Biomaterial Interfaces
Room 321 - Session BI1-TuM

Biomaterials and Nanomaterials Fabrication I

Moderators: Joe Baio, Oregon State University, **Sapun Parekh**, University of Texas at Austin

8:00am **BI1-TuM-1 Engineering the Human Sense of Touch as the Finger-Object Interface*, Charles Dhong,*** University of Delaware **INVITED**

The human sense of touch is a basic sensory experience, and for those who are visually impaired, a critical source of information. Technologies that interface with the sense of touch or "haptics" have seen progress over the years, but remain limited in the variety of sensations that these devices can reproduce and are nowhere near the the ability to recreate everyday sensations, especially when we compare these haptic technologies to vision or sound.

In this talk, we will show how the mechanical forces generated at the finger-object interface through adhesion and friction phenomena can be leveraged to control, or study, the human sense of touch. Mechanical forces generated at this interface give rise to tactile sensations and ultimately fine touch perception. Manipulating this mechanical interface through surface chemistry, polymer chemistry, and thin-film mechanics can give rise to new kinds of haptic devices while also enabling fundamental investigations into the perception of touch. We will end this talk by giving examples of how advances in the finger-object interface can enable widespread applications, from new insights into sensory neuroscience, to new accessibility technologies, and to medical diagnostics.

8:30am **BI1-TuM-3 Tuning Aggregation for Enhanced Control Over Protein-Based Underwater Adhesives*, Zachary D. Lamberty,*** Naval Research Laboratory*; Chloe M. Skogg, Elizabeth A. Yates,* U.S. Naval Academy*; **Christopher R. So**,* Naval Research Laboratory

Recent advances have enabled the development of hydrogels with significant underwater adhesion, despite the high water content of these materials. These adhesives offer the promise of materials with better underwater compatibility, higher tolerance for rough or fouled surfaces, and lower toxicity than their hydrophobic counterparts. We have recently demonstrated the creation of underwater curing adhesives from two common byproduct proteins – Bovine Serum Albumin (BSA) and α-Lactalbumin (αLa). Depositing aqueous precursors underwater to cure into a hydrogel is inherently risky – the mixture is highly vulnerable to dissolving or washing away until it adequately set up. At the same time, mixtures that cure too rapidly yield poorly organized gels that are fragile and weakly adhesive. The narrow window in which these requirements can be balanced leaves little room to study material relationships and optimize adhesive properties, ultimately hindering our ability to develop stronger, sticker gels. Here I will demonstrate two methods of extending the working range of these materials. First, we perturb the intermolecular forces driving aggregation by the addition of simple salts (NaCl, KCl, MgCl2, and CaCl2) to the environment, allowing us to hasten or delay gelation by up to 60%. Further control over curing kinetics can be achieved by modulating denaturant concentrations. While BSA gels expectedly cure faster with higher denaturant concentration, αLa solutions can be induced into a denatured yet-quasi-stable state that remains liquid for up to two hours at high denaturant concentrations. Instead of dissolving away in water, αLa solutions form protective shells of hardened protein, leaving an inner core that can slowly aggregate into denser, tougher gels with nearly 3x the bond strength of faster curing materials. In general, slower curing gels are found to lead to higher ordered networks that have greater storage moduli and lap shear strengths, despite containing more water.

8:45am **BI1-TuM-4 RF Pulsed Plasma Modified Composite Scaffold for Enhanced Anti-Microbial Activity and Accelerated Wound Healing*, Ajinkya Mahadev Trimukhe,*** University of Milan Bicocca, Italy*; Jose Savio Melo,* Bhabha Atomic Research Centre, India*; Deepa Chaturvedi, Ratnesh Jain, Prajakta Dandekar, Rajendrasing Deshmukh,* Institute of Chemical Technology, India

This study entails the successful synthesis of a biodegradable microporous agarose-chitosan composite scaffold and modifying its surface with diphenyldiselenide (DPDSe), by using low-pressure RF pulsed plasma for enhanced wound-healing applications. The scaffolds' synthesis composition was optimized at a 3:1 agarose-to-chitosan ratio and 4% polymer concentration. The optimized RF plasma treatment parameters for depositing DPDSe on the scaffold surface were at a pulse rate of $5_{ON}/15_{OFF}$ (ms) for 80 minutes. The plasma-modified scaffold surfaces demonstrated superior antibacterial activity against Gram-positive bacteria *S. aureus* and *S. epidermidis*, achieving inhibition zones up to 24 mm and 26 mm, respectively, while maintaining excellent biocompatibility, with 91.9% and 88.6% cell viability for HaCaT and HadF cells, respectively. Surface characterization revealed enhanced hydrophilicity, with contact angles decreasing from 89° to 33°, and from XPS analysis, it was observed that there was increased oxygen content from 19.82% to 21.87%, and successful selenium deposition at an atomic concentration of 1.01%. *In vivo* studies using albino Wistar rats demonstrated accelerated wound healing, with plasma-modified scaffolds achieving 100% wound closure by day 14, compared with 16 days for untreated scaffolds, accompanied by enhanced collagen synthesis, evidenced by a hydroxyproline content of 5.96 µg/mL. The selenium-modified scaffolds showed comparable efficacy to standard Betadine treatment while offering practical advantages as solid dressing materials, making them promising alternatives for treating challenging wounds.

9:00am **BI1-TuM-5 Engineering Curvature-Controlled Polymer Dome Biointerfaces via Condensed Droplet Polymerization*, Haobo Xu,*** *Rong Yang,* Cornell University

Surface-attached dome morphologies are ubiquitous in nature but remain difficult to reproduce synthetically due to limited control over geometric parameters such as curvature. Here we introduce condensed droplet polymerization (CDP), a synthesis strategy that leverages condensed monomer microdroplets as discrete microreactors to produce surface-attached polymer dome arrays with precisely tunable geometry. The potential of CDP for functional interface design is demonstrated in two contexts. Inspired by dome-shaped morphologies on crustacean shells, we investigate antifouling behavior and identify an optimal intermediate dome size (~10 µm) with targeted curvature that significantly suppresses *Pseudomonas aeruginosa* attachment despite a globally hydrophobic surface. In addition, sub-micron dome arrays significantly increase extracellular vesicle yield from M1-polarized murine macrophages (J774A.1), suggesting that curvature-defined biointerfaces can regulate plasma membrane dynamics, particularly the inward budding process associated with the endocytic pathway, thereby promoting the subsequent production and release of extracellular vesicles. These results establish CDP as a versatile platform for engineering curvature-controlled interfaces for antifouling materials and cell-regulating biomaterials.

Author Index

Bold page numbers indicate presenter

— C —
Chaturvedi, Deepa: BI1-TuM-4, 1
— D —
Dandekar, Prajakta: BI1-TuM-4, 1
Deshmukh, Rajendrasing: BI1-TuM-4, 1
Dhong, Charles: BI1-TuM-1, **1**
— J —
Jain, Ratnesh: BI1-TuM-4, 1
— L —
Lamberty, Zachary D.: BI1-TuM-3, 1
— M —
Melo, Jose Savio: BI1-TuM-4, 1
— S —
Skogg, Chloe M.: BI1-TuM-3, 1
So, Christopher R.: BI1-TuM-3, **1**
— T —
Trimukhe, Ajinkya Mahadev: BI1-TuM-4, **1**
— X —
Xu, Haobo: BI1-TuM-5, **1**
— Y —
Yang, Rong: BI1-TuM-5, 1
Yates, Elizabeth A.: BI1-TuM-3, 1