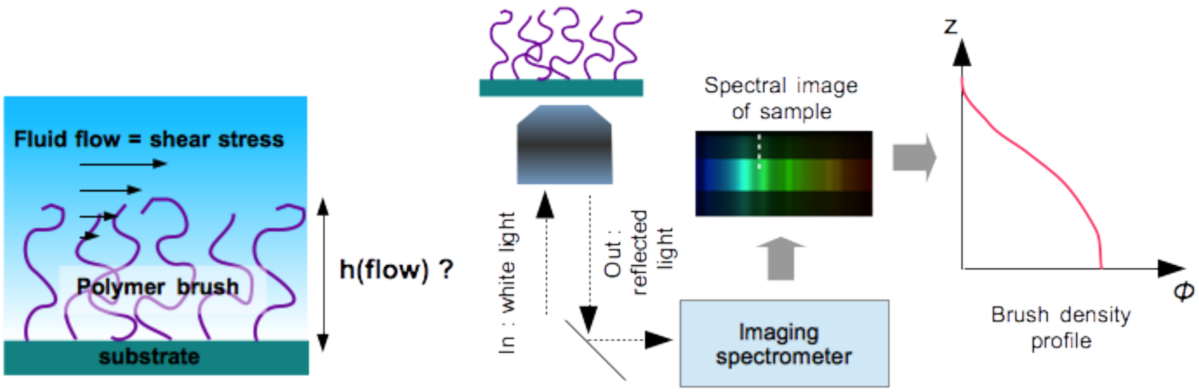
Polymer brushes under flow: an experimental study of how grafted macromolecules couple to hydrodynamics

Polymer brushes are ultrathin layers made of macromolecules tethered by one end to an underlying substrate. Such brushes can be elaborated with tight control over their molecular structure and chemical composition. They thus offer an extremely versatile way to tune surface or interface properties in applications ranging from wetting, friction, or adhesion of biological objects (cells, proteins), to the manipulation of flow in microfluidics.
The latter point, which is of obvious interest for the design of advanced fluidic devices, is also deeply connected to the problem of blood flow in the microvascular system. Indeed, it is well established that the lumen of blood vessels is lined with a layer made of glycopolymers bound to the membrane of the endothelial cells forming the vessel walls. This layer, referred to as the glycocalyx, has a thickness estimated in the range 100− 1000 nm and is exposed to the flow of plasma and blood cells. Beyond its biochemical and mechanotransduction functions, the glycocalyx is also expected to play a hydrodynamic role, which largely remains to be clarified. It has been shown recently, both experimentally[1] and numerically[2], that the presence of a soft layer of macromolecules bound to the wall of a microchannel could induce non-trivial perturbations of the velocity in the fluid flowing nearby. Such perturbations are suspected to arise from the coupling between the flow and the conformation of the polymer chains forming the brush.

This fundamental question is at the heart of the proposed internship. The project will rely on the use of an optical technique, recently developed in our group, which gives access, from reflectivity measurements, to the conformation of polymer brushes immersed in a quiescent fluid[3]. This microscopy technique will be combined with microfluidics in order to control fluid flow and to investigate how the latter alters the brush conformation, and how this depends on flow strength and on the molecular parameters of the brush.



In the course of this interdisciplinary project, the trainee will have the opportunity to learn advanced concepts in surface functionalization, polymer physics, optics, to get familiar with basic microfluidic tools, and to work on an original research instrument. The project will be co-supervised by Lionel Bureau (physico-chemistry, polymer physics) and Delphine Débarre (optics, data analysis).

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[1] L. Lanotte et al. "Flow reduction in microchannels coated with a polymer brush", Langmuir 28, 13758 (2012)
[2] S. Biagi et al. "Surface wave excitations and backflow effect over dense polymer brushes", Sci. Rep. 6, 22257 (2016)
[3] S. Varma et al. "The Conformation of Thermoresponsive Polymer Brushes Probed by Optical Reflectivity", Langmuir 32, 3152 (2016)