Thursday Morning, November 1, 2012

Biofilms and Biofouling: Marine Medical Energy Focus Topic
Room: 23 - Session MB+BI-ThM

Biofilms and Biofouling in Medicine
Moderator: L. Hanley, University of Illinois at Chicago

8:20am **MB+BI-ThM2 Simple and Versatile Approaches to Design Oligoethylene Based Self-Assembled Monolayers using Thiolene Chemistry on Different Metal Oxide Surfaces: Impact on Protein Adsorption**, ***A. Galtayries***, *A. Dellinger,* Chimie ParisTech (ENSCP), France, *V. Semetey*, Institut Curie, France

The control of biomolecules adsorption (such as proteins) and other microorganisms is of high interest for various fields of biotechnology, such as bioanalytics, cell biology, tissue engineering and biomaterials. An efficient method to control adsorption includes the use of well-defined oligo(ethylene glycol)-terminated self-assembled monolayer (SAM). However, multiple processing steps are often required to prepare SAM onto substrate. To address these problems of surface modification, we have developed a simple method using the powerful thiolene reaction to prepare self-assembled monolayer on different metal oxides to control bioadhesion on surfaces starting from commercially available building blocks, and taking the advantage of the photoreaction to easily create adhesive and anti-adhesive patterns.

Such well-controlled grafting strategy has been applied to different metal oxides: from silicon substrates for the methodology set-up to model metal oxides formed on biocompatible metals and alloys. The obtained films are robust; the process is low-cost, simple, and efficient.

Surface characterization as X-ray Photoelectron Spectroscopy (XPS), Time of Flight Secondary Ion Mass Spectrometry (ToF-SIMS) and Infra-Red Surface Spectroscopy (ATR-IRFT or PM-IRRAS) were used to check the surface composition at different steps of the reactions: the thiolene reaction, the PEG grafting, as well as after interaction with protein solutions: albumin for preliminary tests, and fibronectin, an adhesive protein present in the extra-cellular matrix. In addition to quantitative information, obtained by XPS, about the oxide composition and thickness at the different steps, and qualitative information, obtained by XPS and ToF-SIMS, surface patterning could be emphasized with ToF-SIMS chemical surface imaging.

8:40am **MB+BI-ThM3 Antibacterial Studies of Plasma Polymerised Cineole Thin Films**, ***A. Pegalajar-Jurado***, Swinburne University of Technology, Australia, *C.D. Easton,* CSIRO Materials Science and Engineering, Australia, *S.L. McArthur*, Swinburne University of Technology, Australia

Essential oils such as tea tree oil are known for their antibacterial properties. They have been used extensively as effective topical antimicrobial agents and are active against a wide range of micro-organisms. Traditionally, the antimicrobial properties of tea tree oil has been linked to the constituents of the oil including terpinen-4-ol and 1,8-cineole. To translate these antimicrobial properties into medical devices, methods for incorporating or coating materials are required. Recently, thin polymer films from terpinen-4-ol have been fabricated using plasma polymerisation. Initial data suggests that some antimicrobial activity was maintained. While plasma polymer films of 1,8-cineole have been fabricated previously, little focus has been placed on the antibacterial activity of this constituent.

The activity of 1,8-cineole against *Staphylococcus aureus* (*S. aureus*) and *Escherichia coli* (*E. coli*) was evaluated based on the time-kill approach. Several concentrations of the oil (0.05 %, 0.2 %, 0.3 % and 0.5 % v/v) were added to broth media containing $3x10^8$ CFU/mL of each bacterium. The optical density of the resulting solutions was measured at intervals over 24-hrs to monitor bacterial growth rates. The results demonstrated that concentrations above 0.35% v/v gave a 90% kill rate in the gram-negative *E. coli* after 8-hrs. Interestingly, the oil was less effective against the gram-positive *S. aureus*, producing a lower kill rate and rapid growth recovery in a 24-hour period.

Plasma polymers thin films of 1,8-cineole and 1,7-octadiene (hydrophobic control) were prepared using a stainless steel plasma reactor as described previously, while uncoated glass slides were used as a hydrophilic, positive control. Samples were then exposed to broth media containing $3x10^8$ CFU/mL of each bacteriumto determine the effects of the coatings on bacterial attachment and growth. In this work, bacterial studies of the coating behaviour have focused on the attachment of *S.aureus* and *E. coli*, and biofilm formation of *E. coli*. Comparison of the plasma polymerised cineole (ppCineole) coating with the two controls demonstrated a reduction in bacterial attachments over 18-hrs. The reduction in bacterial attachment was more obvious in the case of *E.coli* in comparison with *S. aureus*. There were not significant differences between plasma polymerised cineole and octadiene in the inhibition of *E.coli* attachment and growth over a period of 18-hours. However, the biofilm studies indicated that only the 1,8-cineole film demonstrated antimicrobial behaviour over a period of time of 5 days.

