Contribution ID: **170**

Type: **Oral Presentation**

Bound water transport by diffusion in wood revealed by Nuclear Magnetic Resonance

Tuesday, 20 May 2025 14:35 (15 minutes)

Wood's unique combination of low density, high strength and stiffness, low thermal and electrical conductivity makes it versatile across diverse fields such as construction, furniture making, woodcarving, tooling, sculpture, boat building, along with production of cellulose fibers and paper. However, as a hygroscopic material, the water content and transport within wood strongly affect the structural performance of wood across diverse contexts. Therefore, understanding the physical mechanisms underlying water transfer processes in wood is crucial for optimizing its applications. This appears challenging considering that wood is a porous medium containing water in a range of pores of size from about 100 microns to less than a nanometer, i.e., the bound water, which plays a fundamental role in water transport in wood [1-2]. Here we present a unique set of results concerning imbibition and drying of wood which allow to fully quantify the bound water transport properties.
Water imbibition within the microstructure of cubic samples was examined using nuclear magnetic resonance (NMR). Dynamic NMR relaxometry enables to differentiate the water in fibers, vessels, or as bound water in cell walls, enabling quantification of these water fractions over time. It was observed that water initially penetrates as bound water, followed by slower infiltration into fibers and subsequently into vessels, which exhibit the slowest rate of invasion. Given that bound water penetrates prior to free water, a global diffusion coefficient of bound water can be estimated based on measurements across different directions [3]. To further investigate the potential coupling between the invasion of various pore types, we isolated the diffusion of bound water by saturating the sample vessels with oil. Remarkably, our measurements show that the diffusion coefficient of bound water alone is independent of the water content, independent of the direction through the wood, almost independent of the wood species, and varies exponentially with the inverse of the temperature, suggesting that bound water diffusion behaves as an activated process.

Country

France

Acceptance of the Terms & Conditions

Click here to agree

Student Awards

Water & Porous Media Focused Abstracts

This abstract is related to Water

References

[1] M. Zhou, S. Caré, A. King, D. Courtier-Murias, S. Rodts, G. Gerber, P. Aimedieu, M. Bonnet, M. Bornert, and P. Coussot, Wetting enhanced by water adsorption in hygroscopic plantlike materials, Phys. Rev. Research 1, 033190 (2019) [2] M. Cocusse, M. Rosales, B. Maillet, R. Sidi-Boulenouar, E. Julien, S. Caré, P. Coussot, Two-step diffusion in cellular hygroscopic (plant-like) materials, Science Advances, 2022, 19, eabm7830 [3] L.Yan, E. Julien, R. Sidi-Boulenouar, B. Maillet, P. Coussot, Water penetration in the microstructure of hardwood revealed by NMR relaxometry, Wood Sci Technol (under review)

Primary author: YAN, Luoyi (École nationale des ponts et chaussées; Laboratoire Navier,)

Co-authors: Dr SIDI-BOULENOUAR, Rahima; Mr MAILLET, Benjamin (Laboratoire Navier, Université Gustave Eiffel); COUSSOT, Philippe (Univ. Paris-Est)

Presenter: YAN, Luoyi (École nationale des ponts et chaussées; Laboratoire Navier,)

Session Classification: MS13

Track Classification: (MS13) Fluids in Nanoporous Media