LadHyX Seminar – March 16, 10:45 – LadHyX library

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Pervaporation-induced drying of biomimetic leaves

The resistance of forests to drought is a growing concern in the context of global warming. Under dry conditions, the sap inside trees may cavitate, forming embolisms. These can grow, invade the sap network, and stop sap circulation if the atmospheric conditions remain dry. However, the physical processes governing this embolism propagation has remained hitherto elusive.

In this context, we propose a physical study to understand the growth of embolisms in a biomimetic leaf. Our biomimetic leaves comprises single channels or channel network of various complexity and topology, mimicking the vein network of real leaves. The channels are embedded in thin layers of PDMS, a material which is permeable to water, like the mesophyll of leaves. Starting from water-filled channels where an embolism is initiated at the entrance, we measure experimentally the dynamics of air invasion in such channels when placed in a dry atmosphere, by following the advancing air/water menisci. We provide a quantitative theoretical explanation of this dynamics, which is induced by pervaporation, i.e. by water transport by diffusion inside PDMS. This enables to capture the drying of single channels [1] and simple networks [2,3] with great accuracy.

Biological measurements show that air invasion is real leaves is intermittent. We show that such a dynamics is crucially related to the presence of constrictions between the cells constituting the sap network. By inserting single constriction in our biomimetic channels, we unravel the physical origin of the intermittency: owing to its geometry, the constriction pins the meniscus for a certain time. During the pinning phase, we show by confocal microscopy that drying contracts the channel cross-section, which reduces the water pressure, until a capillary threshold in reached and fast relaxation with a forward jump of the meniscus follows [4]. Preliminary experiments on several constriction in series, and their comparison with biological observations, will also be shown.

[1] B. Dollet, J. F. Louf, M. Alonzo, K. H. Jensen, P. Marmottant, J. R. Soc. Interface (2019).
[2] B. Dollet, K. N. Chagua Encarnacion, R. Gautier, P. Marmottant, J. Fluid Mech. (2021).
[3] K. N. Chagua Encarnación, P. Marmottant, B. Dollet, Microfluid. Nanofluid. (2021).
[4] L. Keiser, P. Marmottant, B. Dollet, J. Fluid Mech. (2022).