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Exploring the solid wood modification with preserved hierarchical structure via non-cellulosic substances removal

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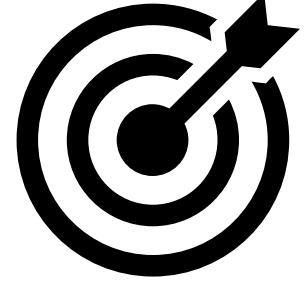
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Introduction

Innovations in wood modification technology have led to the development of novel functionalities and enhancements to the existing advantages of wood. The removal of non-cellulosic substances creates a low-density porous cellulose scaffold with reduced thermal conductivity [1]. Despite various top-down wood delignification methods, there has been a lack of comparative analysis. Additionally, scaling up production using freeze-drying technique presents challenges.

Objectives

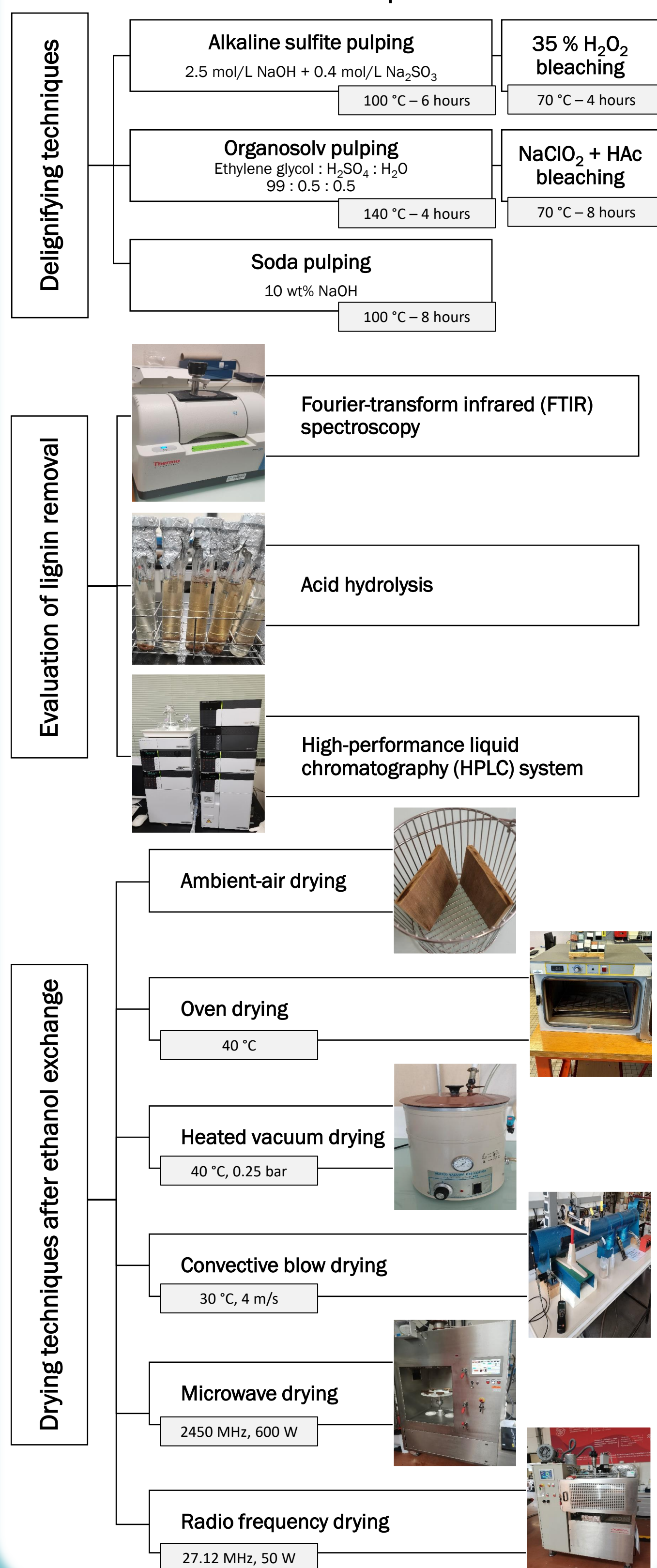


- To evaluate the degree of non-cellulosic substances removal among three delignification techniques
- To identify potential drying techniques for large-scale production



Materials & Methods

French poplar wood planks of 100 mm along the grain and 100 mm by 10 mm section in the transversal plane were used.



