# Technical Session 3:
# Student Presentations

## Thermally Modified Wood Particles for Production of Water and Fungi Resistant Wood Plastic Composites

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ABSTRACT

Wood plastic composites (WPC) are relatively new materials, which have already obtained a disappointing entry in history because of premature degradation. The initially unexpected bio-deterioration and reduction of mechanical properties are just some of the flaws, which have significantly impaired the reliability of these materials. This is unfortunate because the materials have a significant contribution to the environment by the use of plastic waste and wood by-products in their production. A significant effort has been devoted toward improvement of water resistance. The lack of it is the main factor causing irreversible damage by impairing the interface between wood particles and polymer matrix and by ensuring suitable conditions for microbiological activity. To reduce these problems, usually different additives are used. The most common combination for dealing with water and fungal issues is the use of coupling agents and biocides. Although significant improvement can be obtained, degradation during long-term use at moist conditions can still occur due to leaching of biocides and introduction of internal damage related to moisture fluctuations. Besides, leaching of biocides can cause harmful impact to the surrounding environment. Another direction for improving water resistance is modification of wood particles (thermal modification, acetylation, etc.), which have shown promising results. However, not too many studies have investigated the overall performance of these materials by analyzing different test conditions related to water resistance and bio-durability. The objective of the present study was to investigate water and fungi resistance of WPC made with thermally modified (TM) wood particles. In the study, the results of bio-durability against brown rot fungi, soaking/drying cycles, long-term soaking, and soaking/freezing/drying cycles are analyzed and discussed. In addition, the effects of water pre-treatment as well as specimen size on the bio-durability tests are evaluated. Furthermore, the benefit of a coupling agent in the case of WPC with TM wood particles for even more significant improvement of water resistance is investigated. In general, the results showed that WPC with TM wood particles have significant improvement over WPC with unmodified wood particles in several outdoor performance tests. Depending on the thermal modification intensity, all of the listed factors were significantly improved: dimensional stability, strength retention at wet conditions, resistance to fungi, resistance to water absorption, resistance to irreversible mechanical deterioration caused by water absorption, and resistance to cyclic tests. Regarding water and fungi resistance, no drawbacks for WPC made with TM wood particles comparing to WPC with unmodified wood particles were identified. Still, the results showed that some reduction in mechanical properties can occur, however, by addition of a coupling agent they can be completely eliminated. By overcoming discoloration issues, which were identified in our previous study, these composites could be very competitive with other outdoor products, especially in wet conditions.

# Migration Assessment of 16-PAH into Soil and Water Column from Creosote-treated Douglas-fir and Southern Pine Poles: Preliminary Results

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ABSTRACT

To better understand the extent of polyaromatic hydrocarbon (PAH) leaching and mobility from creosote treated posts, three concurrent experiments were developed to assess the leaching of 16 EPA priority pollutant PAHs into soil and water mediums. Firstly, five creosote-treated poles of both Douglas-fir and southern pine were installed in a slow-moving freshwater stream with downstream permeable plastic sachets using two soil types (high organic matter and low organic matter) to capture PAH runoff covering three water column heights and two distances from the poles. The second experiment includes an additional 5 poles of each species plus 2 untreated controls of D. fir installed two feet into soil to measure PAH discharge. Finally, the third experiment is a lab-scale study where 6 creosote-treated poles of both species plus 2 untreated D. fir controls were placed into sealed plastic 55-gallon drums using two soil types to better compare PAH leaching in a real-world scenario to a lab-scale scenario which could potentially replace, or supplement environmental testing. These experiments will run for a minimum of 2 years to assess migration and mobility.

# Switchable Superhydrophobic Titania Coating on Wood Surface by Using Liquid-Precursor Flame Spray Pyrolysis

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ABSTRACT

Wood is a highly versatile material used for tools, furniture, and advanced engineering structures since it is light, mechanically robust, and abundant. However, some wood properties are less desirable for the extended service usage of the wood structures, including low resistance towards moisture and weathering conditions, which degrade dimensional stability and mechanical durability. Wood modification aims to address these undesirable wood properties. A new method of the surface modification of wood is explored by depositing inorganic titania (TiO2) particles on the surface of a southern yellow pine wood veneer by liquid-precursor flame spray pyrolysis (FSP). The reaction between a flame source and a titanium precursor in isopropyl alcohol under controlled air pressure created a thin coating on wood consisting of titania nanoparticles. A superhydrophobic layer with water contact angle (WCA) of ≥150° was deposited on a wooden surface. The influence of the process parameters and fuel sources used in TSC on the overall quality of the coating was studied. Scanning electron microscopy was used to examine morphological

