Confined salty water: phase transitions and pattern formation

Laboratory : Institut Lumiere Matiere
In Cooperation With : iLM
Level : M1 / M2
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Scientific Context :
When water contains salt, evaporation, condensation or temperature variations can trigger salt crystallization or dissolution (deliquescence). These processes are crucial in the atmosphere, where deliquescence turns suspended salt particles into aerosol droplets; conversely, crystallization from solution contained in rocks or concrete can deform geological layers and damage buildings/artwork. Thus, salty water is important in sustainable architecture, heritage conservation, atmosphere & climate, but also in other situations including water availability, energy harvesting and active materials. However, it is mostly unknown how nanoscale confinement, typically present in most of these situations, impact the phase transitions of salty water. We are looking for a motivated student to cover one or several aspects of the project described below, depending on his/her taste and skills.

Missions :
The goal of this project is to use artificial, transparent nanomaterials (confinement ~1 to 100 nm) and advanced optical methods to fully characterize the conditions for phase change (crystallization and deliquescence of the salt, coupled to evaporation and condensation of water). We will focus on two main areas of interest. (1) With materials containing regular arrays of identical pores / nanochannels, we aim at fully identifying the conditions for phase change as a function of confinement size, surface properties and concentration of salt. We will develop theory based on out-of-equilibrium thermodynamics, surface tension phenomena, osmotic pressure, and nucleation models to interpret the experimental results. (2) In systems containing interconnected pores of controlled distributions, we will characterize collective effects and patterns arising from invasion-percolation phenomena and nonlinear coupling between nucleation and transport, both experimentally and with theory and simulations using pore network models. Later, the impacts of these different effects on the deformations and opaqueness/color of the samples will also be evaluated with the design of mechanical and optical metamaterials in mind. The project is supported by a 4-year funding from ANR, and will be developed in a stimulative international environment through collaborations.

Outlooks :
Continuation into PhD is welcome and encouraged (full Internship + PhD funding available through ANR funding).

Bibliography :

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