SOCIETY OF WOOD SCIENCE AND TECHNOLOGY
48TH ANNUAL CONVENTION
June 19, 2005
Delta Québec Hôtel, Room 200B, Québec City, Canada

TECHNICAL FORUM (POSTER) PRESENTATIONS

Sunday, June 19, 4:00-5:30 pm

WOOD MODIFICATION

POSTER 1

Quality Control of Thermally Modified Balsam Fir

Virginie St-Onge, M.S. Candidate, Wood Science, and *Yves Fortin*, Prof., Dept. of Wood & Forest Science, Université Laval, Québec City, QC, Canada; and *Carl Tremblay*, Research Scientist, Value-Added Products, Forintek Canada Corp., Ste-Foy, QC, Canada

Abstract: In Canada, thermally modified wood is still being produced on a small-scale basis only, but a growing interest is noted for this new product. No standards of quality control have been defined so far for thermally modified wood in this country. In this project, two parameters of quality control were considered for thermally modified Balsam Fir (Abies balsamea L. Mill.): the color change with the temperature of treatment and the detection of internal checking by a non-destructive method.

For the colorimetric part, values of L* and b* can be related to the temperatures of treatment for planed and rough wood. Results also suggest that width of the annuals rings does not seem to affect color measurements.

A nondestructive acousto-ultrasonic method was developed to detect the presence of internal checking in thermally modified wood. The setup is made of the Sylvatest® Duo and a frequency analyzer. Preliminary results show a decrease of wave velocity and wave amplitude (i.e. attenuation of the detected signal compared to the emitted signal) when internal checking is present.

POSTER 2

Physical Properties of Thermally Modified Balsam Fir and Jack Pine

Carl Tremblay and *Torsten Lihra*, Research Scientists, Value-Added Products, Forintek Canada Corp., Ste-Foy, QC, Canada

Thermally modified wood can be defined as wood heated between 160 and 245^{o}C within controlled oxygen reduced atmosphere. This treatment results in chemical modification of the wood structure such as degrading of the hemicelluloses and lignin reticulation. As a result, physical properties of thermally modified wood are different from those of regular wood. The colour of wood is also modified. Higher temperatures tend to amplify these modifications.

For twenty years, many heat treatment processes have been developed in order to be used at an industrial scale in France, Finland and other countries. Industrial production of thermally modified wood has been performed at a small scale in Eastern Canada. However, interest for thermally modified wood products is growing rapidly in Canada.

Since 2002, the eastern laboratory of Forintek Canada Corp. has conducted studies on thermally modified wood. The general objective of the present study is to determine wood properties of thermally modified balsam fir and jack pine vs. natural kiln dried wood. Tests were performed on balsam fir and jack pine thermally modified at 210^{o}C by three different commercially available technologies. Assessed wood properties were wear resistance, dimensional stability, resistance to fungal decay, impact and static bending (MOE and MOR). Test results of thermally modified wood show a significant reduction of wear resistance and impact bending. However, dimensional stability and resistance to fungal decay were improved.

POSTER 3

Densification of Aspen Wood with Methyl Methacrylate and Styrene Monomers

Abdelkader Chaala, Research Scientist, SEREX, Amqui, QC, Canada; *Tony Chabot*, Maintenance Superintendent, Kruger Scierie Parent, Parent, QC, Canada; and *Julie Lesard*, M.S. Research Professional, SEREX, Amqui, QC, Canada

In Canada, dense, hard and resistant woods (maple, oak, etc.) are becoming increasingly scarce and expensive. Plentiful woods like aspen wood of Matapedia Valley (Bas Saint-Laurent and Gaspésie, (Québec)) can, after upgrading, substitute the rarefied species. In order to enhance the quality of aspen and enlarge its use as a raw material, several processes of chemical modification are developed.

Aspen wood sticks were impregnated at room temperature and under various pressures with methyl methacrylate monomer, styrene monomer and their mixtures at different ratios. The impregnated wood was then polymerized in a reactor at a temperature of 70-80°C and different pressures and residence times. Optimisation of the impregnation and polymerisation processes has been performed in a semi-pilot plant at SEREX center of Amqui city (Québec).

The optimal conditions of densification which allow obtaining a good quality material have been determined. The physico-mechanical characterisations of the product obtained showed that the main properties of aspen wood such as relative density, hardness, compression strength, elasticity and dimension stability have been improved. Detailed results will be presented at the technical forum.

POSTER 4

Conversion of Bark Tree Species into Bakelite-Like Thermosetting Materials by Phenolation of Them

Mustafa Akyüz, Forest Industry Engineer and Dir., and *Aypegül Pahyn*, Eastern Blacksea Forestry Research Inst., Trabzon, Turkey; and *Hakky Alma* and *Ybrahim Bektap*, Associate Professors, Dept. of Industrial Engineering of Forestry, Univ. of Sutçu YmamK.Marap, Turkey

Because of increasing of petrol prices and the high energy requirements in the production of synthetic polymers, the evaluation of bark wastes or other lignocellulosics in material applications rather than in energy production is getting great importance gradually. Moreover, a big necessity to develop degradable polymeric products (i.e., biodegradable, photodegradable, chemidegradable, envirodegradable ones) has been increasing from ecological standpoint, thus demanding that waste biomass incorporate into biodegradable. Bark constitutes approximately 10-15 % of a tree in value. This ratio changes remarkably according to tree species. In this study, barks of several tree species (Cedrus libani, Eucalyptus camaldulensis, Robinia pseudoacacia, Alnus glutinosa, Castanea sativa, Picea orientalis, Pinus brutia, Qercus cerris) will be phenolated in the presence of mineral acidic catalyts (e.g., HCL and H2SO4) The obtained phenolated barks were cured with hexamethylenetetramine (HMTA) at 190°C under pressure. Condensation of wood barks with phenol:

