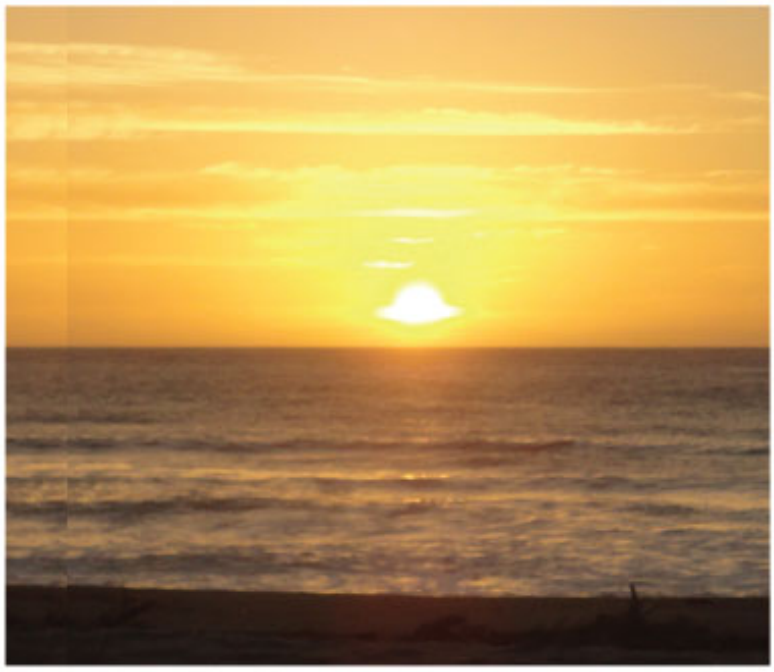
Process Technologies for the Forest and Biobased Products Industries

PTF BPI 2023

October 30 – November 1, 2023
St. Simons Island, Georgia, USA

Book of Abstracts



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Process Technologies
for the Forest and Biobased Products
Industries
PTF BPI 2023

https://www.ptfbpi.com/

7th International Conference on Process Technologies for the Forest and Biobased Products Industries

PTF BPI 2023

October 30 – November 1, 2023
St. Simons Island, Georgia, USA

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Book of Abstracts of the 7th International Conference on Process Technologies for the Forest and Biobased Products Industries – PTF BPI 2023
St. Simons Island, Georgia, USA: October 30 – November 1, 2023
https://www.ptfbpi.com/

Published by: The University of Tennessee
Editors: Timothy M. Young and Alexander Petutschnigg

ISBN: 979-8-3507-2156-0

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The PTF BPI Conference Series

The first international conference on *Process Technologies for the Forest and Biobased Products Industries* (PTF BPI 2010) was organized by Salzburg University of Applied Sciences, Kuchl Austria. The goal of PTF BPI is to bring practitioners from the forest products industries together with academic researchers to provide an international forum for the networking and exchange of innovative ideas. Since PTF BPI 2010, the conference has been held almost biennially between Kuchl Austria and St. Simons Island GA. PTF BPI 2018 was held at the Technical University of Munich, Germany. The conference was postponed in 2020 due to the COVID pandemic. The 7th edition (PTF BPI 2023) is organized by The University of Tennessee, the School of Natural Resources and the Forest Products Society (FPS). This year's conference is dedicated to the exchange of applied research findings on process and product innovation.

Topics covered in the conference are:

Wood Adhesives and Material Science
Structural Wood Materials
Processing Technologies
Data Science, Machine Learning, and AI
New and Evolving Opportunities for Wood
Value Added Products
Alternative Technologies for Cellulose
Industry Trends

Our main objective is to welcome talks that have great potential in solving real-life manufacturing problems, and offer new methods, analytical tools, and practices that will advance process and product innovation. The high standard of the conference is guaranteed by our strong international scientific committee.

Special thanks to our speakers, reviewers, both scientific and organizing committees, and all of the conference attendees. We greatly appreciate the generous contributions of our sponsors.

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PLENARY SESSION ABSTRACTS

Moderator: Timothy M. Young, The University of Tennessee

GAME THEORY: INFINITE VS FINITE GAME AND THE STRUGGLE BETWEEN ACADEMICS AND INDUSTRY EXPERTS

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Abstract

If you belong to one of these two camps you have either overheard, been directly told, or even said one of two things while passing through the hallways or at one of these meetings. Either 1) “Academics don’t work on what we need now, they are always working on weird stuff that does not apply today.” Wherein the Academic may respond to the sentiment with 2) “All they want us to work on are things they are already doing with just slight changes.” Herein lies the problem; these two groups are playing different games. In Game Theory, there are two main types of game: the finite and infinite. The finite game has a winner, a loser, and an ending, like football. In the infinite game the rules change and there is no true winner the goal is to stay in the game, life might be a good example of the infinite game. For our industry to continue, both sides must play the infinite game where we look to the future and how things need to change but also the finite game where we address the needs of today. For the long-term health of the wood industry, both Industry and Academics need to work together and change their respective games to including aspects of each other’s game to achieve success and remain relevant. In this talk I will discuss a case study which will to help prove the need for interdependency of the academic and industrial game styles.

Keywords: Game theory, finite, infinite, case study, wood products

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CLOSING THE GAP BETWEEN P-MDI AND PHENOLIC RESIN PERFORMANCE IN HIGH MOISTURE ENVIRONMENTS

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Abstract

Steam-preheated continuous presses, high moisture strands and/or added free water can have a negative impact on the cure of phenolic resole resins in the production of oriented strand board (OSB). Isocyanate chemistry (pMDI) is less affected by free moisture and water is one of the mechanisms of better cure. Continuous press face resins were predominately PF or MUPF chemistry until the advent of the steam preheater. Wash-out and strike-in negatively affect phenolic resin cure with the steam preheater. Most systems use all pMDI. Hexion has worked diligently to develop phenolic resins that perform in these systems. We'll present some of our latest work with resins that handle this steam environment.

Keywords: High moisture strands, cure, phenolic resole resins

ADVANCES IN SOY-BASED WOOD ADHESIVES

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Abstract

The demand for wood adhesives is rapidly growing for a wide range of applications and biobased adhesives are at the forefront of new technology development. Manufacturers are increasingly moving towards wood adhesives with an improved health, environmental, and safety profile that also meet key technical performance attributes. Wood adhesives based on soy flour provide improvements making them ideal for creating wood panels and structural wood composites. Some of the key benefits that will be discussed include attributes such as low VOC, formaldehyde free, improved durability, high biobased carbon content, LEED Building eligibility, and improved indoor air quality. Additionally, it's been found that soy-based wood adhesives require less drying time, use less water, and produce less waste than conventional wood adhesives. Soy-based wood adhesives increase the sustainability of end products and offer benefits not realized with synthetic wood adhesives for both manufacturers and consumers.

Keywords: Soy-based wood adhesives, low VOC, formaldehyde free, improved durability

MAKING INNOVATION WORK WITH THE VARIABILITY ASSOCIATED WITH MANUFACTURING

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Abstract

One of the challenges of making innovation work in manufacturing is understanding the variability that is influencing a large-scale production process. Variability is cumulative in most manufacturing systems. The classic example is feedstock variability. Feedstock for raw fiber arrives at a large-scale production process from many different sources. Even though strategies like blending, and 'first-in-first-out' (FIFO) are used to minimize the impact of shifts in the mean of feedstock quality, the variance is cumulative across suppliers. Companies must innovative to sustain business competitiveness. However, the more researchers and R&D managers understand about the variability influencing a large-scale production process, the more likely the success-rate in implementing this innovation.

The variability associated with a large-scale production process also defines the natural tolerance (NT) of a process or product. The NT is critical in establishing specification limits or the engineering tolerance (ET). Do companies periodically evaluate specification limits, i.e., where did that specification come from? Innovation in the R&D lab must accurately estimate the NT in the design process by estimating the variability associated with a large-scale production process. For example in the design process, are the worst possible feedstocks used and the best possible feedstocks? Does the design process account for tool wear, e.g., refiner plate wear as associated with fiber quality in wood composites manufacturing? Are press-speed changes accounted for in the design process? The more detail that is given in the design process to understanding sources of variation in manufacturing, the greater the potential for success in implementation, which will help improve business competitiveness.

Keywords: Process variability, natural tolerance, innovation, cost

TIMBER MARKETS AND SUSTAINABILITY: OPPORTUNITIES AND CHALLENGES FOR GEORGIA AND THE SOUTHEAST

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Abstract

Georgia is the #1 forestry state in the nation and the Southeast is one of the major timber producing regions not only in North America, but the world. The majority of timberland in the South is privately owned and strong, healthy markets for timber products incentivizes landowners to keep their working forests as forests. The Southeastern United States grows more timber annually than is harvested. There are challenges however, as Georgia and the Southeast are fast growing areas of the country resulting in loss of timberland and forest fragmentation.

This talk will be an overview of current timber production and availability as well as the market situation in the Southeast, with an emphasis on Georgia. Challenges, such as the recent pulp mill closures and opportunities like mass timber, bioenergy and others will be discussed. The need for more markets for traditional timber products and newer technologies will also be presented.

