# DELIVERABLE

# D3.1

# The mechanism of contact formation on wet substrates in limpets


**Grant Agreement number: 642861**

Project acronym: BioSmartTrainee

Project title: Training in Bio-Inspired Design of Smart Adhesive Materials

Funding Scheme: MSCA-ITN-2014-ETN

Project coordinator name: Dr. Alla Synytska
Tel: +49 351 4658 327
Fax: +49 351 4658 98599
E-mail: synytska@ipfdd.de

Project coordinator organization name: Leibniz-Institut für Polymerforschung Dresden e.V.

Project website address: www.biosmarttrainee.eu

Related to a reporting period: RP 1

Milestone no./name: MS 1 and MS 2

Lead beneficiary: UCAM

Nature: Report

Dissemination Level: public

Delivery date from Annex I: month 12 (September 2016)

This project investigates the mechanism of contact formation on wet substrates in limpets and aims to analyze the special adaptations of a biological adhesive system that is highly adapted to wet and submerged environments. In particular, we want to understand how limpet adhesives can cope with the challenges of forming stable and reversible attachments on rough substrates and under fully or partly submerged conditions.
Limpets can attach to rocks under water by alternating between temporary attachment by suction at high tide and long-term attachment by glues at low tide (Smith 1992); these two strategies are associated with a combination of suction and the secretion of two different types of mucus (Smith et al. 1999). Even when using suction, limpets can achieve high adhesive strengths greater than 100 kPa (Smith 1991).
Limpets are able to actively clamp their shell against the substrate in response to strong wave forces and predator attacks (Ellem et al. 2002). Previous studies on limpet adhesion have focused mostly on a range of smooth substrates. Even though one study did measure attachment forces on rough slate (Grenon & Walker 1981), the detailed mechanisms of contact and seal formation on rough surfaces are still unclear, and limpet adhesion has not been tested in a quantitative fashion.
In this project, we will induce freshly collected common limpets (*Patella vulgata*) to attach under water and/or in air within an experimental chamber to well-defined rough or micro-structured substrates. Such micro-structured substrates will be fabricated using photolithography. Techniques will be developed to visualize the adhesive contact zone on micro-structured transparent polymer substrates, allowing direct observations of the sealing of leaks after contact formation, and the process of active clamping. In addition, we will measure pull-off forces on substrates of different roughness at different speeds, combined with pressure measurements in the contact zone. Micro-rheology of the various secreted fluids will be conducted to understand the role of these fluids. Limpet pedal sole surface topography will be visualized using scanning electron microscopy (SEM) to investigate any relationship between the biological and the substrate surface structures.
As the ESR working on this project has started only on 1 September 2016, the project is still at an early stage. So far, most of the ESR's time has been dedicated to the collection of limpets and setting up a marine aquarium tank for long-term maintenance in the laboratory. The first collection site was in Sheringham, UK, on 7 September, and the limpets have been kept in the marine tank since collection. We have made preliminary observations using interference reflection microscopy (IRM) and estimated the thickness of the mucus layer between the limpet and the substrate to be in the range of 10 to 20 µm. More detailed tests are required to validate this finding. We also observed some regular micro-structures on the foot surface, which will be investigated further using SEM.

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