The barks of some tree species (Oven-dry), phenol and sulfuric acid will be charged into pressure-durable to be made of stainless steel and heated at 160 °C under high pressure in an oil bath for 120 min. applying the different ratios of catalyst concentrations. After the completion of each phenolation process (i.e., at the and of desired reaction time) the resulting mixture will be diluted with methanol and then filtered with a glass-fiber filter to separate raw materials residue (methanol-insoluble part) from methanol-soluble part. The resulting raw materials residue will be oven dried and weighed and then the amount of unreacted raw material residue in percent will be determined. Subsequently, methanol will be evaporated from the solution at 50°C under vacuum and the free phenol (unreacted phenol) will be distilled mainly under a reduced pressure of 40 mm Hg at 180°C for 1 h to get condensed phenolated raw materials in a solid form. The obtained phenolated barks were cured with hexamethylenetetramine (HMTA) at 190°C under pressure. Finally, chemical, mechanical and biodegradation properties of the phenolated bark will be determined.

WOOD PHYSICS & MOISTURE RELATIONS

POSTER 5

Moisture Migration Between the Interfaces of Dried Red Oak Samples
Minghui Zhang, Grad. Research Assistant, *Rado Gazo*, Associate Prof., and *Daniel L. Cassens*, Prof., Dept. of Forestry & Natural Resources, Purdue Univ., West Lafayette, IN

In order to obtain the moisture migration rate between the interfaces of two stacked dried red oak samples, a wireless probe system plus weighing method was employed. The upper sample of each group reaches equilibrium moisture content first in an environmental chamber with condition 70 0F and 80% relative humidity. Later, another sample of each group is put under the first sample, with initial moisture content is of 7% and covered by wax and aluminum foil except for the surface adjacent to the upper wood sample. The data from the wireless probe system is analyzed and thereafter the relationship between moisture migration over time of two stacked wood samples interfaces is obtained.

POSTER 6

Explanation of the Process of Water Vapor Adsorption in Wood
Minghui Zhang, Grad. Research Assistant, *Rado Gazo*, Associate Prof., and *Daniel L. Cassens*, Prof., Dept. of Forestry & Natural Resources, Purdue Univ., West Lafayette, IN

We found a stepwise phenomenon during water vapor adsorption in wood through a series of experiments when dried wood picks up moisture. This phenomenon led us to reconsider the earlier sorption theories. Thus, a new explanation for the process of water vapor adsorption is offered.

POSTER 7

Influence of Wood Structure on Moisture Desorption of Five Tropical Hardwoods
Giana Almeida. Ph.D. Student, *Roger E. Hernández*, Prof., and *Michele Pontin*, M.S. Student, Dept. of Wood & Forest Science, Université Laval, Québec City, QC, Canada

The study of the water drainage in wood during drying is very important to improve the use of this material. Two experimental techniques, the saturated salt solutions (between 58% and 90% RH) and the pressure membrane method (above 96% RH), were used to perform moisture desorption tests at

25ºC on wood specimens of five tropical species coming from the Peruvian Amazonia: cachimbo (Cariniana domesticata), congona (Brosimum alicastrum), huayruro (Ormosia coccinea Jackson), pumaquiro (Aspidosperma macrocarpon Mart.) and tornillo (Cedrelinga cateniformis Ducke). These sorption tests were combined with quantitative and qualitative anatomical analyses. The technique of double staining (safranin and fast green) was used to differentiate the anatomical elements of wood. SEM images were also used to evaluate the micro-structure of wood. At high relative humidities, the shape of the desorption curves changed markedly among species. This region is mainly controlled by the capillary forces and consequently by the anatomical structure of wood species.

POSTER 8

Effects of Equilibrium Moisture Content and Temperature on Mechanical Properties of Black Spruce Wood (*Picea mariana*)

Mariella de la Cruz, M.S. Student, and *Yves Fortin* and *Roger E. Hernández*, Professors Dept. of Wood & Forest Science, Université Laval, Québec City, QC, Canada

The six-specimen technique was used to determine the elastic parameters of black spruce wood (Picea mariana (Mill.) BSP) under eight conditions of equilibrium moisture content (EMC) and temperature. Specimens were cut with a cross section of 20 mm by 20 mm and a height of 60 mm. They were oriented under six different directions with respect to the load axis (three orthotropic directions and three diagonal directions at an angle of 45 degrees to the load axis). Specimens were first equilibrated at four EMCs (7%, 12%, 18% and above the fiber saturation point) at 20ºC and then compression tests were performed at 30°C and 50°C in a temperature/humidity controlled atmosphere. Axial strain was measured over a span of 40 mm on the central section of the specimen, using a two-side clip gauge provided with a Sangamo DG1.0 linear displacement sensor (LVDT). Transverse strain was measured using two semi-ring extensometers. The Young's modulus, Coulomb's modulus and Poisson's ratios were calculated. The results of this study will help to better understand the mechanical behavior of wood during kiln drying at low temperature.