properties and X-ray diffraction to determine crystallinity and phase information of the TiO2 coatings. The switching characteristics of the TiO2-wood surface from being superhydrophobic to superhydrophilic (WCA ~0°) and back to superhydrophobic were examined through UV exposure (0.0032 W/m2), WCA measurements, and vacuum drying at ~0.14 mBar. Furthermore, the treated samples will be tested under accelerated weathering conditions to determine its prolonged resistance against UV and moisture. This research seeks to examine the potential of the liquid-precursor FSP as a facile, economically viable, and less energy-intensive method for the surface modification of wood.

# Selected Mechanical and Physical Properties and Durability of Modified Alder Wood (Alnus glutinosa Gaertn.)

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ABSTRACT

In Poland, alder wood is a material used for the construction of furniture and for the preparation of veneers for furniture elements covering, or for plywood. Its mechanical properties are not high, e.g., compared to pine wood, the most popular type of wood in Poland, it has a lower modulus of elasticity and lower hardness perpendicular to the grain. In addition, this wood often has visible discoloration, and so-called core spots can also be found. Alder wood can undergo thermal modification processes in industrial conditions in an atmosphere of overheated steam to change its color and improve dimensional stability. Thermal modification of alder wood, similarly to other types of wood, e.g., ash or beech, with natural discoloration, results in the uniformity of the color of the wood. The color variation becomes smaller. From light European wood, with discoloration, we obtain a material that resembles the wood of dark exotic species. The extended abstract presents the results of determining selected mechanical and physical properties of natural alder wood, thermally modified and next thermo-mechanically densified under industrial conditions using a high pressure press used previously for hot stamping technology. The wood density, color, the equivalent moisture content for climate conditions close to normal, density profiles, MOE, MOR in bending and compression, and also the hardness of the wood were determined. Moisture content of tested wood seasoned in a laboratory room for natural alder wood was 8.7%, for natural wood densified 8.1 %, for thermally modified wood 6.2%, and for thermally modified and densified wood was 5.3%. Thermal modification of alder wood combined with wood densification allows one to obtain a new wood material for use on furniture tops with significant higher hardness. Thermal modification of alder wood with visible color defect makes this wood more attractive for customers and allows one to make better use of wood.

# Development of Preservative-Treated Cross-Laminated Timber: Effects of Panel Layup and Thickness on Preservative Penetration and Retention

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ABSTRACT

Cross-laminated timber (CLT), a prefabricated multilayer engineered wood panel, has been recognized as a promising construction material for mid-and-high rise buildings due to its good mechanical properties, renewability, and low-carbon footprint. However, the vulnerability of CLT to biodeterioration limits its broad applications. Preservative treatment is an effective method of increasing the service life of wood products, while the treatment of CLT is barely studied. Herein, we prepare preservative-treated CLT through a conventional vacuum impregnation of prefabricated CLT panels with Cu-based preservatives, and the effects of panel layup (longitudinal and crosswise) and thickness (3-and 5-layer) on the impregnation quality are investigated. The penetration and retention of preservatives across the CLT panels treated with copper-azole (CA) and micronized copper-azole (MCA) were evaluated using a color-based indicator approach and Xray fluorescence spectroscopy (XRF), respectively. Our results show that the traditional southern pine vacuum impregnation method is also suitable for treating CLT with satisfactory preservative penetration and retention. Specifically, for the 3-layer CLT panels, CA-C treated panels have better preservative penetration than MCA-treated panels, especially in the longitudinal orientation. The higher penetration ratio observed in the longitudinal orientation could be due to the shorter diffusion path compared to the crosswise orientation. Further, there is an increased penetration ratio at the edge of the panel compared to the center for the 5-layer CLT. Similarly, the Cu retention values at the edges are higher compared to the center for both 3- and 5-ply treated CLT panels. Overall, this study suggests that the post preservative treatment is a promising method to fabricate preservative-treated CLT.