Single molecule nanofluidics within a polymeric prewetting film

Internship with possibility for extension as a PhD

Florian Dano, Jean Comtet, Emilie Verneuil
jean.comtet@espci.fr
SIMM Laboratory, ESPCI PSL, 10 rue Vauquelin, 75005 Paris

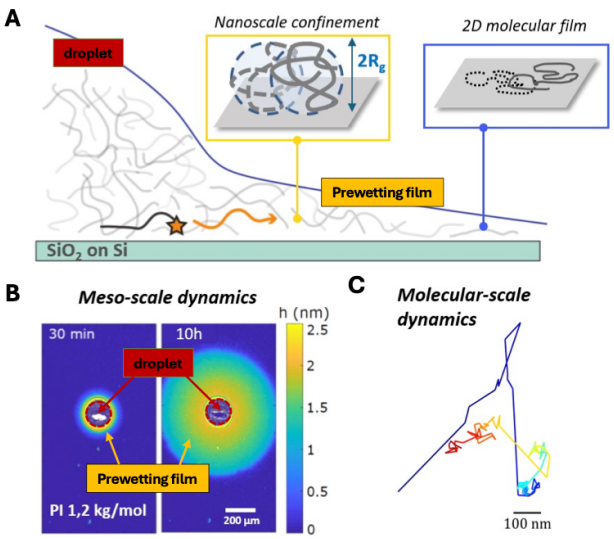

Figure. (A) Wetting of a droplet of polymer melt and its precursor film allowing for tunable confinement. The melt contains a fraction of fluorescently tagged chains (star) used for subsequent single-molecule tracking. **(B)** Ellipsometry mapping of the spreading of a prewetting film of polyisoprene polymer melt. **(C)** Preliminary data showing single-macromolecule tracking of fluorescently tagged PDMS at silica surface. Temporal resolution is 20 ms.

Liquids and polymers confined down to nanometric scales can show a range of exotic behaviors, with broad relevance from engineering to biology. Significant progress in our understanding has been achieved in the recent years, driven in part by experimental efforts in the fabrication of nanofluidic devices reaching exquisite control over the degree of liquid confinement or by highly controlled measurements of the relaxation dynamics of thin polymeric films. However, transport dynamics in these sophisticated configurations is still probed by macroscopic and ensemble-averaged approaches, unable to reveal in a clear and direct manner sub-continuum transport effects.

In this internship, we aim to bridge this gap by developing novel experimental approaches to directly **visualize and quantify molecular motion in nanometrically confined liquids**, focusing on **polymeric liquid melts as model systems**. To do so, we will rely on a simple experimental configuration, whereby a polymeric liquid drop deposited on a high energy surface spontaneously develops around it a prewetting film allowing for tunable confinement from macroscopic scales down to a bidimensional molecular film (Figs. A, B and [1]). Dynamics in this experimental configuration will be probed through state-of-the-art single-molecule and super-resolution fluorescence microscopy techniques, which can be used to localize and track the motion of individual fluorophores with nanoscale resolution and high temporal resolution (Fig. A, C and [2-4]). In particular, a fraction of the polymeric molecules will be tagged with a fluorophore, and by selectively imaging the interface with an evanescent wave, we will be able to directly localize their position and follow their long-term dynamics (preliminary results for tagged PDMS in Fig. C). These single molecule measurements will be coupled with statistical analysis of the dynamics, allowing ultimately for a detailed understanding and modelling of macromolecular transport in confinement.

Revealing previously invisible molecular motion, our approach will allow us to tackle key long-standing questions associated to the role of confinement on molecular transport.

We are looking for a student strongly motivated by experimental work involving custom-made Single-Molecule Localization microscopy setup, physical-chemistry and extensive data analysis, and with a strong background in physics (soft matter, hydrodynamics, optics…) or physicochemistry (polymers). This internship could be followed by a PhD.

References.

[1] Schune et al. (2020). ***ACS Macro Letters*** 9.6: 843-848. https://doi.org/10.1021/acsmacrolett.0c00144
[2] Velay et. (2026). ***arXiv***:*2605.04318* https://doi.org/10.48550/arXiv.2605.04318
[3] Comtet et al. (2020). ***Nature Nanotechnology***, *15*(7), 598-604. https://doi.org/10.1038/s41565-020-0695-4
[4] Schwartz et al. (2014). **JACS**, 136(4), 1327-1332. https://doi.org/10.1021/ja407396v