WOOD QUALITY & ANATOMY

POSTER 10

Variation in Growth, Juvenile Wood Density, and Color of *Calycopheyllum spruceanum* Benth. from the Peruvian Amazon

Carmen Sotelo Montes, Ph.D. Student, and *Roger E. Hernández*, Prof., Dept. of Wood & Forest Science, Université Laval, Québec City, QC, Canada; *Jean Beaulieu*, Canadian Forest Service; and *John Weber*, ICRAF

In the Amazon there has been almost no research on genetic and environmental variation in growth and juvenile-wood properties of hardwood species, even though juvenile wood is commonly used by industry and farming communities. *Calycophyllum spruceanum* Benth, known commercially as capirona, is an economically important forest species in the Peruvian Amazon. Its dense, tan-colored mature wood is used for parquet floors, walls and other high-value products for national and international markets. Farming communities use stems containing juvenile wood for construction poles, and use both stems and branches for charcoal and firewood. In addition, trees produce stump sprouts after coppicing, thereby providing successive harvests. In this poster, we present results of a study of variation in tree growth, juvenile wood density and color of capirona. Results are based on 3-year old trees measured in a provenance/progeny test. The test was established in three planting zones

located in one watershed in the Peruvian Amazon. The planting zones differ in soil fertility and rainfall. Analyses of variance were carried out to estimate the relative effects of genetic factors (provenance, half-sib family within provenance), environmental factors (planting zone, replication within zone) and interactions between genetic and environmental factors on variation in growth, wood density and color. Phenotypic and genetic correlations among these traits were also estimated for each of the three planting zones, and across the three planting zones. Results will be presented and practical implications will be discussed, in particular regarding the relationships between tree growth and juvenile wood properties.

POSTER 11

Bulk Density, Moisture Content, and Specific Gravity of Loblolly Pine Tree Length Pulpwood Logs in Southern Arkansas

David W. Patterson, Prof., and *Paul F. Doruska*, Associate Prof., Arkansas Forest Resources Center, Univ. of Arkansas-Monticello, Monticello, AR

The authors investigated the weight and bulk density of 183 loblolly pine pulpwood trees in southern Arkansas. Six trees were measured and weighed from each of eight stands during each season over one year's time. Data from nine trees were lost due to wet conditions. Two stands each were used for 6, 7, 8, and 9-inch DBH class trees. It was found that the bulk density varied by season from a low of 66.4 lbs./ft3 in the winter to a high of 71.6 lbs./ft3 in the spring. Moisture content also varied by season but specific gravity was constant within stand throughout the year indicating bulk density differences were moisture content related.

POSTER 12

Biodiversity in Tropical Moist Forests: A Study of Sustainable Use of Non-Wood Forest Products in Western Nepal: Monitoring and Evaluation of Ecological and Socioeconomic Variables

Pradeep Singh Suwal and *Arati Basner*, Researchers, Plants Preservation & Research Center, Kathmandu, Nepal

The present study on Monitoring and Evaluation of Ecological and Socio-economic Variables is a continuation of the earlier one on Biodiversity in Forests: A Study of Sustainable Use of Non-wood Forest Products in the Western,Lumbani zone. This was carried out in Palpa and Sanja forest areas during the period April to December 1999, with the aim to monitor, evaluate and update data on ecological and socio-economic variables which have been collected during the first phase of the study. In addition, an attempt was also made to examine diversity, distribution and biomass production patterns of selected Non-wood Forest Product (NWFP) species in Palpa Forest Division. All the NWFP species, enumerated at palpa and Sanja in the previous study, were also recorded when inventory was done during this study. In Palpa, the natural forests cover an area of about 243 km2. In these forests, Asparagus racemosus, Costus speciosus , Curcuma aromatica , Desmodium velutinum , Dioscorea pentaphylla, Hemidesmus indicus , Phyllanthus amarus , Pseudarthria viscida , Sida rhombifolia , Solanum indicum and Solanum viarum , are some of the important NWFPs being collected by the tribal people during August-December every year. These species were studied for their density, distribution and biomass production patterns. Among the species studied, Sida rhombifolia showed highest density followed by Costus speciosus. However, standing biomass of

useful part/s was highest in the case of Costus speciosus followed by Asparagus racemosus. The study also indicated that plapa harbours a biomass worth of about Rs.49,32,633 in respect of the above 11 NWFP species. There are differences in the distribution and quantity of biomass of useful part/s of any given NWFP species among the four Forest Ranges in Palpa. Based on this the Forest Ranges are arranged in the descending order of harvesting intensity of NWFP species. Most of the NWFPs, having medicinal properties, are consumed by the pharmaceutical companies and other traditional users. Based on their demand, nine medicinal plants such as Adhatoda zeylanica Aegle marmelos , Holostemma ada-kodien , Rauvolfia serpentina, Saraca asoca , Coscinium fenestratum , Kingiodendron pinnatum , Symplocos cochinchinensis and Trichosanthes cucumerina were selected for propagation and enrichment planting in the study areas. Attempts were made to propagate these medicinal plants on large scale and results indicated that selected species can be propagated using simple methods. An attempt was also made to update the data relating to socio-economic aspects of collection, marketing and living conditions of selected tribes collected during the first phase of the study. The analysis showed a significant increase in the quantity of NWFPs collected during the period 1982-83 to 19999-2001 with variations in different years. Further, the collection charges received by the gatherers of NWFPs and sale value realised by the authorised marketing agency of the products, viz. Lumbani Zone Scheduled Caste and Scheduled Tribe Development Co-operative Federation Ltd (an apex body of Tribal Service Co-operative Societies in Nepal) also showed an increasing trend. However, because of inflation, the increase in the collection charges of the gatherers has not brought about a corresponding increase in their real income. The socio-economic condition of the selected tribes during the study period did not change much from that of recorded earlier.

