Biomaterials Plenary Session (ALL-INVITED)
Room B117-119 - Session BP-SuA

Coupled Phenomena in Biomaterial Systems (ALL-INVITED SESSION)

Moderators: Kenan Fears, U.S. Naval Research Laboratory, **Markus Valtiner**, Vienna University of Technology, Austria

4:00pm **BP-SuA-7 BID Early Career Awardee Talk: Large-Scale Vascularized Polymers Enable Continuous Sensing of and Responding to Bacteria at Interfaces**, *B. Dixon, A. Briley, K. Marquis, B. Chasse,* ***Caitlin Howell***[1], University of Maine **INVITED**

Large-scale, non-destructive detection and active response to cellular layers at interfaces is crucial for the scale-up of controlled biointerfaces. One way Nature accomplishes this passive detection and active response process is through the use of complex vascular systems that aid in transporting signals and responding accordingly. In this work, we embedded vascular networks in polymeric hydrogels using 3D printing to create a non-destructive detect-and-respond system for living bacteria at the material surface. Tests with *E. coli* as a model system showed that bacteria-specific signals could be detected through the vascular network. The cells could then be precisely targeted at the surface by introducing gentamicin into specific sections of the vascular channels. Theoretical models of the system were developed to permit the rational design of the detect-and-respond system suitable for other applications. This work lays the foundation for the fabrication and use of vascularized polymers as an adaptive system for the early detection of and response to bacteria or other cells at interfaces.

4:40pm **BP-SuA-9 Learning from Nature to Tackle Adhesion in Wet and Challenging Conditions**, ***Ali Dhinojwala***, University of Akron **INVITED**

A small magnitude of roughness and wetness can disrupt interfacial bonding and reduce adhesion. I will discuss how roughness affects both dry and wet adhesion, and the lack of our current theoretical framework to explain these results. Particularly in the case of underwater adhesion, the presence of trapped water can accentuate the challenges in creating molecular contact with rough surfaces.The drainage of confined water is a function of both roughness and surface chemistry. I will describe how nature has developed strategies to stick to rough and wet surfaces: fibrillar structures used by geckos and insects to create molecular contact and improve water drainage; the use of hygroscopic salts by spiders to reduce the water next to hydrophilic surfaces; or the use of catechol groups by mussels to bind to polar surfaces. I will discuss how these strategies have inspired new synthetic adhesives (with emphasis on sustainability) for improving adhesion to wet and rough surfaces with an impact on biomedical and engineering applications.

5:20pm **BP-SuA-11 Mechanoresponsive Proteins - from Molecular Mechanisms Towards Applications in Biology and Materials Science**, ***Kerstin G. Blank***, Johannes Kepler University Linz, Austria **INVITED**

Mechanoresponsive proteins undergo structural and functional changes when experiencing mechanical stimuli. These proteins play crucial roles in various cellular processes, including cell adhesion, tissue development, and mechanotransduction. Moreover, they are essential building blocks for biogenic materials where they determine the structure-mechanics relationships of these materials from the molecular to the macroscale. In our research, we aim to engineer mechanoresponsive proteins to understand their fundamental structure-mechanics relationships and to utilize them as molecular force sensors and programmable building blocks for smart bioinspired materials. Coiled coils are prototype mechanoresponsive protein building blocks that are highly abundant in mammalian tissues. Using single-molecule force spectroscopy, we have uncovered key factors that determine the stability of these structures against shear forces [1-5]. We have then employed this knowledge to establish a library of synthetic and mechanically calibrated coiled coils. These building blocks are currently being developed as molecular force sensors to measure cell-generated traction forces at the cell-material interface and as mechanoresponsive hydrogel crosslinks [2,6,7]. Another example are proteins from the arthropod cuticle that interact with chitin. We have started with chitin-binding domains as the basic molecular building block and determined their binding strength to chitin fibers. Single-molecule force spectroscopy shows bond lifetimes on the second to minute timescale, indicating that these proteins may act as sacrificial bonds that facilitate energy dissipation and cuticle self-healing. Our next goal is to explore the application of engineered chitin-binding domains in chito-protein composite materials, where they can serve to crosslink chitin fibers or chitosan polymers. In conclusion, these examples demonstrate the potential of protein building blocks with tunable and calibrated mechanical properties. These building blocks allow for the bottom-up control of smart materials and interfaces that can sense and respond to external forces, with potential applications in biomedicine, robotics, and nanotechnology.

[1] Goktas et al. (2018) Chem. Sci. 9:4610
[2] Tunn et al. (2018) Nanoscale 10:22725
[3] López-García et al. (2019) Phys. Chem. Chem. Phys. 21:9145
[4] López-García et al. (2021) Angew. Chem. Int. Ed. 60:232
[5] Tsirigoni et al. (2023) Macromol. Biosci. 2200563
[6] Tunn et al. (2019) Biomimetics 4: 25
[7] Grad et al. (2020) Front. Chem 8:536

[1] **BID Early Career Researchers Award**

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