ESPCI PARIS

CBI CHIMIE BIOLOGIE INNOVATION

Laboratoire Colloïdes et Matériaux Divisés

Master internship (M2):
Design an flow properties of hydrogel-based granular materials

Over the past years, we have developed a microfluidic process for making sub-millimetric size hydrogel-based spherical objects (Fig. 1(a)). The hydrogel is currently composed of alginate, a natural polyelectrolyte, that is physically cross-linked by divalent cations. These soft particles can be structured as liquid-core capsules, encapsulating an aqueous solution or an immiscible liquid, or as plain beads [1, 2]. The hydrogel can also incorporates nanoparticles that give rise to increased functionalities, like electronic conductivity in a water medium when carbon nanotubes are used [3]. A collections of such hydrogel-based particles then behaves as a wet granular material that has both liquid, it can flow (Fig. 1(b)), and solid like properties, it has a finite angle of repose (Fig. 1(c)). These systems have many applications in the fields of cosmetics, agriculture and even energy.

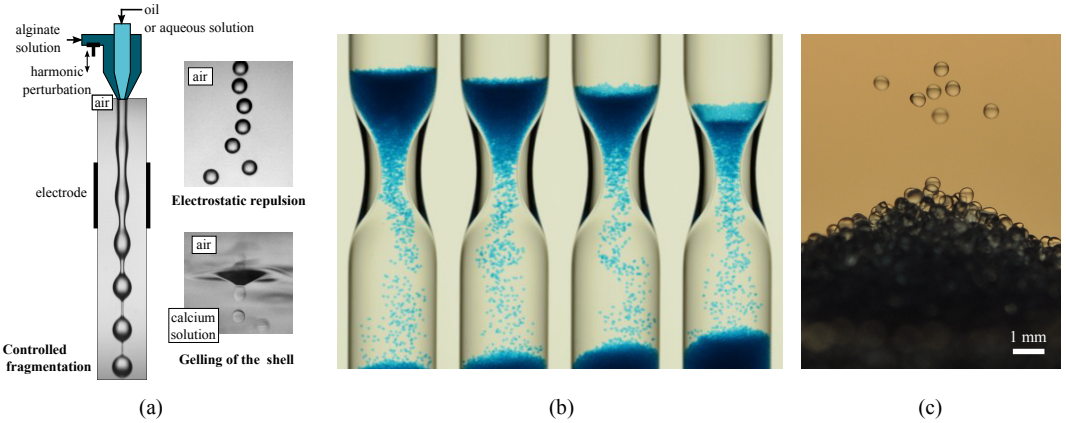

Figure 1: (a) Formation of sub-millimeter size liquid/core hydrogel capsules or hydrogel beads. (b) Flow of hydrogel capsules in a liquid filled hourglass. (c) Stack of hydrogel capsules in water.

For the present internship, we aim to design and to assess the rheological properties of hydrogel-based granular materials. As a first step, the hydrogel will be free of conductive nanoparticles. One of the objective is to make a link between the formulation of the hydrogel (type of divalent cations, type and concentration of alginate, ...) and the elastic properties of the hydrogel as well as the friction/adhesion between hydrogel beads. Rheological properties will be assessed with a rheometer having sandblasted surfaces for avoiding wall slippage. Taking advantage of quartz-tuning fork based Atomic Force Microscope with sub-nanoNewton resolution and following [4] we will measure the pairwise force profile and the frictional interactions between pairs of particles. We have previously observed that the presence of surfactants may impact on frictional features of such a system. This phenomenon will be quantified with the above mentioned techniques along

with a setup dedicated for the evaluation of static angle of repose. Finally, the behavior of such a soft granular material under flow when interstitial liquid flow occurs, like in a liquid filled hourglass, will be studied.

We look for a highly motivated candidate having a strong background in physics/mechanics (solid/fluid mechanics, rheology, ...) and physico-chemistry of soft matter. The master internship will continue with a PhD thesis sponsored by ANR.

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References

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