Keywords: Timberland, Georgia, timber production, availability

TECHNICAL SESSION I: WOOD ADHESIVES TECHNOLOGIES

Moderator: Dr. Terry Liles, Huber Engineered Woods

APPLICABILITY OF THREE TYPES OF COMMERCIAL ADHESIVES TO BONDING WOOD TO NON-WOOD MATERIALS

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Abstract

Softwoods are the most commonly used for structural elements. Their advantages over hardwoods include low density and weight and up to 38% better thermal insulation properties. On the other hand their low biological durability and the need for larger cross-sections result in more material consumption presents the main motivation to investigate the possibilities of using hardwoods with smaller reinforced cross-sections instead of softwoods in construction. Various materials and designs of reinforcements have been studied. These include natural fibre materials, steel bars and profiles, glass fibres (glass fibre reinforced plastics, GFRP), carbon fibres (CFRP i.e.carbon FRP), or plates. The compatibility of various non-wood materials as reinforcements and commercial adhesives is not yet fully understood, and the strength and durability of such bonds are not adequately addressed.

Two different types of non-wood implants: CFRP and GFRP, were glued into the wood with epoxy resin (ER), polyurethane adhesives (PUR), and polyvinyl acetate adhesive (PVAc) and tested for shear strength in compression according to ISO 6238:2018. According to this investigation, a comparative study of two types of fibres reinforcements (carbon, glass) was done to improve the mechanical properties of oak wood laminated beams following their end-use conditions (laminated beam, glass wall or other non-load bearing element). Carbon and glass fibres reinforced implants were introduced in various numbers of layers in both tensile and compression zone of the model beams.

The results are presented in the form of the shear strength values for adhesives and the ultimate load to failure, mid-span displacements and deformations of reinforced model beams. Test results indicated that applying PUR adhesives for bonding carbon and glass fibres with oak-wood can sufficiently replace two-component ER, which is generally recommended for such purposes but is expensive and very challenging to utilize in industrial conditions. Also, GFRP implants offer less improvement in flexural strength of laminated wood beams than CFRP. However, being aware that glass fibre materials can be up to 9 times cheaper than carbon fibre sheets, the benefits of GFRP use are disproportionally positive. The reinforcement effect of introducing two layers of pre-stressed glass fibres increased ULF by

39%, effective stiffness by 51%, ductility by 32%, and increased displacements at ULF by 10%.

Keywords: Implants, epoxy adhesives, PUR adhesives, PVAc adhesives, laminated timber, reinforced polymer

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USING THE BIO-BASED BYPRODUCT OF BIO-DIESEL PRODUCTION TO ENHANCE PMDI ADHESIVE PERFORMANCE

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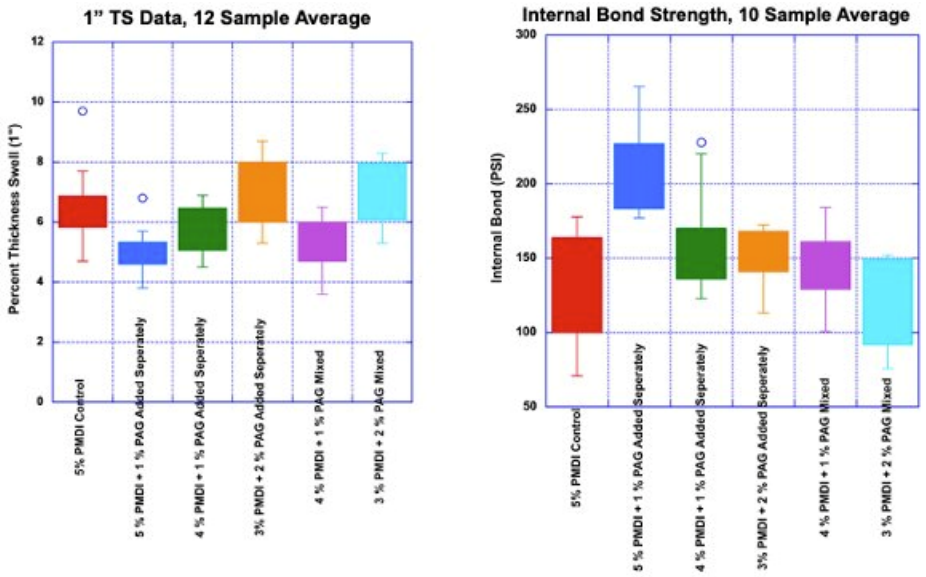
Abstract

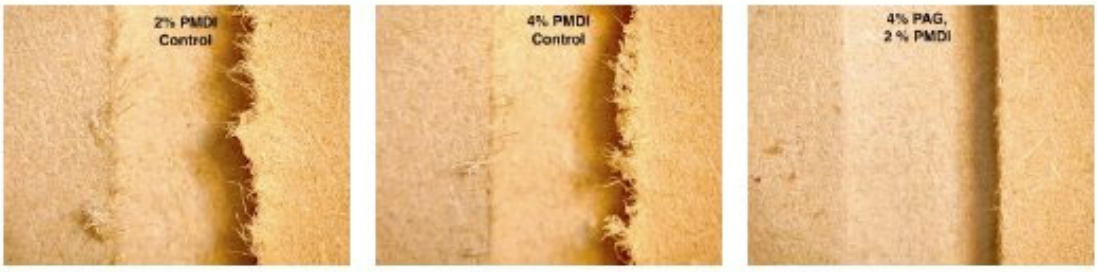
The efficiency and performance of polymeric methylenediphenyl diisocyanate (PMDI) wood adhesives is well known. In wood composites, PMDI primarily reacts with water to form strong polyurea networks within the wood composite. PMDI also has the potential to react with polyhydroxy containing molecules in wood or when mixed with other polyhydroxy molecules like glycerol. The growth of the bio-diesel industry has resulted in a large amount of “crude” glycerol as a byproduct of biodiesel production. The large amount of available glycerol makes it a viable starting material for synthesizing biopolymers. This work will discuss the use of glycerol-derived polyacrylated glycerol (PAG) as a biobased polymer additive to enhance the performance and lower the cost of PMDI adhesives in wood composites like Oriented Strand Board, Particle Board, and Medium Density Fiberboard. Data obtained from OSB studies shows that PAG can replace up to 40% of the PMDI in the composite and still maintain equivalent performance. In addition, studies of PMDI bonded MDF showed that the addition of PAG can improve the machinability of MDF bonded with PMDI.

The data illustrates that the incorporation of PAG into PMDI bonded wood composites can reduce overall composite cost while maintaining and/or enhancing performance. The combination of PAG with PMDI in wood composites also enhances the bio-based content of PMDI bonded wood composites.

Keywords: Adhesive, polyacrylated glycerin, polymeric methylenediphenyl diisocyanate, wood composites



Thickness swell and Internal Bond data for boards having 20% and 40 % replacement of PMDI with PAG.



MDF made at the Fraunhofer Institute for Wood Research pilot blow-line in Braunschweig Germany. The pictures show the difference in how the boards machine when routed.

UNDERSTANDING THE FUNDAMENTAL INFLUENCE OF EXTRACTIVES ON WOOD ADHESION

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Abstract

Queensland Australia features a variety of attractive, high-density hardwoods that hold value in composite products like laminated veneer lumber. *Corymbia citriodora* (spotted gum) stands out due to its challenging adhesive-bonding characteristics. Spotted gum appears to be one of the most difficult-to-bond woods encountered; it is ultra-sensitive to surface deactivation during drying- apparently due to high levels of lipid and phenolic extractives- and adhesive penetration is essentially absent because the vessel cells in this high-density wood are completely occluded by tyloses. The primary objective of this study is to understand the influence of extractives on wood adhesion. We face an unusual experimental methodology: adhesion testing of solid wood that has undergone solvent extraction. Although solvent extraction of solid wood is a complex process rarely conducted, we selected accelerated-

solvent extraction (ASE) with elevated pressure and temperature (1,500 psi; 75°C or 85°C) to facilitate extraction. Ultimately, we hope to extract solid wood with solvents of different polarity (non-polar dichloromethane and cyclohexane, or polar methanol/water or 95% ethanol), and correlate adhesive durability to these extractions, and specific extractive compounds. Early results from the extraction process showed successful removal of extractives while maintaining the integrity of the specimens. However, the extractions were incomplete, implying that only the surface-level extractives were removed. Ground-material extractions revealed a remarkable increase in extracts for the methanol/water and dichloromethane extraction systems, with sixfold and twentyfold more extracts, respectively, compared to solid wood extractions. Polar solvents exhibited superior extraction capabilities and acted as better swelling agents than non-polar solvents. This study also involved analyzing the wood sample's chemical composition using NREL/TP standards, and thermogravimetric analysis (TGA) to evaluate the thermal behavior. The chemical composition revealed approximately 11% extractives, 22.5% lignin, 50.0% cellulose, and 19.57% hemicellulose, aligning well with literature values for Spotted gum and Black locust. TGA indicated the main degradation stages corresponding to moisture, cellulose, hemicellulose, and lignin. In conclusion, this study proposes a novel technique for removing extractives from solid wood and investigates the impact of different solvent systems on extractives removal and adhesion properties. These findings hold promise in developing enhanced bonding strategies for this high-density wood species in engineered products.

