. Chemical treatments included borate with concentrations ranging from 5% to 16.5% (Boric Acid Equivalent) and Imidacloprid with concentration ranging from 0.005 to 0.02% applied as spray. Non chemical methods included treatments in conventional kiln and microwave at 50°C, 55°C, 60°C and 65°C.

Results obtained showed that Imidacloprid treatments concentrations of 0.01% and above were effective at sanitizing infested logs. Borate treatments resulted in significant reduction in insect emergence in indoors rearing conditions but did not achieve full control of the insect infestation. For non-chemical treatments, kiln temperatures of 65ºC were successful for sanitization of infested logs. Microwave treatments were not as effective as conventional heat for controlling insect emergence, and we hypothesized that this was due to the uneven distribution of the heat inside the microwave used in the study. Approaches to improve the microwave treatment are proposed.

Key words: Emerald ash borer, borate, imidacloprid, heat treatment, microwave treatment, sanitization, quarantine, exotic insects

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Do Insects Infest Wood Packing Material with Bark following Heat-treatment?

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As a result of international trade, many bark- and wood-infesting insects are inadvertently transported in wood packing materials (WPM) such as crating, dunnage, and pallets. WPM is suspected as the likely pathway for most of these borers, although the exact mode of entry into the USA is unknown for all 25 borers. The top 10 countries of origin were, in decreasing order, Italy, Germany, China, Spain, Belgium, Russia, India, Mexico, France, and United Kingdom.
We initiated studies in 2004 and 2005 to evaluate post-treatment insect colonization of logs and lumber with varying amounts of bark. *Acer rubrum* (red maple), *Carya glabra* (pignut hickory), *Pinus resinosa* (red pine), and *Quercus rubra* (northern red oak) were selected. All bark was retained on the logs. The logs were either heat treated according to ISPM-15 standards (56°C core temperature for 30 minutes) or left as untreated control logs. Overall, bark- and wood-boring insects (primarily Cerambycidae and Scolytidae) colonized and successfully reproduced in all treated and untreated logs of all four tree species tested.

Although our studies indicated that borers will infest barked surfaces of WPM after heat treatment under ideal field conditions, it was not known to what degree treated WPM contains bark, and how often borers live are associated with the bark. A survey revealed that about 0.11% of all marked WPM entering the USA harbored live borers. The results of the surveys and studies may help regulators to judge the relative risk of bark associated with WPM and whether there is justification to require that WPM be manufactured from bark-free wood.

Key words: Wood packing materials, insects heat treatment, quarantine, bark

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Potential of some Insecticides as Wood Protectants in South Indian Condition

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Wood continues to be one of the most widely used raw material in spite of the introduction of many modern materials and its demand increases progressively with the improvement in living standards of human beings and increasing world population. This naturally renewable resource being an organic matter is amenable to the attack of biodeteriorating organisms. Though some wood species are known for their natural resistance to agents of biodeterioration, their availability is constantly decreasing, besides being too expensive. The increasing demand for timber instigates the humans to utilize timbers lacking natural durability. This is made possible only through treatment of perishable woods with wood preservatives and insecticides. Many earlier marketed organochlorine compounds provide total protection against termites for years. However, with the increasing awareness on environmental safety and ban on organochlorine insecticides, the organophosphorous and pyrethroid insecticides as wood protectants became more popular.

In this paper we reviewed the insecticides being used to protect woods in the Indian condition. Further studies were undertaken to evaluate the efficacy of rubber wood stakes impregnated by pressure (15 minutes vacuum followed by 50 lbs./sq.inch air pressure for 30 minutes) with a organophosphorus insecticide, chlorpyriphos @ 1% & 2% a.i. and three synthetic pyrethroid insecticides viz., fenvalerate 1% & 2% a.i., cypermethrin @ 0.5% a.i and alphacypermethrin @ 0.5% a.i. against subterranean termites. The data collected indicated that within 6 months of implantation there was damage of 61.4 % in untreated stakes, which was total within 12 months of implantation. Among the insecticides chlorpyriphos and fenvalerate treated stakes were free from any damage at both the evaluated concentrations for more five years while stakes treated with, cypermethrin and alphacypermethrin recorded 84% and 80% damage at 5 years after exposure. These findings demonstrated that the insecticides like chlorpyriphos and fenvalerate could be effectively used for preservation of highly perishable woods.

Key words:

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FST (Formosan Subterranean Termite) - Resistance of Wood Composite Boards made of Dawn Redwood (Metasequoia glyptostroboides)

R. C. TANG*, T. F. SHUPE and C. Y. HSE

In recent years, the Formosan subterranean termite (FST: Coptotermes formosanus shiraki), considered as a "super termite" by entomologists worldwide, has caused serious damage in houses and light-frame buildings in 12 States (including Haiwaii) in the southern USA. In this study, 1.27 cm [0.5-in.] thick environmental-friendly lightweight flakeboards [i.e. non-chemicals treatment] were lab-fabricated with flakes (dimension: 25.4 mm wide x 76.2 mm long x 0.381-0.508 mm thick [1 in. x 3 in. x 0.015-0.020 in.]) of 100 % sapwood of Dawn Redwood (SPD) [Group-I]; 100 % heartwood of Dawn Redwood (HTD) [Group-II]; and 50-50 mixture of sapwood and heartwood of Dawn Redwood (SHD) [Group-III] by using a liquid phenol-formaldehyde resin. The efficacies of the FST-resistance of these 3 groups, each containing 10 small-size specimens, along with two groups of solid wood [IV: heartwood and V: sapwood], were Lab-tested under ambient room conditions by using a no-choice forced feeding method with each group had 300 freshly collected FST containing 250 workers and 50 soldiers. The testing results were compared with that of the newly commercial-produced zinc-borate [ZB] treated Southern pine OSB [oriented strand boards]. The air-dried density of Group-I, -II, -III, -IV, and -V was, respectively, 0.632 gr/cm^3 [39.46 pcf], 0.637 gr/cm^3 [39.74 pcf], 0.655 gr/cm^3 [40.88 pcf], 0.332 gr/cm^3 [20.74 pcf], and 0.360 gr/cm^3 [22.46 pcf], while the ZB-SP-OSB had a value of 0.676 gr/cm^3 [42.2 pcf]. Results of a 90-day no-choice forced-feeding FST test indicated that 100% and 99% mortality was observed in the Group-IV [100% HTD wood] and Group-II [100% HTD flakboards], respectively, which are comparable with the ZB-SP-OSB [100% mortality], as reported in our previous study. However, a moderate (76%) and low (60%) mortality was found in the Group-I [100% SPD flakeboards] and Group-III [50-50 mixture of SPD and HTD flakeboards], respectively, while a very low mortality (32%) showed in the Group-V [100% SPD wood]. This finding suggests that developed environmental-friendly composite boards, made of the heartwood of the fast-growth and lightweight Dawn Redwood, may have potential to be manufactured as commercial composite panels for using effectively as web materials for fabricating lightweight I-joists and siding in residential housing constructions for against the FST attack.

Key words: Dawn Redwood, Metasequoia glyptostroboides**,** Environmental-friendly lightweight flakeboards, Formosan subterranean termite (FST) resistance, Zinc-borate treated southern pine OSB

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Durability of Timber from Exotic Species against Termite Attack in Indian Conditions

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The high demand, ban on timber felling, escalating cost and poor supply of conventional timbers, has forced the consumers in India to utilize secondary timbers, plantation timbers and exotic timbers. Secondary and exotic timbers are presently being used on a large scale for varied purposes like building, furniture making, handicraft products, packing cases etc. Hence it is essential that we know the natural durability of these timbers against termites so that the service life of the timber can be predicted and also decision to use preservative treatment can be taken. Exotic trees species like *Acacia mangium*, *A. auriculaeformis* and their hybrid are widely grown in India for multiple uses including timber use.

Studies were conducted to test their durability against termites with and without treatments and in comparison to Rubber. The treatments were dip diffusion, spraying and pressure impregnation. Test panels (30.5 x 3.8 x 3.8 cm) were prepared from pure heartwood and treated with CCA (Copper-Chrome-Arsenic), Permethrin and Cashew Nut Shell liquid (CSNL) formulation. They were buried three-fourth in the grave yard along with untreated stakes and rubber wood stakes and tested as per Indian standards (IS 4833-1968). Observations taken for a period of 5 years is presented here. *A. auriculaeformis* and the hybrid were found to be highly resistant to termite attack and both treated and untreated stakes were found undamaged upto 5years. *A. mangium* was also more durable as compared to rubberwood (which was fully damaged within 6 months of field exposure); Treated stakes of *A. mangium* were also totally protected against termite attack in the field. The comparative performance is discussed in the paper.

