Probing molecular interactions between polymer and surface through hydrogel friction experiments

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Polymer dynamics near solid surfaces is of great importance for mechanics, adhesion, friction, and interfacial flows, as it sets the boundary conditions and the macroscopic response of polymer systems. However, directly obtaining the physical characteristics of polymer/substrate interaction from macroscopic experiments can be challenging. Indeed, the macroscopic response of interfaces may strongly couple molecular contributions from the interfaces with mechanical response from the bulk.

To isolate polymer/substrate interactions in gels, we develop specific friction experiments in which a spherical silica probe rotates and slides over swollen polymer networks often referred to as gels [1]. The set-up shown in the figure was designed to minimize bulk dissipative processes and allow homogeneous sliding at the interface.

In these systems, we demonstrated that measuring the velocity dependence of the friction force enables the determination of both the polymer/substrate interaction energy and the surface density of adsorption sites. The experimental results are analyzed using a theoretical model where energy dissipation at the sliding interface arises from sequences of polymer chain pinning, stretching, and desorption from the gel onto silica [1]. This study delves into dissipative mechanisms by tuning the physicochemistry of the interface, leveraging polyelectrolytes and neutral polymers. Experimental parameters—such as pH and salt concentration—are systematically adjusted to screen or enhance electrostatic interactions between the polymer and substrate. Additionally, we investigate the influence of polymer chain stiffness on frictional response. To achieve this, we engineer polymer brushes of controlled length at the hydrogel interface, enabling modulation of tribological properties.

Keywords:
Hydrogels, Tribology, Polyelectrolytes, Interface

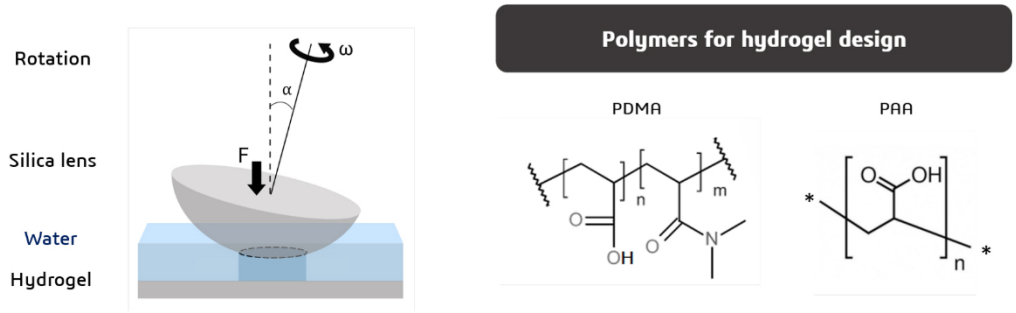

Figure 1 – Schematic of the experimental set-up with in situ contact visualization and the studied physicochemical conditions.

References:

[1] Ciapa, L. et al., Friction through molecular adsorption at the sliding interface of hydrogels : theory and experiments, *Soft Matter* , 2024, **20** , 5933-5943.

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