Keywords: Spotted gum, extractives removal, accelerated solvent extractor, hardwood.

ENHANCING PARTICLEBOARD PERFORMANCE: COMPARING WOOD FLOUR AND SOY FLOUR SUBSTITUTION IN PMDI RESIN

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Abstract

This study investigated the feasibility of using wood flour (WF) as a partial substitute in polymeric methylene diphenyl diisocyanate (pMDI) resin and compared its performance with soy flour (SF) substituted in pMDI resin. The physical and mechanical properties of experimental particleboards made with WF and SF substituted in pMDI resin at different substitution percentages were evaluated. The viscosity for the WF at different substitution ratios (5%, 10%, 20%, and 30%) ranged from 314.7 to 6,256.3 cP, whereas SF-substituted resin ranged from 249.7 to 1,291.8 cP. During the production of the boards, it was observed that because of the high viscosity of WF substituted in pMDI resin above 10 percent, it was exceedingly difficult to apply it through spraying and brushing, either to wood particles or veneers. Dimensional stability test results established that the incorporation of SF assisted in mitigating board thickness swelling. The results from the study showed that panels made with SF substituted in pMDI resin at 5 and 10 percent exhibited the overall best performance in all the properties considered compared with panels made with WF substituted in pMDI resin.

Keywords: Wood flour, soy flour, particleboard evaluation

TECHNICAL SESSION II: ADVANCED MATERIALS TECHNOLOGIES

Moderator: Dr. Robert A. Breyer | Bakelite Chemicals

ADDRESSING HIGH COST ISSUES DURING THE PRODUCTION OF NANOLIGNIN AND POTENTIAL APPLICATIONS

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Abstract

Lignin is the second most abundant biopolymer of land-based biomass, and the most common kraft lignin from the pulp paper industry currently accounts for 170 k tons/year. Lignin could be converted into novel bio-nanomaterials. The nanolignin nanoparticles possess several favorable characteristics, including a high specific surface area, tunable chemical structure, and well-defined surface performance, enabling comprehensive applications in delivery systems, high-performance catalysts carriers, agents in advanced composites and so on. Usually there are two ways of manufacturing nanolignin, a bottom-up method represented by self-assembly and a top-down method with mechanical external force for fragmentation. Compared with chemical methods that require the use of large amounts of organic solvents, mechanical methods generally use water as the medium, reducing the pollution of the environment. However, mechanical methods require a large amount of water and energy. In this presentation, we will summary our recent efforts to address high cost and water issues during the production of nanolignin and potential applications. After investigating the effect of processing temperature on nanolignin quality during ultrafine friction grinding, we concluded that we could use 1/3 of processing time to process nanolignin. We also achieved significant energy savings via reducing water content during the process. Finally some applications will be discussed.

Keywords: Lignin, nano, energy, water, application

STUDY OF DYNAMIC-STATIC PROPERTIES OF BAMBOO TEXTILE REINFORCED POLYMER

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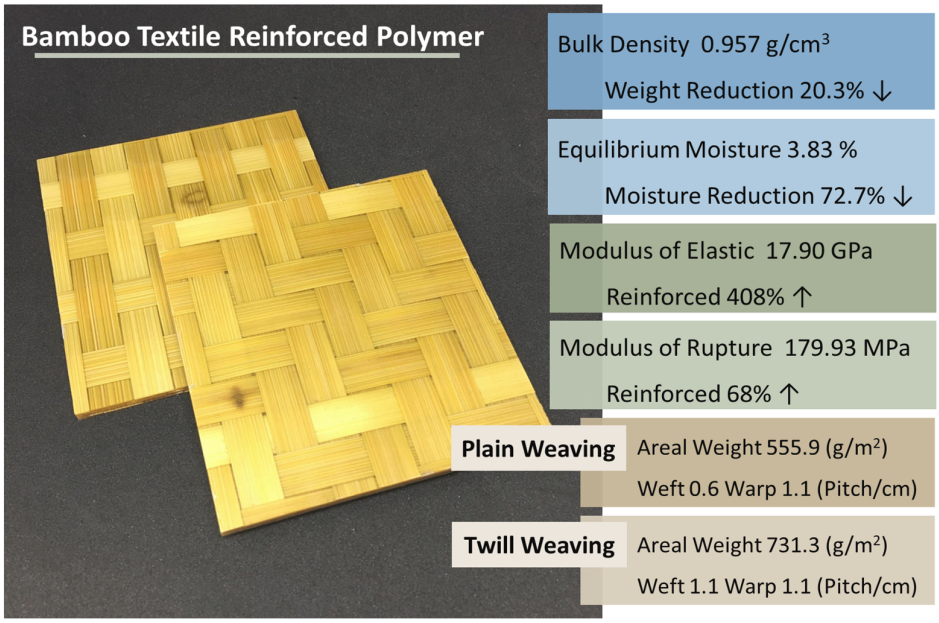
Abstract

Bamboo, an important forest product in Asia is a fast-growing plant with high carbon sequestration efficiency. Under the trend of net zero carbon emissions, using forest products and promoting them to more end-use areas is an important strategy to achieve sustainable goals. Bamboo is recognized as having excellent mechanical properties and processing characteristics which make it a high potential industrial fiber. Fiber-reinforced resin composites (FRP) are widely used in the fields of aerospace, marine, and automotive engineering. Bamboo fiber can be processed as chopped fiber, continuous fiber, and timber, making it a great candidate for FRP reinforcement. In this study, we developed a high-performance composite by molding bamboo strips into a woven preform with epoxy resin. Vacuum-assisted resin transfer molding (VARTM) was applied to benefit from the woven material's geometric flexibility and advantageous mechanics. This innovative material combines the benefits of continuous fibers, woven structures, and VARTM and is known as Bamboo Textile Reinforced-Polymer, BTRP. The study intends to assess the carbon footprint and show the dynamic and static performance through engineer standards of various weaving architecture BTRPs. Static properties such as density (ASTM D3039), hygroscopicity, dimensional stability (ASTM D1204), flexural behavior (ASTM D790), tensile properties (ASTM D3039), and in-plane elastic constants such as Poisson's ratio and shear modulus are included (ASTM D7078/5379/3518). Dynamic performance includes two types of tests (simple beam support and weight-dropping impact) (ASTM D7136/5628) and a discussion of fractography. The results show that while the density of BTRP is fairly low, it has a Young's modulus comparable to that of Glass fiber reinforced polymer. The outstanding moisture resistance and dimensional stability further guarantee the lifetime of biobased materials. The gradual fracture feature is also advantageous. The woven bamboo preform may considerably improve the efficiency of absorbing impact energy in terms of impact results.

Keywords: Bamboo, textile preform, resin transfer molding, dynamic-static properties, carbon footprint



MULTIFUNCTIONAL BIOCOMPOSITE FILMS FOR FOOD PACKAGING: TUNING OF PHYSICOCHEMICAL AND FUNCTIONAL PROPERTIES

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Abstract

Bio-composite films for food packaging could offer both environmental and health benefits juxtaposed to their synthetic-based counterparts. However, bio-based films have poor barrier and mechanical properties limiting their application in food packaging. Blending different biopolymers from wood/biomass could be a strategy to overcome these limitations and obtain multifunctional films for diverse applicability. This study aimed at developing composite films with improved mechanical, optical, and UV-barrier properties for food packaging via the combination of different polymers such as pectin, nanocellulose, and hemicellulose. The effect of varying pectin/nanocellulose contents (0 –100%) and adding 25%Tara gum (w/w) as filler on the physicochemical, mechanical, optical, and thermal properties of the films were studied.

Chemical structural changes, optical properties, and hydrophobicity were analyzed using Fourier Transform infrared spectroscopy (FTIR), UV-visible spectroscopy (UV-Vis), and contact angle measurements. A thermogravimetric analyzer was used to study the thermal behavior of films whereas atomic force microscopy (AFM) was employed to monitor the surface topography. The mechanical properties of films were assessed using the Instron machine, and the interaction between the polymers was studied with Quartz crystal microbalance with dissipation (QCM-D) monitoring and surface plasma resonance (SPR). Self-supporting films with thicknesses in the range of 0.046 to 0.10 mm were obtained for the films. Pectin-based films presented low UV shielding properties with high visible light transmittance compared with LCNF-based films. The addition of Tara gum to pectin/LCNF films did not have a significant impact on the UV barrier properties, however, a significant improvement in hydrophobicity and thermal properties was observed due to the enhanced interaction between components. FTIR spectra showed the emergence of new peaks and a shift of the broader -OH stretching vibration to lower wavenumbers with the addition of Tara gum. QCM-D and SPR confirmed the interaction between the polymers. Thus, blending different polymers with diverse properties could be a strategy to develop bio-composite films with enhanced physicochemical and functional properties for food packaging.

