

Experimental Molecular Dynamics - Watching individual polymers moving at interfaces

Internship with possibility for extension as a PhD (Doctoral School ED397)

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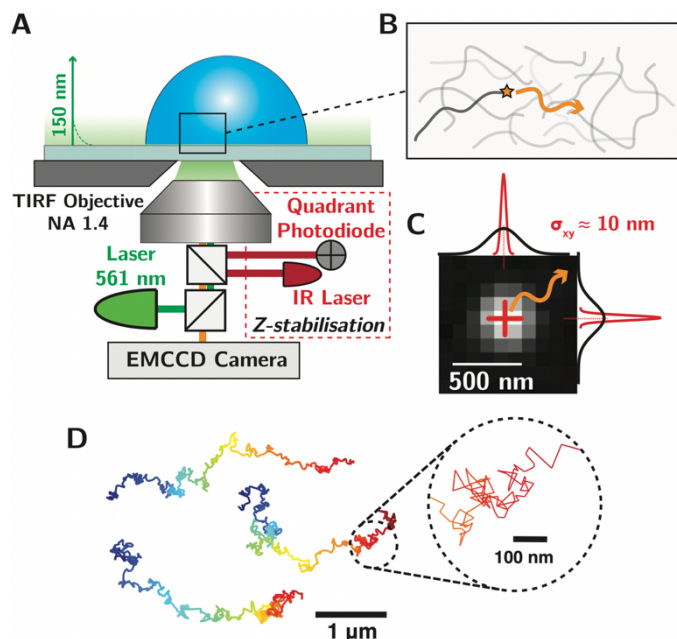


Figure. (A) Schematic of the experimental Single-Molecule fluorescence Microscopy set-up. The solid/liquid interface is selectively illuminated by an evanescent wave and imaged with a sensitive EMCCD camera. (B) Zoom on the local liquid melt structure, made of interacting polymeric molecules. Some polymers are tagged with a single fluorophore, allowing to follow their spatiotemporal trajectories. (C) Typical fluorescent signal on the EMCCD camera, with a single diffraction-limited spot related to the emitting fluorophore, localized and tracked with nanometric resolution and high temporal resolution (10 ms). (D) Trajectories of PEG macromolecules adsorbed at the solid/solution interface and dragged by a hydrodynamic flow of solvent.

Molecular-scale interactions between polymers and solid surfaces govern a large range of processes in soft-matter, from wetting, elastomer and gel friction, down to confined flows in porous media. These situations are typically probed at an ensemble level and described by averaged phenomenological coefficients accounting for the behavior of the interface, e.g. a slip length in the case of the interfacial friction of a polymer melt. However, the molecular foundations behind this averaged vision remain unclear, due to our current inability to experimentally observe the intrinsically nanoscale molecular processes taking place at such interfaces.

We aim here to bridge this gap by exploring novel experimental approaches to directly visualize molecular motion in dense polymeric liquid melts at the nanoscale. We will rely in particular on 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.

Preliminary results in our group have focused on the interfacial dynamics of flowing polymer solutions, demonstrating the feasibility of our approach for single-macromolecule tracking (Fig. D). Here, we aim to focus on dense polymeric melts (e.g. PDMS molecules), whose relaxation time and viscosity can be tuned over large time-scales through the control of their molecular weight or temperature. A fraction of these molecules will be tagged with a fluorophore (Fig. B), and by selectively imaging the interface with an evanescent wave, we will be able to directly localize their position (Fig. C) and follow their long-term dynamics. A fine control of the molecular-scale interactions between polymer chains and surfaces will be obtained by tuning surface physicochemistry. These single molecule measurements will be coupled with statistical analysis of the dynamics, allowing ultimately for a detailed understanding and modelling of macromolecular interactions with solid surfaces.

We are looking for a student strongly motivated by experimental work involving custom-made Single-Molecule Localization microscopy setup, and with strong a background in physics (soft matter, hydrodynamics, optics...) or physicochemistry (polymers). This internship can be followed by a PhD (funding by the Ecole Doctoral ED397).

- References.**
- Comtet et al. (2020). *Nature Nanotechnology*, 15(7), 598-604.
 - Schwartz et al. (2014). *JACS*, 136(4), 1327-1332.