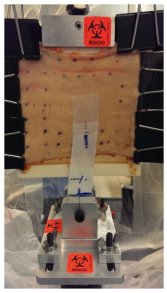
RESEARCH CLUSTER A: Adhesion

Cluster Co-Leaders: Alfred Crosby and Duncan Irschick

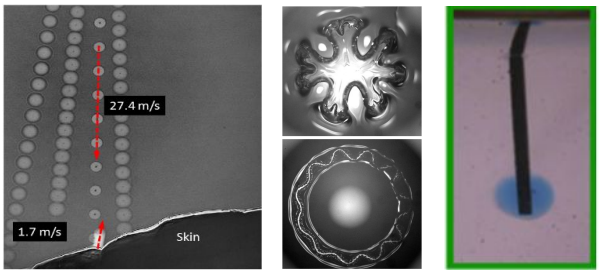
Overview: Cluster A focuses on the preparation and characterization of interfaces between synthetic materials and dynamic materials, such as biological tissues. We aim to uncover the properties characteristic of such interfaces as a function of time and size scale through the implementation of traditional and novel characterization methods. We use principles learned from evolution and natural variation to create new materials that provide desirable multi-functional, robust interfaces with living systems.



(l-r: Adhesive device based on Geckskin™ design principles demonstrating adhesion to human skin; Gehyra on glass)

Dynamic Cluster: This dynamic cluster provides access to experts in Evolutionary Biology, Polymer & Materials Science and Engineering, Biomedical Engineering, Medical Science and Mechanical & Industrial Engineering encouraging the flow of information in multidisciplinary directions. Cluster researchers not only share with industry the results of their research, but also industry representatives are encouraged to share with Cluster researchers their real world problems with the goal of igniting new fundamental discoveries and insights into the materials science of living systems while also providing advances that can be leveraged to spur new technological innovations.

Available Resources: Adhesion characterization instrumentation; ultra-thin film mechanical property measurement; optical profilometry; 3D printing; cavitation rheology; contact mechanical characterization; generation of nonparametric 3D models of biological structures; finite element analysis; statistical analyses of size, shape and variation in 1D, 2D and 3D space; biological specimens representing a diverse array of vertebrates; detailed knowledge of vertebrate anatomy and evolution; acquisition of fresh human skin; enrollment of human subjects.



(l-r: Laser induced impact on skin; adhesion interface during separation; cavitation deformation at tip of a needle embedded within an elastomer)

Example Research Focus Areas

Adhesion and Friction of Interfaces with Complex Geometry

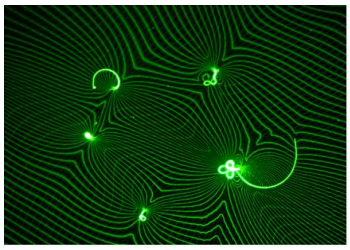
Cluster researchers use an array of commercial and custom-built characterization equipment to provide a multifaceted study of the adhesion and friction of interfaces between complex interfaces, such as skin, and synthetic elastomers. This multifaceted approach aims to provide structure-property-performance relationships between the synthetic elastomer and skin as a function of both biological and synthetic parameters.

Mechanical Characterization of Soft Gels and Ultra-thin Layers

Similar to the adhesion and friction of synthetic interfaces, the mechanical properties of the materials at a living interface play a critical role. However, current abilities to characterize the mechanical properties of soft biological tissues and ultra-thin soft materials used in adhesive applications at relevant size and time scales, especially in vivo, are limited. Cluster researchers implement novel characterization methods including cavitation rheology, laser-induced cavitation, extreme velocity microballistics, and 3D photogrammetry to characterize the materials properties and state of stress and strain in soft tissues and materials near an interface.

Synthetic Adhesives for Dynamic Environments

A key challenge in materials science, and more specifically adhesion, is the development of materials that can change or evolve with dynamics environmental conditions. This need exists in a range of applications, from attaching sensors to living tissues to ecological monitoring. However, clear guidelines for structure-property relationships related to adhesion in meeting these needs are not established. Cluster researchers aim to develop new engineering guidelines and novel materials that can help meet the challenge of creating robust, healthy, comfortable, and dynamic interfaces.



(Ultra-thin composite of silicone elastomer and nanoparticle ribbon grid accommodating complex strains at a water surface)

Examples of Cluster Participants

Cluster A unites a diverse, multidisciplinary group of scientists and engineers to address the multi-scale, complex challenges that are faced at interfaces. Although Cluster A is dynamic in the sense that faculty involvement will be matched with challenges introduced through collaborative discussions with Cluster A members, here we list a few examples of faculty that serve as core members.

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