Keywords: Bio-composite films, pectin, Tara gum, hydrophobicity, quartz crystal microbalance with dissipation

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ASYMETRICAL PARTICLE–BASED COMPOSITES

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Abstract

Particleboards are usually composed from three layers, which consist of two surface layer and one core layer, creating an almost symmetrical panel with uniform properties, where the orientation of panels (upper or bottom side) is not important. But when exposing panels to bending load and/or compression there is a difference in response of upper and bottom side. The upper side (loading side) is subjected to compressive stresses, while the bottom side (side opposite of load) is subjected to tensile stresses. And since most failures occurs under tensions the materials/panels should be structured in a way to increase resistance against tension, with no decrease in compressive resistance. Since particleboards are symmetrical (almost equal resistance against load of upper and bottom side) our aim was to produce an asymmetrical particle-based panel in order to analyze the differences in response related to panel structure. In order to produce asymmetrical panel, particles were firstly separated into three major groups: (a) fines, (b) middle and (c) coarser particles. Coarser particles were the ones that remained on sieves with opening ≥4.0 mm, middle size are the particles that remained on sieve with opening between 2.0 mm and 4.0 mm, and as fines the particles passed the sieve with opening 2.0 mm. Particles were later blended with melamine-urea formaldehyde resin (resin load 11 %) and pressed into two- and three-layer 16 mm, 0.7 g·cm-3 dense asymmetrical particle based panels. Panels were tested for bending strength, water uptake and creep behavior. The results showed that properties depend on the structure of the panel, the most obvious was at bending strength and creep behavior. The results show the differences in response of the board in relation towards its composition, meaning the side of panel that was exposed to tension stresses at bending or creep test or the side that was exposed to water.

Keywords: asymmetrical panel, bending strength, creep, water uptake

ACKNOWLEDGEMENT

The authors acknowledge the financial support of Slovenian Research and Innovation Agency (ARIS) within research programme P4-0015 (Wood and lignocellulosic composites), and the Infrastructure Centre (IC LES PST 0481-09). The Ministry of Agriculture, Forestry and Food, under the V4-2017 project, also supported part of the published research.

TECHNICAL SESSION III: CURRENT EVENTS

Moderator: Dr. Martin Riegler, BOKU University, WoodK Plus

CONTEMPORARY SOLID AND ENGINEERED WOOD RESEARCH AND DEVELOPMENT AT MISSISSIPPI STATE UNIVERSITY

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Abstract

Mississippi and the Gulf South region of the USA are home to 20 million and 200 million acres (8 million and 80 million hectares) of timberland, respectively. The majority of these timberlands are held by public and private companies as well as families. In Mississippi, the timber growth to drain ratio has been on the order of 2:1 to 3:1 for nearly the last decade. This supply growth has attracted investment to the US Gulf South region in the form of mill expansions and new production facilities. In an effort of maximize landowner value, the Department of Sustainable Bioproducts is actively researching improved valuation techniques, standards, and products. By working with private landowners, production facilities, and federal stakeholders, Mississippi State University has approximately doubled its research activity in this area in the last 10 years. Work on hardwood CLT, novel glue laminated products, timber mats, biobased adhesives, and novel wood preservatives are at the forefront of this growth. This presentation highlights this research activity and how the department has sought strategic partners and grown during a time when publicly funded higher education in the country has faced increasing pressure.

Keywords: Lumber, engineered composites, standards, wood durability and protection, termites, adhesives.

SUSTAINABLE PRODUCT DEVELOPMENT TOWARDS A CIRCULAR ECONOMY

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Abstract

Increasing challenges concerning climate change as well as the vast utilization of diminishing fossil fuel resources have caused researchers to look into more green and viable long-term alternatives for high-end functional materials. While chemicals such as fuels or polymers are integral and indispensable parts of modern human life, the continuous production of these materials from fossil-based resources is simply not justifiable anymore. Sustainability and eco-efficiency are the guiding principles for developing the next generation of materials, products and processes. In recent years, awareness for the introduction of more environmentally friendly consumer goods has increased and therefore has spiked the

research into ecologically conscious, green products. Hence, more sustainable and green alternative feedstocks have to be found.

Our mission is to develop novel, functional materials based on biogenic feedstock, not only as a solution to the growing environmental threat, but also as a way out of petroleum insecurity. Our focus hereby lies on the utilization of regional waste and byproducts from for example the wood transformation industry in order to avoid the use of agricultural products, which could also be used in the food industry. This includes, for example, the investigation of new composite materials based on wood and natural fibers, the development and testing of new thermal insulation materials based on renewable raw materials and the investigation of innovative functional materials for various applications. Here we present a range of our novel materials, which have the potential to pave the way towards a fossil fuel-free circular economy.

Keywords: Circular economy, green materials, resource valorization, sustainable development

INCREASING SCIENCE PROFICIENCY AND DEVELOPING THE NEXT GENERATION OF FOREST INDUSTRY WORKFORCE THROUGH RELEVANT ENVIRONMENTAL EDUCATION

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Abstract

The state of Alabama has a history of racial injustice and inadequate educational performance, particularly in the field of science education. Segregation and unequal resources have persisted in the state's education system, leading to disparities in educational achievement. Specifically, minority populations, concentrated in the Black Belt region, face significant challenges in science proficiency. The Black Belt region hosts Alabama's forest industry [1], making the region reliant on environmental science proficiency to ensure economic productivity and sustainability.

The aim of this study is to examine the inequities in science education within Alabama, propose solutions to enhance science proficiency, and promote the forest industry to secondary students. Previous research suggests that students learn best through relevant hands-on learning material [2, 3] and community involvement [4]. With 70% of the state being classified as woodlands [5] and the largest concentration of forests existing in the Black Belt [1], learning material involving forest products is relatable and stimulating to student learning. To this end, our work focuses on the development and implementation of a hands-on lesson on the use of forest products to remediate contaminated aquatic systems in secondary science classrooms. Pre and post-assessment surveys were employed to measure the effectiveness of the lesson on increasing science proficiency and interest in the field of forestry. Additionally, a free community event on sustainability was held for the Auburn-Opelika community. Surveys were conducted to measure the effectiveness of the event in supporting participants' science proficiency and interest in environmental science-related fields. The results of this study have shown positive improvements in environmental awareness, science literacy, and interest in environmental science-related fields. These findings emphasize the importance of creating equitable and inclusive learning environments and engaging communities to bridge the historic educational gap in Alabama.

Keywords: Diversity, education, equity, forestry, forest products

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THE UNIVERSITY OF TENNESSEE SCHOOL OF NATURAL RESOURCES 'DATA SCIENCE INSTITUTE FOR MACHINE LEARNING AND AI'

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Abstract

The University of Tennessee, School of Natural Resources (UT SNR) has established a new institute starting in January 2024 named 'Data Science Institute for Machine Learning and AI (DSIMLA)'. The goal of DSMILA is to assist companies in learning, adapting, and effectively implementing the latest data science, machine learning, and AI technologies to optimize processes, leading to improved efficiency, utilization, energy savings, and cost reduction. The Institute will function as an expansion of a company's innovation group by providing access to the most current technologies in the rapidly evolving field of data science, machine learning, and AI. An industry executive board will govern DSMILA within the framework of UT system.

DSMILA will include a 'Machine Learning (ML) Cooperative' (ML Coop) to advance the direct application of the most contemporary ML algorithms for real-time prediction of key process parameters and product quality attributes. DSMILA will have the following objectives: 1) Expand the knowledge of a company's workforce in statistical and data analytical methods as applied to manufacturing; 2) Enhance a company's knowledge of analytical software to support continuous improvement efforts in data analytics; 3) Promote learning and networking with virtual webinars, in-person workshops, and an annual conference; and 4) Conduct applied research in data science, machine learning, and AI to support the enhanced optimization of forest products and sustainable biomaterials processes.

The education component of the DSMILA will establish a curriculum for students and industry focused on the general aspects of data analytics, which will be a combination of well-established statistical principles and contemporary methods for continuous improvement. The academic curriculum will be structured to support the MS Forest Business program which is open to students at UT and industry personnel willing to expand their education while working full-time. The MS Forest Business program for industry will consist of a mostly virtual curriculum.

Keywords: University of Tennessee, institute, data science, machine learning, AI

TECHNICAL SESSION IV: PROCESSING TECHNOLOGIES

Moderator: Dr. Danijela Domljan | University of Zagreb

SUPPORTING PROCESS TECHNOLOGY CHANGES IN MANUFACTURING WITH AN INNOVATIVE MICROSCOPY METHOD

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Abstract

Bakelite Chemicals has developed an innovative microscopy technique to view phenol formaldehyde adhesives 'in use'. The cornerstone of the method is based on sample preparation. Samples of a composite product are sanded to a highly polished surface using a progression of sandpaper grits from lowest to highest. This preparation technique differs significantly from historical preparation techniques that rely on soaking samples followed by the creation of thin specimens. The wet preparation technique causes wood cells compressed during production of the composite to swell and change how you see the adhesive within those cells. The addition of water to the sample can also move uncured adhesive along the bond-line. These changes can significantly change the interpretation of how the adhesive performs during the manufacturing process. The new preparation technique combined with standard fluorescence microscopy has provided a ground breaking ability to understand how an adhesive responds to process changes in manufacturing. Improving the understanding of the dynamic relationship between the adhesive and the manufacturing processes will be crucial in helping the wood products industry take advantage of the rapid improvements in processing technology.

