SAXS/WAXS and microfluidics for the structural characterization of complex fluids during the kinetic inspection of a phase diagram

SC 4639, 9 shifts from 18/06/2018 to 22/06/2018

Context

We planned to combine SAXS/WAXS scattering techniques with a microfluidic chip which permits to concentrate aqueous solutions at a controlled velocity [1-3] in order to describe the phase diagram of bio-surfactants (2 sophorolipids and 2 glycolipids [4]); these diagrams remain largely unknown whereas these surfactants are thought to replace conventional ones. The rapid acquisition of spectra (2 mins) is a technological challenge which leads to the kinetic inspection of the underlying phase diagram of the bio-surfactant (aggregation state *vs* concentration). For these systems, the kinetic pathway is of particular importance as we demonstrated recently that the final, very concentrated state depends on the concentration velocity; however, the knowledge of intermediate states, the scope of the present project, is a prerequisite in order to understand the coupling between kinetics and phase diagram.

Overall, the experiment worked very well and we could achieve the inspection of phase diagrams of 4 different unknown surfactants (sophorolipids & glycolipids) + a model system with the setup described in Fig. 1.

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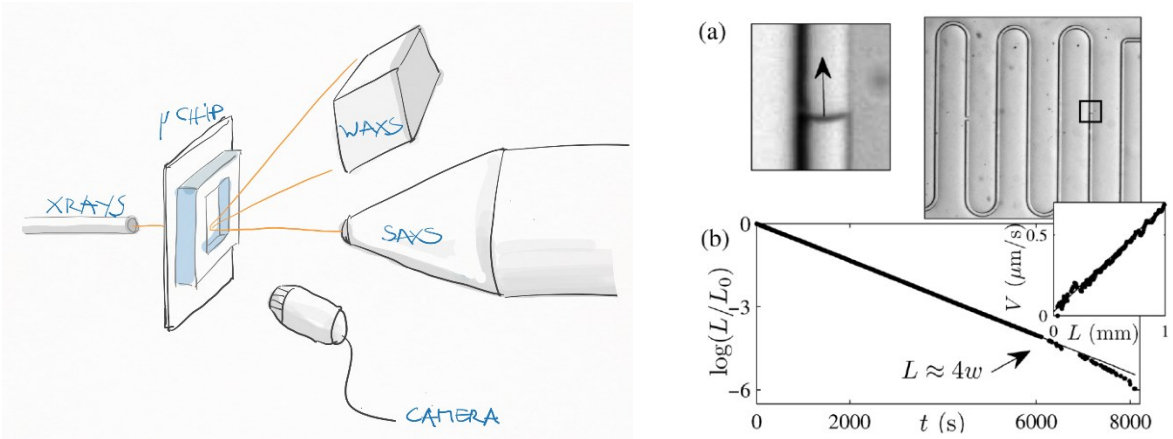

Figure 1. *Left: sketch of the setup @ BM26: a microfluidic chip that permits us to concentrate a solution is mounted on the light line that collects SAXS & WAXS, and optical images of the chip. Right: close-up of the chip where a long, linear droplet looses water upon (in chip) pervaporation, leading to a decrease of the length of the linear drop to a concentration increase within this drop, eventually accompanied with a change of the mesoscopic state of the solution.*

Achievements & results

We installed the microfluidic chip on the BM26 light line easily (figure 1) thanks to a preliminary work performed together with Daniel Hermida Merino who pushed our team to better think of the design of the microfluidic chip. We also managed to install a camera which permitted us to see inside the chip during the experiments, and especially to follow the evaporation process which eventually gives us access to the instantaneous concentration (figure 2, left). Together with the SAXS (figure 2, right) and WAXS patterns, we collected enough data to build the (preliminary) phase diagrams of the surfactants under study. Additional experiments such as microscopy under polarised light shall be performed in order to complement / polish our observations.

A typical example of results we obtained is shown below: on the one hand we monitor and measure the concentration within the chip against time, and on the hand we collect SAXS and WAXS patterns against time. The correlation of the two will give and structural analysis against concentration, that is the preliminary yet compulsory step in the establishment of a phase diagram.

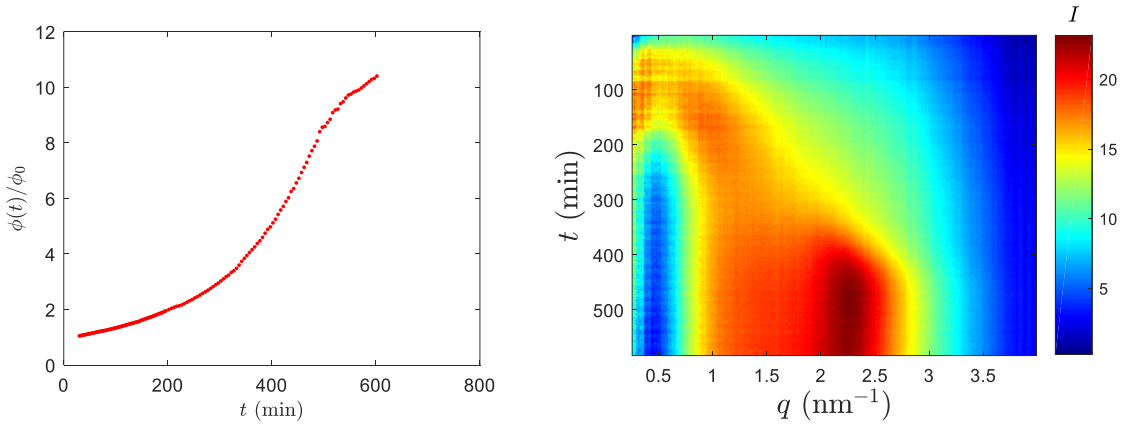

Figure 2. Left: Online monitoring of the concentration of a surfactant solution against time. Right: Online SAXS pattern obtained in the chip during the concentration process of the surfactant. The correlation of the two should lead to the first step of a phase diagram.

References

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