Results & Discussions

❖ Degree of lignin removal

- The decreasing intensity of the peaks at 1730 and 1240 cm⁻¹ assigned to acetyl functional groups was a result of hemicellulose removal [2]. Organosolv & NaClO₂ treatment led to the disappearance of the peaks at 1508, 1465, and 1264 cm⁻¹, indicating the absence of lignin.
- A higher treatment temperature, treatment duration or delignifying solution concentration may be required for NaOH and alkaline sulfite & H₂O₂ modification.
- The high glucose content was maintained in all modified wood, suggesting that cellulose was not much affected by the treatments, only lignin and hemicellulose were preferentially altered.

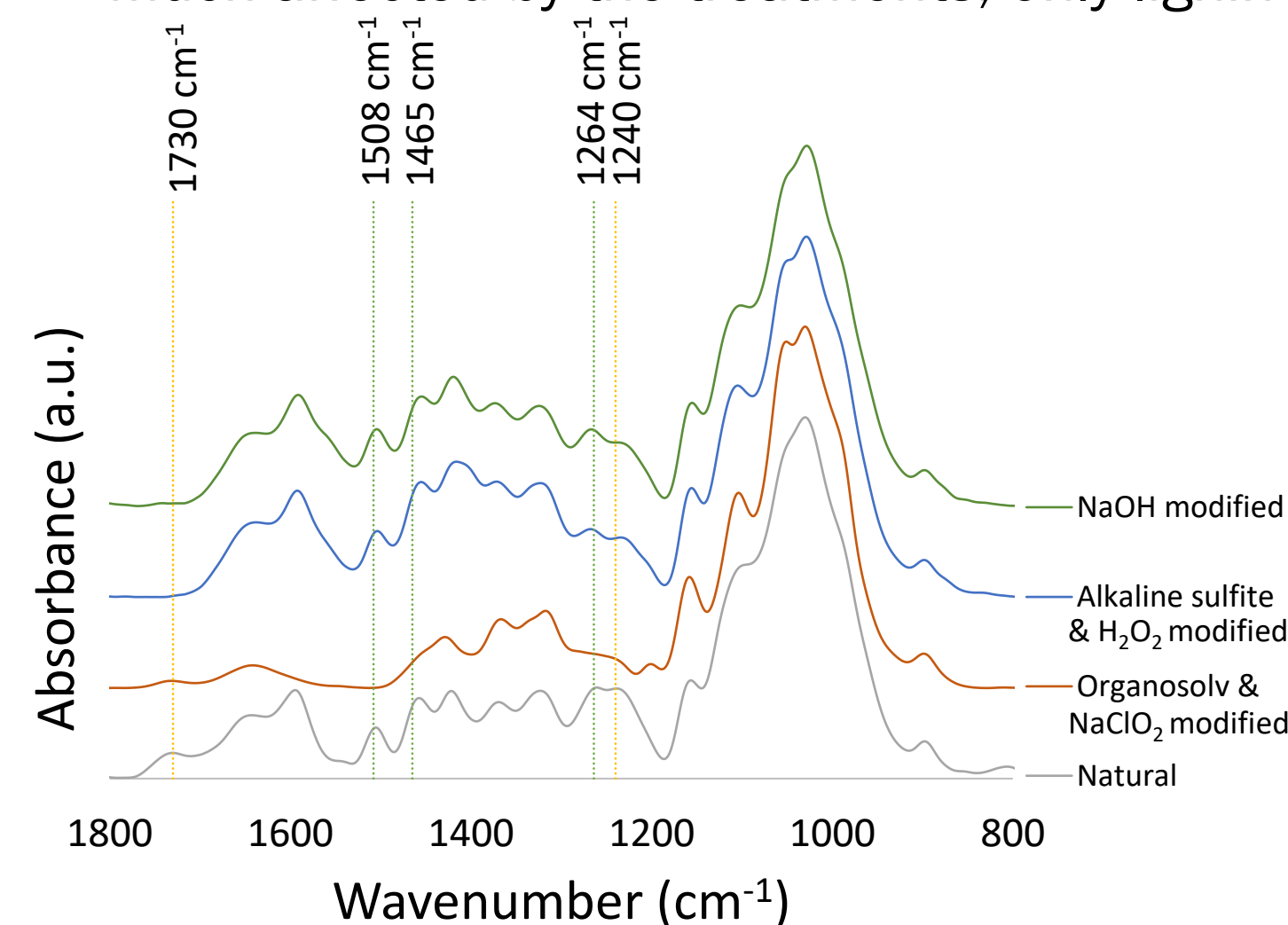


Fig. 1: FTIR spectra of poplar wood under different modification treatments.