Keywords: Fluorescence microscopy, sanding, process support

NANOCOMPOSITES DERIVED FROM NANOCELLULOSE AND METAL NANOPARTICLES AND THEIR APPLICATIONS

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Abstract

Research into the development of sustainable and environmentally friendly nanocomposites is a rapidly growing field due to their potential applications resulting from the combination of unique chemical, optical, and mechanical characteristics of the components. Recently, noble metal nanoparticles (MNPs) such as silver, gold, and palladium nanoparticles have gained incredible attention due to their captivating optical and physicochemical properties, along with their vast range of applications. However, the colloidal nanoparticles, due to their small size and high surface activity, tend to aggregate during application. Furthermore, their recovery poses a tedious challenge, making their reuse difficult. An effective strategy to overcome these drawbacks is the use of a support material. Nanocellulose, a renewable and abundant nanomaterial derived from cellulose, serves as an excellent matrix for the incorporation of MNPs. These nanocomposites benefit from the exceptional mechanical properties, high surface area, and eco-friendly nature of nanocellulose, combined with the unique electronic, optical, and catalytic attributes of MNPs.

Here, we present our research focused on the in-situ growth of silver, gold, and palladium nanoparticles on nanocellulose. Nanocellulose with diverse surface chemistries, including carboxylated, quaternized, and dialdehyde-modified variants, was explored for the in-situ growth of MNPs. A novel, environmentally friendly microwave-assisted method, devoid of toxic reducing agents, was employed. Nanocellulose offers numerous advantages as a support material, facilitating precise size and morphology control during in-situ growth. The resulting nanocomposites were utilized for two key applications: (i) biosensing of small molecules such as glucose, cholesterol, and ascorbic acid, and (ii) catalytic removal of various organic dye pollutants from water. Furthermore, the network-like structure of nanocellulose enabled the preparation of diverse morphologies, including films, foams, and aerogels, offering facile recovery and reusability across multiple cycles.

Keywords: Nanocellulose; metal nanoparticles; biosensing; pollutant removal; recyclability

PREDICTIVE CHEMOMETRIC ANALYSIS FOR THERMAL PROPERTIES OF BIOREFINERY LIGNINS AND CHARACTERIZATION TECHNIQUES FOR BIO-BASED NANOPLASTICS IN ENVIRONMENTAL STUDIES

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Abstract

Biodegradable polymers, such as lignin, derived from natural resources, gained significant attention in substituting petroleum-based plastics. However, biopolymers' manufacturing and biodegrading mechanisms require fundamental knowledge about the intrinsic chemical and thermal properties of their polymeric precursors and decomposition residues. This study evaluated the thermochemical properties of polymer precursors and particle dynamics of biodegradation products. Lignin, a low-value biorefinery by-product, is currently being investigated for high-value materials applications for biopolymers. Therefore, lignin glass transition temperature (T_g) was predicted through principal component analysis and empirical partial least square regression models (PLS) derived from Fourier-transform infrared (FTIR) spectral data. The PLS model shows a robust predictive performance for the T_g based on the strong linear fitting observed in an independent validation set (R^2 = 0.85). This observation suggests that the PLS calibration model can accurately forecast T_g, a crucial parameter for synthesizing polymer blends. Lignin blends of polymer polybutylene adipate terephthalate (PBAT) are promising biocomposites for agricultural applications such as biodegradable mulch films (BDMs). BDMs are used for crop yield maximization when employed on the soil surface. However, the uncontrollable environmental breakdown of these polymer blends into micro- and nanoplastics (MPs, NPs, respectively) requires advanced characterization techniques for environmental fate studies. Therefore, SANS (Small Angle Neutron Scattering) and ULTRA-SANS (USANS) are unique techniques providing information about NPs particle size (1-1000 nm), shape distribution, and aggregation within NP-soil composites. As complementary methods for NPs assessment, FTIR and nuclear magnetic resonance (NMR)

spectroscopy were successfully used in environmental studies. The rapid thermal property prediction through chemometrics can accelerate the manufacture of lignin-based polymers. Furthermore, the novel NP-characterization techniques contribute to a better understanding of ecological risk assessment and fate studies.

Keywords: lignin, biodegradable plastics, regression, nanoplastics, environmental studies

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HIGH FREQUENCY PRESS AS AN ALTERNATIVE PROCESS FOR PRODUCTION OF WOOD POLYMER COMPOSITE

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Abstract

The usual manufacturing process of production of wood-plastic or wood-polymer composites (WPC) involves drying wooden constituents to moisture content in the range of 2% to 4%. Since moisture content of wood at log yard is significantly higher (above 30 %), wooden constituents need to be dried what demands high temperatures of drying hence relatively high energy consumption. If moisture content of wooden constituents is too high, it will result in creation of gaps in matrix or interphase gap between matrix and wood constituent what leads to lower strength properties of produced composites. To minimize the need for drying of wood constituents' high frequency press was used to produce flat pressed WPC. As matrix of WPC polyethylene (Dowlex 2631.10 UE (USA)) in powder form and spruce (Picea Abies) wooden particles were used. Several series of panels were made to estimate the possibility of implementing high frequency for flat pressed WPC, where wood moisture content, wood share and pressing time were changed. According to the results of tensile and flexural strength the most promising parameters were determined. For using high frequency press the most optimal moisture content of wood particles was 26%, with the share of wood between 50% and 75%. The optimal pressing time was 17.5 minutes.

Keywords: wood-polymer composite, high frequency press, tensile strength, flexural strength

ACKNOWLEDGEMENT
The authors acknowledge the financial support of Slovenian Research and Innovation Agency (ARIS) within research programme P4-0015 (Wood and lignocellulosic composites), and the Infrastructure Centre (IC LES PST 0481-09). The Ministry of Agriculture, Forestry and Food, under the V4-2017 project, also supported part of the published research.

TECHNICAL SESSION V: DATA SCIENCE, MACHINE LEARNING AND AI

Moderator: Martin Weigel-Kuska, Holzforschung Austria

MACHINE LEARNING FOR PREDICTING WOOD PROPERTIES DURING MILLING

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Abstract

During the last centuries, numerous manufacturing technologies have been established throughout the value chain of wood and its various products made of. A majority of these technologies were introduced to increase the efficiency of resources needed and the assurance of a constant product quality. However, control loops that ensure the realization of these two aspects are often still missing. Consequently, approaches for monitoring wood machining processes are still subjects of basic research.

The monitoring of processes needs to take place in real-time without slowing down or interfering with the processing itself. Hence, the feasibility of a real-time multi-sensor system in combination with machine learning algorithms was investigated in the present study, to classify different wood products and to predict their product quality. In particular, structure-borne acoustic emissions, airborne sound, cutting forces and power consumption were measured during the milling of different wood products at a cutting speed of 60 m/s. As product qualities, the density and the surface roughness of work pieces were determined.

Using data from the sensors only and applying machine learning, it was possible to significantly differentiate between the wood products machined. Additionally, real-time data from sensors significantly correlated with workpiece properties such as density and surface roughness. This high predictability of types and properties of wood products allow for a feedforward control during wood machining in real-time.

Keywords: Wood machining processes, machine learning algorithms, predictability, density, surface roughness

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CAN THE FOREST PRODUCTS INDUSTRIES IMPLEMENT MACHINE LEARNING AND AI – CHALLENGES AND OPPORTUNITIES

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Abstract

Machine learning (ML) and AI applications in many industries are increasing at an exponential rate. A key foundation for successful applications are fused, relational databases across networks that are aligned based on a primary key. Commercial companies like Amazon, Apple, Google, etc., have incorporated database management and continuous improvement strategies such as Total Quality data Management (TQdM) as core business philosophies. It is very common for commercial companies to have the Chief Data Officer (CDO) managing a data science division. Forest products industries are typically commodity-based industries with some companies having value-added products such as lamination, composite flooring, etc. ML and AI applications in forest products manufacturing are getting some attention. ML and AI can help commodity-based companies' lower costs by making real-time predictions of key process variables such as weight variation, thickness variation, moisture variation, etc. Some companies are outsourcing these services to vendors such as Rockwell Automation, USNR, etc. There are advantages and disadvantages to outsourcing, but the risk of loss of 'institutional knowledge' may be significant. Outsourcing may have the advantages of lower organizational labor costs and lower risk of failure. However, outsourcing does not lead to growth of knowledge within the company, and many solutions are presented by vendors as a 'mysterious box' of algorithms. Algorithms rely on correlations to make predictions and such algorithms do not understand the process. Typically, vendors use supervised learning to manage the training and tuning of the algorithms. Forest products companies understand the variables and parameters of a process. The companies IT staff also understand the difficulties of developing high-quality fused, relational databases. Plant personnel also understand false correlations that may arise during predictive modeling.

