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Biomaterial Interfaces Division
Room On Demand - Session BI-Invited On Demand

Biomaterial Interfaces Invited On Demand Session

BI-Invited On Demand-1 Ion-Assisted Plasma Polymerization: Surface Engineering of Biomimetic Interface, ***Behnam Akhavan***, *M. Bilek,* The University of Sydney, Australia **INVITED**

Titanium-based alloys are promising materials for orthopedic prostheses due to their low toxicity, superb corrosion resistance, and favourable mechanical properties. The sub-optimal biocompatibility of bare metal surfaces, however, often leads to adverse foreign body responses, inflammation, or infection requiring additional medical interventions. The integration of metallic implantable devices with local host tissues can be strongly improved by a plasma polymerized (PP) coating functionalized with biomimetic molecules. The stability of the PP layer in body fluids is indispensable, and the coating must resist failure even when scratched. In this presentation, I talk about a novel approach for the fabrication of chemically and mechanically robust PP coatings on titanium surfaces. A custom-made plasma polymerization system consisting of a radio frequency (RF) electrode and a pulsed voltage source was utilized for PP deposition. The chemical and mechanical stability of the coatings in simulated body fluid (SBF) was examined by incubation of samples in Tyrode's solution at 37 ^{o}C for durations of up to 2 months. As evidenced by both X-ray photoelectron spectroscopy (XPS) data and scanning electron microscopy (SEM) observations, the PP coating resisted failure, and no delamination, cracking, or buckling was observed after scratching and subsequent incubation in SBF solution. XPS results revealed that the excellent interface adhesion is linked to the formation of metallic carbide and carbonate bonds, induced by ion implantation, at early stages of film growth. Such atomic interfacial mixing also resulted in the formation of a continuous smooth film near the substrate as suggested by atomic force microscopy (AFM) and time of flight secondary ion mass spectroscopy (ToF-SIMS) data. I present results demonstrating that multifunctional protein layers, peptide molecules, or silver nanoparticles can be covalently immobilized on such interfaces for improved osteoblast activity and enhanced antimicrobial properties. I also describe our recent work on tuning the orientation and density of immobilized molecules on these PP coatings by tuning pH or applying external electric fields during the biomolecule immobilization.

BI-Invited On Demand-7 NanoSIMS Imaging of Cholesterol and Sphingolipids in Cell Membranes, ***Mary Kraft***, University of Illinois at Urbana-Champaign **INVITED**

Regions with different protein and lipid compositions are present in the plasma membranes of mammalian cells. Correlations between the activities of specific membrane proteins and their distributions within the plasma membrane have been drawn from studies that combined functional assays with the selective imaging of the protein species of interest within the plasma membrane. Certain lipid species and cholesterol are also hypothesized to have non-random distributions within the plasma membrane that may be required for proper cell function. We tested this hypothesis by using high-resolution secondary ion mass spectrometry (SIMS) performed with a Cameca NanoSIMS to image isotope-labeled lipids and cholesterol within mammalian cell membranes with ≤100-nm-lateral resolution. First, we metabolically incorporated ^{15}N-sphingolipids and ^{18}O-cholesterol into the membranes of two mammalian cell lines. Next, we used a Cameca NanoSIMS 50 to image the component-specific isotopic (^{15}N and ^{18}O) and elemental (gold) enrichments in the plasma membrane with a lateral resolution of approximately 100 nm. Finally, we assessed co-localization between the cholesterol and sphingolipids with statistical methods.We found that sphingolipids are enriched within distinct regions within the plasma membrane, but the cholesterol distribution is relatively uniform. This work argues against the prevailing hypothesis that the plasma membranes of mammalian cells contain domains that are enriched with both cholesterol and sphingolipids.

