PhD thesis

Characterisation of the self-assembly of adhesive proteins on surfaces

- **Description**

-Context :

In nature, certain animals produce adhesives that are highly effective in a variety of, sometimes dynamic, environments. Some of these surpass conventional man-made products: they can be reversible and/or effective underwater and on substrates of varying composition and structure. Taking inspiration from natural adhesives could have applications in medicine, biotechnology and industry.

The adhesion mechanism of some natural glues seems to be linked to the self-assembly of proteins secreted by the animal, forming a network of fibers on the surfaces [1,2]. The interaction of these proteins with the materials is a key step in adhesion [2,3]. To study this process, we produced a high-purity recombinant protein inspired by a crustacean adhesive protein. As the variety of materials encountered in the natural environment is significant, we analysed and compared the self-assembly and adsorption of this protein on different surfaces with varying physico-chemical properties [4, 5]. We showed that, depending on the properties of the surface and conditions such as pH and ionic strength, the protein forms fibers with different structures [4].

We aim at pursuing this project in order to understand the protein self-assembly process and its influence on the type of fibers obtained in function of the surfaces. To this end, the various steps of the self-assembly kinetics will be characterized, as the structure of the fibers formed by the protein in presence of different surfaces. The adsorption of the fibers onto the materials and their adhesive properties will also be studied. In order to analyze the relationship between the sequence and structure of the proteins and their fiber formation, this study will be carried out on several proteins (adhesive and non-adhesive).

-Objectives :

The aim of this project is to understand the link between protein self-assembly, material surface and adhesion properties. To this end:

-Proteins inspired by natural adhesives will be recombinantly produced and purified.

-The kinetics of fiber formation will be measured under different conditions using biochemical and spectroscopic tools.

-The protein fibers will be characterized using atomic force microscopy (AFM), transmission electron microscopy (TEM) and Fourier transform infra-red spectroscopy (FTIR).

-The adhesive properties of the various protein self-assemblies will be analyzed.

This project will involve methods for producing recombinant proteins in *Escherichia coli* bacteria (chromatography) and characterizing proteins in solution and on surfaces using biochemical methods (spectroscopies, ELISA) and microscopies (AFM, MET). The adhesive properties of self-assembled proteins will be assessed using tensile tests.

- **Host laboratory**

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). The LMGP offers a multidisciplinary environment and three research teams. The laboratory has gained an international reputation in the fields of growth and functionalization of crystalline materials, nanomaterials, thin-film structured materials, and protein interactions with materials. 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. Located in the heart of an exceptional scientific environment, the LMGP offers candidates an enriching workplace.

- **Requested profile**

We are looking for a student having a Master degree with solid theoretical and practical training in biochemistry/biophysics. The candidate should be interested in multidisciplinary approaches, be able to work in a team and have excellent writing and communication skills (reports, oral presentations).
The candidate should have a good level of English (B2 minimum).

- **To apply** :

https://adum.fr/as/ed/voirproposition.pl?langue=&site=edcsv&matricule_prop=69799

- **Bibilography**

[1] Kamino, K. (2013) Mini-review: barnacle adhesives and adhesion. *Biofouling* **29**, 735–49 https://doi.org/10.1080/08927014.2013.800863

[2] Liang, C., Ye, Z., Xue, B., Zeng, L., Wu, W., Zhong, C., et al. (2018) Self-Assembled Nanofibers for Strong Underwater Adhesion: The Trick of Barnacles. *ACS Appl Mater Interfaces.* **10**, 25017–25025 https://doi.org/10.1021/acsami.8b04752.

[3] Yang, B., Adams, D. J., Marlow, M. and Zelzer, M. (2018) Surface-Mediated Supramolecular Self-Assembly of Protein, Peptide, and Nucleoside Derivatives: From Surface Design to the Underlying Mechanism and Tailored Functions. *Langmuir*. **34**, 15109–15125. https://doi.org/10.1021/acs.langmuir.8b01165.

[4] Khalil, Z. Surface impact on protein fibrillation and adsorption: insights from a barnacle-inspired amyloid adhesive. Thèse 2025. Université Grenoble Alpes.

[5] Ayed, D., Khalil, Z., Picot, C.R., Weidenhaupt, M., Bruckert, F., Mathey, R., Hou, Y., and Vendrely, C. (2026) Unveiling the interactions between a protein inspired from barnacle adhesive and surfaces using surface plasmon resonance imaging. *ACS Appl Bio Mater*. In press. https://doi.org/10.1021/acsabm.5c02186