Biomaterial Interfaces Division
Room Oregon Ballroom 203-204 - Session BI-TuP
Biomaterial Interfaces Flash Poster Session

BI-TuP-1 Spacer Length Variations in Sulfo- and Sulfabetaines Affecting the Resistance Against Pathogenic Bacteria, ***Regina Kopecz***, *J. Karthäuser,* Ruhr University Bochum, Germany*; E. Schönemann, A. Martínez Guajardo, A. Laschewsky,* University Potsdam, Germany*; A. Rosenhahn,* Ruhr University Bochum, Germany

Zwitterionic polymers are characterized by their positively and negatively charged groups and their overall neutral net charge. The typically highly hydrophilic polymers are classified into several groups. Beside the well-studied phosphatidylcholine-, carboxybetaine-, and sulfobetaine-, also more recently developed sulfabetaine-based polymers were found to form fouling-resistant coatings.[1] Out of the large variety of possible geometric arrangements of zwitterionic functional groups, only very few have been explored. Following recent studies demonstrating the importance of the precise molecular polymer structure of sulfabetaines on their marine fouling resistance[2], we synthesized sulfo- and sulfabetaines with varying chain lengths of inter-charge and backbone spacers to investigate the effect of the structural change on the resistance against proteins and pathogenic bacteria. The study included six different zwitterionic polymers synthesized by free radical polymerization of monomers with varying ethyl, propyl, and a long undecyl backbone-betaine spacer in combination with ethyl, propyl, and butyl inter-charge spacers. All zwitterionic polymers consistently exhibited very good wettability determined by contact angle goniometry. The non-specific attachment of proteins on the different coatings was analyzed by surface plasmon resonance spectroscopy and the resistance against bacterial fouling was determined by dynamic attachment assays with the freshwater pathogens *E. coli*, *P. fluorescens,* and *B. subtilis*. The highest resistance exhibited the combination of propyl backbone betaine spacers with sulfonate functional groups.

[1] E. Schönemann, A. Laschewsky, E. Wischerhoff, J. Koc, A. Rosenhahn, Polymers (Basel). 2019,11, 1014. [2] J. F. Karthäuser, J. Koc, E. Schönemann, R. Wanka, N. Aldred, A. S. Clare, A. Rosenhahn, A. Laschewsky, Adv. Mater. Interfaces 2022, 9, [2200677] 1-9.

BI-TuP-2 Frequency-Dependent Mechanical Characterization of Hygroscopic Biological Materials, ***Saima Sumaiya***, *B. Sejour, O. Sahin,* Columbia University

Hygroscopic biological materials constitute a significant portion of the biological world, encompassing a diverse range of biomass from wood to bacterial spores. These materials respond to external stimuli by changing their size, shape, and mechanical properties. This responsiveness allows them to play critical roles in important natural processes such as growth of plants, distribution of seeds etc. Apart for their natural significance, these materials have also demonstrated promising applications in fields such as energy harvesting, development of biohybrid devices, and drug delivery. Our recent results show that these hygroscopic materials can exhibit a jamming-driven transition in mechanical properties at short timescales that differs from glassy and poroelastic behaviors (1). To this end, we have developed an atomic force microscopy (AFM)-based setup that can probe the nanomechanical properties of hygroscopic biological materials across a wide range of frequencies. With this setup, we study the frequency-dependent stiffness of the hygroscopic spores of *Bacillus subtilis* under varying load and humidity levels. We perform frequency sweeps over multiple decades and, alternatively, probe response at a single frequency at varying indentation forces. We interpret the response of the spores in terms of amplitude and phase differences between the applied modulation and cantilever response signal. Through this study, we aim to shed light on the jamming-driven transition in hygroscopic bacterial spores.

[1] Harrellson, S. G., DeLay, M., et al. Hydration Solids.*Nature, in press,* doi: 10.1038/s41586-023-06144-y.

BI-TuP-4 Gas Sensing via Conductive Molecularly Imprinted Polymers (cMIPs), ***Adriana Feldner***, CEST GmbH/University of Vienna, Austria*; P. Lieberzeit,* University of Vienna, Austria*; P. Fruhmann,* CEST GmbH, Austria

Molecularly imprinted polymers (MIPs) are synthetic materials that contain binding sites for selectively rebinding the target analyte. [1] Herein, cMIP blends serve as receptor layers on quartz crystal microbalances (QCMs) and chemiresistors. QCMs are mass-sensitive sensors based on the piezoelectric properties of quartz. [2] Chemiresistors can detect volatile organic compounds (VOCs) in the gas phase through thin conductive polymeric films. [3] The analytes in this case are volatile organic compounds (VOCs) that are known breath biomarkers of breast cancer patients. [4] Those sensors could be preliminary work towards applications in non-invasive early detection of diseases via breath analysis. Alternatively, they could serve as a stepping stone to other conductive MIP systems for VOC monitoring purposes

This work presents the results obtained with cMIPs as sensor materials for detecting 2-propanol, heptanal and acetophenone, respectively. MIPs for the detection of 2-propanol are based on polyurethane. For heptanal detection an acrylamide-based MIP was developed. The acetophenone MIP relies on an acrylate-based system. cMIPs were obtained by blending MIPs with a conductive material. The blends were applied to QCMs and chemiresistors. All sensors were tested in gas flow containing the respective analytes.