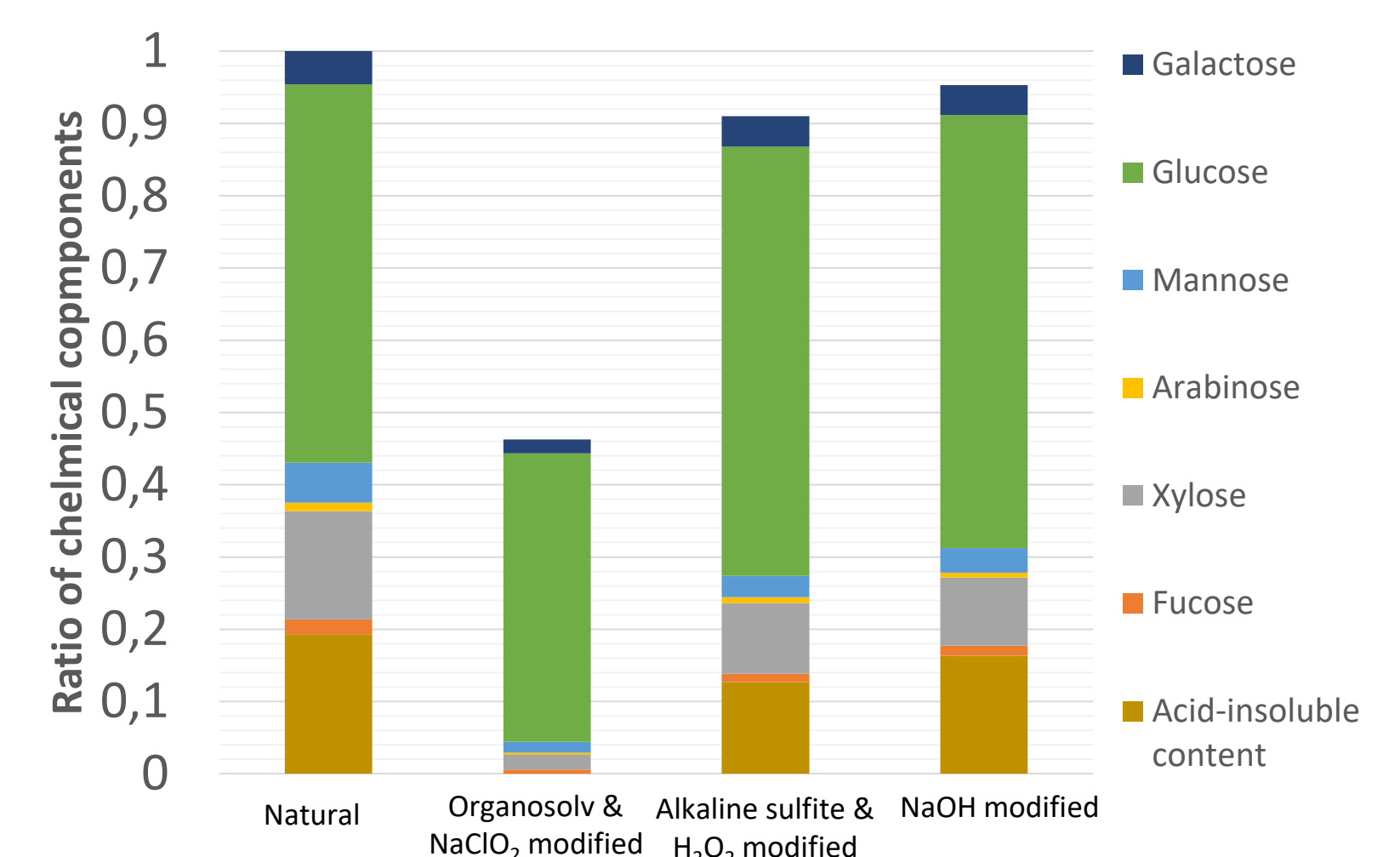


Fig. 2: Ratio of chemical components in poplar wood before and after modification treatments.

