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Detecting condensed water in hydrophobic porous media using inverse gas chromatography

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The relevance of dropwise water condensation in hydrophobic media is evident in applications ranging from water harvesting to energy [1]. However, the physics of water nucleation on hydrophobic substrates (e.g. the impact of structural characteristics versus energetic variability of the surface) is still poorly understood [2]. The reason is lack of experimental tools sensitive to the small amounts of water nucleating at these surfaces before run-off. In this study, we present a novel technique to detect the nucleation point of water in PTFE samples using inverse gas chromatography (iGC).
iGC is a technique for characterizing the physicochemical properties of porous substrates such as BET surface area and surface energy distribution [3]. In iGC a range of gas probes with known chemical properties, are injected into a column packed with the porous sample under investigation. The probe molecules pass through the column and interact with the porous material. The retention time of the probe molecules is then measured using a flame ionization detector. The variation of retentions measured for probe pulses of systematically varied properties, e.g. concentration and polarity, enables us to determine the physicochemical parameters of the internal surface of the investigated material. Recent advances in commercial IGC enable users to perform the iGC measurements at different controlled humidity [4].
We find that condensed water on the surface of the porous substrate at a given relative humidity impacts the retention of the probe molecules passing through the column during the iGC measurement. We demonstrate that the nucleation point can be detected more accurately with iGC compared to other techniques such as gravimetric dynamic vapour sorption: The reason is the large amount of liquid-gas surface area, the iGC is more sensitive to, with respect to liquid volume generated during condensation in the porous medium. We further demonstrate that the nucleation can be linked to structural properties of the material through the Young Laplace equation. These results provide new avenues to research capillary condensation in hydrophobic systems and aid material development for the mentioned applications.

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References

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