The forest products industry is in its 'infant' stage with successful applications of ML and AI relative to other industries. Long-term success for this industry will involve developing high high-quality fused relational databases as a platform for ML and AI. This long-term success will also involve successful partnerships between 'analytically-trained' plant personnel and vendors to ensure that the 'institutional knowledge' grows within the organization.

Keywords: Machine learning (ML) and AI, high-quality fused, relational databases, Total Quality data Management (TQdM)

A GREAT STATISTICAL PROGRAM CANNOT FIX POOR STRATEGY

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Abstract

Today there are statistical programs that can design and analyze experiments. Despite best intentions, poor decisions can lead to costly mistakes. In industry, the cost of poor interpretation and implementation of the data these tools afford us can be costly and none of the programs stop you from making errors in design and analysis. Each method used has - as called by Richard McElreath - golems; or rules that govern the analysis use and interpretation. Failure to heed these can lead to erroneous results. Even academia falls victim to poor interpretation leading to work that cannot be reproduced at other institutions. As industry changes, it will need to increase its use of statistical Design of Experiment (sDOE) and big data analysis to drive future decisions. If the design or analysis is incorrect this could lead to severe consequences. As an example, can wood failure be analyzed using ANOVA? Since it assumes normal distribution the results maybe that a condition can give 110% or -5% wood failure. This talk will discuss pitfalls that, if not addressed during the design phase of a project, could lead to unrepeatable work and costly negative consequences.

Keywords: Statistical programs, design of experiments, design phase

TECHNICAL SESSION VI: STRUCTURAL WOOD MATERIALS I

Moderator: Steve Winistorfer, Huber Engineered Woods

WOOD-EPOXY COMPOSITES EXTRUSION FOR CONSTRUCTION APPLICATIONS

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Abstract

Extrusion-based additive manufacturing is a growing, more environmentally friendly, and efficient method for building construction. It is a quicker construction method with design flexibility, and improved form becoming popular in the construction industry. In a plea to become more sustainable, the construction industry is increasing the demand for research on partially replacing cement, that is currently used in 3D printed buildings, with renewable and more environmentally friendly resources, such as wood/biomass. Wood-based composites preferably thermoset based, due to their profound performance in wood-based building industry, are currently highly attractive for the 3D printing research. This study involves extrusion of wood flour-epoxy composites through a nozzle by means of a low-pressure screw-based mechanism. The printability of the composites and their mechanical, physical, and thermal performances were evaluated. To this aim, different wood particle sizes, wood to adhesive weight ratios (40:60, 45:55, 50:50, 55:45, and 60:40), and the extruding speed (40, 60, and 80 rpm) were studied to print composites containing pine wood flour, Epon-828, and Jeffamine d-400 catalyst. Mechanical and chemical structural changes of the extrudates were studied using 3-point bending test and Fourier transform infrared spectroscopy (FTIR), respectively, whereas the thermal performances were studied using thermal gravimetric analysis (TGA) and fire test. Water absorption and dimensional stability after 24 h soaking in water were also assessed. The results showed that the extrudates with the smaller particle size developed lower number of longitudinal cracks, however, composites with lowest weight ratio of wood: epoxy developed shark skin defects which intensified by increasing the extrusion screw speed. Although by decreasing the ratio of wood to adhesive, the mechanical performance of the composites improved, the ratio of 45:55 demonstrated the best and optimized overall quality in terms of surface quality and mechanical, physical, and thermal properties. The research indicates the promising results and proves that the extruded wood-epoxy composites can be used as a sustainable alternative for layer-by-layer fabrication of building elements.

Keywords: Extrusion, Additive manufacturing, wood-epoxy composites, 3D printing.

USE OF SUSPENSION TECHNOLOGY TO INCORPORATE LIGNIN AND BIO-BASED WAX INTO ENGINEERED WOOD PANELS

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Abstract

Wax emulsions (or dispersions) are well known in the forest products industry to improve hydrophobing characteristics of engineered wood panels. In recent years, there has been a trend towards on-site emulsification, which allows for the utilization of "hot emulsions" incorporating a minimal amount of emulsifiers. These hot emulsions, designed to be used immediately after production are referred to as "suspensions". The use of suspensions provide an avenue for the incorporation of novel materials that would otherwise be difficult to produce and ship to the mill by a 3rd party manufacturer.

Two bio-based materials of interest in this presentation are kraft lignin, specifically those produced using the "LignoForce" or "LignoBoost" process, as well as bio-based waxes, or triglyceride waxes. Walker Emulsions has developed technology specifically with SmartWax Systems currently employed at many OSB mills, as well as Particle Board and MDF facilities. in particular, when using triglyceride waxes, emulsions or suspensions of high drop melt point (DMP) and low iodine value (IV) that are quite unstable when supplied in the form of a dispersion can be effectively utilized in suspension form.

Keywords: Suspensions, lignin, wax, triglycerides

OPTIMIZING ORIENTED STRAND BOARD QUALITY: ASSESSING THE INFLUENCE OF B-CYCLODEXTRIN-ESSENTIAL OIL TREATMENTS

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Abstract

Dimensional instability of oriented strand board (OSB) has long been a persistent issue due to water exposure, weathering, and excessive loads. This creates the need to develop a product that is resistant to water absorption and biological degradation while also having superior strength and internal bond properties. In this study we aimed to assess the dimensional stability and mechanical durability of OSB treated with 1% of four different beta-cyclodextrin essential oil complexes (BCD-EO): eugenol (EUG), trans-cinnamaldehyde (tCN), carvacrol (CARV), and thymol (THY). To fabricate the boards, Southern Yellow Pine (Pinus spp.) wood strands were dried to 5% moisture content and mixed in a drum mixer for 10 minutes with the different BCD-EOs and diphenylmethane diisocyanate (pMDI) adhesive that was atomized with a spray gun and air compressor. After mixing, the strands were all oriented in the same direction and pressed in a Diefenbaker press to produce a 34 by 34-inch board that was 0.46 inches thick. After the boards were cured, they were cut into the size required for the ASTM D1037 internal bond and dimensional stability test as well as the ASTM D3043 bending test. In the internal bond test, the EUG, tCN, and CARV treatments exhibited a decrease in internal bond strength when compared to the control whereas the THY treatment showed a 5% increase. In the bending strength test, all 4 treatment groups had a higher MOE and MOR than the control with the highest percent increase being THY and the lowest percent increase being CARV. In the dimensional stability test, all 4 treatment groups displayed an increase in water absorption and thickness swelling compared to the control after being submerged in water for 24 hours. In conclusion, using BCD-EO complexes in the construction

of OSB holds promise for some properties, however further investigations into degradation and biological durability are necessary to fully understand the potential properties of the BCD-EO complexes.

Keywords: Oriented strand board (OSB), dimensional stability, dimensional stability, mechanical durability, BCD-EO complexes

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FLEXURAL PROPERTIES OF STRUCTURAL INSULATED PANELS (SIPS)

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Abstract

Flexural properties of structural insulated panels (SIPs) were investigated based on the effect of duration of load testing. These SIPs were manufactured by a member of the Structural Insulated Panel Association (SIPA) in accordance with International Code Council-Evaluation Service Report 4689. There were two categories of depths for SIPs including 16.5 cm and 31.1 cm (6.5 in. and 12.25 in.). The SIP's foam cores were expanded polystyrene (EPS), with two densities of approximately 0.016 g/cm3 (1.0 lb./ft3) and 0.019 g/cm3 (1.2 lb./ft3). All specimens had a foam discontinuity in each zone of maximum shear. All SIP specimens had

oriented strand board (OSB) facers with a thickness of 1.11 cm (7/16 in.). All OSB materials were certified, and grade stamped in accordance with APA – the Engineered Wood Association Product Report PR-N610. The OSB facers were full-length and contained no end joints. Short duration 1/3-point bending tests were performed on one half of the specimens, per American Society for Testing and Materials standards. The other half of the specimens was subjected to a 90-day creep test, followed by short duration 1/3-point bending tests. The results of the analysis of variance indicated that no statistically significant differences were detected in the matched static bending specimen P_{max} values before versus after creep testing in either SIPs depth class. The results of Δy_{max} showed statistically significant differences in both depth class.

Keywords: Structural insulated panels (SIPs), duration of load testing, bending test, building products, construction materials

TECHNICAL SESSION VII: NEW AND EVOLVING OPPORTUNITIES FOR WOOD

Moderator: Dr. Rich Vlosky, Louisiana-State University

THERMALLY MODIFIED HARDWOOD: A SUSTAINABLE ALTERNATIVE

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Abstract

Many methods exist to modify wood to improve its material properties for architectural and exterior applications. Thermal modification (TM) improves the durability, dimensional stability and modifies color. TM is performed by heating the wood in lack of oxygen at temperatures between 180 °C and 220 °C. Thermally modified wood (TMW) has been commercially available since the early 1990s in Europe, where it was developed as an alternative to tropical hardwoods and preservative-treated wood for exterior applications. TMW products provide opportunities for the use of low-value timber due to their increased performance against biological organisms and increased dimensional stability, leading to increased value.