Key words: Exotic species, durability, *Acacia*, permethrin, CNSL

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Development of Boron/Linseed Oil combined Treatment as a Low-toxic Wood Protection: Evaluation of Boron Fixation and Resistance to Termites

Florent LYON, Marie-France THEVENON*, Yuji IMAMURA, Joseph GRIL and Antonio PIZZI

Combinations of boric acid as a first step of treatment and linseed oil as a second step have been performed in order to enhance boron fixation to leaching and wood resistance to termites. Classic leaching and termites resistance standards are inappropriate to evaluate this combination which can be considered as both a wood preservation treatment and a coating.

Japanese Industrial Standard (JIS K1571, 2004) on Japanese cedar (*Cryptomeria japonica*) exposed to subterranean termite *Coptotermes formosanus*, and, European standards EN84 and EN117 on Pine (*Pinus sylvestris*) exposed to termite *Reticulitermes santonensis* have been performed for the same boron/oil treatments.

Addition of oil as a water repellent to boron treated wood gave promising results with about 30% of initial boron retained. Termite mortality rates and efficiency thresholds using the different standards are determined and compared. Moreover, the relevance of Japanese mass loss indicator and European visual evaluation are discussed in the case of unconventional wood protection system such as boron/linseed oil combination.

Key words: Wood preservation, boric acid, linseed oil, leaching, termite tests

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5.03-IRG – Posters

Difficulties in Applying Heat Treatment according to ISPM No. 15, when Fast Growth Species are used

Osvaldo ENCINAS*

In 2002, the Interim Commission on Phytosanitary Measures (ICPM) adopted an International Standard for Phytosanitary Measures (ISPM) No. 15 (*Guidelines for regulating wood packaging material in international trade*). Two treatments are recognized: Heat Treatment (HT), in which wood must be heated to a core temperature of 56°C for 30 minutes, and fumigation with methyl bromide. As the last treatment use methyl bromide, recognized to have negative atmospheric effects and is being phased out by 2005 by the Montreal Protocol on Substances that Decrease the Ozone Layer, the fumigation of wood packaging using methyl bromide has raised environmental concerns. For many countries around the world only HT is applicable.

When the wood utilized comes from fast growth plantations, as Caribbean pine (*Pinus caribaea* var. *hondurensis*), many problems are identified concerning the nature of such wood, because the high amount of soluble sugars and starch allowing the growth of other pathogenic agents, mainly fungi. Even if the wood has been dried below the Equilibrium Moisture Content (EMC) before the wood packaging material is stored in closed containers for sea transportations, and despite the low initial temperature and humidity inside the container, during the several weeks at sea blue stain and mould fungi still will occur. In the fact 56 °C for 30 minutes is not enough to eliminate fungal spore contaminants in the wood.

Furthermore, as many export goods are quarantined, some plastic film wrappers retain the humidity in the wood, stimulating the development of fungi.

Wood technologists know very well that for better phytosanitary treatments, bark free wood must be used, higher temperature is required to sterilize wood; and also it is highly recommended to use kiln dried wood if the target is to avoid pathogenic agents, because the temperature exceed that stipulated by ISPM 15.

Key words: ISPM 15, heat treatment, kiln dried wood, wood packaging materials

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5.05 D
COMPOSITES SCIENCE

Papers

Dimensional Stability and Mechanical Properties of Particleboard made from Carboxylic Acid Anhydride Modified Bagasse

Mohammad Reza MASTERY FARAHANI and Mehdi JONOOBI

The purpose of this study was to evaluate the dimensional stability and mechanical properties of three-layer particleboard produced from linear chain carboxylic acid anhydride modified bagasse particles. Modification was performed via esterification of bagasse using acetic and propionic anhydrides without using any catalyst and solvent at 120°C for 240min at lab scale. After being de-pitted, dried, hammer-milled, screened and re-dried, bagasse with two particle sizes (fine and coarse) were modified. Different weight percent gains (WPGs) were obtained with different sizes and reagents. The maximum WPG was 28%. This maximum WPG was obtained when the fine particles were modified with propionic anhydride. Esterified and unmodified bagasse particles were pressed into three-layer particleboards using phenol formaldehyde (resole type). The mechanical and physical properties of the boards were tested. The dimensional stability of the particleboard made from unmodified bagasse particle was low. The thickness swelling (Ts) of the unmodified bagasse particleboard after 24h water soaking was %30.3 which is above the maximum allowed by European standard(EN312-P3). The particleboards made from esterified bagasse particles were more dimensionally stable than the control boards from untreated bagasse. The Ts of the esterified particleboards was very lower than the maximum accepted by the standard. The performance of the moderately acetylated particleboard in reducing TS was close to the highly propionylated particleboard. The module of rupture (MOR), and internal bond (IB) of the esterified particleboards were lower than the minimum accepted by the standard. The mechanical properties of highly propionylated particleboard were lower than those for the moderately acetylated particleboard.

Key words: Bagasse, esterification, acetylation, propionylation, three -layer particleboard

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Effects of APP on the Fire-retardant and Mechanical Properties of Wood-flour-HDPE Composite

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Ammonium polyphosphate (APP) was applied to wood-flour-HDPE composite as a fire retardant. The burning behavior and the isothermal combustion kinetics of the composite were studied with a cone calorimeter, and the mechanical properties of the composites were tested statically. The results showed that considerable fire-retardancy was observed with APP, thus, at a heat reflux of 35kW/m^2 and by the addition of 15% APP (by weight), the peak value of Rate of Heat Release (RHR) and Total Heat Release (THR) of the fire-retardant wood-flour-HDPE composite decreased 50% whereas the charcoal yield increased 150% (weight) compared to the control. The combustion of wood-flour-HDPE composites (with or without APP as fire retardant) can be described as the chemical kinetic equation of first order reaction $\ln(1-\alpha) = -kt + C$, in which the reaction rate constant k and half life $t_{1/2}$ are 0.0075 s^{-1} and 121.6s respectively, when the combustion temperature is 675°C and without APP. The value of k decreased and $t_{1/2}$ increased by the addition of APP. The impact strength of wood-flour-HDPE composite was considerably decreased by the addition of APP. However it did not loss high value when the content of APP was less than 20% (weight). APP did not have much influence on the Flexural strength and only minor influence on the tensile strength of the composite, but increased the tensile and flexural modulus of the composite. The optimal content of APP as a fire retardant of wood-flour –HDPE composite is about 15%.

Key words: Wood-flour-HDPE composites, cone calorimeter, fire retardancy, mechanical property, ammonium polyphosphate, APP

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Properties Enhancement of Palm Plywood through Veneer Pre-treatment with Phenolic Resin

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One of the problems dealing with oil palm stem plywood (OPSP) is the high veneer surface roughness that resulted in high resin consumption during the plywood manufacturing. In this study, evaluation was done on the effects of pretreatment of OPS veneers with phenolic resin on the bonding integrity and bending strength of OPSP. OPS veneers were soaked in low molecular weight phenol formaldehyde resin (LMW PF) for 5 seconds to obtain certain percentage of resin uptake. A total of 24 five-ply OPSP were produced in this study, using two types of lay-up (100% outer veneer type and 100% inner veneer type) and two Urea Formaldehyde (UF) adhesive spread rates (200g/m^2 and 250g/m^2). The glue bond and static bending specimens were tested according to BS EN 314-1: 1993 and BS EN 310: 1993, respectively.

