Biomaterial Interfaces
Room 209 F W - Session BI1-MoA

Functional Biomaterials and Sensing

Moderators: Sapun Parekh, University of Texas at Austin, **Rong Yang**, Cornell University

1:30pm **BI1-MoA-1 Casting Light on Exceptional Biointerfaces***, Joe Baio,* Oregon State University **INVITED**

Abstract: From cell membranes to sticky frog tongues, the natural world abounds with novel biointerfaces. In this talk, we will explore how these biological materials have inspired the design of new biomedical systems. Specifically, we will examine surface-driven self-assembly of biomaterials that mimic natural processes. The presentation will begin with the development of analytical methods that enable visualization of the structure and organization of biomolecules at interfaces. With these tools in hand, we will then investigate the surface phenomena that govern the intricate system muscle cells use to repair plasma membrane damage. Finally, the discussion will expand to recent experiments uncovering the structures of biomolecules that drive wet adhesive processes in nature.

2:00pm **BI1-MoA-3 Molecular Modeling of Nucleic Acid-Based Nanomaterials***, Elizabeth Skelly,* University of North Carolina at Charlotte*; **Christina Bayard,*** North Carolina State University*; Joel Jarusek,* University of Nebraska*; Benjamin Clark,* North Carolina State University*; Laura Rebolledo, Yasmine Radwan, Phong Nguyen, Melanie Andrade-Muñoz,* University of North Carolina at Charlotte*; Thomas Deaton,* North Carolina State University*; Alexander Lushnikov,* University of Nebraska*; Sharonda LeBlanc,* North Carolina State University*; Alexey Krasnoslobodtsev,* University of Nebraska*; Yaroslava Yingling,* North Carolina State University*; Kirill Afonin,* University of North Carolina at Charlotte

DNA and RNA-based nanotechnology offers transformative potential for precision medicine, particularly in drug delivery and therapeutic applications, due to their inherent ability to precisely target and execute molecular functions. Nucleic Acid NanoParticles (NANPs) serve as versatile scaffolds for assembling functional nanomaterials. However, systematic understanding of how NANP design parameters, such as size, shape, sequence, composition, flexibility, and linker strands, govern their physicochemical properties and drive their self-assembly into supramolecular structures remains limited. Here, we employ multi-resolution molecular dynamics simulations, integrating all-atom (AA) and dissipative particle dynamics (DPD), to investigate how these parameters influence NANP structural, mechanical, and self-assembly characteristics. Furthermore, the integration of inorganic nanoparticles (NPs), such as quantum dots (QDs), into nucleic acid systems significantly enhances their functionality. QDs offer exceptional luminescence, photostability, and resistance to photobleaching, making them ideal biological markers. Functionalizing QDs with nucleic acids merges their superior optical properties with therapeutic functionalities. Due to the inherent limitations of experimental characterization techniques (e.g., TEM), we applied DPD simulations to elucidate mechanisms governing the formation and structural dynamics of QD-DNA condensates, providing detailed insights unattainable through experimental approaches alone. These findings advance our fundamental understanding of nucleic acid-based nanomaterials and facilitate their strategic development for next-generation biomedical applications.

2:15pm **BI1-MoA-4 Surface-Immobilized Fibronectin Conformation Drives Synovial Fluid Adsorption and Film Formation***, Syeda Tajin Ahmed,* University of California Merced, United States Virgin Islands*; Ummay Honey, Lenka Vitkova, Diego Jaramillo Pinto, Katelyn Lunny, Warren Flores, Kaleb Cutter,* University of California Merced*; Yidan Wen, Kevin De France,* Queens University, Canada*; **Roberto Andresen Eguiluz**,* University of California Merced

