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Visualizing imbibition in thin porous media with high-speed NMR

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The imbibition of liquids in thin, porous films is a widely studied phenomenon [1]. For example, in the print industry, understanding the penetration of ink inside paper provides tools for improving the quality of the print. However, measuring inside submillimeter opaque films like paper with a high temporal resolution is a challenging task. Here we introduce a Garfield Nuclear Magnetic resonance [2] (NMR) approach for measuring liquid imbibition into thin, porous films. Firstly, we were able to measure liquid distribution inside porous films with a spatial resolution of 10μm on a time scale below 0.1s. Moisture profiles were measured for different model liquids inside PVDF and cellulose nitrate membranes. Secondly, microliter sized droplets were used to study the penetration process inside thin porous PVDF membranes (approx. 110 μm). Moisture profiles were measured with time frames as low as 25ms, which is to our knowledge the fastest NMR measurement used to study penetration ever reported. The front position inside the membranes, is determined from the liquid profiles, which allows to quantify the imbibition process. To illustrate the experimental power, the effect of viscosity and pore radius on the penetration process where investigated. To study the effect of pore size, two different PVDF membranes with a well-defined pore radius of 0.65 and 0.22μm where tested. The penetration process was performed with different water glycerol mixtures to study the effect of viscosity on the process. First results show a rather sharp imbibition front, additionally the imbibition dynamics obeys Stokes'flow, but cannot be explained with the classical Lucas-Washburn equation [3]. The presented high-speed NMR imaging approach allows to measure the motion of liquid fronts on time and length scales that were not accessible before.

Time Block Preference

Time Block B (14:00-17:00 CET)

References

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