The results show that pretreating the veneer with LMW PF could reduce the penetration of the adhesive into the fibre during gluing step. UF adhesive spread of 200g/m² is sufficient to produce good quality OPSP. The analysis of variance (ANOVA) indicates high significant interaction between treatments (untreated and phenolic treated veneer), glue spread rates and lay-up types in bonding integrity and strength properties. Glue spread rates, however, gave marginal effect on the bond quality in this study. A further evaluation on the interaction of condition and lay-up type show that phenolic treated OPSP made from 100% outer veneers consistently gave high glue bond strength (shear strength of 1.0MPa) and 100% wood failure. The phenolic treated veneer for OPSP also exhibited superior performance of shear strength in wet condition with shear strength retention of 161%. Superior strength values were obtained by the 100% outer veneer plywood with MOR >35MPa and MOE >4500MPa. The increment in bending strength was between 125% (100% inner veneer type at 200g/m²) to 18% (100% inner veneer type at 250g/m²) and in stiffness between 67% (100% inner veneer at 200g/m² UF adhesive) to 52% (100% inner veneer at 200g/m²). The presence of vascular bundles contributed significantly in bonding integrity and strength properties of OPSP, whilst the parenchymatous tissues were observed to absorb more resin but did not have any influence on the properties. The technique used in this study was able to enhance the mechanical properties of OPSP, as well as, reduced the amount of resin consumption by at least 30%. The economics of production cost increase and use for the industry were not studied

Key words: Oil palm stem plywood, low molecular weight phenol formaldehyde resin, mechanical properties, bonding integrity

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Feasibility of Manufacturing Paper-plastic Laminates using Waste Paper

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The purpose of this study was to evaluate the feasibility of fabricating fiber-plastic laminates as an alternative for paper recycling. Pre- and post-consumer office papers were used to mix with virgin and recycled low-density polyethylene films of 0.03, 0.06, and 0.09 mm thickness to make 12 types of fiber-plastic laminates of various configurations. The laminates were fabricated by interleaving paper with plastic films, followed by hot pressing, cooling, and setting. Target thickness of the 12 laminates was 3mm, with compaction ratio to original thickness varying from 17 to 22%, panel density ranging from 0.93 to 1.05 g cm^{-3} and fiber loading around 48, 60 and 72%. Mechanical tests on the 12 fiber-plastic laminates showed that the bending strengths were between 45.1 and 65.7 MPa (MORb) and 4.20 and 7.27 GPa (MOEb), tensile strengths at breakage lied between 30.4 and 56.9 MPa, hardness ranged from 63 to 73 Shore D, heat deflection temperatures fluctuated between 121 and 130 ^{o}C , and absorption energy of Izod impact bending tests were between 139 and 300 j/m. This study showed that flexural strength and stiffness of paper-plastic laminates was 1.5 fold higher than extruded woodflour-plastic composites, indicating paper-plastic laminates might be a viable alternative for paper recycling.

Key words: Paper-plastic laminates, polyethylene, waste office paper

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Evaluation of Physical and Mechanical Properties of Cardboard Reinforced with Veneer and High Pressure Laminate (HPL)

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The objective of this study was to investigate physical and mechanical properties of composite cardboard panels reinforced with wood veneer and high pressure laminate (HPL). The experimental cardboard samples manufactured from recycled carton containers of milk, juice, and beverages which are typically made of 77 % paperboard for strength, 18% low density poliethylen (LDPE) to provide a moisture barrier and a bonding agent, and 5% aluminum foil with an avearage thickness of 6.35 µm for UV light, and gas barrier. Particles were generated by breaking down carton packages using an industrial type chipper at Yekas Recyling Inc.. 15 mm thick mats were formed using the paperboard-LDPE-aluminum particles without having any resin or additives and compressed in a computer controlled hot press. The pressed mats prior to lamination had average density of 1040 kg/m³. The panels with dimensions of 500 mm by 500 by mm by 15 mm were consecutively overlaid with wood veneer sheets and HPL. Firstly, the panels were overlaid with 1.5 mm thick beech veneer sheets (*Fagus orientalis* Lipsky) using of phenol-formaldehyde resin at a temperature of 120°C and for 10 min in a hot press and then covered with HPL using PVA resin at 60°C and 10 min. For physical properties, density, thickness swelling and water absorption while for mechanical properties modulus of rupture, modulus of elasticity, screw holding, and bonding strength between overlays and the panels were determined according to European and DIN standards. Covering of the panel surfaces with veneers and HPL enhanced mechanical properties of the samples as compared to uncoated ones. Panels overlaid with veneer had thickness swelling, modulus of rupture, modulus of elasticity values with an average of 0.76%, 53.2 N/mm² and 4866.4 N/mm² while uncoated ones had 0.20%, 18.65 N/mm² and 2350 N/mm², respectively. Based on the findings of this study, reinforced composite cardboards could be considered as an alternative raw material with accepted properties to be used in furniture applications such as counter tops, flooring, and kitchen cabinets. It appears that using above recycled material to manufacture value-added composite panels may result in sustainable utilization of resouces from the environmental perspective.

Key words: Cardboard, recycled carton containers, composite panel

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Assessment of the Flexural Strength and Dimensional Stability of Cement-bonded Boards Manufactured from Maize-cobs and *Gmelina arborea* Sawdust.

Julius B. ADEWOPO* and B. AJAYI

Single-layered cement-bonded particleboards (350mm×350mm×6mm) were manufactured using a blend of maize-cob particles (2mm) and *Gmelina arborea* sawdust. Boards were manufactured at five levels of blending ratio, *Gmelina*:maize-cob (0:100, 25:75, 50:50, 75:25, 100:0) and two levels of mixing ratio, cement:blended material (2:1 and 3:1) with two replicates per treatment combination. The board density was constantly at 1200 kg/m³ and the chemical reagent ($CaCl_2$) was at 3%. The boards manufactured from 100% maize-cob particles did not bond to form boards and were not viable for the testing. The water absorption (WA), thickness swelling (TS), linear expansion (LE) and modulus of rupture (MOR) were affected by the blending ratio of *Gmelina*:maize-cob and the mixing ratio of cement:blended material. The dimensional stability and flexural strength of the formed boards increased as the blending proportion and mixing ratio increased; hence, the most dimensionally stable boards were produced at the optimum blending ratio and mixing ratio of 75:25 and 3:1 respectively. However, the analysis of variance (ANOVA) shows that the interaction between the two treatments has no significant effect on the board properties. The Duncan's multiple range and student-t tests were independently used to carry out the follow-up test for the blending ratios and mixing ratios respectively, and this showed that viable boards can be manufactured at 75:25 blending proportion of *Gmelina arborea*:maize-cobs and 3:1 of cement:blended material.

Key words: Particleboards, flexural strength, dimensional-stability, blending, maize-cobs, *Gmelina arborea.*

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5.05 D – Posters

Dimensional Stability of WPC made from Polyester and Wood Particle and Fiber

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The study investigated physical properties of experimental panels manufactured from combinations of polyester, wood particles and fibers. Influences of raw material characteristics on the panel properties were evaluated. Different types of wood plastic composite (WPC) panels were made using 10 % and 15 % wood in the form of fine polyester powder and coarse particles of spruce and polyester. Panels with combinations of 5 % and 10 % fiber of beech, pine, and polyester in addition to 100 % polyester as control samples were produced. Average target density of the panels ranged from 1,58 g/cm^3 to 1,67 g/cm^3. Thickness swelling and water absorption of the samples were determined based on European Standard for wood based panels. Based on initial findings of the study, it appears that both thickness swelling and water absorption of samples increased as higher percentage of fine particles and fibers were added into the mats. The highest thickness swelling value for 24 hours water soaking test was found 0,36 % for the samples made from 10 % particles and 90% polyester. Average thickness swelling 100 % polyester was 54 % lower than those of above samples. Based on statistical analyses no significant different was found between dimensional stability of the panels made from particles and fibers at 95% confidence level.

Key words: Thickness swelling, water absorption, polyester based panels

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Properties of Wood Sawdust/Polypropelyne Composites

H'ng Paik SAN*, Yeoh Beng HOONG, Teo Seow CHIAN and Yeoh Poh HUN

A wood plastic composite (WPC) was developed to convert the low value wood resources into high value products by mixing with thermoplastic resins. WPCs are typically made using of 20% to 70% wood filler. Most composites research has used wood flour as filler in plastics. Wood flour is made commercially by grinding postindustrial material, such as planer shavings, chips, and sawdust, into a fine, flour-like consistency. Wood fiber, although more difficult to process than wood flour, can lead to superior composite properties and act more as a reinforcement than as a filler. Wood fiber is available from both virgin and recycled sources. Recycled sources include pallets, demolition lumber, and old newsprint. Wood from small-diameter trees and under-utilized species can also be used. However this wood filler come with a cost, either small or large amount, they will affect the wood plastic composites to be competitive with other wood based products. This study investigates the properties of wood-flour/propylene composites where the wood flour is screened sawdust with 40 mesh direct taken from furniture factory. Wood flour particles (40 mesh) were compounded at 10%, 20% and 40% by weight with polypropylene. Increases in modulus of elasticity of the wood flour composites were found to correspond with increases in aspect ratio. However, flexural strength reduced as the wood filler percentage increase from 10% to 40%. Dimensional stability under soaking 24 hour and linear expansion due to humidity change shows this product has good potential to be used as outdoor materials.