All described QCMs sensors react to the desired analyte in gas flow with concentration dependency. The cMIPs have also proven suitable for chemiresistors where binding of the analyte leads to a reversible concentration dependent change in the electric resistance. Detailed results for all analytes including selectivity studies with other VOCs will be presented on the poster.

References

[1]Haupt, K. et al., Molecularly Imprinted Polymers. Molecular Imprinting. Topics in Current Chemistry **2011**, 325, 1-28.

[2]Alassi, A.et al., Quartz Crystal Microbalance Electronic Interfacing Systems: A Review. Sensors **2017**, 17 (12), 2799.

[3]Yan, S. et al., Inexpensive, Versatile and Robust USB-Driven Sensor Platform **2017**, 1 (6), 1-4.

[4]Phillips, M. et al., Prediction of breast cancer using volatile biomarkers in the breath. Breast Cancer Research and Treatment **2006**, 99 (1), 19-21.

BI-TuP-7 3d Mass Imaging of Bacterial Biofilm Composition Using Water Cluster Sims, ***Kate McHardy***, *N. Sano,* Ionoptika Ltd., UK*; N. von Jeinsen, D. Ward,* University of Cambridge, UK

Here we present recent work related to the study of biofilms; Microbial communities embedded in a 3D extracellular matrix. The matrix is composed of a complex array of extracellular polymeric substances that contribute to the unique attributes of biofilm lifestyle. Samples of bacteria and the biofilms they evolve are prepared and the growth arrested after a set period, with the resulting sample analysed with two distinct imaging techniques. We present data from water gas cluster ion beam secondary ion mass spectrometry (Water Cluster SIMS) which offers a mass and depth resolution to aid understanding of the spatial composition of the biofilm by visualising the 3D structures within.

One of the key benefits of Water Cluster SIMS is its ability to achieve high depth resolution due to the low kinetic energy of the water clusters which allows for the analysis of surface and subsurface structures with a high degree of precision. The use of water clusters as the primary ion source enhances secondary ion sensitivities of high mass molecules, in addition, it also minimises sample damage and fragmentation of high mass molecules which are common issues with other cluster ion beams. The water cluster beam was used in Ionoptika's J105 Cluster SIMS system with a beam spot size of 1.5um.

The results here show species consistent with biofilms and tracing masses through the sample in 3D, allows the differentiation between known surface features, for example, biofilm components, fixative residue, growth medium and substrate.

Despite the work being at an early stage, a significant step forward has been made in delivering new methods for the study of highly topical bio-samples that are of wide interest and application.

BI-TuP-8 Characterization of Commercial Catheter Surfaces with Bio-Inspired Liquid-Infused Surfaces, ***Evan Leonard***, University of Maine

Hospital-acquired infections (HAIs) affect over 1.7 million patients annually and are often treated with antibiotics, which can contribute to antibiotic resistance. Catheter-associated urinary tract infections (CAUTIs) are the most common type of HAI, resulting in an estimated $390-450 million in treatment and increased length of stay-associated costs annually. Previously, a bio-inspired coating on commercial catheter surfaces has demonstrated the ability to reduce the need for antibiotics by minimizing both protein and bacterial adhesion to the catheter surface as well as the spread of bacteria to other organs. In this work, we treated commercial catheters with the bio-inspired liquid-infused coating to investigate changes

in properties such as length, mass, and French size. Confocal microscopy was used to examine the catheter and coating interface, while material tensile testing was conducted to quantify bulk material properties after coating application. Through the development of liquid-infused treatments for commercial catheters, we aim to create a widely available, cost-effective solution for preventing CAUTI and reducing the need for antibiotic use in patients who need indwelling catheters.

