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 Biodegradable Scaffolds Loaded with Metallic Particles for Enhanced Wound Healing**, ***Narayan Bhattarai***, NC A&T State University; *Alexis Moody, Sita Shrestha,* North Carolina A&T State University **INVITED**

Chronic wounds are a persistent clinical challenge, marked by impaired healing, infection susceptibility, and tissue degradation. To address these complexities, we developed bioactive nanocomposite scaffolds incorporating zinc (Zn) and magnesium (Mg) within the polymer polycaprolactone (PCL). Fabricated using electrospinning and 3D printing, these metal based scaffolds were designed to deliver soluble therapeutic ions while providing a structural framework to promote tissue regeneration.Due to their distinct biological roles, Zn and Mg were studied in scaffold formulations. In this study, Zn-loaded scaffolds improved fibroblast proliferation, collagen deposition, and cell differentiation. In vitro assays with NIH3T3 fibroblasts showed that Zn-containing scaffolds led to an increase in cell viability compared to controls and significantly enhanced migration and expression of α-SMA, vimentin, and collagen IV, key markers of fibroblast differentiation and matrix remodeling. Mg based scaffolds promoted cellular proliferation and supported anti-inflammatory effects, consistent with magnesium's role in modulating immune response and vascularization. Morphological analysis revealed that metal incorporation decreased fiber diameter, optimizing surface area and topography for cellular interaction, while ion release studies confirmed sustained Zn^{2+} or Mg^{2+} delivery under physiological conditions with minimal cytotoxicity. To further enhance scaffold performance, a subset of Zn scaffolds was surface-modified with a decellularized fibroblast-derived extracellular matrix (ECM), resulting in PZE scaffolds. This modification improved protein deposition, initial cell attachment, cell viability, and cell migration *in vitro*. *In vivo* studies in murine models demonstrated that the scaffolds supported tissue repair,showing early recruitment of M2-like reparative macrophages and improved healing responses compared to controls. These findings highlight the therapeutic potential of Zn and Mg as bioactive agents in wound healing applications. Their ability to provide targeted antimicrobial effects, modulate immune responses, and enhance tissue regeneration within tunable polymeric scaffolds presents a scalable, multifunctional strategy for treating chronic wounds. This approach holds promise not only for wound care but also for broader use in tissue engineering and regenerative medicine.

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 Exploring New Materials as Biomimetic Growth Factor Delivery Systems**, ***Brooke Farrugia***, The University of Melbourne, Australia

Tissue engineering and regeneration is an inter-disciplinary field of research that combines principles from both biology and engineering. While the use of biomaterials has long been associated with this field of research, more recently there has been a paradigm shift for the modern biomaterial to be biomimetic, through replication of the *in vivo* situations they are trying to substitute. Growth factors and their use as a therapeutic is of great interest in tissue engineering and regenerative applications however, to achieve a beneficial response, appropriate administration of growth factors is required. Furthermore, due to biological heterogeneity of the molecules that control growth factor activity *in vivo*, their low abundance, and difficulty in isolation from mammalian tissues, there is a need to develop an alternative source of these biomimetic materials.

This prestation will explore the use of materials that mimic biologically derived sulphated sugar structures, known as glycosaminoglycans, that are responsible for the protection and delivery of growth factors *in vivo*. It was hypothesised that by adjusting structural variables, the specificity and affinity of these biomimetic materials towards different growth factors can be modulated, with the aim of developing a suite of materials that can be implemented in various tissue engineering applications to sequester and deliver growth factors and potentially modulate their downstream biological function.

3:00pm **BI1-MoA-7 Nanoparticle biosensing in 3D Cell culture**, *Miriam Kael, Paul Stoddart,* Swinburne University of Technology, Australia*;* ***Sally McArthur,*** 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.

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