POSTER 13

Properties of Three Plantation Species: Affecting Solid Wood Bending

Elvina O. Bondad, Science Research Specialist II, and *Emmanuel D. Bello*, Dir., Forest Products Research & Development Inst., Laguna, Philippines

The Physical (relative density), mechanical (compression and tension parallel to grain), chemical (holocellulose and lignin content), anatomical properties (fiber length, fiber diameter, cell wall thickness and lumen width) and bending properties (radius of curvature) of gubas (Endospermum perltatun Merr.), mangium (Acacia mangium Wild.) and river red gum (Eucalyptus camaldulensis Dehnh.) were determined.

An analysis of variance conducted on the different properties showed highly significant differences among species, except lignin content.

Radius of curvature of the three species is directly correlated with fiber length, fiber diameter, lumen width and cell wall thickness and inversely correlated with relative density, holocellulose content, lignin content and mechanical properties (SPL, MCS, MOE and T//g).

Results shows that mangium and river red gum have "very good" bending quality and gubas is classified as having "fair" bending quality.

This study indicates the need to investigate the relationship between basic wood properties and bending property of more species to come out with the general equation in estimating the minimum radius of curvature in solid wood bending.

POSTER 14

Inducement of Almaciga (*Agathis philippinensis* (Warb.)) Resin Production Through Ethrel Application

Arsenio B. Ella, Scientist III, and *Mario Ramos*, Science Research Specialist II, Forest Products Research & Development Inst., Laguna, Philippines

In the Philippines almaciga resin tapping has become a livelihood for the people in areas where these species abound. The resin is used in the manufacture of varnishes, paints, printing inks, paper sizing and other industrial products. Although regarded as a minor forest product, almaciga resin is one of the country's top dollar earners. In 2001, 201,000 kg of resin valued at US $161,000 was exported to France, Spain, Switzerland and the USA. The application of a compound with brand name ethrel to stimulate resin flow in exudates-producing plant like almaciga was initiated to study the influence of ethrel application and tapping length on almaciga resin production; and to establish whether month of tapping, ethrel treatment and tapping length affect resin yield.

In the study, almaciga trees were tapped for resin production at three different lengths (10, 20, and 30 cm), same width (2 cm) and same depth. Ethylene was sprayed once per tapped tree soon after cutting using the commercial compound ethrel at 4 concentrations (0, 0.5, 1.5 and 2.5%). Retapping (or rechipping) after the weekly resin harvest was done immediately above the previous cut. The effect of tapping length and ethrel concentration was studied.

Increasing tapping length directly influenced resin yield with the 30 cm length giving the highest yield. Ethrel concentration significantly affected resin yield which was highest at 2.5%.

It has been concluded that the interaction of tapping length and ethrel concentration significantly influences resin yield. Resin yield is highest at 30 cm tapping length and 2.5 ethrel concentration; and rainfall has a significant inverse relation with monthly resin yield for ethrel concentrations 1.5% and 2.5% and for tapping lengths 10 cm and 20 cm.

Basing from the results of the study the following were recommended: Conduct further experiments using other variables such as diameter classes, crown ratio, other chemical stimulants preferably in paste form, and depth of tapping cut; experiment on trees that have never been tapped for resin production to ensure better results; and study methods of cleaning and grading almaciga resin.

POSTER 16

Wood Characteristics of Black Spruce Trees at Different Stand Density and Sampling Height

Jérôme Alteyrac, Ph.D. Candidate, and *Alain Cloutier*, Prof., Dept. of Wood & Forest Science, Université Laval, Québec City, QC, Canada; *S.Y. (Tony) Zhang*, Senior Research Scientist and Group Leader, Forintek Canada Corp., Ste-Foy, QC, Canada; *Jean-Claude Ruel*, Prof., Dept. of Wood & Forest Science, Université Laval, Québec City, QC, Canada; and *Chhun-Huor Ung*, Research Scientist, Natural Resources Canada, Canadian Forest Service, Ste-Foy, QC, Canada

Abstract: Thirty-six black spruce trees were collected in the Chibougamau area, 450 km north of Québec City and assigned into three stand density groups. The trees were cut into three logs of 2.7-m length from which the upper 30-cm length bolt was sawn and used as sampling material. The aim of the project was to study the variations of wood properties in relation to stand density at different sampling height. The following properties were studied; wood density, growth rate, mechanical properties and the anatomical structure. These properties were studied on the same sample in order to highlight the relations among them. Wood density and ring characteristics were obtained by X-ray densitometry. Microfibril angle was measured by the SilviScan technology at CSIRO Forestry and

Forest Products, Australia, and the mechanical properties were determined by static bending on specimens taken from pith to bark.

SWST STUDENT POSTER COMPETITION

POSTER 15

How Porosity Can Explain Wood Desorption at High Humidities

Giana Almeida. Ph.D. Candidate, Dept. of Wood & Forest Science, Université Laval, Québec City, QC, Canada

The knowledge of the fluid paths within a material is important to improve its utilization. The efficiency of mercury porosimetry to explain the influence of the wood structure on water movement or sorption behavior was studied for one temperate (*Fagus grandifoli*a) and one tropical hardwood (*Robinia coccinea*). Two experimental techniques were used to perform moisture sorption tests at 25ºC; the first used saturated salt solutions (from 33% to 90% RH) and the second used the pressure membrane method (above 96% RH). Mercury porosimetry and quantitative anatomical analyses were performed to study the porous characteristics of these woods. Double stained anatomical images were treated with tools derived from mathematical morphology in order to make measurements of the different wood tissues. The wood species studied exhibited different anatomical structures, which was reflected on the desorption curves. These differences were more marked at high moisture contents, which are mainly controlled by the capillary forces. The mercury porosimetry allows a good evaluation of the fluid paths and their characteristics within wood, which leads to the prediction of liquid water behavior during longitudinal drainage. The complexity and the heterogeneity of the wood microstructure observed in this work corroborate the analyses done by porosimetry.