Key words: Wood flour/propylene composite, sawdust, wood filler

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Electrical Properties of Composite Cellulose Material

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We have studied the electrical properties of cellulose in order to expand the fields of wood utilization. We considered that the highly orientated cellulose film has a higher dielectric constant than ever. Especially, the cyano-ethylated cellulose among the cellulose derivatives has a high dielectric constant of 12-15. The cyano-ethyl group should contribute to a polarization. But the film is very fragile, so the cyano-ethylated cellulose film cannot be drawn highly.

We prepared the piezoelectric ceramics powder (BaTiO3 and PZT, #200) and cyano-ethylated pullulan to make the high dielectric material at first. The composite film could be improved the dielectric constant applying the poling. The condition of poling was DC 5kV at 140°C. The piezoelectric and pyro-electric constants were improved than those of control. Furthermore, the ferroelectric phenomena could be induced such as the D-E hysteresis loop by poling.

We made the cyano-ethylated cellulose film with the different D.S. (about 1-3), and drew in a chamber at 120-130°C to clarify the effect of orientation. The piezoelectric, dielectric and elastic constants have been measured from -150°C to 100°C using Rherographsolid (Toyo Seiki Co. Ltd.). The behaviors of piezoelectric and dielectric relaxation have changed with D.S. The dispersions of the piezoelectric and dielectric relaxation were shifted to higher temperatures than control by the heat drawing.

We considered that it was necessary to be composed of a cyano-ethylated cellulose and BaTiO3 or PZT in order to improve the dielectric and pyro-electric constants.

Key words: Electrical property, cyanoethylated cellulose, dielectric constant

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Properties of Composite Panels made from Recycled Office Paper and Plastic

Poo CHOW*, Charles T. BOWERS, James H. MUEHL and Andrzej M. KRYZSIK

The objective of this on-going research is to develop and advance technologies for recycled wood and plastic products. This project demonstrated the viability of using office wastepaper and recycled plastics in producing thermoplastic composites. Recycled office paper and plastics are abundant post-consumer waste products. Waste paper, that is not re-pulped, and used plastics are normally sent to landfills. Any further use that can be developed for these waste products could add value to them and would reduce the demand on landfills. The success of this study may mean tremendous economic advantage to many communities. This report presents the progress of this research focusing on optimizing the manufacturing techniques and testing of both air-laid non-woven and melt-blended office waste- paper/plastic composite panels. To form the panels, two methods of mat-forming were used: a) air-laid non-woven mats; and b) melt-blend technology formed mats using extruded pre-formulated and pelletized stocks. A chemical coupling agent was used to improve the bonds between the recycled plastic molecules and the recycled office paper. Each series of experimental panels was made with a specific combination of copolymer chemical agent, virgin or recycled post-industrial polypropylene powder, and recycled office waste paper fibers. The physical properties including dimensional stability performance and mechanical properties, such as maximum bending stress, modulus of elasticity, tensile stress, and internal bonding strength of the experimental composite panels were determined. Most of the physical and mechanical property values met the standards for commercial hardboard products. These composite panels could be used in building and farm construction, interior automobiles parts and plastic floor tiles that are water resistant and easy to clean.

Key words: Recycled office paper, polypropylene fiber, composite panel, coupling agent, extrusion, non-woven mats.

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Applying High Frequency to Heat Wood-based Panel Evenly

Cheng Jung LIN*

When high frequency is applied to heat wood-based panel in industrial production, the through heating method is usually used. In this method the two plates are situated on either side of the material being heated. The whole of the material is evenly heated throughout in theory, but in practice the temperature of top and bottom could be cooler more than the center by as much as 15 to 20 □. Because those materials are always contact with the electrodes and the metal of the electrodes conducts some of the outside heat away.

For improving the gluing quality of wood-based panel, some types of board with low power factor, namely, polyethelene, teflon and oven dried balsa wood, were used as insulation layer between electrodes and material. Meanwhile, a new method for measuring the temperature in the material with intermittent heating time and with thermal couples was developed.

From the results found in this study, the temperature in the panel can be easily and precisely measured with intermittent heating time and with thermal couple method. And, as the oven dried balsa wood is used as insulation board in the heating assembly, wood-based panel can be heated evenly.

Key words: High frequency heating, through heating method, thermal couple, wood-based panel manufacturing

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Manufacturing and Properties of Wood-plastic Composite Plywood

Liang CHANG, Zheng WANG, Li GAO and Wenjing GUO

Wood-plastic composite plywood is a new hybrid product made from plywood veneers and wood-plastics binders. This new plywood takes thermoplastic film and veneer as raw material, and is made by panel process. It has been approved as an invention patent in China.

This paper mainly introduces the manufacture process and properties of this new wood-plastic plywood, and contrasts its manufacturing costs to traditional plywood. It has higher production efficiency than extrusion process. As interior plywood product, it is formaldehyde free, and has good bonding strength and water-resistance properties. This product can take waste plastic as raw material, which will reduce the pollution of waste plastic and benefit for environment protect. In addition, the cost of the new plywood when using waste plastic is below that of traditional E_1 plywood.

As an environmental friendly product, this new plywood would replace traditional UF plywood in all applications.

Key words: Wood-plastic composite plywood, manufacture process, formaldehyde free, cost

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Modifying of Hornbeam Wood (C*arpinus betulus* L.) by Hot Pressing

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Wood is natural material that uses either solid or modified form. One of wood modifying methods is compressing in hot press that lead to produce “compressed wood”. The objective of this study was to determine optimum processing conditions to achieve the best physical and mechanical properties of hornbeam compressed wood.

The variables were moisture content at two levels: 15% & 25%, press temperature at three levels: 100, 150 & 200°C and compressive strain at four levels: 10, 20, 30 & 40%. Totally 25 treatments in addition one control sample were examined. Spring back, compression set, dry density, impact energy, EMC, MOE and MOR of the samples were determined and compared with the control samples.

The results indicated that moisture content had an adverse effect on physical and mechanical properties of the compressed samples. At 15% moisture content, with increasing press temperature and compressive strain, spring back increased and compression set decreased. Highest impact energy was observed in treatment with 15% M.C. and 100°C press temperature. Also compressed samples at 100°C had the highest MOR. There was no significant difference among MOE of different treatments. Finally samples with 15% moisture content that were made at 100°C heat of press and 20% compressive strain selected as the best regarding the physical and mechanical hornbeam compressed wood properties.

Key words: Modify, *Carpinus betulus*, hot press, compressed wood, spring back, MOE, MOR

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The Effect of Door Leaf Constructions on Fire Endurance of Wood-based Fire Doors

Sheau Horng LIN and Quan Zhen JI

Galvanized steel plate (GSP), magnesium oxide board (MOB) and three wood-based materials (WBM)--plywood, flax board and medium density fiberboard (MDF) were used as raw materials in this study to explore the best configuration of door leaf structure that would meet the requirement of the one hour fire-rated fire door regulated by Chinese National Standard (CNS 11227). Wood-based fire doors of 45 mm in thickness were thus manufactured and the fire endurance performances were examined. Specimens were heated with the small-scaled Laboratory furnace. We found that the best configuration of specimens were MOB-GSP-MOB-WBM-MOB-GSP-MOB, while the potential combinations could be MOB-WBM-MOB-GSP-MOB-WBM-MOB, or MOB-GSP-WBM-GSP-MOB and GSP-MOB-WBM-MOB-GSP. Which wood-based materials would give the best fire endurance performance when they are incorporated into the door leaf? The flax board was the best among the three types investigated, and plywood was the poorest. As for the strength of the joint in a door frame structure, the tenon type showed better result than that of conventional nail-joined one. .

Key words: Composite materials, wood-based materials, fire endurance performance, one hour fire-rated.

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Manufacture of Wood-pottery Composite Board

Andi HERMAWAN, Takeshi OHUCHI, Noboru FUJIMOTO* and Yasuhide MURASE

Pruned wood is generally processed into woody fiber by a cutting mill after the wood is crushed with a chipper. In Japan, part of the pruned wood is used as compost, mulching material, and soil improvement material. However, the majority is still incinerated or is unused and put underground. Therefore, a new use for prune wood is desired. On the other hand, in the porcelain manufacturing process, when a pottery stone as the raw material becomes brown through the progress of drying and oxidation, it is no longer possible to use it as a raw material. Therefore, the development of an effective use of this pottery stone scrap that has become brown is also desired.

