Laboratoire Colloïdes et Matériaux Divisés

Master internship (M2):
A microsystem for probing the diversity of electroactive bacteria

Microbial fuel cell (MFC) is a promising technology for the treatment of wastewater and the production of electrical energy from red-ox degradations of natural substrates and pollutants [1]. This green technology is based on the use of bacteria acting as bio-electrocatalysts and transferring charges towards electrode materials. Selecting the most active microorganisms is a critical challenge towards a greater efficiency of MFCs. High throughput encapsulation is an efficient way to explore cell phenotype diversity. We have developed a novel protocol of liquid core capsule formation well suited for cell culture since the fabrication procedure involves a minimal number of steps and is only based on aqueous solutions and biocompatible compounds [2]. The basic principle is to gel a liquid core-shell structure template formed by a co-extrusion technique in air (Fig. 1 (a)). We recently made the capsule shell conductive by incorporating carbon nanotubes within the alginate hydrogel [3].

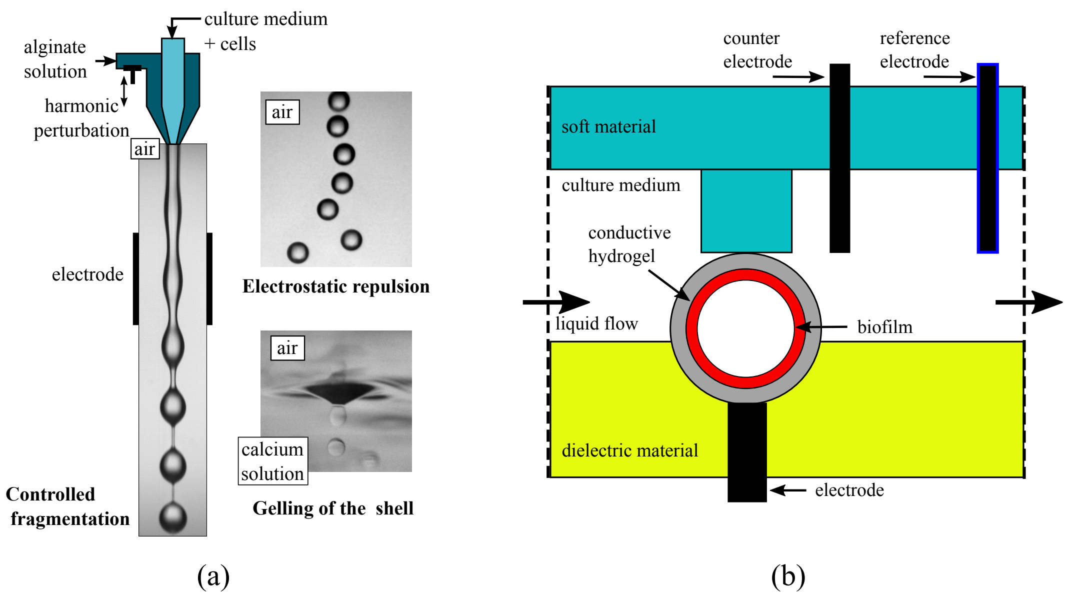

Figure 1: (a) Principle of liquid core hydrogel capsule formation. (b) Schematic of the microfluidic system for probing the electroactivity of bacteria growing in a conductive hydrogel capsule.

We have shown that millimetric capsules produced in a dripping regime can be electronically conductive and used as anode for the generation of current produced by bacteria [4]. For the present project, we wish first to downscale the size of the capsules. This implies to work in a jetting regime with the help of a microfluidic injector where the fragmentation of the compound jet is controlled via a harmonic perturbation (Fig. 1 (a)). Then, the student will have the mission to develop a microfluidic system that will be the subunit of a screening platform. A schematic of the subunit is reported in Fig. 1 (b). The microsystem is composed of i) a liquid core capsule having a conductive hydrogel membrane where a biofilm of electroactive bacteria grows ii) a well that electrically connects the capsule shell to a potentiostat together with a counter electrode and a reference electrode iii) a structured soft roof for keeping the capsule into the conductive well while flowing fresh culture medium and for ensuring contact with the electrode. Depending on the advancement of the project and the motivation of the candidate, the use of such a microsystem with bacteria will be validated.

We look for a candidate having a strong background in microfluidics and physicochemistry of soft matter. Knowledges in 3D printing, electrochemistry and microbiology are welcomed. We wish to continue this project with a PhD thesis.

Contact: Nicolas Bremond - nicolas.bremond@espci.fr - 01 40 79 52 34.

References

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[3] Noel, J.-M., Mottet, L., Bremond, N., Poulin, P., Combellas, C., Bibette, J., and Kanoufi, F. Multiscale electrochemistry of hydrogels embedding conductive nanotubes. *Chem. Sci.* **6**, 3900–3905 (2015).

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