POSTER 17

A Finite Element Model for the Evaluation of MDF Hot Pressing Process

Marcia Vidal Bastias. Ph.D. Candidate, Dept. of Wood and Forest Science, Université Laval, Québec City, QC, Canada

Hot-pressing operation is one of stages of manufacture of wood-composites with a high consumption of energy in a short time. The objective of this study was to demonstrate the potential of finite element method to predict the more important variables during the MDF hot-pressing process in 2-D and 3-D models.

A numerical solution for two- or three-dimensional mathematical model is presented to describe the MDF hot-pressing process. The model is based on the work of García (2002) for OSB panels and Turner and Perré (1995) for wood drying. The coupled and highly non-linear nature of the heat and mass transfer equations that govern the hot-pressing process are solved by the finite element method program called MEF++. This software has been developed by GIREF (Groupe Interdisciplinaire de Recherche en Éléments Finis) at Laval University. This dynamic model predicts the evolution of variables such as total gas pressure, moisture content and temperature during the hot-pressing process. This set formed of three-coupled equations is a more comprehensive physical description for the hot-pressing of a MDF panel at the macroscopic level and randomly formed. Differently to previous model, we have first introduced a new term in the vapor equation and secondly to solve the model we have used Newman non-linear at boundary conditions. We consider that the diffusion term

is not negligible in the hot-pressing process and that it is produced simultaneously with the bulk flow. It is recognized that the finite elements method is more versatile and presents advantages when the boundary conditions are irregulars.

POSTER 18

Juvenile Wood Impact on the Kiln Drying Characteristics of Pacific Coast Hemlock Square Timbers

Slobodan Bradic. MS Student, University of British Columbia, Wood Science Dept., Vancouver, BC, Canada

Large volumes of small-diameter logs are generated from sustainable sources such as Pacific Coast hemlock second-growth forests. Percentage of juvenile wood in this kind of material is respectively higher compared with limited old growth wood supplies. This investigation evaluates the drying quality of Pacific Coast hemlock structural timbers as a function of juvenile wood shown with the pith location at their end-surface, cutting season and drying target moisture content.

Timber specimens were classified into four groups depending on the presence and location of the pith. A total of 640 timber pieces were dried in a laboratory conventional (heat-and-vent) kiln to 15% and 20% target moisture content, where in each case, one charge was from the summer and other from the fall cutting season. After the drying, the specimens were planed to the final cross-section of 105x105mm.

The volumetric shrinkage was not influenced by the pith location, but it was higher with a higher range between the initial and final moisture content. Timbers sawn closer to the pith shows higher bow. Twist was attributed by interactions of the pith location and cutting season, and the pith location and target moisture content. There is a lack evidence to claim an effect of the controlled factors on diamonding. Surface checking was higher if the target moisture content was lower and if the pith was closer to the centre of cross-section. Planning significantly reduced diamonding and surface checks. The central pith location class was graded lower then others. The general conclusion is that Pacific Coast hemlock timbers with the central pith location should be avoided in the production of 105x105mm structural products

POSTER 19

Mechanism to Improve Toughness and Moisture Resistance of a Typical OSB Resin

Sudip Chowdhury. Graduate Research Assistant, WMEL, Washington State University, Pullman, WA

The following study investigates the effect of maleic anhydride polypropylene (MAPP) on the cure kinetics and toughness of phenol formaldehyde (PF) resin. Blends of resin systems were prepared by mixing atomized MAPP in liquid PF resin. The cure kinetics of these resin systems were studied using differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA). Damping property of the cured adhesive formulations, as an indirect measure of toughness, was investigated using DMA. Cure temperature and time were determined by dynamic and isothermal curing of the adhesive systems in DSC. Results indicated that two minutes at 140 ^{o}C was adequate for complete curing of all the formulations. Dynamic temperature ramp test was done in DMA to examine the changes in the storage modulus (E'), loss modulus (E") and tanδ (E"/E') during cure of the adhesive systems. Addition of MAPP into PF showed improvement in the stiffness of the resin system, however, higher levels of MAPP indicated adverse effects on the stiffness. Shift in the peak value of tanδ during cure indicated higher curing time required for higher amounts of MAPP in the resin system. Dynamic strain sweep test of the cured specimens using DMA was conducted to evaluate

damping property of different formulations. Improvement in the damping was observed with the addition of MAPP at the lower strain level. The effect however leveled off for blends with higher MAPP percentage. Fracture cleavage tests, to determine the effect of MAPP on the toughness and moisture resistance, are now ongoing and the results will be presented in the poster. With the outcome of these analytical tests, optimum resin blends will be formulated to fabricate oriented strand composite panels with better moisture durability and enhanced mechanical properties.

