Biomaterial Interfaces
Room 209 F W - Session BI2-MoA

Microbes and Biofilms

Moderators: Joe Baio, Oregon State University, **Caitlin Howell**, University of Maine

4:00pm **BI2-MoA-11 Influence of Copper on the Establishment of Marine Biofilms***, Sara Tuck, **Kenan Fears,*** U.S. Naval Research Laboratory

Biofouling, the accumulation of unwanted organisms on submerged assets, is an ongoing challenge within the maritime industry and has additional repercussions on human health. Biofouling build-up increases fuel consumption, asset drag, and operational costs in addition to facilitating the transfer of environmental and pathogenic bacteria from one location to another. Conventional methods to inhibit biofouling includes the application of antifouling coatings, the most popular of which are copper based. In biological systems, copper is tightly regulated and, in an attempt to exploit this, some antifouling coatings contain up to 75% copper (I) oxide by weight. Despite these high loadings, the efficacy of these coatings is rapidly declining with the emergence and spread of copper tolerant species. Microbial communities resistant to copper have been found to form mature biofilms on these coatings, which could be altering the interfacial properties to create more favorable conditions for the settlement of a broader biofouling community. To gain an understanding of the mechanisms responsible for the loss of antifouling performance, coated and uncoated polyvinyl chloride panels were deployed at field sites to harvest early biofilms. From these collections, we isolated, cultured, and identified bacterial species. Copper tolerance profiles were developed by re-exposing individual colonies to copper sulfate in broth microdilution assays. We also investigated copper biocide release from copper-ablative coated glass coverslips over a short time frame to better understand the copper environment that is susceptible to primary colonization.

4:15pm **BI2-MoA-12 Biofouling Prevention by Constant and Alternating Potentials***, Jana Schwarze, Emily Manderfeld, **Axel Rosenhahn,*** Ruhr University Bochum, Germany

The application of electrochemical potentials to surfaces is an easy and direct way to alter surface charge density, the structure of the electrochemical double layer, and the presence of electrochemically activated species. We investigated how applied potentials affect the colonization of surfaces by microorganisms. Different constant potentials as well as the regular alternation between two potentials were investigated, and their influence on the attachment of the biofilm-forming microorganisms on gold-coated working electrodes and laser induced graphene was quantified in laboratory and in field experiments. In order to be able to study the attachment under dynamic conditions, different electrochemical approaches have been developed to merge dynamic assay conditions e.g. microfluidics or rotating disks with potential control by potentiostats. In addition to the effect of the applied potentials on fouling, the electrochemical processes on the working electrode were analyzed by cyclic voltammetry and correlated with chemical analysis that provided insight into the reactive oxygen species formed. The electrochemical processes that occur on the surface will be discussed in view of the observed antifouling behavior and discussed regarding the protection of structures and ships in contact with seawater and technological applications such as desalination by reverse osmosis.

4:30pm **BI2-MoA-13 NO-Releasing Hybrid Material Coatings with Low Fouling Properties Against Pathogenic Bacteria***, **Luciana Natascha Herbeck**, Samantha Muhring-Salamone, Regina Kopecz, Axel Rosenhahn,* Ruhr-University Bochum, Germany

One serious, global issue facing human mankind is the uncontrolled accumulation and growth of organisms and organic matter onto man–made surfaces, known as biofouling.[1] Negative outcomes attributed to freshwater biofouling comprise clogging or corrosion, the spread of pathogenic bacteria in water distribution or food processing systems, and is the root of medicinal infections.[2–6] As the trend in coating design is moving towards sustainable and bio–friendly approaches, one strategy is to mimic nature's concepts in counteracting biofouling, e.g. by using secondary messenger molecules such as nitric oxide, which has been found to disperse biofilms and to exhibit antimicrobial effects.[7] This property has already been utilized in research on catheters and wound healing patches.[8,9] In this work, the secondary messenger molecule nitric oxide was integrated into a sustainable coating matrix consisting of the naturally occurring polysaccharide alginate, tetraethyl orthosilicate and an aminosilane capable to serve as an NO–acceptor/donor group. Two different nitrogen oxide species were formed in the coating after NO binding at elevated pressures and the ratio of the two species depended on the ratio of the two silane compounds. The NO-binding and release was characterized by UV-Vis spectroscopy and Griess–assays. Antifouling properties of the coatings against the freshwater bacteria *Bacillus subtilis*, *Pseudomonas fluorescens* and *Escherichia coli* were verified in dynamic attachment assays, revealing a significant reduction for NO–releasing samples compared to coatings without NO–release.

