# PhD Subject 2026

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| **Title:** 3D-AFM study of the organization of polymer brushes at Liquid / Solid interfaces: Application to Biosensors and Tribology<br>**Titre:** Etude de l'organisation de brosses de polymères à l'interface Liquide/Solide par 3D-AFM: Applications aux bio-interfaces et à la tribologie | |
| **Scientific field:** Atomic Force Microscopy- Experimentation –Physical-chemistry at interface | |
| **Key words:** AFM, force measurements, 3D –AFM, hydration layers, polymers at interface, Hofmeister ions | |
| **Institution:** Ecole Centrale de Lyon | |
| **Laboratory:** Institut des Nanotechnologies de Lyon/ UMR 5270<br>**Web site:** http://inl.ec-lyon.fr/ | **Laboratory :** Laboratoire de Tribologie et Dynamique des Systèmes UMR 5513<br>**Web site:** http://ltds.ec-lyon.fr/ |
| **Team:** Chemistry and Nanobiotechnology (INL) | **Group:** ComPETe (Compréhension des Phénomènes Elémentaires en Tribologie) |
| **Supervisors:** Pr. M. Phaner-Goutorbe<br>**Email:** magali.phaner@ec-lyon.fr | **Supervisors:** Dr. F. Dubreuil<br>**Email:** frederic.dubreuil@ec-lyon.fr |

**Dead line to candidate: 10 of April 2026 -ready for information now !**

**Background, Context:**

The deposition of polymer brushes on solid surfaces creates versatile platforms for a wide variety of practical applications in the fields of biomedicine, nanotechnology, catalysis, photovoltaic devices, water conversion, as well as certain functions designed to reduce energy costs. Depending on the chemical composition of the polymers and the associated liquid environment, polymer brushes can be adapted to a specific application [1].

In our study, we are particularly interested in biocompatible polyelectrolyte polymers that have the ability to stretch or collapse depending on external stimuli (pH, ionic strength, temperature, etc.) [2]. In biomedicine, by choosing their functional groups and modifying the pH or ionic strength, it is possible to promote the adhesion of species present in the target solution, such as proteins, to create a highly sensitive biosensor (Figure 1a). Conversely, non-specific protein adsorption can interfere with the functioning of the bioactive surface, in the case of medical implants, and in this case a polymer brush capable of repelling unwanted entities in the physiological environment will be chosen [3,4]. By grafting these brushes onto two surfaces, it is possible, depending on the experimental conditions, to promote sliding between the surfaces in contact and thus minimize friction and damage to the surfaces for improved energy efficiency (Figure 1b) [5,6].

To characterize these different polymer brushes, atomic force microscopy (AFM) is used, which in its spectroscopic mode allows the measurement of interaction forces between its tip and the grafted polymer brush. The force curves provide information on the influence of the liquid (ionic strength, pH, hydrophobicity, viscosity, etc.) on the conformation of the polymers.

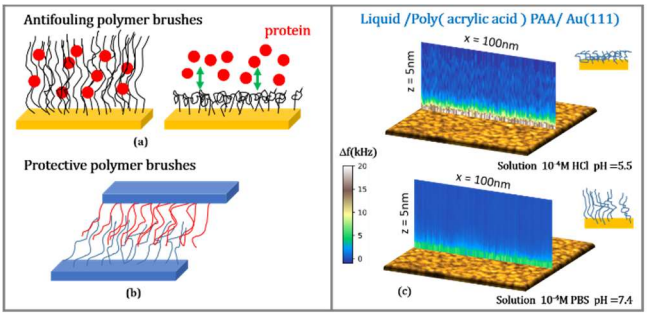


Figure 1: (a) Scheme of the antifouling on proteins and (b) protective activities of polymer brushes (c) 3D mapping of PAA/Au interface in 2 different solutions leading to 2 elongation of the polymers.

The LTDS and INL laboratories and their representatives Frédéric Dubreuil and Magali Phaner have been working together since 2021 on the implementation of an innovative technique called 3D-AFM (the only one of its kind in France) that makes it possible to characterize liquid/solid interfaces at the nanometric scale by

studying the behavior of the liquid and its ions based on force measurements [7]. In a first thesis, the technique was developed and has proved its value in the study of polymer brushes on a gold substrate (Figure1c) [8].

**Research subject- work plan:**
The objective of the thesis is to study a new system composed of polymer brushes onto a silicon substrate in order to determine the organization of the solvation layers and the elongation or not of the polymer brushes.
This study will be performed with various polymer lengths and charges, grafting densities. The impact of the solutions in their composition, pH and ionic strength as well as the chaotropic character of the salt will be considered. One can thus choose the ideal solution to enable an antibacterial effect (antifouling) of polymers for applications in nanomedicine (Figure 1a) or an anti-friction effect of polymers deposited on two contacting surfaces for applications in tribology (Figure 1b).

**Scientific environment:**
The PhD student will be supervised by Prof Magali Phaner-Goutorbe at the INL lab and by Dr Fréderic Dubreuil at the LTDS lab, both specialists of AFM since several years in the field of biology and tribology [8].
***INL*** The Chemistry and Nanobiotechnology group is conducting interdisciplinary research activities focusing on coupling micro/nanotechnology and molecular biology for biology, health care and environmental applications.
***LTDS*** The ComPETe group is working on the knowledge of all elementary friction phenomena and is focused on the usage of nanoparticle, lubricant additives, tribochemistry at the local scale to reduce friction and wear in the contact area. *Scientific collaborations with other labs will be developed for comparison with other techniques and computer IRIS Lab for analyses of the 3D mapping by IA models*

**Candidate skills:**
The PhD candidate should ideally have a background in physics and in physical chemistry of surfaces and some knowledge in classical AFM. The candidate must have a strong taste for experimental work (sample preparation, characterization) but also for data analysis via the development of codes using high programming languages like Python or Matlab environment. Knowledge for programming (python) would be a plus for the force curves interpretation since some codes have been developed for the 3D -AFM data analysis. Also, the candidate must be able to work at the interface between physics, chemistry, mechanics and biology. However, no specific skills are required in biology.
Firstly, the master's student will be introduced to the classic AFM mode of imaging in air and liquids and then he/she will work on the polymer brushes in liquid. In parallel, knowledges on the mechanical and chemical forces involved in these experiments will be given to the candidate to facilitate the work in curves interpretation.

**Funding:**
In the framework of the "Ecole Doctorale Matériaux", the candidate will apply in April 2026 to a PhD grant beginning October 2026 for 3 years. In complement to this grant, the candidate can also participate to the teaching of ECL's students (lab exercices) if desired.

Contacts to postulate and for more information: magali.phaner@ec-lyon.fr, frederic.dubreuil@ec-lyon.fr

This research, through its future applications in biomedicine and tribology, is fully in line with the sustainable development goals (SDGs).

References


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