POSTER 20

Mortel Intelligence for Latin American ESC-certified Wood Panels in the US and Caribbean Markets

Pablo Crespell. Ph.D. Candidate, Dept. of Wood Science and Engineering, Oregon State University, Corvallis, OR

General Objective: Provide relevant and updated market information to the Latin American FSC certified wood panels producers, particularly to the markets of the U.S and the Caribbean. Specific Objectives • Identify market trends for wood panels, particularly for plywood • Update market trends for certified wood panels • Identify: The markets and final users by type of panel • Price ranges for wholesalers • The general value chain Conclusions: 1. Latin American producers are focused mainly on rotary plywood (BB/CC grade). Their exports account for 50-80% of their production. 2. In 2003, Latin America represented 14% of U.S. imports of tropical plywood (US$ 52 million) 3. After Brazil, other exporters of importance are Ecuador, Colombia and Guyana 5. The U.S. dollar is weak compared to the Brazilian Real driving the cost in Brazil upward. On the other hand, the exchange rate between the Chinese Yuan and the U.S. dollar has remained stable for years meaning an even buying/selling market that favors the competitiveness of Chinese exports. 6. There is no interest in using lesser known species (LKS). Wholesalers don't want to take the risk of not finding customers. 7. For plywood, supply inconsistencies and defaults to the contract are the most common complaints. There are also complaints about quality. 8. Importers prefer agents because they take much of the risk, and provide value through services such as quality control and assistance with the paper work. 10. Fifty-one percent of the 115 identified companies dealing with tropical plywood/veneer are currently environmentally certified

POSTER 21

Moisture Content Determination in Frozen and Unfrozen Lumber using Ultrasound

Hermanus van Dyk. Graduate Research Assistant, Department of Wood and Paper Science, North Carolina State University, *Robert Rice*, Professor, Department of Forest Management, University of Maine.

This study investigated whether ultrasound could be used as an indicator of moisture content in frozen and unfrozen spruce lumber. Initial experimentation indicated that velocity and the attenuation coefficient of ultrasonic waves would be the best methods to determine moisture content. Experiments to determine ultrasonic velocity in the radial direction were conducted at five different moisture content levels and three moisture levels were used for attenuation testing. The results show that a strong inverse relationship exists between ultrasonic velocity and moisture content in both frozen and unfrozen lumber. The wave velocity in frozen wood was consistent and about five percent

greater in frozen wood than in unfrozen wood. The relationships existed both above and below fiber saturation and the differences were statistically significant. The attenuation coefficient decreased with a decrease in moisture content in both frozen and unfrozen lumber. Furthermore, no statistically significant difference was fond between the attenuation coefficient in frozen and unfrozen lumber at the three moisture levels. While the main research effort centered on the differences in wave velocity between frozen and unfrozen wood at specific moisture content levels, a study was also done to determine the effect of temperature on ultrasonic velocity. Ultrasonic velocity decreased linearly with an increase in temperature. The findings of this study suggest that both ultrasonic velocity and the attenuation coefficient can be applied as moisture indicators in either frozen or unfrozen lumber.

POSTER 22

Impact of Log Ellipticality on Red Oak (Quercus rubra) Lumber Grade and Volume Recovery for Current Sawing Practices

Roncs Ese-Etame. Graduate Research Assistant, Dept. of Wood Science and Forest Products, VPI & SU, Blacksburg, VA

Red oak is one of the most common species processed by U.S. hardwood sawmills. The volume and value of lumber produced from sawing red oak logs is influenced by log size, grade, and sawing practice. Much work has been done to determine the influence of these factors on round logs. No literature exists describing the impact of red oak log ellipticality on lumber grade and volume recovery for current sawing practices.

The objective of this research was to assess the impact of two degrees of eccentricity of red oak logs on green lumber grade and volume recovery under current sawing practices. Comparisons were made between the lumber grade yield for low and high degrees of ellipticality. It was determined that lumber grade produced was highly correlated to log ellipticality.

POSTER 23

Quantification of CCA in Wood Using Laser-Induced Breakdown Spectroscopy

Brad Gething. Ph.D. Candidate, Dept. of Agricultural Science, Penn State University, University Park, PA

The disposal of CCA-treated lumber is a growing issue for the waste management industry. In response to the concern, research methods such as laser induced breakdown spectroscopy (LIBS) have been explored to identify CCA-treated lumber and separate it from non-treated lumber in the waste stream. The present study analyzes the potential of using laser induced breakdown spectroscopy (LIBS) to quantify the amount of CCA in treated lumber, so that the lumber may not only be separated but also effectively reused in other applications. LIBS has been an accepted form of analysis for two decades however it has only been recently that a commercial system has come to market enabling the development of practical applications such as bulk materials analysis.

LIBS techniques employ a high-intensity laser pulse to produce a high temperature microplasma at the surface of the sample. Using a high-resolution spectrometer, it is possible to identify the atomic emission lines in real-time that correspond to the elemental content of the sample. The magnitude of these emission lines allows for the quantification of desired elements. An Ocean Optics LIBS system was used to measure the amount of copper, chromium, and arsenic on the surface of standardized southern yellow pine specimens treated at levels of 0, 0.13, 0.25, 0.41, and 0.67 pounds per cubic foot

of CCA. The results reveal that LIBS is capable of differentiating between definite treat levels of CCA in wood, although additional refinement to the process is necessary to ensure reproducible, substantial conclusions

POSTER 24

The Application of Refrigerated Air and Cryogenic Treatment Reduces Tool Wear When Machining Medium Density Fiberboard

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Cutting tools treated with refrigerated air and cryogenic treatment may result in the reduction of tool wear. By reducing tool wear, tool life is increased and the cost of tool replacement and production downtime is minimized. To reduce tool wear, six double-flute, tungsten carbide tools machined medium density fiberboard (MDF) on a computer numerical control router with a total of 166,000 m in length of cut per flute. Three of the six tools were cryogenically treated to strengthen the metal structure of the tools. Three each of the cryogenic and non-cryogenic tools were used to cut at the temperatures of 20ºF, 40ºF, and 70ºF. A cold gun generated the 40ºF cutting temperature, while the temperature of 20ºF was produced with the addition of ice to the cold gun. Power consumption data were collected to monitor the router bit performance. Surface quality of the MDF from cutting was observed according to an ASTM Standard. Tool wear area was measured with the light microscope with IPLab software. Scanning electron microscope (SEM) photomicrographs were taken at the knife edge at high magnification, allowing for inspection of the tool surface to further determine tool wear. Energy-dispersive spectroscopy analysis using the SEM allowed for characterization and quantification of elements present in the tools. The combination of cryogenic treatment and refrigerated air at a temperature of 20°F reduced tool wear, although 40°F was optimum for the reduction of tool wear.

