Biomaterial Interfaces Division
Room 318 - Session BI2+AS-TuM

Characterization of Biological and Biomaterials Surfaces

Moderators: Kenan Fears, U.S. Naval Research Laboratory, **Graham Leggett**, University of Sheffield, UK

11:00am **BI2+AS-TuM-10 Getting to the Surface of Biology***, Lara Gamble,* University of Washington **INVITED**

A variety of different surfaces (or interfaces) exist in biology. The surface of a biomaterial is the interface between that biomaterial and the biological environment. State-of-the-art instrumentation, experimental protocols, and data analysis methods are needed to obtain detailed information about these surface and interface structures and their compositions. Surface analysis tools such as time-of-flight secondary ion mass spectrometry (ToF-SIMS) can provide images of polymer biomaterials, cells, and tissues with chemical and molecular specificity. These chemically specific images could revolutionize our understanding of biological processes such as the role of changes in tumor metabolism that affect responses to chemotherapy. Since many biomaterials (e.g. porous polymer scaffolds), cells, and tissues are three-dimensional constructs, it is of interest to be able to characterize their chemical composition in 3D. However, it is challenging to characterize these topographically complex materials with surface-sensitive techniques. With the use of gas cluster ion beams (GCIBs) surface analysis tools such as x-ray photoelectron spectroscopy (XPS) and ToF-SIMS can attain very fine z-resolution (<10 nm) in-depth profiles. In this presentation, ToF-SIMS analysis of biologically relevant samples in 2D and 3D will be presented.

11:40am **BI2+AS-TuM-12 3D Investigation of Sr^{2+} Mobility in Bone Marrow by ToF- and Orbi-SIMS***, C. Kern, A. Pauli, R. Jamous, T. El Khassawna, Marcus Rohnke,* Justus Liebig University Giessen, Germany

Next generation biomaterials will be functionalised with drug release systems. In osteoporosis research strontium ions (Sr^{2+}) have emerged as promising therapeutic agent in modified bone cements for better fracture healing. In previous work we focused on the Sr^{2+} release off a functionalised bone cement and its dispersion in the mineralised areas of rat bone. [1, 2] Here, we go one step further and investigate Sr^{2+} transport within the much more complex system bone marrow in a passive dispersion experiment. First, we present an experimental cryo-workflow for transport studies within bovine bone marrow. As analytical tools for tracking the Sr^{2+} diffusion in 3D and spatially resolved characterisation of the bone marrow we apply time-of-flight secondary ion mass spectrometry (ToF-SIMS) and orbitrap secondary ion mass spectrometry (Orbi-SIMS). Within a time-dependent experimental series, the validity of our experimental approach is shown. Average diffusion coefficients of Sr^{2+} in bovine bone marrow in fast diffusion areas ($D_{bovine,FD}$=(2.09±2.39)·10^{-9} cm^2s^{-1}), slow diffusion areas ($D_{bovine,SD}$=(1.52±1.80)·10^{-10} cm^2s^{-1}), and total area diffusion ($D_{bovine,TA}$= (1.94±2.40)·10^{-9} cm^2s^{-1}) were obtained. In a subsequent proof-of-concept study, we successfully applied the developed protocol to the determination of Sr^{2+} diffusion in bone marrow of osteoporotic rats [fast diffusion: $D_{rat,FD}$=(9.02±5.63)·10^{-10} cm^2s^{-1}); slow diffusion: ($D_{rat,SD}$=(6.48±3.88)·10^{-10} cm^2s^{-1}); total area diffusion ($D_{rat,TA}$= (8.89±5.37)·10^{-10} cm^2s^{-1}]. Detailed 2D and 3D mass spectrometric imaging analysis as well as Orbi-SIMS spectral analysis revealed that Sr^{2+} diffusion is slower in bone marrow areas with high intensity of lipid and fatty acid signals than in areas with less intensity of lipid signals. Overall, our results provide important insights about Sr^{2+} diffusion in bone marrow and we are able to show that both cryo-ToF-SIMS and Orbi-SIMS are useful tools for the investigation of rapid diffusion in water-containing highly viscous media.

[1] M. Rohnke, S. Pfitzenreuter, B. Mogwitz, A. Henß, J. Thomas, D. Bieberstein, T. Gemming, S.K. Otto, S. Ray, M. Schumacher, M. Gelinsky, V. Alt, Strontium release from Sr^{2+}-loaded bone cements and dispersion in healthy and osteoporotic rat bone, J. Controlled Release **262** (2017) 159

[2] C. Kern, M. Quade, S. Ray, J. Thomas, M. Schumacher, T. Gemming, M. Gelinsky, V. Alt, M. Rohnke, Investigation of strontium transport and strontium quantification in cortical rat bone by time-of-flight secondary ion mass spectrometry, J. R. Soc. Interface **16** (2019) 20180638

12:00pm **BI2+AS-TuM-13 Comparison of NAP-XPS and Cryo-XPS for Studies of the Surface Chemistry of the Bacterial Cell-Envelope***, Paul Dietrich,* SPECS Surface Nano Analysis GmbH, Germany*; M. Kjærvik,* BAM Berlin, Germany, Norway*; M. Ramstedt,* Umeå University, Sweden*; W. Unger,* BAM, Germany

Bacterial interactions with the environment are based on processes involving their cell-envelope. Thus, techniques that can analyze their surface chemistry are attractive tools for providing an improved understanding of bacterial interactions. One of these tools is x-ray photoelectron spectroscopy (XPS) with an estimated information depth of <10 nm for Al Kα-excitation. XPS-analyses of bacteria have been performed for several decades on freeze-dried specimens to be compatible with the classical ultra-high vacuum conditions needed. A limitation of these studies has been that the freeze-drying method may collapse cell structure. However, recent developments in XPS allow for analysis of biological samples at near ambient pressure (NAP-XPS) or as frozen hydrated specimens (cryo-XPS) in vacuum. In this talk, we present the analysis of bacterial samples from a reference strain of the Gram-negative bacterium *Pseudomonas fluorescens* using both techniques. We will present the results obtained and, in general, observed good agreement between the two techniques. Furthermore, we will discuss advantages and disadvantages of these two analysis approaches and the output data they provide. XPS reference data from the bacterial strain are provided, and we propose that planktonic cells of this strain (DSM 50090) to be used as a reference material for surface chemical analysis of such bacterial systems.

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