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Wetting/drying mechanisms associated with nanoconfined salt solutions: an optical reflectance study on vapour phase imbibition and adsorption

Monday, 30 May 2022 15:10 (1h 10m)

The wetting and drying cycles of salt solutions confined in conductive nanoporous electrodes are conceived to generate energy from low-grade waste heat by coupling the pore drying/wetting process with the charging/discharging cycles of the electrodes. The key factor being the surface area of the electrode in contact with the adsorbing/desorbing liquid films. This objective could be realised by achieving the right set of physical conditions that allow a systematic control and manipulation of the electrically charged layers that develop inside the porous host matrices. The first step initiated in this direction is studying the percolation of water from the vapour phase in to the nanopores through a single exposed edge of the nanoporous host matrix (Vycor®). The porous host is maintained under controlled temperature and vapour pressure (humidity), and is illuminated by a diffuse white light source. The change in the grey-scale intensity with respect to the empty state is monitored to follow the pore-filling process as a function of time. Through systematic measurements at increasing relative humidity steps, the transition from diffusive percolation to imbibition is established. Likewise, the pore-emptying phenomenon is monitored by "degassing"the system in defined pressure steps, and the imbibition/drying mechanisms are rationalised with appropriate thermodynamic and kinetic models. The focus of the next phase of such investigations shall be on the wetting/drying mechanisms of nanopores carrying salt crystals, with complementary small/wide angle x-ray scattering experiments with the objective of obtaining information on the potential thin liquid films that may form in capillary bridges in the porous host matrices upon drying, and the re-distribution of ionic clusters as a consequence of such wetting/drying cycles, both of which could lead to spurious capacitances being exhibited by the porous electrodes. The thickness and electrical conductivity of such films have been investigated on flat macroscopic surfaces with similar surface chemistry as the pore walls of the nanoporous host with the objective of predicting the influence of such post-cursor films (left behind in the drying pores) on the electrode capacitance with respect to their dry state. In a separate set of experiments, vapour phase adsorption/desorption isotherms are obtained via optical reflectance with the objective of unravelling the influence of salt concentration on the vapour sorption characteristics, in particular playing with the contact angle of the meniscus of the adsorbed liquid film by appropriate pore- surface hydrophobization. The thermodynamic information revealed by such experiments, coupled with the imbibition characteristics will play an important role in fine tuning the pore filling and emptying kinetics in order to achieve electrodes with desirable energy storage capabilities.

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References

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Time Block Preference

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

Participation

Online

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