POSTER 25

Penetration of Polyethylene Glycol in Wood Cell Walls

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Effective wood chemical treatment is predominantly affected by the ability of the chemical to penetrate and remain in cell wall microvoids. The chemical accessibility to microvoids is dependant, among other factors, on molecular weight (MW) and capability of solute to transfer from solvent to the wood structure. Our research comprises studies of penetration and extractability of polyethylene glycol (PEG) from wood. PEG was chosen as a non-toxic, wide-range molecular weight polymer soluble in both polar and non-polar solvents.

Red pine samples equilibrated to different equilibrium moisture contents (EMC) were treated with 30% PEG-1000 dissolved in polar (water) and non-polar (chloroform) solvents. Ability of PEG-1000 to penetrate cell walls has been confirmed by volumetric swelling of the samples after treatment and Transmission Electron Microscopy – Energy Dispersive X-ray Analysis (TEM-EDXA) of samples treated with brominated PEG. Amount of PEG in cell walls was estimated by sequential extraction from cell lumens and cell walls, and by Raman spectrometry.

PEG-1000 showed inability to penetrate wood cell walls in absence of water. Higher PEG penetration from water than chloroform was noticed for all EMCs. Amount of water in the cell walls appeared to play a significant role in PEG penetration, even for the PEG-in-water solution.

Two distinctive extraction rates characterized PEG extractions with toluene, by both extraction and Raman methods. The higher extraction rate is believed to be due to easily accessible PEG in cell lumens, while the lower one was attributed to much reduced PEG dissolution from the cell walls.

POSTER 26

Droplet Behavior and Shape Analysis of Wood Adhesives on the Wood Surface

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Understanding wetting behavior and surface coverage of an adhesive on a wood surface is important to obtain a satisfactory adhesion and optimize adhesive application for wood composite manufacturing. The objectives of this study were to (1) evaluate droplet behavior and shape of thermoset resins on wood surfaces (Loblolly pine, Tallow tree, Red oak, and Sweetgum) using 3D image analysis and (2) develop predictive models of resin behavior and shape. This study also accessed micro-contacting angels of UF (urea formaldehyde) and PF (phenol formaldehyde) thermoset resins on wood surfaces using atomic force microscopy (AFM). Resin droplets generated with a system of "Air Automation" were on a micro scale (generally from 1 to 100 □m) and showed differing wetting behavior based on droplet size and surface conditions. AFM characterized the interphase of the micro-droplets and the wood surfaces with the various probe materials. Droplet behavior parameters such as volume, angle, height, and radius changed as a function of time were generated with an image analysis system. Rougher wood surfaces prevented micro-droplet spreading irregardless of wood species and resulted in higher contact angles with the exception of loblolly pine. Contact angles parallel to the fiber direction of the hardwood species significantly differed from the angles collected perpendicular to the fiber direction. Sessile droplet models and critical Eotvos numbers (E_o) were used to develop the parameters governing the resin change from a spherical droplet to an enclosing hemispherical droplet for each of the four different species. Droplet dispersing areas with sweetgum showed 33 to 38% faster area changes parallel to the fiber surface as compared to perpendicular to the fiber surface.

POSTER 27

Effects of Abrasive Mineral, Grit Size, and Feed Speed on the Quality of Sanded Surfaces of Sugar Maple Wood

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Sanding is a common practice required in preparing wood surfaces to coating. Little literature is available regarding the effect of sanding parameters on the quality of surfaces. Sugar maple wood surfaces were evaluated in samples that had been sanded using one of two abrasive minerals, three grit sizes and four feed speeds. Roughness, wetting properties and cell damage were used to assess surface quality. For both abrasives, roughness decreased from 100 grit to 120 grit size. No further reduction was obtained by adding a 150-grit stage. Higher feed speeds produced rougher surfaces, due to higher fibrillation. Surfaces produced by silicon carbide were smoother and less damaged than those obtained with aluminium oxide. However, the surfaces sanded with aluminium oxide were more wettable and showed no significant difference in wetting time as a function of grit size. For these surfaces, the wetting time was reduced as feed speed increased. In general, the surface energy increased as the number of sanding stages increased and feed speed decreased. The capillaries produced by silicon carbide appeared to be too narrow to allow a complete wetting by water. In this latter case, the wetting by water was probably more affected by the surface energy than by the capillarity forces.

POSTER 28

Effectiveness of a Nondestructive Evaluation Technique for Assessing Standing Timber Quality

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The primary objective of this study was to determine the usefulness of two stress wave analysis techniques, one which was developed in the laboratory and has proven to be effective in determining standing timber quality; the other a recently-developed commercial tree evaluation tool. The secondary objective of this study was to investigate the quality of plantation-grown red pine (*Pinus resinosa*) and ponderosa pine (*Pinus ponderosa*) trees. Field measurements using both tools were conducted on sixty red pine trees in south-central Wisconsin and 115 ponderosa pine trees in western Idaho. After *in-situ* measurements were taken, thirty tested red pine trees were felled and a 15-foot-long butt log was obtained from each tree, while all tested ponderosa pine trees were felled and an 8½-foot-long butt log was obtained, respectively. The butt logs were sent to the Forest Products Laboratory and nondestructively tested using a resonance stress wave technique. The red pine logs were nondestructively tested using center-point static bending to determine modulus of elasticity. Results of this study indicate that the new instrument gives results comparable to those of the original stress wave method, and that *in-situ* stress wave measurements correlate with wood modulus of elasticity. These results indicate that stress wave testing may be a valuable method for determining standing timber quality..

