Biomaterials Plenary
Room 117 - Session BP-SuA

Biomaterials Plenary Session (INVITED SESSION)

Moderators: Kenan Fears, U.S. Naval Research Laboratory, **Christopher So**, Naval Research Laboratory

4:15pm **BP-SuA-6 Biomimetic Chemistry from Sea Creatures for Making Sustainable Adhesives*, Jonathan Wilker,*** Purdue University **INVITED**

Adhesives are wonderful materials, holding together our electronics, furniture, and packaging. However, most of these glues are petroleum-based, do not degrade, and prevent substrate separation, thereby meaning that most consumer products end up in landfills for centuries. These glues and the materials held together contribute to land-based and ocean microplastics. Given the amount of adhesive use, impact in the marketplace will arrive only when alternative adhesives are high performance, low cost, easy to make, and the components are already available at large scales. In order to begin down this path of adhesive sustainability, we have turned to sea creatures for design cues. Mussels, barnacles, and oysters all bond to rocks using chemistry not found in commercial glues. Characterization insights on biological materials have provided a starting point for adhesive design. Here we report new materials based upon epoxidized soy oil. Cross-linking with bio-based, multifunctional alcohols and acids was examined. Plant-based compounds such as malic acid reacted with the soy oil. However, catechol-like chemistry, found in marine mussel glue, was required to bring about the extreme degree of cross-linking needed for curing into viable adhesives. In the best of cases, bond strengths could be of quite high strength, similar to epoxies. Spectroscopic characterization showed that all components, including tannic acid, cross-linked with each other, although some reactions were more prominent than others. Water resistance studies showed a middle ground of being able to withstand being submerged for a short period of time while enabling debonding at later time points. Bulk scale costs worked out to be a modest ~1/3 premium over incumbent materials. Preliminary calculations indicate that, considering sourcing, manufacturing, and curing, this new adhesive system is, overall, carbon negative. By making new adhesives from bio-based components and demonstrating high bonding performance we hope that, soon, several environmental problems may be solvable.

4:45pm **BP-SuA-8 Interfacial Bonding in Underwater Adhesion*, Joelle Frechette,*** UC Berkeley **INVITED**

Underwater environments are particularly challenging for adhesives, as water weakens the interfacial bonds that underlying adhesion. A promising strategy for improving underwater adhesion is the incorporation of multidentate Hydrogen bonding groups. However, it remains challenging to quantitatively relate the macroscale adhesive strength to cooperative hydrogen-bonding interactions at the interface, limiting our understanding of the bonding mechanisms. This presentation will discuss efforts to understand how the presence of multidentate hydrogen bonding groups leads to strong underwater adhesion. To do so we show a relationship between the bond activation energy to the macroscale adhesive strength and how this relationship can be employed in self-arresting crack measurements. We will also report on measurements using the Surface Forces Apparatus to show that epoxies modified with tridentate hydrogen bonding groups exhibit robust adhesion to both mica and ultra-smooth aluminum substrates in water. These results inform our understanding of how molecular debonding mechanisms impact macroscale adhesion, aiding our ability to connect adhesive chemistry to performance.

5:15pm **BP-SuA-10 Protein Structure at Interfaces – Its Where the Action Is*, Tobias Weidner,*** Aarhus University, Denmark **INVITED**

Proteins are the machinery of life -– understanding protein structure provides important clues about their mode of action. For this reason, more than 100.000 protein structures have been determined experimentally and are available in databases. At the same time, information about interfacial proteins is sparse. Not a single structure of an interfacial protein can be found in databases. We lack critical information about interfacial proteins to understand biomembranes, the protein control of biominerals, the health impact of artifical biomaterials and the toxicity of microplastic. In addition, for sensor or nanotechnology application, understanding protein binding to surfaces will be key. The current lack of information is, in part, explained by the experimental difficulty of determining the structure of protein within a monomolecular layer in the overwhelmingpresence of unbound proteins in solution near the interface. Here, sum frequency generation (SFG) spectroscopy has been developed into a surface sensitive tool to probe protein structure in detail. We have recently developed methods combining molecular dynamics (MD) simulations with SFG spectroscopy to follow the binding, structure and motion of interfacial proteins. As recent examples, I will discuss breakthroughs in understanding how the formation of neurotoxic aggregates of α-synuclein, the protein implicated with Parkinson's disease, is accelerated at cell membrane. Our data show that at slightly elevated concentrations, α-synuclein assumes a binding pose that promotes lateral aggregation at membrane interfaces. Interfacial effects can also be pronounced atnanoparticle interfaces – which can be important for health in view of the large amounts of plastic particles found in humans. When elucidating the toxicity of plastic particles, we find that nanoparticles affect the conformation of human proteins much more than flat surfaces, with significant consequences for the toxicity of plastics particles.

Author Index

Bold page numbers indicate presenter