❖ Drying kinetics

- For all drying methods, the drying rate decreases as the moisture content of samples reduces.
- Dielectric heating (microwave and radio frequency) is the fastest drying technique, yet it causes great dimensional shrinkage despite organic solvent exchange.

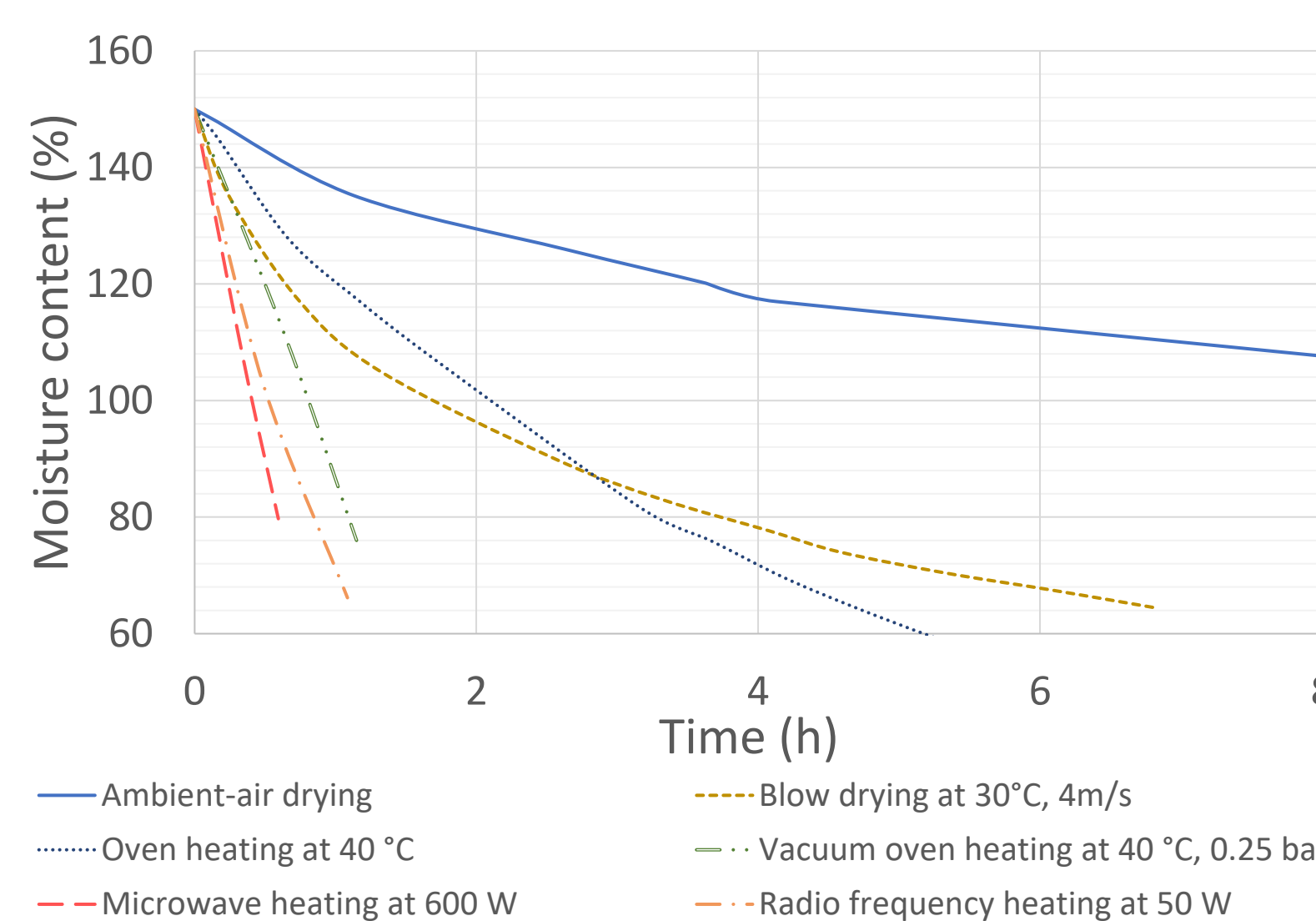


Fig. 3: Moisture content evolution of NaOH modified wood by different drying techniques.