In this study, on the effective use of both prune wood and pottery stone scrap, a wood-pottery composite board made from both of these was developed. Conditions for the manufacture of a wood-pottery composite board as a board for a construction material were examined and evaluated the physical and mechanical properties in accordance with Japanese Industrial Standard (JIS) A5908 and incombustibility properties in accordance with JIS A1322. Single-layer composite board, which mixes prune wood and pottery stone scrap; and three-layer composite board, which makes surface layer pottery stone scrap and makes core layer prune wood, were produced. Target density of composite board was 0.8 g/cm^3. The weight ratios of prune wood to pottery stone scrap in both of single-layer and three-layer composite board were 40:60, 50:50 and 60:40, respectively.

The main results obtained are as follows: The composite board has excellent thickness swelling properties, which was around 2.16–5.46%. Three-layer composite board was corresponding to the third class of fireproof board accordance with JIS A1322. The MOR and MOE of the composite board was around 0.60– 6.53 MPa and 0.08–2.38 GPa, respectively. Therefore, it will be necessary to improve the bending properties of the board by changing the density of the board as well as the size both of the pottery stone scrap and prune wood.

Key words: Pruned wood, pottery stone, composite board

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Manufacture of Agroforest Waste Particle-plastic Composites and its Properties

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Wood, bamboo, rice-hull waste particles and high density polyethylene (HDPE, P) were used as raw materials for this study. The method for producing agroforest waste particle-plastic composites to fill a prescription of mixture ratio (60:40, 70:30 and 80:20) by flat-platen pressing (0.25 MPa, 180 ^{o}C, 6 ~ 8 min) have been used. The density of this composites showed 0.78 ~ 0.90 g cm^{-3} and their moisture content displayed 4 ~ 6%. It was observed that distribution of plastic powder can be improved by adding 5% and 10% stick agents in the composites form a processing image. Both the thickness swelling and water absorption of composites were increased by increasing the weight proportion content of agroforest waste after soaking in water for 24 h. On the other hand, when the weight ratio of wood particles to HDPE is 60:40, which composites showed the best MOR (17.4 MPa). When the weight ratio of bamboo particles to HDPE is 60:40, that composites had the highest retention percentage on bending strength, and the best wood screw holding strength (880.7 N). The internal bond strength of all composites appeared 0.31 ~ 1.55 MPa, except for rice-hull particles-HDPE (R80P20, R is rice-hull and P is HDPE.).

Key words: Agroforest waste, particle-plastic, composites

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5.07 D
CHEMICALS FROM WOOD

Papers

Thermo-chemical Conversion of Wood Biomass *Populus alba* × *gradulosa* to Monomeric Sugars by Supercritical Water Treatment in Presence of Inorganic Acid Catalysts

Don-Ha CHOI*, Tae-Su CHO, Joon Weon CHOI, Hyun Jin LIM and Kyu Sung HAN

In this study a possibility for sugar conversion of wood biomass by supercritical water treatment was investigated in presence of organic/inorganic acids catalysts. Supercritical water treatment (SCWT) of poplar wood (*Populus alba* × *glandulosa*) was performed at different temperature conditions (325, 350, 380, 400, 425°C) under the pressure 230 - 240atm for 60 seconds using flow type system. As organic/inorganic acid catalysts acetic acid, hydrochloric acid and sulfuric acid were added to mixture of poplar wood meal (20g) and water (1L) to the concentration of 0.05% (v/v) prior to SCWT reaction, respectively. After separation of solid residues from SCWT products, the monomeric sugars in aqueous part converted from poplar wood meal were quantitatively determined by high performance anionic exchange chromatography (HPAEC) equipped with PAD detector and CarboPac PA10 column. Poplar wood meal was degraded up to 90% by SCWT in presence of hydrochloric acid and sulfuric acid, while acetic acid didn't help with the degradation of poplar wood meal (*ca.* 60%). The total sugars converted from poplar wood meal were yielded up to 23% and 21% (based on oven dry weight of wood meal) at 380°C by addition of hydrochloric acid and sulfuric acid, respectively. However, SCWT of poplar wood meal with acetic acid gave only 6% of total sugars at 425°C. Considering the previous data for sugar production by SCWT of same biomass (ca. 7% at 425°C) without acid catalyst, the optimum temperature for sugar conversion is not only further mitigated but hydrolysis potential of wood biomass by SCWT can be also enhanced in inorganic acid atmosphere. In addition, 5-hydroxymethyl furfural, 4-oxo-5-methoxy-2-pentene-5-olide and phenols were identified as minor products in SCWT products and were expected to be formed by pyrolytic reaction of cellulose and lignin during SCWT of biomass.

Key words: Supercritical water treatment, *Populus alba* × *glandulosa*, monomeric sugars, acid catalyst, high performance anionic exchange chromatography

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Bundling of Slash Material - The Answer for an efficient Energywood Supply Chain in Central Europe?

Hannes LECHNER* and Gero BECKER

In Scandinavia bundling of slash material for energy production is an established supply system. Former studies showed that the productivity of the forwarder-bundler mainly depends on the amount of slash material per hectare and the concentration and the condition of the slash material. This makes the bundler ideally adapted to clear cuts in coniferous forests. In Central Europe however forests mainly are managed with selective thinning and contain in many cases mixed in broadleaved trees. Contrary to Scandinavia bundling on the site is difficult because the remaining trees obstructing the bundler which has a working width of about 7 m. Therefore the slash material had to be forwarded to the forest road before bundling. There the slash material was bundled with the Timberjack bundler Fiberpac 370B mounted on a truck.

Main objectives of this study were:

- General survey of the feasibility of the bundling technique for Central European conditions (selective thinning, low and scattered felling volume per hectare, broadleaved species)
- Analysis of productivity and costs of each step of the supply chain
- Development of approaches for further adaptation and optimisation of the supply chain with a bundler

The bundler was tested on 15 sites of different age classes and species mixtures. Altogether 1,700 bundles were produced. The mass output per hectare ranged from 9 up to 79 bundles/ha. The measured productivity of the bundler (17 to 27 bundles per productive machine hour) is comparable to the productivity of bundlers operating on clear cut sites in Scandinavia. The overall costs of the supply chain, including transport and chipping, were 18.20 EUR/bundle or 15.10 EUR/m^3 wood chips. The highest share of the costs was caused by the truck mounted bundler with 7.14 EUR/bundle followed by the forwarder with 5.50 EUR/bundle. The costs for the transport of the bundles with a conventional log truck over a distance of 30 miles were 4 EUR/bundle. Chipping costs were 1.80 EUR/bundle.

The study proved the general suitability of the bundler for both coniferous and broadleaved species and selective thinning systems when the slash material is forwarded to the forest road and bundling takes place there. However the costs of the supply system are not competitive to alternative supply systems like chipping at forest road. Further optimisations are necessary and possible.

Key words: Slash bundler, bioenergy, energy wood

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Resin Salve from Norway Spruce (*Picea abies* [l.] Karst.)

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Homemade resin salve from Norway spruce is traditionally and widely used in folk medicine in northern Finland to heal various skin infections and wounds. We performed laboratory studies to solve the action mechanism of resin salve. Resin salve exhibited a bacteriostatic effect against all tested Gram-positive bacteria, including methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant enterococcus (VRE). The tests suggest that the antimicrobial effect is more likely bacteriostatic than bacteriocidic.

The main terpenoid component of spruce resin is dehydroabietic acid. Other resin acids found in Norway spruce are levopimaric, pimaric, palustric, isopimaric, sandracopimaric, abietic and neoabietic acids. They were detected by gas-liquid-chromatography (GLC) in the water phase after sonication for 30 mins or for 1 hour in an ultrasonic bath. Large proportions of lignans (pinoresinol, lariciresinol and matairesinol) and cinnamic acid were also found in the water extract. The profile of the extractives of pure spruce resin in the water phase was similar to that of resin salve. Our preliminary experiments (unpublished data) with abietic acid show mostly similarities with the antimicrobial (and antifungal) effects of resin salve, indicating that the resin acids may represent the therapeutically effective antimicrobial components of resin salve.

