Doctoral position
2021

Deadline for application : April 2nd , 2021

Thesis supervisors

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Thesis topic: Aging of complex liquid foams

Keywords: Soft condensed matter, microfluidics, complex fluids, foam, emulsion, elasticity, plasticity, capillarity, experiments

Scientific description: Aerated materials are a promising route towards smart light sustainable applications in a variety of domains (building construction, remediation,…). However, controlling the morphology and the functional properties of foamed materials constitutes a difficult task. This is due to the intrinsic aging processes at play in liquid foams[1] before the hardening step, among which coarsening remains challenging to be counteracted. This effect is detrimental to the production of well controlled foamed materials. In the building industry for example, lighter foamed construction materials could be produced if coarsening were efficiently controlled. Actually, strong scientific questions remain about coarsening, especially in the case of liquid foams made with complex fluids[2, 3,4, 5].

To inhibit ageing, we propose to use yield stress foaming fluids as we expect the material yield stress to provide the mechanical behavior to resist both coarsening and fracturing. But, it is to say that our current understanding of the coarsening process in such complex liquid foams is very limited, and only few studies have considered this new topic.

In this thesis project we propose a full study of coarsening of foams made with complex materials possessing yield stress properties, tackling the following open question: What are the elastic

1 Cantat, Cohen-Addad, Elias, Graner, Höhler, Pitois et al, Foams : Structure and Dynamics, OUP (2013)
2 Deleurence et al, Soft Matter, 11 (2015) 7032
3 Bey, Wintzenrieth, Ronsin, Höhler, Cohen-Addad, Soft Matter, 13 (2017) 6816
4 Pitois, Rouyer, Current Opinion in Colloid & Interface Science, 43 (2019) 125
5 Schneider, Zou, Langevin, Salonen, Soft Matter, 13 (2017) 4132-4141

properties of a yield stress foaming liquid required to inhibit coarsening? Unveiling the elasto-capillary coupling between coarsening process, elastic stresses up to yielding and material microstructure will require multiscale investigations that will involve experiments performed both on earth (in our labs) and under microgravity conditions on-board the International Space Station[6].

The approach will be based on the use of model yield stress fluids, such as concentrated oil-in-water emulsions, that exhibit a simple elastoplastic behavior, i.e. characterized by only two rheological parameters: the elastic modulus and the yield stress[7],[8]. Foams and emulsions will be elaborated with micro- or milli-fluidic devices. Material coarsening will be investigated combining several probes and methods: videomicroscopy, multiple light scattering. For systems studied on earth, X-ray radiography and tomography will be used to measure the coarsening-induced gravity drainage.
The results will be interpreted in order to identify the conditions for which coarsening is efficiently counteracted by the emulsion elasticity and plasticity, in terms of critical dimensionless numbers, as a function of gas volume fraction[9]. Coarsening dynamics in such yield stress foams will be analyzed and compared to dynamics in simple aqueous foams in order to propose a global description of coarsening in foams.

Type of thesis: Experimental

Techniques/methods in use: Microfluidic, videomicroscopy, light scattering. Data and image analysis.

Applicant profile: Background in material science (physics/chemistry) or fluid mechanics. A taste in experimental work is expected.

Learning outcomes: Scientific and lab work management. Physics of liquid foam. Modelling. Light scattering spectroscopy techniques. Data and image analysis tools.

Sources of funding: From European Space Agency (ESA) and French Space Agency (CNES)

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[6] ESA project " Hydrodynamics of wet foams", P.I. D. Langevin

[7] Cohen-Addad, Höhler, Pitois, Annual Review of Fluid Mechanics, 45 (201) 241

[8] Cohen-Addad, Höhler, Current Opinion in Colloid & Interface Science, 19 (2014) 536

[9] Gorlier, Khidas, Pitois, Journal of Colloid and Interface Science, 501 (2017) 103-11