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PhD Position: Heat and moisture transfers in biobased construction materials: impact of ambient conditions

Bio-based construction materials are systems containing or formed of vegetal particles, such as wood, hemp, cellulose, flax, cotton, etc., possibly linked with a mineral paste or an organic binder. They represent a promising solution for carbon emission reduction, due to their low production cost and their partial or full recyclability. Moreover, they bring more comfort to the occupants thanks to their moisture-buffering capacity, and they require less energy for heating or cooling. These qualities are obtained through exchanges between water vapor and "bound water", i.e., water absorbed in the solid structure, combined with heat transfers. Consequently, understanding and predicting water and heat (hygrothermal) transfers in such materials is essential to selecting them appropriately, adjusting their conditions of use, and designing innovative materials. However, the current analysis of their performance is generally based on limited evaluations at a global scale or via macroscopic models lacking physical information. Our group has recently developed original approaches and tools that allow to clarify and quantify the internal heat and mass transfers thanks to a proper description of boundary conditions, along with new NMR and MRI techniques [1-5] providing spatially and temporally resolved distributions of the water in its different phases.

The objective of this PhD work is to further explore the impact of the boundary conditions on the heat and mass transfers of biobased construction walls. Note that this research is also applicable to naturals textiles, for which the same problematic exists. The research work will focus on the relative impact of velocity and temperature on the drying of an initially saturated biobased material, with the objective to develop a physical knowledge and a detailed quantification of the processes. This will be carried out with the help of NMR and MRI measurements giving insights in the time evolution of the spatial distribution of moisture throughout the material, measurements with a special device providing the distribution of temperature inside the sample over time, numerical simulations of the air flux, and full modelling of the heat and mass transfer based on our recent developments in the group. The ultimate objectives are to develop a relevant predictive model of heat and humidity transfers in fibers + mineral paste systems, to optimize the control of air flux and temperature in biobased buildings for a reduction of energy consumption.

The work will be carried in Laboratoire Navier, within the framework of the ERC Advanced Grant PHYSBIOMAT (2023-2028). The candidate will thus benefit of a very favorable work environment within a group of research including various students or researchers experts in the different experimental or theoretical aspects of the project, along with all equipments for material characterization and physical observations.

Skills: The candidate is expected to have a solid background in fluid mechanics, chemical or material engineering, and a strong motivation for research.

Duration: 3 years

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

Gross salary: 2420 euros per month

Start date: October 2025 or later. Selection process will start immediately and go on until the position is filled

Supervisor: Philippe Coussot (Navier)

Application to philippe.coussot@univ-eiffel.fr including a CV and a short letter of motivation

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) [5] Zou et al., *PNAS Nexus*, 3, pgad450 (2024)

LABORATOIRE NAVIER

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