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Capillary imbibition in wood governed by water adsorption in walls

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Water transfers through wood structure play a major role in wood behavior under various conditions such as drying, imbibition, sapflow, for which various problems may occur, such as shrinkage, cavitation, fracture, swelling. The physical understanding of these transfers is in some cases rather poor, as illustrated by the fact that it is still sometimes considered that the permeability of wood varies with the sample length, which would mean that it is not an intrinsic material property.
Here we focus on imbibition properties of wood (here hardwood) along the longitudinal direction. We first show that the dynamics of water penetration in hardwood exhibits a contradiction when it is considered within the standard frame of capillary imbibition: on one side we have a very slow dynamics a priori associated with an extremely poor wetting, on the other side the water is finally able to climb at a high level against gravity as for good wetting. This contradiction is confirmed by 3D Synchrotron images of the internal structure obtained during imbibition, which show that the liquid-air interfaces in the capillary vessels remain planar, which implies negligible Laplace pressure, but significantly advance along the vessels, again unexpectedly.
From further examination of the dynamics of water penetration and wood microstructure evolution from Synchrotron images and MRI measurements allowing to distinguish bound and free water, we show that this contradiction is explained by the adsorption of a slight amount of bound water in the cell walls, and at the origin of wood swelling. This adsorption governs the process: it momentarily damps wetting then allows further advance when the walls are saturated with bound water. Finally we definitely prove this mechanism with the help of experiments with model materials, i.e. hydrogels, from which both the ascent of free water and the adsorption and propagation of bound water may be directly observed.

References

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Primary author: Mr COUSSOT, Philippe (univ. Paris-Est)

Co-authors: Mr COURTIER-MURIAS, Denis (Univ. Paris-Est); Mrs ZHOU, Meng (Univ. Paris-Est); Ms CARE, Sabine (Univ. Paris-Est); Mr RODTS, Stéphane (Univ. Paris-Est)

Presenter: Mr COUSSOT, Philippe (univ. Paris-Est)

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