Master internship

Comparing barnacle and mussel adhesive systems for interactions with surfaces

- **Description**

-Context :

Nature offers many examples of highly effective adhesives in specific contexts. In marine environments, animals and algae have developed adhesive substances to adhere in harsh conditions, *i.e.* in water, with high concentrations of sodium chloride and under the mechanical stresses of the tides. These adhesives could inspire the design of glues for effective adhesion in dry or wet environments [1]. At LMGP, we investigate how barnacle glues work. Barnacles are sessile crustaceans that attach the base of their bodies to various natural or artificial materials. Adult barnacles are attached by a layer of protein glue a few microns thick between their basal plate and the surface. These proteins self-assemble to form a network of fibres. In the context of bioadhesion and our project, the surface properties of materials play an important role in the self-assembly of proteins [2] as well as in the process of protein adhesion to their surface.

In an initial study conducted between LMGP and SyMMES [3], we used surface plasmon resonance imaging (SPRi) to show that a protein inspired by barnacle cement, adsorbs as well strongly and irreversibly onto a wide variety of surfaces, and that this ability is linked to the protein's specific sequence. In the marine environment, mussels use a completely different adhesive system that is extremely strong and durable. The proteins in this adhesive contain modified amino acids such as 3,4-dihydroxyphenylalanines (3,4-DOPA) and hydroxylations [4]. The polymerisation of the glue is linked to oxidation, *i.e*. the cross-linking of DOPA radicals between themselves and to the surface. Synthetic adhesive interfaces and materials inspired by mussels have been extensively applied, with success. However, a limited number of studies have been conducted to investigate the interactions with large panel of surfaces using SPRi.

-Internship topic:

In this project, we aim to compare the functioning of barnacle and mussel adhesive proteins in order to better understand the relationships between protein sequence and surface chemical properties. To this end, we have designed and synthesized a simplified sequence of the barnacle protein which serves as a model for barnacle adhesive. At the same time, we have designed and synthesized, a peptide with the same sequence but with a dihydroxyphenylalanine at the carboxy-terminus to form a simplified model of mussel adhesive. During the 6-month internship, we will conduct a systematic exploration of a full matrix of environmental and surface parameters in real time using SPRi technique. Using multiple surface functionalization thanks to a micro-spotter at SyMMES, we will analyze the barnacle-inspired protein adsorption behavior on surfaces with different physicochemical characteristics (hydrophobic, hydrophilic, positively and negatively charged surfaces) under different environmental conditions, such as pH and ionic strength. As mussel adhesive reticulation process is related to a modification of the DOPA oxidative state, the difference in the adsorption behavior of oxidized and reduced DOPA containing peptides will be questioned. As preliminary results, different conditions to stabilize the reduced state of the peptide have been tested at the platform BIOMade (SyMMES).

- **Host laboratories**

The internship will take place within the IMBM team at the Laboratory of Materials and Physical Engineering (LMGP, Interfaces between Materials and Biological Matter - IMBM – www.lmgp.grenoble-inp.fr). At the laboratory, the IMBM team is interested in protein interactions with interfaces, particularly their

adsorption/desorption and self-assembly through their interactions with interfaces. The Molecular Systems and nanoMaterials for Energy and Health (SyMMES) laboratory and the CREAB team from the CEA Grenoble (https://www.symmes.fr) has recognized expertise in SPRi for sensing biological elements such as proteins, bacteria. All SPRi experiments will be conducted in this lab.

- **Requested profile**

A student in a Master's program or in last year of engineering school, with core courses on chemistry/biochemistry (and possibly in material sciences). The student should be able to work in a team, have good communication skills (report, presentation…) and good knowledge of at least one of the languages used in the lab: French, English.

- **Funding**

Allowance of ≈ 600 €/month.
Starting date : January or February 2026 – Duration : 6 months.

- **Contacts :** send *C.V.* and motivation letter to :

Dr Charlotte Vendrely, charlotte.vendrely@grenoble-inp.fr and
Dr Yanxia Hou-broutin, yanxia.hou-broutin@cea.fr

References

[1] Flammang P and Santos R. (2015) Interface Focus 5: 20140086. DOI: 10.1098/rsfs.2014.0086
[2] Yang B, Adams DJ, Marlow M, Zelzer M. (2018) Langmuir 34, 15109–15125. DOI: 10.1021/acs.langmuir.8b01165
[3] Ayed D, Khalil Z, Picot C.R., Weidenhaupt M, Bruckert F, Mathey R, Hou Y, Vendrely C. Submitted.
[4] Lee BP, Messersmith PB, Israelachvili JN, Waite JH. (2011) Annu. Rev. Mater. Res. 41:99–132. DOI: 10.1146/annurev-matsci-062910-100429.