Key words: Norway spruce, resin acids, lignans, antimicrobic, bacteriostatic

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Charcoal from Biomass Residues of a *Cryptomeria* Plantation and its Carbon Fixation Benefit Analysis

Yu-Jen LIN* and Gwo-Shyong HWANG

Charcoal production is an age-old industry, it not only supplies fuel in developing countries, in recent decades, it also becomes a means of supplying new multifunctional materials for environmental improvement and agricultural applications in developed countries. These include nano-particle carbon with far infrared (FIR) capability in functional textile and shielding of electromagnetic radiation etc. Paradoxically, charcoal production could also be conducive to the curbing of greenhouse gas emission. In this study, we made charcoals from discarded branches and tops of a *Cryptomeria* plantation wood after its thinning by using a still operational earthen kiln. Woody biomass was used as a carbonization fuel. The effect of such carbonization on carbon fixation was calculated and its benefits evaluated. The results show that the recovered fixed carbon reached 33.2%, i.e., one-third of the biomass residual carbon was conserved as charcoal which if left on forest ground would decompose and turn into carbon dioxide in total, and based on a net profit of 1.13 US$/kg for charcoal, annual net profit of US$14,665 per year could be realized. Charcoaling thus appears to be a feasible alternative to promote reutilization of woody resides which not only reduces greenhouse gas emission, but also provide potential benefits to regional economy in developing countries.

Key words: Carbonization, carbon sequestration, earthen kiln, biomass residue

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Fuel Value of Wood Residue and Charcoal Briquettes

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Wood is the major source of domestic fuel in rural areas in Nigeria. About 86% of people in Nigeria use wood for their domestic energy needs. The annual consumption of fuel wood in the country is about seventy million cubic meters. The rate of firewood consumption in the arid and semi-arid parts of Nigeria (which has about 85% of the total population and covers 78.7% of the land area) surpasses the rate of regeneration of wood in these regions. This creates a situation of wood deficit in these areas. The production of briquettes from wood residues generated in forest industries in the more heavily forested rainforest belt of Nigeria could be used as alternative bio-fuel. Its use is considered in this paper.

Wood briquettes were produced from air-dried sawdust and carbonized sawdust samples collected from sawmills in Akure. Starch and clay at 15, 30 and 40% weight of substrate were used as binders in the briquettes. Combustion related properties of the briquettes, viz: moisture content, heating value and energy captured during water boiling tests were determined. The moisture content of air-dried briquettes ranged between 13.00 and 17.00%. Starch bonded briquettes generally had lower moisture content than clay bonded briquettes. The gross heat of combustion of the briquettes, ranged between 19.50 and 20.20 MJ/kg. Briquettes produced from carbonized wood dust had comparatively greater gross heat of combustion than ordinary sawdust. The highest energy captured during water boiling test, 2.6 KJ/g was recorded for starch-bonded briquettes while the least energy captured 1.43 KJ/g was recorded for clay bonded briquettes. Briquettes produced from starch bonded carbonized wood had the best combustion characteristics. The burning properties of starch-bonded briquettes were generally better than those of clay bonded briquettes.

Key words: Sawdust, briquettes, combustion, heat value

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Investigation of Transformation Mechanism from Wood to Charcoal at Elevated Temperature

Sung-Min KWON* and Nam-Hun KIM

The anatomical characteristics of *Quercus variabilis* woods carbonized at 310 to 350°C were examined with an optical and scanning electron microscopy and an X-ray diffraction analysis. Dimensional change and weight loss were also investigated. Volume of wood samples decreased with increasing the carbonization temperature, and checks were developed along with radial direction. Vessel diameter in tangential direction showed higher shrinkage than that in radial direction. Weight loss of samples increased with increasing carbonization temperature. Especially, the weight loss rapidly increased at the temperature ranging from 330 to 340°C. SEM study presented that the cell walls of samples carbonized at below 320°C showed the layering structure. However, it was revealed that the layering structure was disappeared at 330°C and over and showed an amorphous-like structure without cell wall layering. Interestingly, the existence of cellulose crystalline substance at 340°C was confirmed by an X-ray diffraction analysis, but it was not detected at 350°C. Consequently, it was suggested that the critical temperature for carbonization of wood might be considered about 350°C.

Key words: Carbonization, *Quercus variabilis*, charcoal, SEM, X-ray diffraction

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5.11 B

NON-WOOD FOREST PRODUCTS-ALTERNATIVE FOREST PRODUCTS FOR A SUSTAINABLE FUTURE

Papers

The Role of Indigenous Fruit Trees in Food Security and Dietary Diversity for Pastoralists in the Borana Rangelands, Oromia, Ethiopia

Abebe YADESSA, Mohammed ADILO and Dechasa JIRU

The Borana rangelands harbor diverse indigenous fruit tree species rich in health protecting phytochemicals (vitamins and minerals). However, these diverse foods available locally have been underutilized or neglected. An ethnobotanical study was conducted in three districts (Liban, Arero and Moyale) in south Oromia, Ethiopia using participatory rural appraisal (PRA) methods. The objectives of the study were to assess the role and importance of wild fruits for human consumption and local markets, to identify the major important indigenous fruit tree and shrub species, and to prioritize the species by local peoples' preferences.

About 29 priority tree species belonging to different families were identified. Wild fruits from important trees like *Grewia villosa, Cordia sinensis*, *G. bicolor*, *Rhus natalensis*, etc., and an edible gum from *Acacia senegal* represent an important supplement to the daily diet in the Borana area. They also provide marketable products that generate cash for resource-poor pastoralists and agro-pastoralists in the area. These different fruit species ripen at different seasons, which enables indigenous fruits to compensate for variations in nutrient intake. Fruit trees are more productive during the dry season, which is a period of food shortage for pastoralists. This is an added advantage for pastoral communities as this coincides with shortage of animal feed and subsequent decline in supply of milk and milk products (stable food for pastoralists).

Thus, promoting indigenous fruit trees and formulating a domestication strategy is essential to sustain biodiversity and ensure food security, adequate nutrition and health in this pastoral area.

Key words: Borana, domestication, food security, rangelands, and wild fruit trees.

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The Changing Structure of the Philippine Non-wood Furniture and Handicraft Industries: Marketing, Trade and Policy Implications

Isabelita M. PABUAYON*

The non-wood industries particularly rattan and bamboo have changed considerably through time in terms of product design, raw material sourcing and usage, production capacity, market shares, and export contribution. In recent years, the use of different materials in combination resulted in the development of new product designs. While remaining export-oriented, quality products are becoming increasingly available for high-end local markets. In view of global competition and scarcity of locally-sourced raw materials, rattan products in particular have declined in production capacity and export shares vis-à-vis wood products. Export destinations, however, have remained focused on the midrange and high-end segments of the market.

Despite the decline of the non-wood industries, the Philippines will continue to be a major world supplier of premium quality products. These industries will remain a significant source of income and livelihood to upland and forest communities providing the raw materials, and to rural and urban workers engaged in the production and marketing of non-wood products in small home-based and medium- to large-scale factories. A comprehensive and strategic course of action in order to remain competitive requires the following: effective raw material supply management; continuing R&D for product, process, and market development; and favorable support systems (policy, institutions, and infrastructure) in the entire value chain from government and private sectors.

Key words: Non-wood industries, trade, markets, policy

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In vitro Clonal Propagation of *Crataeva magna* (Lour.) DC, a Tree of Medicinal Importance

Nishritha BOPANA and Sanjay SAXENA

Crataeva magna (Lour.) DC. (Synonym *C. nurvala*) is a high-value medicinal tree that grows almost all over India, including the semi-arid regions. In Ayurveda, the plant finds use in the treatment of a variety of urinary disorders. Lupeol, a pentacyclic triterpene isolated from the stem bark, has been shown to significantly minimize the deposition of stone forming constituents and promote the discharge of kidney stones. Investigations have also indicated anti-arthritic, hepatoprotective, and cardio-protective actions. The multiple uses of *C. magna* have resulted in its over-exploitation. Erratic seed germination combined with destructive harvesting and habitat destruction in the form of deforestation has added to the magnitude of the problem. Therefore, the need for conservation of this plant is critical. Development of an efficient micropropagation protocol will play a significant role in meeting the requirement of quality planting material for commercial cultivation, thereby conserving the species in its natural habitat. In the present study, a shoot multiplication fold of 4.5 was achieved by culturing single node segments derived from a field grown tree on Murashige and Skoog's (MS) medium supplemented with 2.66µM BAP, 1.39µM kinetin, 0.57µM IAA, and 3% sucrose. Ninety-six percent rooting was achieved within 22 days by culturing the *in vitro* formed shoots on half strength MS medium with 11.42µM IAA, 9.8µM IBA, 0.46µM kinetin, and 198.25µM phloroglucinol. The plants were hardened through sequential transfer of plants to greenhouse, polyhouse, shade area, and finally to the field where 25 plantlets were established with 100% success. To this date 500 plants have been produced which are at different stages of hardening and shall be transferred to the field in the next planting season. Inter Simple Sequence Repeats (ISSR) analysis has been employed to confirm genetic uniformity of the tissue-cultured plants.

