Funded by the European Union

# Postdoctoral Position

## Physics of water transfers in bio-based materials

Water transfers in bio-based materials such as wood, plants, paper, hair, natural textiles are essential in our everyday life, but their physics is still poorly known. A specificity of these materials is that they are hygroscopic, i.e., they can absorb, from vapor, a huge amount of water in the form of nanoscale water inclusions between the microfibrils of cellulosic or keratin fibers. This so-called “bound water”, which evaporates in a dry ambient air, is at the origin of the swelling or shrinkage of these materials. Moreover this bound water appears to be very mobile, i.e., it can diffuse throughout the material. The bound water diffusion and its exchanges with free (capillary) water and vapor, are key to the physics of water transfers in such materials, which in turn is key to reducing energy consumption for ventilation and heating, or controlling various processes such as the wetting or drying of such materials.

Our group has recently developed original approaches and tools that allow to clarify and quantify the role of bound water. They are based on the use of well controlled materials and a proper description of boundary conditions, along with the development of new NMR and MRI techniques [1] providing spatially and temporally resolved distributions of the water in its different phases. In particular, it was shown that the spontaneous capillary imbibition of water in a hardwood sample can occur only when the material is saturated with bound water, which slows down the global process by several orders of magnitude of time [2]. Also, the drying of a wood sample containing both free and bound water was shown to occur as a result of the extraction of the free water in depth, then the transport in the form of bound water up to the surface [3]. Such experimental data provide the basis for predictive models of diffusion as a function of the characteristics of the material structure [4].

The general objective of this postdoctoral work, within the framework of the ERC Advanced Grant PHYSBIOMAT (2023-2028), is to further quantify these transport processes and understand their physical origin. The work will rely on microfluidic and/or macroscopic experiments of sorption, drying, imbibition, with model systems such as cellulose fiber stacks possibly modified with physico-chemical or mechanical treatment. The candidate will also have the chance to use our NMR spectrometers and Magnetic Resonance Imager, to get detailed information on the water content inside the material or on the exchanges between bound water and free water in wood or cellulose fibers. The work will be carried out under the supervision of Ph. Coussot (http://philippecoussot.com) in collaboration with NMR experts in Lab. Navier: R. Sidi-Boulenouar and B. Maillet, with the support of the technical team of the lab, and in relation with several PhD students of the group working in related fields.

**Skills**: The candidate is expected to have a PhD, a solid background in physics and/or fluid mechanics, and achievements proving his/her strong motivation for research. Prior experience in NMR may be a plus, but is not mandatory.

**Duration**: Initial contract for 18 months, extendable to 3 years

**Location:** Laboratoire Navier, Univ. Gustave Eiffel campus, Champs sur Marne, France

**Gross salary**: 3000 euros per month

**Start date**: Late 2023 or early 2024. Selection process will start immediately and go on until the position is filled

**Application** to philippe.coussot@univ-eiffel.fr including a CV, list of publications and a short letter of motivation, along with the names of at least two references.

**References**:
[1] Maillet et al., *Langmuir*, 38, 15009−15025 (2022)
[2] Zhou et al., *Physical Review Research*, 1, 033190 (2019)
[3] Cocusse et al., *Science Advances,* 8, eabm7830 (2022)
[4] Zou et al., *Cellulose*, 30, 7463–7478 (2023)

LABORATOIRE NAVIER

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cnrs

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