Project A5: Friction on textured surfaces: Inspiration from insect-plant interactions

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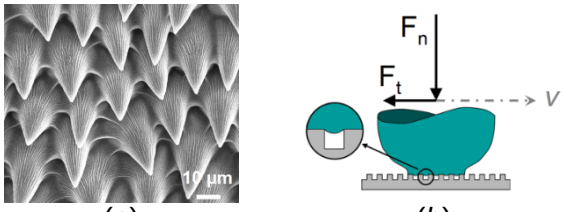
Current state of the research. In many applications, the frictional and adhesive properties of polymer surfaces represent key features controlling performance and durability. For example, it is often crucial to fine-tune the adhesive properties, especially if adhesion should be weak to allow for easy attachment and detachment. A possible solution to this problem is micro-texturation of the polymer surfaces, inspired by the current understanding of how insects and lizards can adhere reversibly to many substrates. References reveal the complex interplay of the geometry, softness, and aspect ratio of the model patterns. The present project intends to integrate these considerations into a larger study which addresses not only adhesive but also frictional properties of micro-patterned polymer surfaces directly inspired by plant leaves which impede insect attachment due to surface topography.

Contributions of the principal investigators. The Strasbourg group has developed experimental devices for mechanical probing of polymer surfaces ("dynamic JKR" test, micro-scratching/sliding machine with in-situ visualization of the contact between the probe and the material, nano-indenter/scratcher) and has long-standing expertise in the analysis of friction phenomena and in Finite-Element modelling. The Freiburg group has recently developed its activities toward the biomechanics involved in the interaction between plants and insects. The group has experience in the replication of biological surfaces and their characterisation as well as force tests with insects.



(*a*) (*b*)

Figure: (a) Example of a textured surface from the gliding zone in the trap of a carnivorous pitcher plant; (b) principle of friction tests on textured surface.

Research project and collaboration. The aim of this project consists in understanding how surface topography (shape and scale) influences adhesive and frictional properties.
To achieve this goal we propose an approach comprising three interconnected parts:

- *Texture synthesis (in Freiburg):* Replicas of several chosen plant leaves will be fabricated (biomimetic surfaces) by direct moulding of soft matter stamps. The topography of the surfaces will be characterized (microscopy, profilometry,...). The relevant scales for the major texturation will range from 1 µm to few 100 µm (see Figure *a*).
- *Experimental study (in Strasbourg):* The friction response of the replica surfaces will be explored by tests involving the sliding contact with a soft matter spherical probe modelling the adhesive pads of insects (see Figure *b*) coupled with in-situ observation of the contact. Adhesion properties will be also explored by Pull-off and JKR tests. Furthermore we aim to develop a model system for characterising the anti-adhesive properties of biological micro-patterned surfaces without performing friction force measurements with live insects.
- *Numerical modelling (software available in Strasbourg and Freiburg):* This part will be helpful to validate the interpretations from the experimental study and also allow the generalization of underlying physical principles through the study of the influence of patterns' shape and scale.

Work plan. The doctoral researcher will work in Strasbourg (micro and nano-friction tests, JKR measurements, modeling) and in Freiburg (preparing samples, characterization).