Key words: Axillary branching, conservation, ISSR, medicinal plant, micropropagation

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Socio-economic Importance of Main Non-wood Forest Products Collection and Use for Inhabitants in the Czech Republic

Ludek SISAK*

The paper reviews the socio-economic importance of collection and use of non-wood forest products (NWFP) by inhabitants of the Czech Republic (CR) in 1994-2006. The collection and use of NWPF in the CR has been systematically analyzed every year since 1994. Research projects have been supported by various institutions in individual years, mainly by the Grant Agency of the CR, National Agency for Agricultural Research, and especially by the Ministry of Agriculture. NWFP, mainly edible mushrooms, forest berries, and medicinal plants, are of great non-market and market importance in the CR. They can be picked freely by forest visitors for their own use, irrespective of forest ownership.

The results of analyses prove that NWFP collection is quite important for the inhabitants of the CR. Investigations based on questionnaire surveys show that 2/3 of the inhabitants and 4/5 of the households collect NWFP. On average, 10.6 kg of principal NWFP (mushrooms and berries) were picked by every household in 1994-2006, which amounts to 39.1 mil. kg, and 3,100 mil. Czech Crowns (CZK), in the total CR. The value corresponds to 1/6 of the timber harvest value in an average year. NWFP are collected also in forests affected by emissions. A comparatively small part of the population collect NWFP to save money (about 12%), and an even lower share sell NWFP in the market (1.5%). The data obtained in these studies help to improve the quality of forestry policy. Significant data have been incorporated into statistical surveys and reports issued annually by the Czech Ministry of Agriculture.

Key words: Non-wood forest products, socio-economic importance, Czech Republic

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MAPs for Biodiversity Conservation and Poverty Reduction: Case Studies from South Asia

R.B.S. RAWAT, N. BHATTARAI and D. CHOUDHARY

Medicinal and aromatic plants (MAPs), the principal non-wood forest resources, have long been supporting the livelihood needs of the rural poor in the Himalayan region. The trade in wild harvested MAPs has increased enormously, leading to over-harvesting of resources and habitat loss threatening the resource base.

The International Centre for Integrated Mountain Development (ICIMOD) based Medicinal and Aromatic Plants Programme in Asia (MAPPA) has been involved in the MAP-focused research, development and management efforts in South Asia since a decade. The experiences gained revealed that if people can benefit financially from forest-based enterprises, they will actively involve and participate in conserving and sustaining the resources.

MAPPA project in Chhattisgarh, India, is working with the “Peoples Protected Areas” (PPA) program for *in situ* management of MAPs by local communities. poor collectors and producers have initiated community based enterprise (CBE) for improved marketing by manufacturing 19 types of traditional knowledge-based medicines. As a result, regeneration of some species has increased by 200% while the local prices of raw herbal materials have doubled.

In Himachal Pradesh, India, group of farmers have been linked to the value chain of large corporations to supply standardized plant products. Cultivation promotion efforts have considerably supported the sustainable harvesting in the wild and enhanced the regeneration of species.

In Nepal, marketing cooperatives with endowment funds have mainstreamed collection and marketing of MAPs. Project interventions have resulted in 50% increase in the local price of raw materials benefiting the local producers.

Recently ICIMOD/MAPPA has launched the CFC-funded projects in Bangladesh, Bhutan and Nepal. The objectives are to conserve natural resources, reduce poverty and improve livelihoods of rural mountain communities through strengthened supply chains of herbal commodities involving collectors, farmers, producers and traders to better access national, regional and international markets.

Key words: MAPs, conservation, management, poverty reduction, South Asia

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5.11 B – Posters

Marketing of Anahaw (*Livistona rotundifolia*) Fans in selected Sites of Quezon Province, Philippines

Arsenio B. ELLA and Anie C. MERIDA

This study analyzed the marketing of *anahaw* fans in selected sites of Quezon province such as the towns of Lopez, Calauag, and Gumaca based on availability of the raw materials in the area and expertise of local residents in the production of *anahaw* fans. The production process of *anahaw* fan was done manually and labor intensive without the use of any sophisticated technology.

Fan producers considered the cost of raw materials, prevailing market price and production costs as factors to consider in setting the price of *anahaw* fans. The price of *anahaw* fan varied depending on the design. Pricing of fan was tremendously affected brought by decline of raw materials due to heavy rainfall.

Anahaw fan producers distributed their products following both the direct and indirect channel of distribution. Majority of the producers distributed their products directly to ultimate users or buyers. They also channeled their products indirectly through retailers, wholesalers, and to exporters. They employed the "word-of-mouth" or referrals to inform customers of the availability of their products. The problems faced by fan producers consisted of bad weather conditions, rejection of ordered woven fans, and lack of working capital.

Results showed that respondents complained of the delayed payments of the buyers, cancellation of orders and seasonality of product demand. Due to lack of financial capability, the marketing strategies adopted were very simple. Majority displayed fans in front of their houses to attract potential buyers. Some employed the "word of mouth" or referrals to inform customers of the availability of their product. Only one respondent participated in a trade fair.

Key words: Anahaw, Livistona, fan, marketing, Quezon

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Impact of the Distribution of Commercialization Raw Margins on the Harvested Medicinal Plant in Benin

Fifanou VODOUHE, Brice SINSIN and Ousmane COULIBALY

Medicinal plants play an important role in the life of human beings who use them as medicines for their primary healthcare. But a lot of threats influence these interesting species and some of them are disappearing. The market integration of these plants is perceived by some authors as one of the demand increase and would represent a prejudice for their sustainable use. The goal of this survey was to contribute to a better understanding of the effects of the integration into the market of seven medicinal plants *Bridelia ferruginea* Benth, *Rauvolfia vomitoria* Afzel, *Caesalpinia bonduc* (L.) Roxb, *Mondia whytei* (Hook. F.) Skeels, *Sarcocephalus latifolius* (Smith) Bruce (ex *Nauclea latifolia*), *Nauclea xanthoxylon* (A. Chev.) Aubrev. and *Zanthoxylum zanthoxyloides* (Lam.) Zepen. & timber on their sustainable use.

The survey took place in the Southern and Centre market of Benin: Bohicon, Covè, Sèhouè, Abomey-Calavi and Cotonou. Data are collected from the main collectors, the wholesalers, the retailers, the local healers and sick peoples.

The results of ANOVA and the Student-Newman-Keuls test showed that collectors are the actors who have the weakest margins and retailers as actors who have the most elevated margins. Wholesalers have intermediate margins. This situation is the same in all markets surveyed. This inequality of commercialisation margins would be the basis of pressures that weighs on these species. As showed by the study results, in this area, only *Bridelia ferruginea, Rauvolfia vomitoria and Caesalpinia bonduc* have management witch can assure the viability of their natural population.

Key words: Medicinal plants, commercialisation margins, organs collections techniques, durability, Benin

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Effect of Finger Joints on the Flexural Properties of Glued Laminated Bamboo Member

Min-Chyuan YEH and Yu-Li LIN

Bamboo is one of major bio-materials growing in Taiwan with 1.1 billion commercial standing stocks in forest lands. Laminated bamboo products have become popular in furniture manufacturing recently, but not in structural applications. To extend the use of laminated bamboo as an engineered product, mechanical properties of laminated bamboo, especially with finger joints, must be evaluated. The purpose of this study is to investigate the effects of bamboo species, position of culm, length of finger, and orientation of finger joint on the bending properties of laminated bamboo. The static bending tests were performed with the wide direction of the layers either horizontal or vertical. The results showed that the modulus of rupture (MOR) of laminated bamboo using strips from the lower growth height of culm was 10 to 21% lower than that of using strips from either the middle or the top growth height of culm. The MOR of laminated Moso bamboo was 10% higher than that of laminated Ma bamboo. Also in the case of Moso bamboo species, the MOR of laminated bamboo jointed with finger length of 12 mm was 17 to 27% lower than that of finger with either 15 mm or 18 mm long fingers. Furthermore, the higher MOR can be obtained as the finger formation of the laminated bamboo showing on the width direction during flexural test. In general, the finger joint efficiency of laminated bamboo member is 53 to 82%, while better joint efficiency can be obtained as the finger formation of the laminated bamboo showing on the width direction in the flexural tests.

