RESEARCH CLUSTER B: Polymers in Drug Delivery and the BioArena

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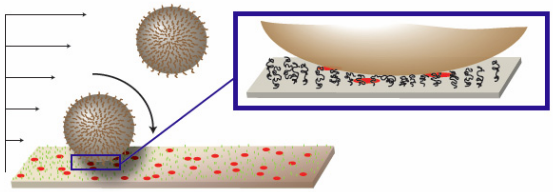
The interface between biological systems and synthetic materials is of critical importance to modern science and medicine. It forms the basis for numerous medical advances, disease treatments, diagnostics and sensors, drug delivery systems, and implants. Indeed, a historical association between the fields of polymer science and biology, more recently in the biomedical arena, derives from the polymeric nature of many naturally occurring biomolecules. Cluster B's mission is to develop fundamental insight into the complexities of these interactions thus facilitating the discovery of novel technologies, smart materials, and innovative treatment modalities for disease.

Materials interact chemically with biomolecules while cell-material contact and signal transduction to the cell interior is governed by both biochemical and mechanical signals. Research within the cluster explores and exploits molecular-, cell-, and tissue- level interactions on surfaces, at interfaces and in bulk biomaterials.

Targeted Drug Delivery and Drug Delivery Carriers: Targeted drug, peptide and biologic delivery represent important challenges at the interface of polymer and biological/medical sciences. The synthesis of novel macromolecules and the design of new soft material (from vesicles to implantable scaffolds) that achieve specified performance are of critical importance. Developing an in-depth understanding through data driven methods for matching a bioactive and its delivery needs to a suitable carrier is critical for translation of promising candidates from the bench to the patient. Progress includes delivery of fully functional proteins and antibodies into primary suspension cells. For chemotherapeutics, new polymer-drug conjugates are prepared having extended circulation half-lifes in vivo and improved uptake into tumor tissue. Integration of design elements from the molecular to mesoscopic are incorporated into new materials with focus on 3-D structure and surface/interface control. The combined expertise within the cluster fosters a much deeper understanding into complex structure-property relationships of the biomaterial-cellular interactions.

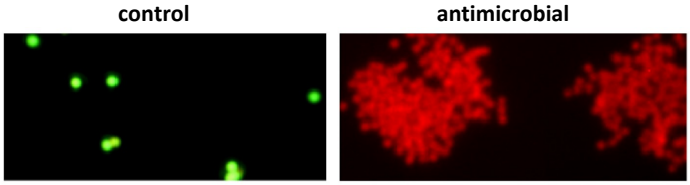
Surfaces for Controlled Cell Interactions: Biomimetic surfaces are being developed with artificial receptors to interact with cells and tissues in a variety of situations. Newly synthesized macromolecules for implant coatings direct specific interactions with neighboring tissue. Novel bio-active surfaces are being developed to selectively capture flowing bacteria or mammalian cells through specific interactions, allowing for their further manipulation. This represents a coupling of chemical, mechanical, and hydrodynamic stresses, with the outcome being the targeted dynamic cell response. Cells are subject to stresses from shear fields, and from adhesion to the material. Cells may be made to roll for purposes of separation or transfer of molecules to the cell surface, they may be exposed to surface-immobilized biochemical signals, they can be grown to confluence, and later individual cells or tissues may be released. Material surfaces in this thrust area have applications in fields such as implants, catheters, sensors, diagnostics, microfluidics and cell engineering.



Selective surface designed for bacterial manipulation / cell sorting

BioInert and Bio-targeting Surfaces: The body's response to artificial surfaces controls the efficacy of implants and other medical devices including materials that contact fluids outside the body, such as those used in aphoresis and dialysis. The first interactions involve the adsorption of dissolved proteins, determining the ultimate fate of the biomaterial. Research in this area focuses on the synthesis of new bioinert surfaces or coatings as well as novel applications of established biocompatible molecules. Capabilities include high precision quantification of protein adsorption and cell adhesion in real time. Additionally, center expertise includes the modification of surfaces for controlled biomolecular and cellular interactions, in quiescent conditions and in flow.

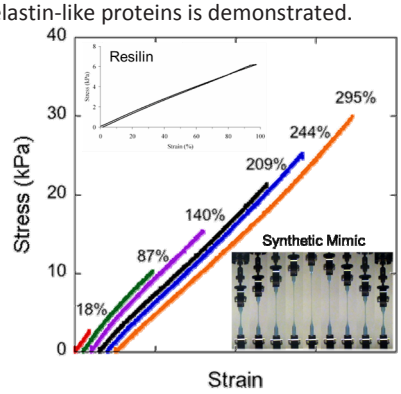
Polymers with Protein-like Bioactivity: The ability of synthetic macromolecules to perform protein-like functions remains an important challenge. Work has demonstrated the ability to effectively capture the antimicrobial activity of proteins from the innate immune system. Viral-like proteins for transduction of cargo (therapeutic or imaging) inside cells has also been mimicked. These represent important 'proof of concept' principle demonstrations that novel polymers can be designed with protein-like biochemical properties.



Staph. Aureus (green) in the control are alive; when exposed to our antimicrobial polymers they aggregate, (red), and are killed.

This antimicrobial technology has been translated into coatings based on a wide variety of polymers, and, further, it can be broadly active and can kill bacteria quickly upon contact.

Coupling Novel Chemistries to Mechanical Response: An important forefront area in soft materials is learning to couple novel chemistries and mechanical properties to cellular response. This newer effort in the Cluster represents an expansion of the research expertise. Here novel, completely synthetic soft materials with mechanical properties similar to natural elastin-like proteins is demonstrated.



Mechanical properties of a novel degradable hydrogel

Additional Areas of Expertise

- Biomaterial Surfaces and Coatings
- Biomimetic Membranes and scavengers
- Material-Directed Cell Signaling
- Biologically-Active Polymers
- Cell Separation: In Vitro and Ex-vivo
- Nanofiltration and Biosensors
- High oxygen permeable materials
- Wound dressings
- Antifouling and Superabsorbent Materials
- Soft Material Mechanics
- Cell Signaling and Stem Cell Manipulation
- Gene Delivery-Cell Penetrating Peptide Mimics

Contact Information

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