Microfluidics with in-situ SAXS to probe the time evolution of the lamellar-microemulsion transition induced by a concentration jump

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The use of microfluidic devices with *in-situ* small-angle X-ray scattering (SAXS), offers new interesting possibilities for the study of soft materials under out-of-equilibrium conditions [1,2]. In particular, when flowing in micron-sized channels, fluids become easier to manipulate, which allows for an experimental control (e.g. rate of mixing, shear rate, concentration gradients, confinement) and reproducibility, that has been previously unavailable, opening the possibility for new experiments.

In this work we study the SDS-pentanol-water ternary system's lamellar to oil-in-water (o/w) and lamellar to water-in-oil (w/o) microemulsion transitions, induced by mixing a lamellar phase with water or pentanol in a crossed microchannel configuration (Figure). By manipulating the individual flow-rates, one can carefully tune the final composition following the concentration jump, and furthermore, probe different time-scales of the transition. The ongoing structural evolution is simultaneously monitored *in-situ* with SAXS.

The main findings show that the lamellar to o/w droplets transition (by mixing with water) occurs through a gradual stripping down of bilayers from the lamellar phase, with a microemulsion SAXS signature coexisting with the initial lamellar peak since very early mixing times. Conversely the lamellar to w/o reverse droplets transition (through mixing with pentanol) involves the formation of an intermediate lamellar phase with a smaller spacing before giving place to the reverse droplets.

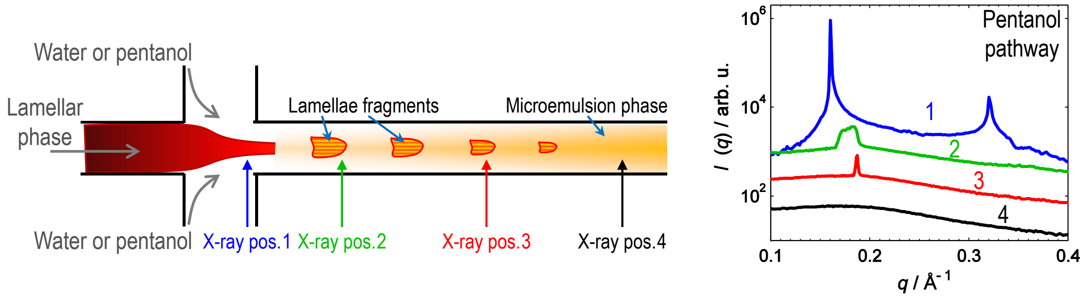

Figure: Schematic of the described microfluidic concentration-jump experiment (left) and representative SAXS patterns from different locations on the chip for the pentanol pathway (right). The lamellar phase is flowed in the middle microchannel (100x100 µm cross section), and mixed with either water or pentanol, flowing from the side channels. The three flow rates and their ratios determine the final composition of the system and the observation time. In the pentanol pathway, the initial lamellar phase shrinks to smaller spacings before transitioning to microemulsions.

Acknowledgement: Supported by DOE-BES DOE-DE-FG02-06ER46314, NSF DMR-1101900, and a Marie Curie International Outgoing Fellowship within the EU Seventh Framework Programme no. PIOF-GA-2009- 252701. The X-ray scattering work was carried out at Stanford Synchrotron Radiation Lightsource (SSRL) and Swiss Light Source (SLS). We are thankful for all of the help and hard work by the local staff at both centres.

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