The authors evaluated the properties of several low-value Appalachian hardwoods to determine the effect of TM on physical and mechanical properties. In addition, they evaluated the differences in TMW properties for several commercial processes. The properties investigated include hardness, MOE, MOR, decay resistance, termite resistance, adhesive bond shear strength, adhesive bond durably, dimensional stability, and equilibrium moisture content (EMC).

The effect of TM varied between species, however, thermal modification led to the darkening of the wood, increased dimensional stability, reduced EMC, and increased decay resistance but no increase in termite resistance. TM led to increased modulus of elasticity and decreased modulus of rupture, and the impact on hardness varied with species. The shear strength of polyurethane and polyvinyl acetate bonded material was approximately 30% lower than that of unmodified samples; however, the observed wood failure was over 88%, indicating good adhesion characteristics. For commercial applications, several physical and mechanical properties were shown to have statistical differences between the processes. However, the mean differences were numerically small. They would have a limited impact on the actual performance of the products, negligible when compared to un-modified samples of the same species. By increasing our understanding of how TM impacts wood properties and the variability between different commercial processes of different Appalachian hardwoods, we can provide useful information to users.

Keywords: Thermally modified wood, thermal modification, hardwoods, mechanical properties

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MASS TIMBER TODAY: SUCCESSES, CHALLENGES & OPPORTUNITIES

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Abstract

This presentation provides insight into the growing Mass Timber industry. The US Forest Service Wood Innovations Program has funded over $55 million to stimulate and support the mass timber marketplace since 2014. We continue to support opportunities related to education, technical assistance, research and code, and initiatives mass timber projects. There are over 1700 buildings in the U.S. that were built using mass timber. Cities like Boston, New York City and Atlanta are encouraging the use of mass timber to reduce the carbon footprint of new buildings. Mass timber is being considered more and more as an opportunity to build green affordable housing in both rural and urban communities. The Forest Service along with its many, many partners such as Woodworks, ThinkWood and the Softwood Lumber Board are continuing to support and invest in these and other initiatives. There is still a lot of work to be done with mass timber, but it is moving in the direction of a long-term stable market opportunity to support healthy forest management.

Keywords: Mass timber, industry status, growth, challenges, successes

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WHAT DO PEOPLE REALLY THINK ABOUT ENVIRONMENTAL, SOCIAL, AND ECONOMIC IMPACTS OF THE WOOD PELLET INDUSTRY

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No Abstract Available

ENVIRONMENTAL, SOCIAL, AND ECONOMIC IMPACTS OF THE WOOD PELLET INDUSTRY IN THE U.S. SOUTH: PERCEPTIONS OF RESIDENTS LIVING NEAR PELLET PLANTS VS. URBAN RESIDENTS

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Abstract

This presentation provides insight into the wood pellet manufacturing industry from residents' perspectives in the US South, focusing on environmental, social, and economic constructs. The region is the world's largest producer and exporter of wood pellets. We investigate in-depth socio-economic dynamics and fill a gap in knowledge of the human dimension relationships between the wood pellet industry and public perceptions in the US South. Two rounds of a web-based survey were sent to 7,500 residents in the two pellet-producing sub-regions within the US South: the Gulf Coast (Louisiana and Mississippi) and the Atlantic Coast (South Carolina, North Carolina, and Virginia). Within these regions, surveys were sent to randomly selected residents, by zip code, 18 years or older, who live within a 50-mile radius of selected pellet mills (*rural*) or in the two largest Metropolitan Statistical Areas (MSA) (*urban*) within each state containing a pellet mill. We'll share public perception comparisons for: (a) Urban vs. Rural and (b) Gulf Coast vs. Atlantic Coast regions.

Keywords: Wood pellet industry, resident perceptions, environmental, social, and economic impacts

TECHNICAL SESSION VIII: STRUCTURAL WOOD MATERIALS II

Moderator: Dr. Sergei Medved, University of Ljubljana

INNOVATIVE CONSTRUCTION MATERIAL FOR BUILDING ENVELOPES: COLD-FORMED WOOD-BASED CORRUGATED PANELS

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Abstract

In the current study, a corrugated core was developed for a wood-based sandwich panel using compression molding with a cold-forming process. Commercial plywood was layered to form a corrugated shape mold. The corrugated core for the sandwich panel was formed using THIS wooden mold by compression molding of four plies of southern yellow pine (*Pinus spp.*) veneer with an average thickness of 4mm. Likewise, the face sheets of the sandwich panel were fabricated using three plies of the veneer from the same batch. Flat panels were made using consistent veneer in number, thickness, and orientation to investigate the influence of the corrugated core on the structural performance of the sandwich panel. A four-point bending test was conducted on both sandwich panels and flat panels. An increase of bending stiffness by 1741% was observed in THE sandwich panels compared to the flat panels. Likewise, the result from the bending test was also compared with the other commercial building materials from other studies such as Structural Insulated Panels (SIPs), Stud walls, and Sandwich panels made from a hot-pressing technique. The cold-formed sandwich panels performed better than the commercial building materials having a higher structural performance.

Keywords: Cold-forming process, corrugated core, sandwich panels

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TECHNICAL SESSION IX: VALUE-ADDED TECHNOLOGIES

Moderator: Dr. Anton Astner | The University of Tennessee

DESIGN OF DECORATIVE WOODEN WALL PANELS FROM PRODUCTION RESIDUE OF SLAVONIAN OAK VENEER USING DESIGN ELEMENTS AND PRINCIPLES

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Abstract

Wood is a beautiful natural material with a unique visual appearance. There are no two identical pieces of wood in nature, therefore we consider wood a special material, and its application creates the impression of a unique product. This work connects two fields - design and wood technology and shows how we can use the unique visual aesthetics of wood material, which in terms of production and technology is considered waste and in the industry is treated as the residue of the lowest quality raw material (for firewood), while in the visual-aesthetic design approach it achieves various interesting decorative appearances. These appearances create the foundations for the development of new products of potentially high aesthetic and economic value. The paper investigates the natural appearance of oak veneers (*Quercus robur L.* subsp. slavonica) as unique wooden motifs for the purpose of implementing and developing decorative wall panels and their use in interiors. The principles of aesthetics - elements and principles of design are applied and connected with the appearances of the observed residue oak veneer in order to form visually unique decorative wall panels with more added value. The results present conceptual ideas of decorative wall panels made of veneer with different appearances and their possible arrangements in interiors using Adobe Photoshop and Fusion 360 computer programs.

The research is carried out as part of the project "Research and development of innovative wooden wall coverings, partitions and load-bearing walls for sustainable construction in Spačva doo", KK.01.2.1.02.0244, financed by the European Fund for Regional Development in Croatia OP Competitiveness and Cohesion 2014-2020, Strengthening the economy by applying research and innovation.

Keywords: Slavonian oak veneer; veneer production technology; use of wood residue; decorative wall panel design; design elements and principles

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TRENDS IN THE GENERATION OF WOOD WASTE FROM THE EUROPEAN WOOD INDUSTRY SECTOR

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Abstract

The increase in the amount of waste and poor waste management contribute to climate change and air pollution and directly affects many ecosystems and species. Wood is a natural, renewable, and sustainable material for building. Maximizing wood use in both residential and commercial construction could remove an estimated 21 million tons of C02 from the atmosphere annually equal to taking 4.4 million cars off the road. At European level, the priority is the optimization of the collection and aggregation processes of scraps, in order to have quantities of recycled wood sufficiently large to guarantee the economic viability. The importance of protecting our living space is one of the most important problems in modern times. The European Union, in numerous documents, presented the concept of sustainable development, which introduces a systematic solution to the issue of environmental protection, sustainable consumption and production, waste management in an environmentally friendly way and the process of informing the public about negative impacts and the production of environmentally friendly products. For example, Finland has become an icon on the use of wood for the development of bio-economy and circular economy aiming to carbon-neutral society. Wood waste utilization and recycling in wood manufacturing not only has environmental benefits but also economic benefits by reducing waste, conserving resources, and creating new markets for recycled wood products. Adoption of sustainable practices in wood manufacturing can also help companies meet customer demands for sustainable products. Recycling in wood manufacturing can create new jobs in several areas, including collection, processing, and manufacturing. Moreover, reusing materials can also extend the lifespan of equipment and machinery. The objective of this work is to analyze the trends in the generation of wood waste from the European wood industry sector based using a secondary data provide by Eurostat in order to encourage all relevant stakeholders to think better about potential of wood waste and its re-use. In 2020, in the EU 27, 48,28 million tons of wood waste was generated in comparison to 2010 when the amount of generated wood waste was 56,2 million tons. Further, in 2020, over 89% of the aforementioned amount was produced by economic activities other than households, with the largest wood waste-producing sector

being the manufacture of wood and of products of wood and cork (except furniture; manufacture of articles of straw and plaiting materials) with 24,81%, followed by construction (17,79%) and manufacture of paper and paper products (5%). Although 96,11% of the EU-27's wood waste generated was non-hazardous, there is still a small share of hazardous wood waste generated in Europe, generally used for energy production, which requires disposal at specialized facilities.