Key words: Finger joint, laminated bamboo, bending strength, moso bamboo

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Impregnation of Bamboo Strips with Low Molecular Weight Phenol Formaldehyde Resin: Impregnation and Drying Process

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A study was under taken to determine an impregnation process and suitable drying duration for phenolic treated bamboo strip at basal and middle portions of *Gigantochloa scortechinii*. The strips were impregnated using vacuum process. After treated with low molecular weight phenol formaldehyde resin (LMwPF) using different duration of soaking, the weight percent gain (WPG) of bamboo strips was measured. The weight percent gain (WPG) of the impregnated *G. scortechinii* (basal and middle portions) increases when longer soaking time. After 150 minutes of soaking, the WPG were 14% and 15% for basal and middle portions, respectively. The specimens were then dried in an oven for 3 to 12 hours at 60^{o}C. The reduction of moisture content (MC) was plotted in a graph and analyzed. The suitable drying duration for bamboo strips were found to be between 6 to 9 hours. A significant difference ($p<0.05$) WPG was observed at middle portion but not within the basal portion. Moisture content of bamboo strips reduced with drying duration from average of 20% to 5%. However, the optimum drying duration should not exceed 9 hours after which the samples start to cupping.

Key words: Bamboo strips, low molecular weight phenol formaldehyde, impregnation, drying

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Marketing of Non-timber Forest Products: A Case Study of Tumrakheda Village in Raisen District of Madhya Pradesh, India

Manish MISHRA and Teki SURAYA

India is primarily a rural country with 74.29% of its people residing in rural areas. India has also one of the largest tribal populations in the world. There is a rapid build up of evidence from various studiessuggesting that Non Timber Forest Products (NTFPs) play an important role in the life of forest fringe communities, especially, the tribal and other marginalized groups. In many areas of Madhya Pradesh state, NTFPs are a major source of livelihood. This case study was undertaken in Tumrakheda village of Raisen District in Madhya Pradesh state to find out the existing marketing system, channels, and dependence of households on NTFPs for their survival. The existing three marketing channels for NTFPs movement from production site to end user were identified in Obaidullahganj tahsil of Raisen district as :(a) subsistence use (direct consumption or barter at the local level), (b) sale to private trader/middleman and (c) sale through co-operative. An analysis of the purchase price and sale price of the trader indicates that there is a big spread in prices, with a very nominal portion of end user selling price going to the primary collectors; most is consumed by the middlemen, especially in the case of NTFPs like Achar (*Buchanania lanzan*), Aonla (*Emblica officianlis*), Imli(*Tamarindus indica*), Safed Musli(*Chlorophytum spp*.), Lac, Mahua (*Madhuca latifolia*) flowers and fruits.

The local tribal people get a substantial portion of total (income) survival requirement in the form of both cash and in kind from NTFP collection and sale.

Results suggest that a co-operative society at the village (primary collector) level can play a crucial role as an alternative marketing channel for efficient handling of NTFPs, as well as to ameliorate the socio-economic conditions of the local tribals.

Key words: Sustainable, marketing channel, socio-economic, NTFPs

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Composition and Bioactivities of the Leaf Essential Oils of *Cinnamomum subavenium* Miq. from Taiwan

Chen-Lung HO*, Yu-Chang SU and Eugene I-Chen WANG

Leaves of *Cinnamomum subavenium* Miq. were collected from 2 sites in Taiwan: Fushan Botanical Garden (FSB) of the northeast and Lienhuachih Research Center (LHC) of central Taiwan. Leaf essential oils of *C. subavenium* were extracted using hydrodistillation and headspace-GC methods to analyze their ingredients and yields. Antioxidant and antimicrobial activities of various essential oils obtained were evaluated as well. Forty-four and 88 compounds were identified from the leaf essential oils obtained of the FSB and LHC samples through hydrodistillation, with yields of 0.71~0.82 ml/100 g o.d. leaves. Whereas 26 and 65 compounds respectively were identified by headspace-GC method. We also to use multiple headspace extraction (MHE) method to determine the yields of the 2 samples, which gave 0.74 and 0.85 ml/100 g o.d. samples, respectively. The main components and yields from MHE method were comparable to those of the hydrodistillation method. The main components of the FSB essential oil were methyl eugenol, linalool, and eugenol; those from LHC were *p*-cymene, 1,8-cineole, and linalool. Both leaf essential oils had excellent antioxidant activities, with the FSB essential oil having the best free radical scavenging capacity, and an IC_{50} value of merely 29.50 μg/ml. Both leaf essential oils had excellent antimicrobial activity as well. The FSB sample had the best suppression activity. We deemed that the main sources of bioactivities were phenolic compounds, such as eugenol, thymol, and carvacrol among others.

Key words: *Cinnamomum subavenium* Miq., multiple headspace extraction (MHE), essential oil, antioxidant activity, antimicrobial activity

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Regional Initiatives for Sustainable Non Wood Forest Products Management in South Asia

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South Asia has been the second fastest-growing region in the world, after East Asia, with annual economic growth averaging over 5%. Yet the region contains 40% of the world's poor, most of whom live in rural areas and many depend on a fragile natural resource base for their survival. The region covers an area of approximately 4,485,000 Km^2 and supports a dense human population of about 1,207 million people. However, over the years there has been a rapid loss of NWFP resources in this region due to large scale deforestation, forest fires and unsustainable harvest to meet increasing demand for the herbal industry. Urgent and decisive action is needed to conserve and maintain the large NWFP resource.

Non-Timber Forest Products constitute a critical component of food security and an important source of income for the poor in many South Asian countries. NTFPs underpin the livelihoods of huge numbers of rural people in the region, as they are used for food, medicines and other materials for consumption, barter and income generation. (Sameer, 2005) However, challenges such as insecure land tenure, inequitable access to markets, elite-capture of high value NTFPs, and the potential danger of low value NTFPs as poverty traps will have to be addressed immediately.

South Asia Co-operative Environment Programme (SACEP) is an Intergovernmental Organisation established in 1982 to addresses regional concerns in close collaboration with the Ministries of Environment of eight member countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.. SACEP's main role is to facilitate projects in its member countries through promoting cooperation and linkages of government ministries and institutions, with donors and other organizations in its mandated areas to address these issues. Exploring the lessons learned from these various approaches and the implications for collective management, livelihoods, and the forests are its main focus areas. SACEP is collaborating with several International agencies like UNEP, UNCRD, RECOFTC, IUCN, UNESCO, and FAO to initiate various programmes in the forestry sector in the South Asian region. It has also collaborated with the Secretariats of CBD and the Royal Belgium Government to develop the Clearing House Mechanism in South Asia. Recently, we have entered into an MoU with TRAFFIC International to develop the South Asia Wildlife enforcement Network for combating illegal trade in Wild flora and Fauna. These initiatives by SACEP will go a long way in facilitating the sustainable Management of NTFP resources in the region and augmenting the livelihood support that is available to the fringe forest area population from these resources.

Key words: South Asia, sustainable livelihoods, NWFPs, SACEP Initiatives

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Anti-cancer Activity of *Antrodia cinnamomea, Ganderma lucidum* and *Auricularia polytricha*

Yih-Hsin CHANG, Yue-Ken LIAO, Ming-Yuh SHIAU and Shih-Hao LEE*

Antrodia cinnamomea, Ganderma lucidum and Auricularia polytricha are medicinal and edible fungi, which are used as Chinese traditional herbal drugs. The anticancer activity were interested and focused on this study. The anticancer activity of cultured *Antrodia cinnamomea,* commercial available *Ganderma lucidum and Auricularia polytricha* were investigated. Three kinds of cancer cells, H1299 lung cancer cell, HepG2 liver cancer cell and Colo205 Colorectal cancer cell, were selected for testing anticancer activity. The results show only *Antrodia cinnamomea* has the anticancer activity among these fungi. Moreover, the effective anticancer activity is in a dose dependent manner.

Key words: *Antrodia cinnamomea*, *Ganderma lucidum, Auricularia polytricha*, anticancer activity

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