Tuesday Afternoon, November 10, 2009

Biomaterial Interfaces
Room: K - Session BI-TuA

Biofouling
Moderator: G.P. Lopez, University of New Mexico

2:00pm **BI-TuA1 Anti-Fouling Hydrogels for Biomaterials and Sensing Applications**, ***B.G. Liedberg***, Linköping University, Sweden **INVITED**

The present contribution describes a novel set of hydrogel coatings prepared by self-initiated photografting and photopolymerization (SIPGP). The method is based on UV free radical polymerization of methacrylate and acrylate monomers into 0-200 nm thick coatings on top of virtually any organic/polymeric substrate. The vast majority of the coatings are based on different mixtures of PEG containing methacrylates. These hydrogels display excellent protein rejecting properties in simple single component solutions and mixtures, as well as in serum and plasma [1]. Recent studies on platelet adsorption looks also were promising. The UV fabrication technology is also compatible with patterning on the micrometer length scale, thus providing an attractive platform for biochip development and microarraying [2]. The preparation of gradients is also discussed for tuning the physio/chemical properties of the hydrogel coatings [3]. A novel set of charged balanced hydrogel gradients have been prepared for studies of protein adsorption from protein mixtures and plasma with encouraging results [4]. Finally we describe an approach for array fabrication of nanobrushes/bushes on a pre-patterned template generated by Dip Pen Nanolithography (DPN).

1. A. Larsson, T. Ekblad, O. Andersson, B. Liedberg, *Biomacromolecules*, **8**, 287-295 (2007).

2. A. Larsson, C-.X. Du, B. Liedberg, *Biomacromolecules*, **8**, 3511 (2007).

3. A. Larsson, B. Liedberg, *Langmuir*, **23**, 11319 (2007).

4. T. Ekblad, O. Andersson, F.-I. Tai, T. Ederth, B. Liedberg. *Langmuir*, **25**, 3755 (2009).

2:40pm **BI-TuA3 Emerging Strategies to Prevent Bacterial Colonization of Medical Biomaterials**, ***J.D. Bryers***, University of Washington **INVITED**

Nosocomial (hospital-acquired) infections are the fourth leading cause of death in the U.S. with >2 million cases annually (or ~10% of American hospital patients). About 60-70% of all such infections are associated with an implanted medical device causing >$4.5 billion medical costs in 2002 and ~99,000 deaths annually. Over 65% of hospital-acquired infections are associated with implants or indwelling medical devices, with the case-to-fatality ratio between 5-50%. It is estimated that over 5 million artificial or prosthetic devices are implanted per annum in the U.S. alone. Microbial infections have been observed on most biomedical devices, including: prosthetic heart valves, orthopedic implants, intravascular catheters, artificial hearts, left ventricular assist devices, cardiac pacemakers, vascular prostheses, cerebrospinal fluid shunts, urinary catheters, ocular prostheses and contact lenses, and intrauterine contraceptive devices.

Traditional strategies to control medical device-based biofilm infections are based on the use of compounds that kill or inhibit the growth of *freely suspended* bacteria. However, "biofilm-bound" bacteria tend to be significantly less responsive to antibiotics and antimicrobial stressors than planktonic organisms of the same species. In fact, studies have shown that sub-lethal doses of antibiotics can exacerbate biofilm formation. Consequently, systemic antibiotic treatment typically fails to clear a biofilm infection and inevitably requires removal of the device. Moreover, the risk of antibiotic resistance development is drastically increased under the current standard use of systemic antibiotic treatment of medical-device infections.

Here novel non-antibiotic based concepts in biomaterials design (novel stealth surfaces or biomaterials that biologically prevent bacterial colonization) will be presented.

4:00pm **BI-TuA7 Protein Adsorption - Influence from Surface and Protein Characteristics**, ***M. Holmberg***, *X. Hou*, Technical University of Denmark

Competitive protein adsorption from human serum and protein mixtures onto unmodified and plasma polymerised polymer surfaces has been investigated using radioactive multi-labelling. By using several different isotopes it is possible to monitor several proteins simultaneously and thereby analyse the interaction between the different proteins during adsorption processes.