Keywords: European Union, wood waste utilization, energy production

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BIO-BASED SOLUTIONS FOR CONTROLLED-RELEASE OF AGRICHEMICALS

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Abstract

In the agricultural industry, one of the most important activities is the delivery of nutrients and pesticides to the soil and crops to optimize performance. Currently, this is achieved through the use of polymer carriers obtained from fossil fuels, which possess environmental risks and contribute to global carbon emissions. Cellulose-derived products are gaining recognition in scientific and commercial fields due to their wide availability, renewable nature, and versatility in film, bead, and coating processing. This study focuses specifically on cellulose-based assemblies, due to their notable characteristics including large surface area, significant porosity and renewability as well as potential biodegradability. In this presentation, strategies of the use of a variety of cellulose materials as carriers of pesticides will be discussed. Data on greenhouse and in-field studies shows that cellulose could extend pesticide's half-life and efficacy in tree species, which could result in decreased application rates, positively impacting both cost and environmental health.

Keywords: Agricultural industry, cellulose-derived products, environmental health

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TECHNICAL SESSION X: INDUSTRY UPDATES ON NEW STARTUPS

Moderator: Dr. Scott Leavengood, Oregon State University

NO ABSTRACTS FOR THIS TECHNICAL SESSION

REDUCTION OF MULTIPLE-PIECE BAT FAILURES IN MAJOR LEAGUE BASEBALL

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ROSEBURG FOREST PRODUCTS UPDATES

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TECHNICAL SESSION XI: ALTERNATIVE TECHNOLOGIES

Moderator: Dr. Brian Bond, Virginia Tech

THE TIMBERLOOP-PROJECT: CHEMICAL CONTAMINATION AS AN OBSTACLE FOR TIMBER RE-USE

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Abstract

TimberLoop is a fundamental research project dedicated to the circular use of solid wood (https://www.holzforschung.at/en/research-development/project-list/details/timberloop/). Development of the currently linear-oriented wood working industry with embedded downstream cascade use (e.g. particle board, energy) towards a circular economy is strongly driven by European politics (i.e. EU-Green Deal). The current practice though entails a huge number of unsolved obstacles. Re-use of wood and wooden products which are not subjected to massive structural degradation offers the potential to save resources, energy and CO_2. Starting now, building products, constructions or even whole objects should thus be designed for re-use. The reuse of non-circular resources is far more complex.

Compared to new wood products wooden products from earlier use require new considerations concerning quality control. One of these is the chemical composition. On the one hand recovered wood may show natural alteration in terms of photocatalytic or biochemical degradation, that might influence re-use on a technical level. On the other hand, contaminations may occur due to original treatments, retrofitting, accidents or environmental migration.

Depending on the source and planned application, several laws, certification schemes or other regulations may apply and define threshold values e.g. for heavy metals or specific organic substances. However, neither sampling specifications nor specific selection and definition of substances and thresholds is available for high-level reuse of wood.

TimberLoop offers deep insight to common wood contaminations and their depth profiles. The project aims i.a. to develop a practical oriented decision tool for reasonable chemical analytics to be executed for the re-use of wood. While the project also addresses other issues such as the assurance of full functionality, new business opportunities arise for the wood-working industry. Holzforschung Austria cooperates with companies from business areas such as timber construction, parquet flooring, wooden windows, surface treatment, recovery, planning, and research to increase knowledge in the circular use of construction wood.

Keywords: Re-use, timber, wood preservatives, fire retardants, contamination

SODIUM POLYACRYLATE – AN ULTRA-LOW DOSE STRENGTH ADDITIVE FOR WOOD PANELS

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Abstract

Sodium polyacrylate (PA) is a common absorbent used in products like baby diapers because it can easily absorb and retain approximately 100 times its weight in water. The high retention means that only ultra-low dosages are necessary resulting in low PA costs. pMDI is an adhesive in which isocyanate reacts with water to form carbon dioxide resulting in reaction and crosslinking. During manufacturing, the wood is often dried to 2 to 8% moisture content depending on the product and process and thus the water at the bondline might be limited. Our hypothesis suggests that PA could be mixed with water and pMDI to keep water local to the bondline resulting in better bonding between the wood substrate. Lab results support this hypothesis and show higher dry strength properties. When PA is mixed with pMDI, bubbles were observed, indicating a release of CO_2 and consequently indicates the presence of a reaction. This presentation will show our preliminary results for this new technology.

Keywords: Sodium polyacrylate, pMDI, water, reaction

DEVELOPMENT OF A NATURAL WOOD PRESERVATIVE SUITABLE FOR WOOD COMPOSITE PRODUCTS

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Abstract

The incorporation of additives during the production of wood composites could interfere with the bonding strength development between wood and adhesive and potentially compromise the structural performance of wood composite products. This study is focused on the preparation and incorporation of natural preservatives into wood composites and their influence on the mechanical strength of the wood composites. The natural preservative was synthesized by incorporating essential oils (EOs), including *trans*-cinnamaldehyde (*t*CN), carvacrol, thymol, and eugenol, into β-cyclodextrin (βCD), a starch derivative, using an ultrasonication method to form βCD-EO inclusion complexes. The formation of the inclusion complexes was confirmed by using attenuated total reflection Fourier transform infrared spectroscopy and X-ray diffraction analysis, while the inclusion yield of βCD-EOs was estimated using thermogravimetry analysis and UV-visible spectrophotometry (UV-vis). The estimated inclusion yield at a production scale of 2 g ranged from 113% to 142% and from 64% to 101% by UV-vis and TGA, respectively. A similar inclusion yield was achieved with the production scale to 25 g. The influence of βCD-EOs as an additive on the viscosity and bonding strength of polymeric methylene diphenyl diisocyanate (pMDI) resin was tested by adding βCD-*t*CN at 3%, 5% and 7.5% loadings to pMDI. The viscosity was measured using TA Instrument Rheometer (AR 1500 ex) while the bonding strength of the pMDI resin with βCD-*t*CN was assessed by a lap shear strength test using 3-ply Southern yellow pine plywood, following ASTM D906-20. The viscosity of pMDI only increased by up to 23% while the average shear strength of all panels ranged between 1.5 N/mm^2 to 2.1 N/mm^2, exceeding the minimum requirement of 1.0 N/mm^2 for characteristic shear strength for cross-layer bond lines, according to the European standard EN 16351. This performance indicates that βCD-EOs inclusion complexes could be implemented in the manufacturing process of wood composite products.

Keywords: Natural wood preservatives; Inclusion complexes; Viscosity; Bonding strength; Wood composite products

ADVANCING AMAZON TIMBER INDUSTRY: SPECIES DIVERSIFICATION FOR LONG-TERM VIABILITY

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Abstract

The Brazilian Amazon, renowned for its extraordinary biodiversity, harbors an astonishing array of species. Surprisingly, a mere 2% of the wood species available on the market dominate a substantial 50% of the timber industry's production volume. This high logging of a restricted number of species challenges their long-term commercial viability, potentially putting the productivity of production forests at risk. Thus, diversifying the commercially managed species becomes crucial in fortifying the forest sector's sustainability At Instituto de Manejo e Certificação Agrícola e Florestal (IMAFLORA), we spearheaded a groundbreaking effort to compile a list of lesser-known or underutilized species within forest management. We meticulously gathered quantitative data on the production of proposed species from official Brazil forest control systems' databases. This included the invaluable forest guides provided by IBAMA through the DOF/SINAFLOR system, SISFLORA Mato Grosso, and SISFLORA Pará, spanning from January 2007 to December 2020. Next, we applied four key criteria to pinpoint the most promising species. We considered their abundance in the forest, threat level, current logging rates, and our collective knowledge regarding their wood characteristics. This

method resulted in a curated selection of 30 species, offering a diverse range of choices based on factors like basic density ($310 \leq \rho \leq 880$ kg/m^3) and aesthetic appeal. While similar lists of alternative species to the most commercialized exist, this work distinguishes itself by focusing on species with genuinely low logging activity in recent years, bypassing the subjective assessments often associated with existing lists driven by perceived demand. In our study, we provide a comprehensive overview of the wood properties of these forest species and their potential applications. Additionally, we present a proposed comparative table between the most heavily harvested timber species in the Amazon and the promising species aligned with current markets based on wood density. To advance the industrial timber sector's diversification efforts, we advocate for rigorous field identification of managed species, investigations into the occurrence and prevalence of promising species in production forests, consolidation of knowledge regarding their attributes, experimentation with wood technology to enhance specific properties, and the dissemination of these promising species throughout the production chain.

Keywords: Sustainability, forest management, logging, production