POSTER 29

Effect of Solution PH and Ionic Composition on the Solubility of Chromium and Arsenic from CCA-Treated Aspen

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Availability of potentially toxic arsenic and chromium and speciation of Cr leached from wood treated with chromated copper arsenate wood preservative (CCA) depends on factors such as pH and ionic composition of the leaching medium. Wood sawdust of trembling aspen treated with CCA-C to 6.4 kg/m^3 was completely fixed before extraction with solutions of pH 1 to 10 adjusted with HCl and NaOH and with a range of 1*M* extractants (NaH_2PO_4, NH_4Cl, $MgCl_2$, NH_4OAc, NH_4HCO_3, $NaHCO_3$ and NH_4OH). Cr and As in extracts were analyzed by ICP-AES and Cr(VI) by Ion Chromatography. Solubility of Cr and As followed similar pattern within investigated pH range. Maximum Cr and As solubility found at pH 1 decreased rapidly to pH 4, and remained low toward pH 10. Extraction yields in 1*M* extractants were significantly higher than expected from their pH values. Anion composition affected the availability of both components in a sequence: HCO_3^- (from NH_4HCO_3) > PO_4^{3-} > OH^- > HCO_3^- (from $NaHCO_3$) > CH_3COO^- > Cl^-. 1*M* NH_4HCO_3 showed remarkable efficiency in extracting both Cr and As. Oxidation of Cr(III) to Cr(VI) was observed in all instances above pH 8. pH of the solution governs availability of Cr and As in absence and at low concentrations of inorganic ions, while at high concentrations ionic composition becomes principal factor. Oxidative transformation of Cr(III) present in treated wood indicates an important route for the generation of highly toxic and soluble Cr(VI) form at alkaline conditions.

POSTER 30

Evaluation and Improvement of Connection Systems for Prefabricated Wall Panels

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The scope of this research is the evaluation and improvement of linear connections of prefabricated shear walls. To evaluate the behaviour of the walls, 18 shear tests (in plane) and 9 bending tests (out of plane) will be done on full-size specimens. The walls will be composed of two parts of 4 by 8 feet connected with three types of linear connections. The shear wall tests will be done monotonically and cyclically according to ASTM standards. Two types of wall-to-foundation connections will be evaluated in the shear wall tests, the first one with hold-down anchors and shear bolts; and the second type is with 16d nails per 16 in. The bending wall tests will be done according to a proposed protocol based on the calculation of the wind pressure related to five hurricane categories from 70 mph to 160 mph. In addition, monotonic and cyclic tests will be conducted on individual connection specimens to input in a finite element model of the walls. This model could allow analysis of the connection and the wall performance in order to improve the behaviour of the wall.

POSTER 31

Water Vapor Sorption in Dried Red Oak Lumber Package Stored in a High Humidity Environment

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Water vapor sorption in a commercial dimensional dried lumber package has never been investigated although sorption equilibra and rate were studied for wood samples. In this research, a wireless probe system is used to monitor moisture content (MC) change for representative thirty nine positions of dried red oak lumber package. End coating was applied to both ends of each board prior to drying to 7% MC, but was removed from one end for this experiment to study the effect of end-coating. The environmental chamber which holds the package was set to temperature 21.1 ^{0}C and relative humidity 80%. The distribution of moisture content of the package over 19 weeks was obtained and a mathematic model was developed to predict moisture gain over time. The results show that sorption process is controlled not only by Fick's law, but also by swelling stress relaxation. Stepwise function and fluctuation phenomenon from the experiment results are also explained by a new concept – gas creeping motion.

POSTER 9

Mass Customizing U.S. Furniture--Wooden Furniture Dynamics.

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Mass customization is currently perceived in some circles as a means by which the U.S. furniture industry might compete effectively against offshore manufacturers. Mass customization (MC) has offered significant benefits in other industries that have embraced this business paradigm. They have leveraged their manufacturing capabilities to resolve the trade-off between cost and efficiency on one hand and quality and customization on the other hand. MC must be applied in furniture firms in a way that avoids the pitfalls that earlier customizing organizations encountered.

To what extent might MC concepts be applicable to the U.S. furniture industry? How will MC change the furniture industry dynamics in association with, or as opposed to mass production? What are the critical enablers of MC for wooden furniture manufacturing scenarios? What kind of internal

systems and structures are necessary to implement the MC paradigm? How does MC add to firm value?

An in-house pilot study in the Purdue Wood Research Laboratory confirmed some of the major lessons from other industries including the need for a seamless transfer of information between processing centers and for a spontaneous availability of standardized materials.

In the main study I examine the impact of mass customization on the value of the firm and test the hypothesis that mass customization is a feasible option the U.S. furniture industry might adopt to improve its competitiveness. I will adopt a case-study approach focusing on manufacturing system scenarios for wooden furniture. I will use the principles of modularity, agility, quick response and competitive cost as proxies for the industry's readiness to implement mass customization concepts. I will examine the response of firm value to changes in the indicator variables.

The study will extend the knowledge frontier of mass customization as an emerging manufacturing business principle; guide the development of a sustainable framework for a competitive business model for the U.S. furniture industry; and enhance long-term industry survival through the resulting agility to anticipate and respond quickly to marketplace changes.