Biomaterials Plenary (ALL-INVITED SESSION)
Room 317 - Session BP+BI-SuA

Biomaterials Plenary Session (ALL-INVITED)

Moderators: Christopher So, Naval Research Laboratory, **Rong Yang**, Cornell University

3:00pm **BP+BI-SuA-1 Bio-Inspired Design of Multifunctional Materials**, ***Kenan Fears,*** US Naval Research Laboratory **INVITED**

Biology serves as an inspiration for researchers due to the countless examples of nature evolving elegant solutions to complex problems humans have difficulty overcoming with engineered materials. For example, acorn barnacles, known for their ability to form a robust underwater cement that withstands harsh marine environments, have also evolved methods to compromise the attachment of the fouling organisms. We discovered barnacles secrete a phase-separating material at their basal interface that oxidizes and lifts off microbial biofilms ahead of growth and cement deposition. Proteomics analysis and confocal microscopy indicate haloperoxidases are present and active at the barnacle's adhesive interface.

Inspired by this approach to combating biofouling, we devised materials and coatings that mimic surface cleaning processes evolved by barnacles. These novel antifouling materials are comprised of surface-active glasses, that is, glasses that intentionally degrade in aqueous environments. We demonstrate the glasses deter marine biofouling by a combination of mechanisms: 1) deterring macrofouler settlement by elevating the concentration of potassium and magnesium ions, which are naturally abundant in seawater, and 2) compromising the adhesion of microbial foulers through the formation of reaction layers that generate reactive oxygen species.

3:30pm **BP+BI-SuA-3 Synthetic Brochosomes: From Biomimicry to Function**, ***Tak-Sing Wong,*** The Pennsylvania State University **INVITED**

Leafhopper-produced brochosomes are hollow, buckyball-like nanostructures with distributed nanoscale cavities, representing a unique class of biological optical materials. Inspired by these architectures, we develop synthetic brochosomes with demonstrated broadband, omnidirectional antireflective performance and optical camouflage capabilities [1-3]. This talk highlights recent advances in elucidating geometry-driven optical functionality of brochosomes, where hierarchical pore structures and particle size synergistically suppress reflection across ultraviolet–visible wavelengths [4]. We further discuss scalable manufacturing via droplet microfluidics and interfacial self-assembly, enabling high-throughput production of synthetic brochosomes with tunable architectures [5]. These results position synthetic brochosomes as a versatile platform for optical coatings, signature management, and photonic applications.

References:

[1] L. Wang, J.S. Choi, T.-S. Wong, *Nano Res.* **17**, 734-742 (2024).

[2] S. Yang, N. Sun, B. B. Stogin, J. Wang, Y. Huang, T.-S. Wong, *Nat. Commun.* **8**, 1285 (2017).

[3] Z. Li, L. Wang, X. Liu, J. Li, H.S. Yun, Z. Wang, X. Zhang, T.-S. Wong, S. Sheng, *Sci. Adv.* **10**, eadl4027 (2024).

[4] L. Wang, Z. Li. S. Sheng, T.-S. Wong, *Proc. Natl. Acad. Sci. USA.* **121**, e2312700121 (2024).

[5] J. Choi, T.-S. Wong, *ACS Nano* **19**, 42175-42187 (2025).

4:00pm **BP+BI-SuA-5 Gas Bubble-Encapsulating Microcapsules (GEMs): Pressure-Triggered Drug Delivery and AI-Enabled Fabrication**, ***Daeyeon Lee,*** University of Pennsylvania **INVITED**

Pressure-triggered drug delivery holds significant promise for treating pathologies characterized by sudden increases in localized hydrostatic pressure, such as traumatic brain injury and orthopedic injuries. Conventional microcapsules designed for compression-triggered release are liquid-filled, rendering them intrinsically insensitive to pressure. To address this limitation, we develop Gas Bubble-Encapsulating Microcapsules (GEMs), which incorporate gas bubbles via osmotic cavitation, endowing them with the compressibility necessary for pressure-sensitive mechanical response. To systematically optimize GEM structure, we develop an AI-empowered Automated Droplet Library (ADLib) generator that integrates convolutional neural network-based object detection with real-time microfluidic feedback control, autonomously generating 25 distinct monodisperse double-emulsion populations within 2–3 hours, compared to weeks of manual effort. Using ADLib, we identify two critical structural parameters governing the transition from non-destructive buckling to shell rupture: the shell thickness-to-diameter ratio and the gaseous volume fraction. We establish quantitative design principles that link GEM structure to pressure sensitivity and release kinetics, providing a generalizable platform for pressure-responsive microstructures in targeted drug delivery.

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