ESPCI PARIS CBI ANR

Laboratoire Colloïdes et Matériaux Divisés

PhD:
Design and properties of conductive hydrogels

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, which 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 acts as a semipermeable membrane and allows to culture cells, from microorganisms to mammalian cells. In that way, encapsulated microbial populations or micro-tissues can be created (Fig. 1(b)). Nanoparticles can also be incorporated in the hydrogel which give rise to increased functionalities, like electronic conductivity in a water medium when carbon nanotubes are used [3] (Fig. 1(c)). These systems have many applications in the fields of cosmetics, agriculture, energy and biotechnologies. In particular, conductive hydrogel can serve as bio-electrode or used for water desalinization via capacitive deionization.

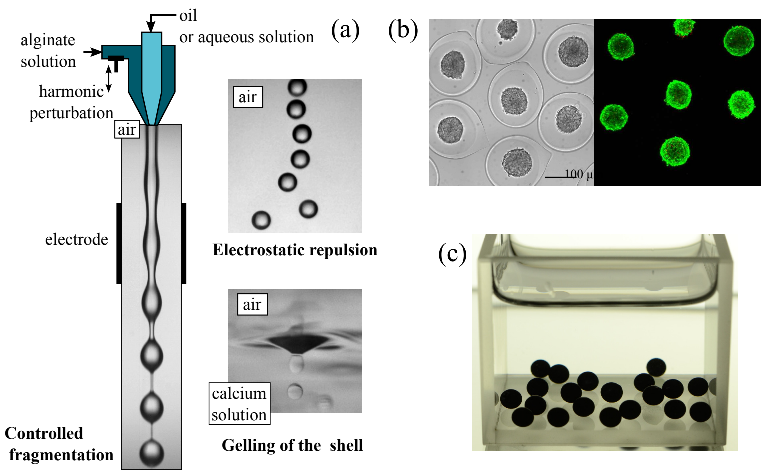

Figure 1: (a) Formation of sub-millimeter size liquid/core hydrogel capsules or hydrogel beads. (b) Formation of cell aggregates (spheroids) in liquid core capsules. (c) Incorporation of carbon nanotubes in the hydrogel which becomes electronically conductive.

During this PhD project, we aim to design and to assess the electrical and rheological properties of composite hydrogels shaped as micro-spheres, fibers or sheets. Controlling electro-mechanical features are essential for applications. We wish to switch from a physical hydrogel, which is ionically cross-linked, to a chemical hydrogel, which is covalently cross-linked, in order to increase the resistance of the hybrid hydrogel under stress. One of the objective is to make a link between the formulation (type of carbon based nanoparticles, polymers, ...) of the hydrogel and the electrical and elastic properties of the hydrogel as well as the friction/adhesion between hydrogel beads. The mechanical and electrical response of a collection of beads or a hydrogel slab under compression will be investigated. In that way, we will estimate the equation of state of the system, i.e. the pressure as a function of the volume fraction ϕ, as well as the conductivity as a function of ϕ. 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 look for a highly motivated candidate having a strong background in physics/mechanics (solid/fluid mechanics, rheology, ...) and physico-chemistry of soft matter. The PhD thesis is sponsored by ANR through a collaboration with the group of Philippe Poulin at CRRP in Bordeaux.

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