Proposal for a Master 2 intership

How to modify the structure and properties of gels with micro-organisms

With F. Giorgiutti (**frederique.giorgiutti@universite-paris-saclay.fr**)
Laboratoire FAST, Université Paris Saclay
A. Izzet, adrien.izzet@inrae.fr
Laboratoire SayFood, INRAE-AgroParisTech, Université Paris Saclay

Hydrogels consist of a porous matrix saturated with liquid. They can be highly porous, and thus have a great capacity to retain or release liquid. For these reasons, they are used in a wide range of applications, notably in the environmental sector (soil decontamination or hydratation) or in the food industry where hydrogels are mainly designed to function as a carrier system for bioactive compounds, or to adapt the texture and water retention of foods.These gels can be made of a dispersion of nano-particles that form aggregates through drying process. To design new gels with controlled structure and mechanical properties, a promising way of research concerns the addition of swimming micro-organisms in the dispersion; this "active bath" can modulate the effective inter-particle interactions and then control the aggregation process. Thus, when swimming micro-organisms are dispersed in a fluid, there is a complex interplay with the collective dynamics of micro-organisms and the surrounding fluid; if this system is let to dry, there will have some flows due to the evaporation of solvent and then at the end of the drying process, a gel is formed: the structure of the gel and its final mechanical properties depend on how the particles have aggregated. The role of the bacteria and how they modify the fluid flows during drying and the aggregation process has to be understood.

We will consider the case of a suspension of colloidal nanoparticles mixed with motile agents such as bacteria suspended in a motility medium. A 2D drop sandwiched between two glasses is let to dry, and will be placed for observation under microscope (see figure). At the end of the drying process, for dilute suspensions, in some cases some hydrodynamic instabilities of a viscous fingering type can appear (see figure). For concentrated suspensions, at the end of the drying process, a gel is formed with a highly porous structure (see figure) that depends both on the aggregation mechanism between the particles and on the advection of particles due to the flows in the drop.

Particle tracking techniques coupled with microscopy will be used to characterize both the spatial distribution of the bacteria, colloids and the flow within the drop during drying. The structure of the gel would be deduce from light diffusion techniques and the mechanical properties by nano-indentation measurements. The internship will be essentially experimental and can be continued as a thesis.

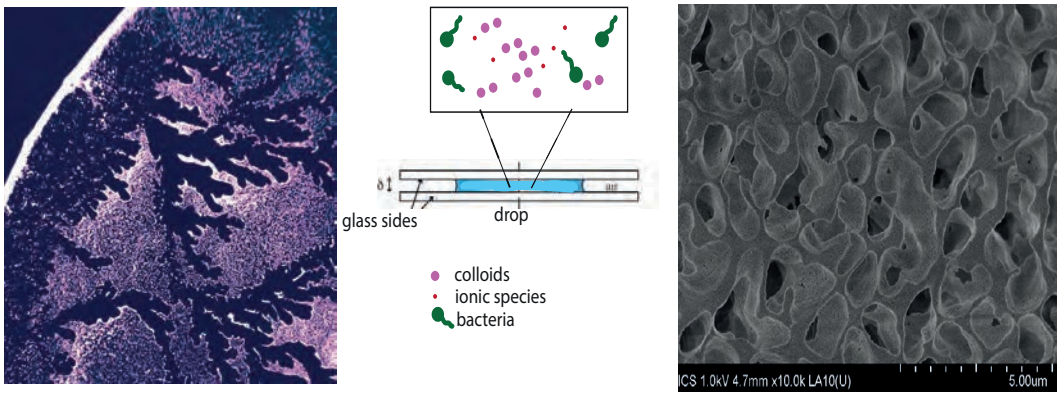

Figure 1: Center: experimental set-up of a 2D drop between glass plates. Left: instabilities observed during the drying of a drop of dilute suspension of bacteria. Right: scanning electron microscope view of the porous structure of an hydrogel.