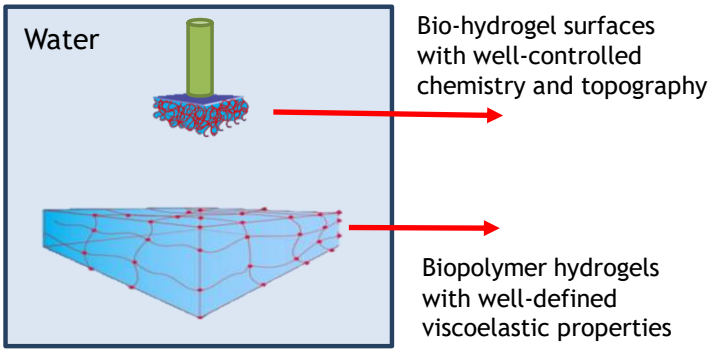
Research Internship at ESPCI Paris – SIMM Laboratory

Control bio-adhesion with biopolymer-based hydrogels

Research in bio-adhesion is relevant for the development of new biomaterials for tissue engineering, surgical implants, drug delivery *etc*. While significant experimental and theoretical advances have been made on adhesion of synthetic materials [1], there is still a clear lack of knowledge on more complex bio-adhesion processes in wet conditions. This can be addressed by a systematic design of bio-based adhesives with controlled and variable surface topography, chemically active interactions and viscoelastic properties.

The internship project addresses important questions arising in a bioadhesion process. What is the contribution of the viscoelastic properties of the bio-based hydrogel materials to the adhesion energy? What is the impact of the surface roughness on contact formation? Which molecular interactions are the most suitable to switch from weak to strong adhesion? The host laboratory has an international recognized expertise in the areas of polymer science (design of hydrogel materials, polymer surface chemistry, mechanics and adhesion of soft materials) to tackle these questions.

In this internship, we will design biopolymer soft adhesives with gelatin and carrageenan. These bio-adhesives will be synthesized with suitable architecture combining physical and chemical cross-links to adjust their viscoelastic properties for adhesion tests [2]. We will also synthesize surfaces grafted with hydrogels with good control of the topography [3]. The adhesion properties between biopolymer soft adhesives and hydrogel-grafted surfaces will be investigated by using under-water adhesion home-made device under physiological conditions [4]. During the debonding process, the stress-strain curve is obtained to determine the adhesion energy can be used to characterize the adhesion properties depending on the viscoelastic properties of the biopolymer adhesive as well as the interface (chemical interactions and topography) between the adhesives and the surfaces.



References:

1. Creton, C.; Ciccotti, M. Fracture and adhesion of soft materials: a review. *Rep. Prog. Phys*. **2016**, 79, 046601.

2. Chollet, B.; Li, M.; Martwong, E.; Bresson, B.; Fretigny, C.; Tabeling, P.; Tran, Y. Multiscale surface-attached hydrogel thin films with tailored architecture. *ACS Appl. Mat. Interfaces* **2016**, *8*, 11729-11738.

3. Guo, H.; Sanson, N.; Hourdet, D.; Marcellan, A. Thermoresponsive toughening with crack bifurcation in phase-separated hydrogels under isochoric conditions. *Adv. Mater.* **2016**, *28*, 5857-5864.
4. Sudre, G.; Olanier, L.; Tran, Y.; Hourdet, D.; Creton, C. Reversible adhesion between a hydrogel and a polymer brush. *Soft Matter* **2012**, ***8***, 8184-8193.

Techniques/methods in use:
Hydrogel synthesis, Rheology, Differential Scanning Calorimetry, Surface modification and lithography, Spin-coating, Ellipsometry, Microscopy, Underwater adhesion test.

Applicant skills:
General knowledge of polymer physico-chemistry and skills for experimental work.

Supervisors:
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