The articular cartilage extracellular matrix (ECM) is a complex network of biomolecules that includes fibronectin (FN). FN acts as an extracellular glue, controlling the assembly of other macromolecular constituents to the ECM. However, how FN participates in the binding and retention of synovial fluid components, the natural lubricant of articulated joints, to form a wear-protecting and lubricating film has not been established. This study reports on the role of FN and its molecular conformation in mediating macromolecular assembly of synovial fluid ad-layers. FN films as precursor films on functionalized surfaces, a model of FN's articular cartilage surface, adsorbed and retained different amounts of synovial fluid (SF). FN conformational changes were induced by depositing FN at pH 7 (extended state) or at pH 4 (unfolded state) on self-assembled monolayers on gold-coated quartz crystals, followed by adsorption of diluted SF (25%) onto FN precursor films. Mass density, thin film compliance, surface morphologies, and adsorbed FN films' secondary and tertiary structures reveal pH-induced differences. FN films deposited at pH 4 were thicker, more rigid, showed a more homogeneous morphology, and had altered α-helix and β-sheet content, compared to FN films deposited at pH 7. FN precursor films deposited at pH 7 adsorbed and retained more synovial fluid than those at pH 4, revealing the importance of FN conformation at the articular cartilage surface to bind and maintain a thin lubricating and wear protective layer of synovial fluid constituents. This knowledge will enable a better understanding of the molecular regulation of articular cartilage-SF interface homeostasis and joint pathophysiology and identify molecular interactions and synergies between the articular cartilage ECM and SF to reveal the complexity of joint biotribology.

2:30pm **BI1-MoA-5 Growable Mycelial Coatings: A New Approach to Bio-Based Plastic Replacements***, Sandro Zier, Liza White, **Caitlin Howell**,* University of Maine

Sustainable and compostable plastic replacements are in growing demand as we learn more about the health and environmental hazards associated with single-use plastic packaging. However, many biomaterials readily absorb water, making them unsuitable as plastic replacements, while hydrophobic bio-derived plastic alternatives can be expensive to produce. Here, we present an alternative: large-scale coating of a fungal mycelium mixture which grows exponentially over the course of three days to create a densely packed functional surface barrier. The resulting surface is highly hydrophobic (CA >130°) and absorbs water to the same degree as the current accepted standard for shipping materials (water uptake <30 g/m^2 after 120s). The grown coating also shows extremely high oil resistance and can withstand bending and folding. These findings highlight a promising path toward affordable, compostable, and high-performance biomaterials that address the pressing need for sustainable plastic alternatives while maintaining functionality for real-world applications.

2:45pm **BI1-MoA-6 Nanoparticle biosensing in 3D Cell culture** *, Miriam Kael, Paul Stoddart,* Swinburne University of Technology, Australia*; **Sally McArthur**[1]*, Deakin University, Australia

While only a limited number of assays are tailored for 3D, and some are influenced by matrix proteins like collagen, nanoparticle-based biosensors present a valuable opportunity to analyse 3D in vitro cultures. Investigating how the sensor influences the model during in situ measurements is crucial, as is understanding how the model could interfere with the sensor's design. Certain sensors that exhibit potential in 2D may not be applicable in 3D environments. Although gold nanoparticles offer benefits, their detection in a 3D context is limited by traditional darkfield techniques. On the other hand, fluorescent nanodiamonds demonstrate significant potential as probes for 3D cultures.

3:00pm **BI1-MoA-7 Peptide-Polymer Mixtures Form Tunable Biomolecular Condensate Materials***, Tino Zhang, **Sapun Parekh**,* University of Texas at Austin

Liquid-liquid phase separation (LLPS) is increasingly recognized as a promising strategy for designing dynamic and functional materials for catalysis, drug delivery, and synthetic biology. Despite growing interest, the physical and chemical properties of LLPS-based materials remain poorly characterized, limiting their rational design and broader utility. Here, we introduce a minimal, peptide-based bi-component biomolecular condensate (BCs) system that offers a modular platform to construct and interrogate LLPS materials with tunable properties. We generated a library of biomolecular condensates by pairing short, rationally designed peptides with biopolymers such as nucleic acids and proteins. Systematically characterizing their internal environments using Raman microscopy, fluorescence recovery after photobleaching (FRAP), and fluorescence lifetime imaging, our results reveal that peptide sequence and stoichiometry govern critical material features such as viscosity, molecular partitioning, and local chemical structures. These results show that the understanding of LLPS material properties are complex and establish a framework for programming condensates with defined functionalities, highlighting the tunability of the chemical environment in condensates. Looking ahead, we envision applying these designer condensates as responsive microreactors or environment-responding materials, where properties can be modulated via peptide-level design.

[1] **JVST Highlighted Talk**

Author Index

Bold page numbers indicate presenter