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Experimental study of drying in the presence of fluorescent particles in a model porous medium

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The motivation for the present study stems from visualizations of the PTFE distribution in the gas diffusion layer (GDL) of Proton Exchange Membrane Fuel Cell (PEMFC). The GDL is a fibrous carbon layer treated with polytetrafluoroethylene (PTFE), by drying a layer saturated with a solution of PTFE particles, to improve hydrophobicity1. During the fabrication, internal surfaces appears to be hardly covered homogenously causing a mixed wettability in the medium, indeed PTFE distribution strongly depends on evaporation conditions2. In this context, the objective of the present work is to study the pattern formed by fluorescent particles (1µm) in porous media after the evaporation of the water.

Using a SUEX resin microchannel, we studied the effect of the presence of particles on the evaporation dynamics in a single channel3. The experiments showed that the kinematics is slowed down by the presence of the particlesdue to their effect on the thickness of the corner films. They are thicker with pure water than in the presence of particles, at small concentrations, which results in smaller vapour partial pressure gradients in the channel entrance region. Here, the work is extended considering a two-dimensional network of interconnected channels as model porous medium.

To this end, an experimental set up was developed to study the effect of the particles presence in the model porous medium, see Figure 1, and their respective deposit. The drying process is analyzed from optical visualizations, while the deposit is observed under the microscope with confocal green light.

Different parameters were varied in order to better understand the particles preferential regions of deposit and their relation with the drying pattern. For example, changing the wettability of the chip's material completely changes the localisation of the deposit. The particles concentrate in the channels closest to the top edge of the network (open edge of network), while the concentration is decreasing further away in the network. Another variable that was changed, was the total pressure. Using an oven to perform the drying under partial vacuum condition (100mbar) and at ambient temperature, the invasion pattern is very different from the one obtained at the atmospheric pressure under diffusive evaporation condition and the deposit is more homogeneous throughout the micromodel (Fig 2).

In the next step, the experimental set-up will be improved so as to perform the experiment under a green light allowing to track the particles. This should allow us to explain how the liquid displacement influences the particle deposition Finally, it is expected that this will help establish drying procedures leading to improved GDL's hydrophobicity properties for better fuel cell operation.

Participation

In-Person

References

[1] Tatsumi Kitahara & al. Journal of Power Sources, 2010.
[2] Hiroshi Ito, & al. Journal of Power Sources, 2014.
[3] Ghiringhelli & al. Colloids and surfaces A, 2023.

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Primary authors: GHIRINGHELLI, Elisa; PRAT, Marc; MARCOUX, Manuel (Institut de Mécanique des Fliudes de Toulouse)

Presenter: GHIRINGHELLI, Elisa

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