BI-TuP-9 Multi-Component Liquid-Infused Systems: A New Approach to Functional Coatings for Biomaterials, ***Zachary Applebee***, *C. Howell,* University of Maine

Liquid-infused surfaces (LIS) have found utility across the globe due to their diverse applications including bactericidal functionality, ice adhesion prevention, and medical diagnostic equipment enhancement. Recent research has started exploring the broader potential of LIS by incorporating additional components into the liquid matrix. In this work, we present the concept of multi-component liquid-infused systems (MCLIS), in which the coating liquid consists of a primary liquid and a secondary component and review recent examples. At the molecular scale, MCLIS consisting of silicone oils infused with bacterial quorum sensing inhibitor compounds have been shown to stop bacterial biofilms not only from adhering but also from forming. At the nanoscale, MCLIS made from ferrous magnetic nanoparticles within fluorocarbon-based fluids or silicone oil can change their shape upon exposure to magnetic fields, making them useful for the active removal of adherent fouling organisms. Alternatively, MCLIS fabricated by first adding free particulates to the surface of a spherical droplet, then allowing the decorated droplet to be coated with an immiscible liquid, results in a 3D-coated MCLIS system. At the microscale, microdroplet arrays using more than one liquid in a defined pattern have been fabricated and used for high-throughput detection of compounds. By introducing an additional element into the liquid matrix of liquid-infused systems, a diverse spectrum of attributes can be imbued into these materials, creating novel opportunities for applications within the biomedical realm and beyond.

BI-TuP-10 Subcellular Detection of PEBCA Particles in Macrophages: Combining Darkfield Microscopy, Confocal Raman Microscopy, and ToF–SIMS Analysis, ***Elke Tallarek***, Tascon GmbH, Germany*; A. Vennemann,* IBE gGmbH, Germany*; M. Wiemann,* IBe gGmbH, Germany*; D. Breitenstein, B. Hagenhoff,* Tascon GmbH, Germany

The detection of biomedical organic nanocarriers in cells and tissues is still an experimental challenge. Here we developed an imaging strategy for the label-free detection of poly (ethylbutyl cyanoacrylate) (PEBCA) particles. Experiments were carried out with phagocytic NR8383 macrophages exposed to non-toxic and non-activating concentrations of fluorescent (PEBCA NR668 and PEBCA NR668/IR), non-fluorescent (PEBCA), and cabazitaxel-loaded PEBCA particles (PEBCA CBZ). Exposure to PEBCA NR668 revealed an inhomogeneous particle uptake similar to what was obtained with the free modified Nile Red dye (NR668). In order to successfully identify the PEBCA-loaded cells under label-free conditions, we developed an imaging strategy based on enhanced darkfield microscopy (DFM), followed by confocal Raman microscopy (CRM) and time-of-flight secondary ion mass spectrometry (ToF–SIMS). Nitrile groups of the PEBCA matrix and PEBCA ions were used as suitable analytes for CRM and ToF–SIMS, respectively. Masses found with ToF–SIMS were further confirmed by Orbitrap-SIMS. The combined approach allowed to image small (< 1 µm) PEBCA-containing phagolysosomes, which were identified as PEBCA-containing compartments in NR8383 cells by electron microscopy. The combination of DFM, CRM, and ToF–SIMS is a promising strategy for the label-free detection of PEBCA particles.

We thank SINTEF, Norway for providing the samples.

BI-TuP-11 Removal of Free Liquid Layer from Liquid-Infused Silicone Catheters Reduces Silicone Loss into the Environment while Maintaining Adhesion Resistance, ***Chun Ki Fong***, University of Maine*; M. Andersen,* University of Notre Dame*; E. Kunesh, E. Leonard, D. Durand, R. Coombs,* University of Maine*; A. Flores-Mireles,* University of Notre Dame*; C. Howell,* University of Maine

Silicone catheters infused with silicone liquid are an effective alternative to antibiotic coatings in reducing the adhesion and dissemination of bacteria. However, free silicone liquid on the surface of catheters *in vivo* can be lost into the host system, potentially causing complications. To reduce the potential for liquid loss, free silicone liquid was removed from the surface of liquid-infused catheters and the effects on protein and bacterial adhesion were explored. Absorption of the surface liquid from fully saturated catheter surfaces removed the most if not all of the free liquid layer but preserved the slippery properties. As anticipated, significantly less oil could be forcibly removed from the surface of the samples with the free silicone liquid removed than samples that retained their liquid layer. Tests using the catheter infection-associated protein fibrinogen and bacterium *Enterococcus faecalis* revealed no significant differences in adhesion between the material with or without the free liquid layer. To better understand what point infusing liquid saturation becomes important to resisting adhesion, catheter samples were infused to between 5–100% of maximum liquid uptake values then tested for their ability to resist adhesion by fibrinogen and *E. faecalis*. The results revealed that samples infused with ~80% of their performed statistically similarly to fully infused materials. Together, the results suggest that eliminating free liquid layers through either mechanical means or partial infusion can reduce oil loss from liquid-infused catheters into the host system while preserving functionality, improving the safety of liquid infusion as alternatives to antibiotic coatings in catheters.

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