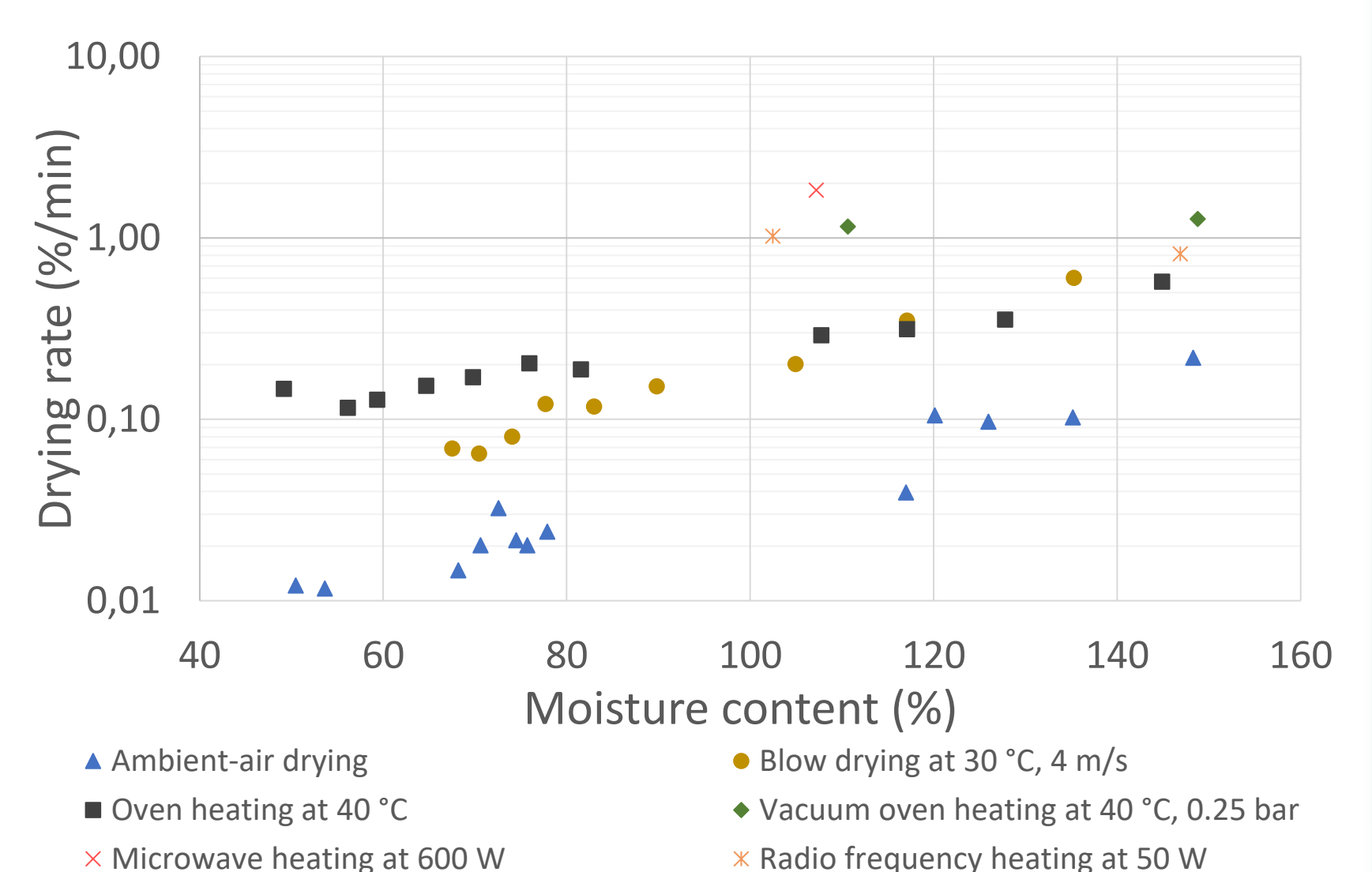


Fig. 4: Drying rate at logarithmic scale of different moisture contents for each drying technique.

Conclusions & Perspectives

- ❖ **Organosolv & NaClO₂ modification**, alkaline sulfite & H₂O₂ modification and NaOH modification appear to be the most to the least lignin removal efficiency respectively.
- ❖ **Dielectric heating** has the highest drying rate across all moisture contents whereas **convective blow drying** exhibits the lowest sectional shrinkage.
- ❖ The information reported allows a better understanding of wood modification and drying mechanisms for the design of appropriate manufacturing procedures.
- ❖ Future investigations should focus on the effects of delignification on the thermal, mechanical, and hygric properties of the French poplar wood.

Acknowledgments

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