Aix Marseille Université - CNRS
UMR 7246: Matériaux divisés, interfaces, réactivité, électrochimie
MADIREL, Centre de St Jérôme 13397 Marseille cedex 20
http://madirel.univ-amu.fr

Doctoral school of chemistry ED250

Thesis proposal

Colloidal suspension freezing: mechanisms and application for new porous material design

An original route to produce meso/macro-porous material has been recently developed at MADIREL Laboratory. It consists in two-step freeze-thaw scenario of nanoparticle aqueous suspensions. Experiments demonstrate that water droplet freezing occurs in two well identified steps: first a fast dendritic growth regime and then a slow regime where latent heat is released. Both regimes involve solid/liquid front propagation with specific kinetics. Recent experiments have shown the ability of these fronts to flocculate the suspension. Moreover, applying two successive freeze-thaw cycles for concentrated suspensions leads to the formation of stable porous materials.

The understanding of the underlying mechanisms of this phenomenon in nanoparticles suspensions is the main focus of the proposed PhD. Work plan will be organized in three sub-topics: the production of the porous spheres, the characterization of the latter and the study of the mechanisms associated with the production, and finally the possible applications.

Porous material will actually be produced in three different ways. Suspended drops configurations in undercooled conditions will first be studied. Then free-falling drops within a thermally controlled fluid system will be used. Finally, nanofluid drops in water-in-oil emulsions will be investigated.

This project will require the candidate to conduct systematic studies including influence of the droplet size, nanoparticles size, pH, ionic strength. Several characterization techniques will be employed such as mercury porosimetry, gas adsorption, optical and scanning electron microscopy, dynamic light scattering and differential scanning calorimetry.

Two potential applications of the produced porous materials will be considered: trapping and controlled delivery of active substances, hybrid material design for chemical probes through new synthesis route based on conductive nanoparticle inclusion.

The candidate is expected to have a Master of Science degree, with solid background in physics and chemistry of interfaces and good skills in thermodynamics. Knowledge in material science and interests in microscopy, calorimetry and data processing would be appreciated. Speaking French at the beginning of the program is not necessary.

Candidates may send their application now to Dr Renaud Denoyel and/or Dr Mathieu Nespoulous.
PhD start: Sept./Oct. 2018

Supervisor : Renaud Denoyel (renaud.denoyel@univ-amu.fr)
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