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

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Wood is extensively applied in various fields such as construction, tooling, sculpture, boat building. The water content within wood plays a crucial role in influencing its performance across different contexts. For example, a large portion of water must be removed from wet or green (fresh cut) wood to mitigate further dimensional variations under varying humidity conditions. In this context, the transport of bound water (absorbed between cellulose microfibrils, up to 30% of the dry mass, and at the origin of swelling) plays a fundamental role. However, measuring these transport properties is challenging as this bound water is contained in nanopore inclusions. Moreover, it was shown that during standard imbibition there is a strong coupling between bound water and free water [1-2].

Here, for the first time, we develop experimental conditions allowing to prevent most free water (in vessels or fibers) imbibition in hardwood (oak and poplar). We then follow the progression of bound water by NMR relaxometry. This allows to determine in a straightforward way the diffusion coefficient of bound water. The results reveal that the transport diffusion coefficient of bound water in hardwood is rather large, typically in the order of 10-9 m2/s. More precisely, the diffusion in poplar occurs at a faster rate compared to oak samples. Additionally, we show that the fastest rates of diffusion are observed in the longitudinal direction, followed by the radial and the tangential directions. This research underscores the mechanisms and complexity of bound and free water transfer in bio-based materials and provides an insight into the processing and protection of wood.

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