Soft nanofluidics: from electroosmosis in a liquid foam to the molecular scale description of interfaces

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Transport at the nanoscale is encountered in many natural systems and applications, from physiology through protein nanopores in cell regulation, to liquid transport through porous materials, relevant to water treatment and filtration. At such scale, surface properties have strong influence on flows. For example, electroosmotic flows (flow induced by an external electric field) take their origin close to the surfaces and are expected to depend on interface properties at the molecular scale such as charge and composition. Since the 2010s, foam films (a lamella of liquid in air covered by surfactants) appear as tools of choice for nanofluidic characterization as they are intrinsically nanometric, have a large range of surface properties tunable through the soapy solution formulation and are deformable [1].

I will first present our recent studies of flows induced by an electric field in a 3D macroscopic dry liquid foam [2]. In such structure, gas bubbles are in contact through the nanometric-thickness foam films, which themselves combine as micrometric-size channels (Plateau borders): foam can thus be seen as poro-elastic media. I will notably show, thanks to experimental studies and modeling, that the expected electroosmotic flow is enhanced by the thermal-gradients-induced flows due to heterogeneous Joule effects in such deformable structure.

Next, I will present how we investigate the molecular structure of the soapy interfaces, of crucial interest for describing nanoscale flow , through surface Second Harmonic Generation experiments. This non-linear optical technique is inherently specific to interface and sensitive to its molecular composition and organization. I will notably present how we question the existence a surfactant-concentration gradient at a soapy interface in presence of an electroosmotic flow [3]. I will also present more general applications of this technique for probing interfacial properties of interest for flows.

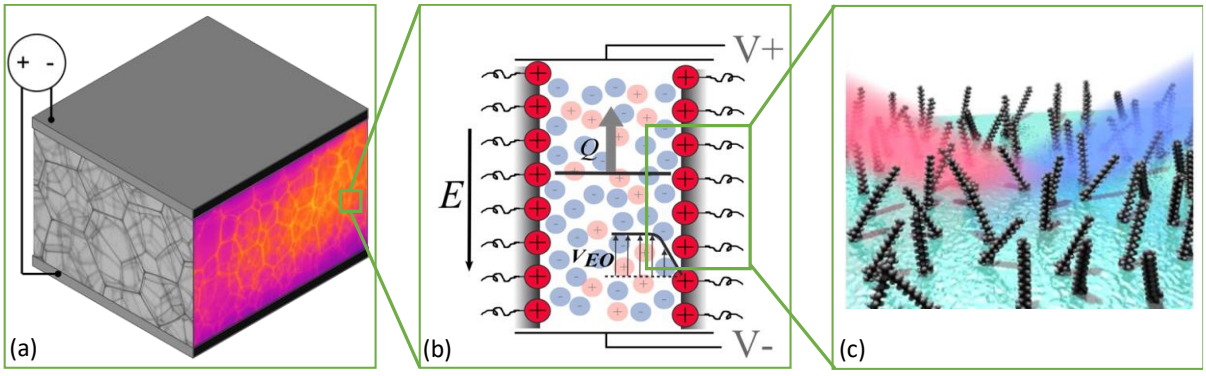

Figure 1: (a) Thermally-enhanced electroosmosis in a 3D liquid foam. (b) Electroosmosis in a nanometric foam film. (c) Surface Second Harmonic Generation experiments to probe surface composition of a soapy interface.

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References

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