BI-Invited On Demand-13 Materials inspired from Catch Bonds and other Biological Adhesion Strategies, ***Sinan Keten***, Northwestern University **INVITED**

Biological materials excel at serving mechanical functions, which may be passive as in structural materials, or dynamic, as in cell motility and adhesion components. Impressive properties of biomaterials often come from novel designs of interfaces and adhesive mechanisms. In this talk, I'll summarize our recent progress on modeling biological adhesion mechanisms at the molecular scale, using innovative coarse-grained simulation techniques. I'll present new advances in interface design enabled by molecular and multi-scale simulations, and translation of developed ideas to nanocomposite design. I'll talk about computational design of polymer grafted nanoparticle assemblies and how interfaces in these materials could take inspiration from bioadhesives to achieve superior stress transfer between nanoparticles. I'll also discuss how examining basic allosteric principles of catch bonds in proteins could be reduced to simple mechanical models to create nanoparticle linkages with counterintuitive force-dependent kinetics.

BI-Invited On Demand-19 Contact Mechanics of Hydrogels, ***Yuhang Hu***, Georgia Tech; *Y. Lai, D. He ,* Georgia Institute of Technology **INVITED**

Gel is composed of cross-linked polymer network and solvent molecules. Gels have broad application in many engineering fields such as drug delivery, tissue scaffold, soft robots and so on. Mechanical characterization of soft gels has been challenging. Recently there is a growing interest in using indentation techniques on gels because of the practical easiness. While relaxation indentation has been developed in characterizing the poroelastic properties of gels, dynamic indentation has been found to provide more accurate measurements in small scale, in which the gel is under oscillatory loading. In this study, we use the characteristic phase lag between the applied indentation displacement and the force on the indenter due to the energy dissipation from solvent flow in the gel to characterize the poroelasticity of gels. We will show that the phase lag degree is a function of two parameters, Poisson's ratio and normalized angular frequency. The solutions are derived for several shapes of indenters. The maximum value of the phase lag over a spectrum of actuation frequencies can be used to characterize the Poisson's ratio of the gel, and the characteristic frequency corresponding to the maximum phase lag can be used to characterize its diffusivity. Besides poroelastic properties of gels, we also use indentation technique to explore the adhesion properties of gels. We carry out the experiment on gels across a wide range of length scales and time scales, and use cohesive zone model to extrapolate the adhesion properties of gels.

BI-Invited On Demand-25 Understanding the Role of Protein Deposition Associated to Catheter-induced Inflammation in the Development of CAUTI, *M. Andersen,* University of Notre Dame; *J. Fong, C. Howell,* University of Maine; ***Ana Flores-Mireles***, University of Notre Dame **INVITED**

Urinary catheterization is a common procedure in hospital setting and nursing homes. Even though, urinary catheters are used to safely empty the bladder, placement of the catheter predispose the patient to develop a catheter-associated urinary tract infection CAUTI. Currently, CAUTI are the most common healthcare-associated infection worldwide and often leads to leading to bloodstream infections with 30% mortality. CAUTIs are a major threat to public health since their treatment and control are becoming challenging due to the rise of antibiotic-resistant pathogens. Urinary catheterization allows a diverse number of pathogens to colonize the bladder, something that otherwise would not occur. Therefore is imperative to understand how urinary catheterization renders the bladder susceptible to an infection. Previously, we found that urinary catheterization elicits bladder inflammation and mechanically disrupts the host defenses, compromising the host for microbial colonization. Our recent findings in mice and humans have shown that fibrinogen (Fg) is released and accumulated in the bladder in order to heal the damaged tissue. Fg is also deposited on catheters, coating them and forming a platform for colonization by *E. faecalis*, *S. aureus*, *C. albicans*, *E. coli*, and *A. baumanni*. We found that Fg levels modulate outcome of the infection, in the absence of Fg, *E. faecalis* is unable to stick to the catheter and colonize the bladder. On the other hand, high Fg levels enhance enterococcal bladder and catheter colonization, suggesting protein deposition on urinary catheters is a key factor for microbial infection. Therefore, we developed bio-inspired liquid-infused catheters that reduce Fg deposition *in vitro*. We tested in our mouse model of CAUTI, finding that liquid-infused catheters not only reduced protein deposition but also prevented biofilm formation of previously mentioned pathogens. This finding provides a new alternative to prevent CAUTI that does not contribute to microbial drug resistance.

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