Q-03-HA

Microwave heat treatment of wood: characterization and process optimization

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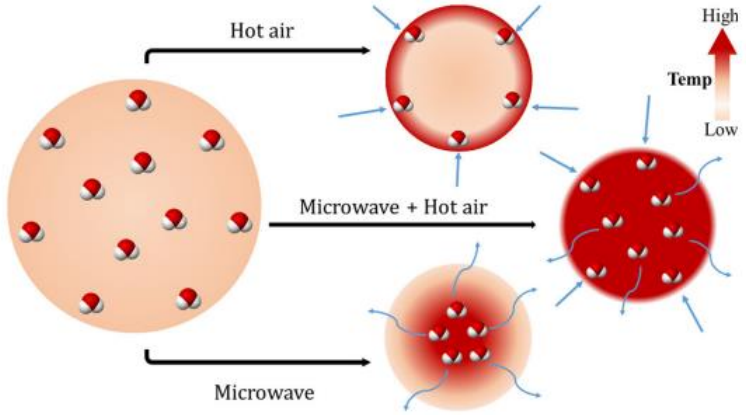
Anticipated Start Date: *October 2024* | Expected Duration: *9 Months*

Need & Industrial Relevance | Goals & Objectives

Need & Industrial Relevance

Industrial applications of microwave (MW) treatment of wood products in drying or adhesive activation has been receiving an increased interest in recent years. However, the impact of the treatment on the chemical and physical changes and how these changes affect the bond strength of wood composites, remains unclear. Investigating such effects will provide valuable insights and knowledge to motivate further advancements in wood treatment processes.

Why MW heating?



Karimi et al. Heat and Mass Transfer (2021) 57:133-146

Research Roadmap Topics **TOPIC 2024-09**

Long Term Goals

The overarching goal of this project is to develop an understanding and assess the potentials of microwave treatment of wood and how this impact the bonding quality of the prepared wood composites. This will be achieved through an experimental approach integrated with a predictive models.

Objectives

- Treat wood samples in a bench-scale MW.
- Characterize MW-treated samples.
- Conduct a modeling study to predict, optimize and maximize the efficiency of the MW treatment process.
- Use MW-treated samples to prepare glued specimens.
- Assess the impact of MW treatment on the bond performance of glued specimens.

Materials and Methods

Samples preparation	Solid lumber or veneer samples from Douglas fir (other wood species may be considered based on discussions with technical advisors).
Microwave treatment	The treatment will be conducted in a bench-scale microwave (Max power 1000 W). Various moisture contents and microwave powers will be studied.
Samples characterization	Microscopy: to assess the microstructure of treated samples vs control. FTIR: to examine functional groups on the surface and throughout the sample thickness. Contact angle analysis for surface properties. Dimensional stability assessment by exposure to humid air and thickness swelling (ASTM D1037) .
Bond performance evaluation	Depending on the type of treated specimens, lap shear or block shear specimens will be prepared using a commercially available adhesive (PF adhesive or as suggested by the technical advisors). ASTM D906/D4501.

Modeling

- A preliminary electromagnetic-thermal coupled modeling method of microwave heating process will be developed.
- Physical and thermal properties of materials will be obtained from lab database or literature.
- Heat transfer mechanisms of microwave and conventional heating processes will be analyzed.
- Temperature distribution in the wood samples under microwave and conventional heating will be predicted.
- Platform for microwave heating simulation: Elmer FEM multiphysical simulation software (finite element simulation)
- Platform for conventional heating simulation: Abaqus (finite element simulation)

Outcomes and Deliverables

Expected Outcome	Deliverable (s)	2024											2025										
		J	F	M	A	J	J	A	S	O	N	D	J	F	M	A	J	J	A	S	O	N	D
Samples treatment	- Samples preparation - MW treatment																						
Characterization of MW-treated samples	- Morphology - Surface characterization - Dimensional stability																						
Modelling	- Process prediction and optimization																						
Bond performance evaluation	- Shear strength of bonded specimens																						
Dissemination	- WBC report - Publication in peer reviewed journal																						

Expected Practical Implications/Impacts

This project aims to understand how MW treatment affects various properties of wood, evaluate the changes occurring during the treatment, and determine how these changes could influence the quality of adhesive bond formed with the treated wood.

The expected practical implications and impacts are as follows:

- Enhance our understanding of chemical and physical changes of MW-treated samples compared to samples treated through conventional methods.
- Bond performance evaluation of the MW-treated samples.
- Predictive model of heat transfer mechanisms in microwave heating vs conventional heating to optimize the process and maximize efficiency.
- Provide a knowledge base that could be useful for other applications of MW treatment (e.g., heat-induced crosslinking reactions).

- Potential challenges: Monitor the temperature inside the wood during microwave treatment.
  - Make use of modeling results.
  - Find commercially available sensors.

Budget

- Graduate student support.
  - Stipends and benefits.
  - Travel will be supported by the PI.
- Materials donation will be asked from members.

BUDGET	AMOUNT
First Year Expenses	
GRA & Benefits	$17,000
Tuition & Fees	$5,500
Materials/Supplies	
Travel	
Other (specify):	
YEAR 1 TOTAL:	$22,500
Expected future request amounts:	$

Thank You

Questions?