Development of an Energy-Efficient, Sustainable Low Temperature Wood Densification Process for Enhanced Material Performance

Summary

The overall goal of the project is to improve the mechanical and physical characteristics of low-quality hardwood species by the densification process, thereby increasing their value. Sustainable chemical modifications and energy efficient low temperature methods will be investigated for densification process and properties will be evaluated. As a result, more low-quality underutilized wood species will be used to create innovative engineered wood products. The project addresses the following research questions: What are the suitable green chemistry approaches for wood densification? How low temperatures can be used for wood densification? Does all the wood species behave the same way in densification process? What are the effects of dedication to wood structure and properties? How to enhance the wood densification process for more efficiency?

Research field:	Chemical, materials and energy technology
Supervisors:	Dr. Heikko Kallakas Triinu Poltimäe
Availability:	This position is available.
Offered by:	School of Engineering Department of Materials and Environmental Technology
Application deadline:	Applications are accepted between June 01, 2025 00:00 and June 30, 2025 23:59 (Europe/Zurich)

Description

The research

This PhD project focuses green chemistry pretreatment of wood before densification to optimize the densification process and lower the densification temperature. The aim is to develop sustainable wood densification method for underutilized wood species and evaluate densified wood properties through dimensional stability, surface properties, mechanical properties and bonding quality.

The project will address the following key areas:

1. Green Chemistry Pretreatment – Developing environmentally friendly pretreatment methods to enhance the wood densification process.
2. Optimization of Densification Process – Reducing the densification temperature while maintaining or improving efficiency.
3. Sustainable Utilization of Underutilized Wood Species – Expanding the potential of lesser-used wood species through densification.
4. Dimensional Stability – Evaluating how well the densified wood resists swelling and shrinking, and spring back.
5. Surface Properties – Investigating changes in texture, roughness, and wettability after densification.
6. Mechanical Properties – Assessing improvements in strength, hardness, and durability of densified wood.
7. Bonding Quality – Analyzing the adhesion performance of densified wood for veneer-based procuts.

The outcomes of this research are expected to valorize underutilized wood species through energy efficient densification process. By providing environmentally friendly densification process, this project aims to drive innovation in the field of veneer-based products and contribute to the sustainable materials industry.

Responsibilities and (foreseen) tasks

- Compile an analytical framework for examining experimental approaches to analyze green chemistry wood pretreatment methods before densification.
- Study and test the low temperature densification process technologies.
- Test and characterize the structure, moisture resistance, dimensional stability, surface and properties.
- Study and characterize the bonding quality of densified wood suitable for veneer-based products.

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- Writing and publishing scientific papers for the project results in peer-reviewed journals and conference presentations.
- Contribute to the organization of research and practitioner workshops where project findings are presented

Applicants should fulfil the following requirements:

- Master´s degree in the field of wood technology, wood science, materials technology and science, wood chemistry, forestry.
- Familiar with methods, procedures and safety of wood chemistry, wood technology or composite material technology, materials technology and science which allows to work independently
- Excellent communication skills (written and spoken) in English
- A clear interest in the topic of the position
- Strong and demonstrable writing and analytical skills
- Capacity to work both as an independent researcher and as part of an international team
- Capacity and willingness to assists in organizational tasks relevant to the project

(The following experience is beneficial:)

- Previous experience in wood technology or materials technology and science would be highly appreciated.
- Previous experience in the most relevant characterization methods (surface roughness, contact angle measurement, tensile and flexural tests) is also expected.
- Previous knowledge about durability testing of the materials.
- Previous knowledge of material structural characterization.
- Working knowledge of data analysis and statistics.
- Data visualization and analysis in R

The candidate should submit a research plan for the topic, including the overall research and data collection strategy. The candidate can expand on the listed research questions and tasks, and propose theoretical lenses to be used.

We offer:

- 4-year PhD position in one of the largest, most internationalized and leading engineering and technology research centers in Estonia.
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of wood and composite materials technology and wood chemistry.

About the department

Department of Materials and Environmental Technology is an interdisciplinary research center of Tallinn University of Technology that focuses to lead the high-level, internationally recognized teaching, research and development in Estonia in the field of materials and environmental technology.

(Additional information)

For further information, please contact Prof. Heikko Kallakas heikko.kallakas@taltech.ee or visit https://taltech.ee/en/department-materials-and-environmental-technology

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