References

[1] R. T. Bachmann and R. G. J. Edyvean, *Biofilms*, 2005, **2**, 197–227. [2] E. A. Zottola and K. C. Sasahara, *Int. J. Food Microbiol.*, 1994, **23**, 125–148. [3] M. Jamal, W. Ahmad, S. Andleeb, F. Jalil, M. Imran, M. A. Nawaz, T. Hussain, M. Ali, M. Rafiq and M. A. Kamil, *J. Chinese Med. Assoc.*, 2018, **81**, 7–11. [4] M. W. Mittelman, *J. Dairy Sci.*, 1998, **81**, 2760–2764. [5] T. S. Rao, *Miner. Scales Depos. Sci. Technol. Approaches*, 2015, 123–140. [6] M. M. H. Oliver, G. A. Hewa and D. Pezzaniti, *Agric. Water Manag.*, 2014, **133**, 12–23. [7] D. P. Arora, S. Hossain, Y. Xu and E. M. Boon, *Biochemistry*, 2015, **54**, 3717–3728. [8] R.-S. Gilly, K. Mary, M. Chris and A.-G. Yossef, *Antimicrob. Agents Chemother.*, 2010, **54**, 273–279. [9] M. L. Jones, J. G. Ganopolsky, A. Labbé, C. Wahl and S. Prakash, *Appl. Microbiol. Biotechnol.*, 2010, **88**, 401–407.

4:45pm **BI2-MoA-14 Effect of Salts on the Aggregation and Strength of Protein-Based Underwater Adhesives***, Zachary Lamberty,* Naval Research Laboratory, Chemistry Division*; Chloe Skogg,* US Naval Academy*; Michael Wilson,* Purdue University*; Maryssa Beasley,* Naval Research Laboratory*; Abdon Vivas Tejada, Amarachi Peters, Elizabeth Yates,* US Naval Academy*; **Christopher So,*** Naval Research Laboratory

While hydrophobic underwater adhesives have often been desired for their ability to remove water from interfaces, their inherent immiscibility with water can also hinder their use. Water-based adhesive systems can lead to improved wetting, lower toxicity, and exhibit dynamic physical responses to aqueous chemistries in the environment. For protein-based adhesives, simple aqueous salts can dramatically alter the driving intra- and intermolecular forces among proteins and with surfaces. Here we investigate the effect of four main salts found in seawater, NaCl, KCl, MgCl2, and CaCl2 on underwater adhesives made from two agricultural byproduct proteins, bovine serum albumin (BSA) and bovine α-Lactalbumin (αLa). We demonstrate that salts can significantly impact the adhesive strength of protein-based adhesives, increasing strength at moderate salt concentrations but decreasing at higher concentrations. Calorimetry and rheology experiments show that a high salt condition hastens gelation time to form weaker materials with lower adhesion, while moderate salt conditions slow protein aggregation to produce stiffer materials with higher bond strength. In general, salts that stabilized native protein structures formed stiffer gel networks but tended to decrease adhesive strength compared to salts with destabilizing effects. When combining simple salts and protein-based adhesives, we demonstrate control over nearly all attributes of adhesive curing and strength as an effective means to improve underwater adhesion.

Author Index

Bold page numbers indicate presenter