The outcome of competitive protein adsorption depends on both surface and protein characteristics, as well as parameters such as protein concentration and adsorption sequence. In this study surface characteristics of polymer surfaces have been modified by using plasma polymerisation where the polymer surface becomes more hydrophilic. Modified surfaces show non-fouling characteristics and have shown to be stable in buffer solutions for at least 24 hours. By changing the sequence of proteins introduced to a surface, different outcome from an adsorption series with the same proteins can be observed and by changing the internal ratio between different proteins concentration, different proteins will dominate the surface during adsorption.

Even though some polymer surfaces show protein monolayer adsorption behaviour and quite low amount of proteins adsorbed, other surfaces loose there resistance to protein adsorption as the protein concentration increases, and on hydrophobic polymer surface one can even see a very thick and cross linked protein multilayer formed. The tendency for protein multilayer formation is also influenced by other proteins present during adsorption and protein characteristics, where some proteins seem to be more fragile during adsorption to hydrophobic polymer surfaces than others.

The objective of the study is two-fold; to investigate basic processes and concepts during competitive protein adsorption and to contribute to development of polymer based biomaterials for use in contact with whole blood.

4:20pm **BI-TuA8 Influence of Physicochemical Surface Properties on the Adhesion of Marine Microorganisms**, ***A. Rosenhahn***, *S. Schilp, X. Cao, F. Wode, M.P. Arpa Sancet, M. Heydt, M. Grunze*, University of Heidelberg, Germany

The prevention of biofouling is a major challenge for all manmade objects which are in long term contact with seawater. In order to systematically develop non toxic coatings, a fundamental understanding of basic surface properties relevant for adhesion of marine inhabitants is required. To determine the influence of selected surface properties we systematically vary wetting, hydration and charge by self assembly of oligo- and polymers. To obtain well defined morphologies, nanolithography and multilayer assembly are used. The biological response is determined in settlement and adhesion strength assays using predominantly the green algae Ulva linza, but also barnacle cyprids and marine bacteria. It turned out that contact angles around the Berg limit, hydration of the coatings and micrometer sized structures render surfaces less attractive. Besides static assays we are interested in the time dependent dynamics of biofilm formation. To acquire and analyze the complex, 3D swimming and exploration patterns of algal zoospores, we apply digital in-line laser holography. The influence of surface properties on the motion patterns and surface recognition will be discussed.

4:40pm **BI-TuA9 *In situ* Characterization of Barnacle Primary Cement Interfaces by ATR-FTIR Spectroscopy**, ***D.E. Barlow***, U.S. Naval Research Laboratory, *G Dickinson, B. Orihuela, D. Rittschof*, Duke University Marine Laboratory, *K.J. Wahl*, U.S. Naval Research Laboratory

Understanding the chemistry of barnacle adhesion is of great interest in the areas of marine biofouling prevention and materials science of adhesives. Barnacles adhere to surfaces by a proteinaceous cement, for which most studies to date have been *ex situ* analyses of the protein composition. However, very little is currently known about the chemical structure and composition in the original, undisturbed cement interfaces of barnacles (primary cement interfaces) that provide the strong adhesion to substrates in marine environments. We will present a method that has been implemented for characterizing primary cement interfaces of barnacles using *in situ* attenuated total reflection - Fourier transform infrared spectroscopy (ATR-FTIR). Primary cement of the barnacle *Balanus amphitrite* (= *Amphibalanus amphitrite*) was characterized without any disruption to the original cement interface, after settling and growing barnacles directly on double side polished germanium wafers. High quality IR spectra were acquired of live barnacle cement interfaces, providing a spectroscopic fingerprint of cured primary cement *in vivo* with the barnacle adhered to the substrate. Additional spectra were also acquired of intact cement interfaces for which the upper portion of the barnacle had been removed leaving only the base plate and cement layer attached to the substrate. This allowed further characterization of primary cement interfaces that were dried or placed in D 2 O. The resulting spectra were consistent with a proteinaceous cement, and allowed analysis of the protein secondary structure and water content in the cement layer. The estimated secondary structure composition was primarily b-sheet, with additional a-helix, turn, and unordered

components. The cement of live barnacles, freshly removed from seawater, was estimated to have a water content of 20% - 50% by weight. These results provide new insights into the chemical properties of the undisturbed barnacle adhesive interface. The ATR-FTIR method presented is also expected to be useful for *in situ* and *in vivo* studies of bioadhesives from other organisms.

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