Keywords: plasma polymerisation, antibacterial activity, cineole

9:00am **MB+BI-ThM4 Robustness Analysis of Biofilm Antibiotic Tolerance**, ***R.P. Carlson***, Montana State University **INVITED**

Biofilms are ubiquitous and are thought to be involved in more than half of all medical infections. Even after decades of investigation, the *in vivo* efficacy of many antimicrobial strategies is still debated suggesting a need for better understanding of biofilm antimicrobial tolerances. The robustness of biofilm antibiotic tolerance to medically and industrially relevant culturing perturbations was characterized. By definition, robust systems return similar, predictable responses when perturbed while non-robust systems return very different and potentially unpredictable responses. Biofilm antibiotic tolerance was found to vary in unpredictable manners based on modest perturbations in culturing conditions. The predictability of an antibiotic tolerance response is essential to developing, testing, and employing antimicrobial strategies. The collective data represents both challenges and opportunities for the rational design of anti-biofilm strategies. The data demonstrates that biofilms can be countered effectively with some antibiotics if the appropriate environmental conditions are applied however, if inappropriate conditions are applied, the efficacy of the treatment can be negated. The results indicate it is essential to evaluate antimicrobial strategies over a range of perturbations relevant to the targeted application so accurate predictions regarding efficacy can be made. In addition, the highly dynamic antibiotic tolerance responses observed here may explain why some current antimicrobial strategies occasionally fail.

9:40am **MB+BI-ThM6 Analysis of Force Curves of *Pseudomonas Aeruginosa* obtained by Atomic Force Microscopy**, *E.V. Anderson, R.L. Gaddis, T.A. Camesano,* ***N.A. Burnham***, Worcester Polytechnic Institute

Pseudomonas aeruginosa is extremely harmful to immune-compromised individuals. An atomic force microscope (AFM) can be used to measure the forces between the AFM tip and the bacterial exopolymers, with which the bacteria attach themselves to surfaces. These forces are characterized with a model that is a function of brush (exopolymer) layer thickness, probe radius, temperature, separation distance, and a molecular volume. Initial experiments with limited data sets are consistent with expected brush thicknesses of a few hundred nanometers. In order to progress – now with rigor – we have just developed a high throughput method for the analysis of force curves on the exopolymers of *P. aeruginosa* [1]. The above-described model is only valid for the region where the tip is in contact with the exopolymers, yet is not perturbing the bacterial membrane. MatLab code was written to determine the location of this region in each force curve, crop the curve to that region, and apply the force model in order to obtain parameters of the exopolymers. The standard deviation of the mean and Chauvenet's Criterion are then applied to the results of sets of one-hundred force curves to increase measurement precision and objectively remove outliers. This procedure removes user subjectivity in cropping, fitting, and outlier removal, decreases analysis time by two orders of magnitude, and increases the precision of fitted results by a factor of ten (for one-hundred curves), which is necessary for demonstrating the statistical significance of our data.

[1] Anderson et al., to be submitted May 2012.

10:40am **MB+BI-ThM9 Light and Dark Biocidal Activity of Conjugated Polyelectrolytes**, ***K. Schanze***, University of Florida, *D.G. Whitten, T. Corbitt, E. Ji, D. Dascier,* University of New Mexico, *A. Parthasarathy, S. Goswami*, University of Florida **INVITED**

Cationic conjugated polyelectrolytes (CPEs) are semiconducting organic polymers that contain ionic solubilizing groups. These polymers are soluble in water and they self-assemble into colloidal nanostructures in solution and layer-by-layer films at interfaces. CPEs interact strongly with bacteria in solution and on coated interfaces, and under short wavelength visible or near UV light irradition they exhibit strong biocidal activity. Mechanistic studies using photophysics and cell live/dead assays find that the CPEs efficiently sensitize the production of singlet oxygen, and this is believed to be at least partially responsible for the light-activated biocidal activity. Structure-property studies find that specific hydrophobic CPEs exhibit strong dark biocidal activity. Studies with membrane models indicate that the dark active CPEs exhibit a strong tendency to interact with and disrupt the cell membrane structure.

11:20am **MB+BI-ThM11 Mechanisms of Antimicrobial Activity of Quaternary Ammonium Compounds in Solution and Immobilized on a Surface**, ***H.C. Van der Mei***, University Medical Center Groningen, The Netherlands

Quaternary ammonium compounds (QAC) are potent cationic antimicrobials used in everyday consumer products like contact lens solutions and mouthrinses as well as in numerous industrial processes, like water purification. Unlike the case for many antibiotics, the development of bacterial resistance against QACs is considered unlikely, although *Pseudomonas aeruginosa* strains isolated from contact lens cases have been shown to possess resistance against QACs. The first step in the antimicrobial action of QACs is the approach of the QAC molecule towards the bacterial cell surface. This is mediated by hydrophobic and electrostatic attractions between positively charged QAC molecules and the negatively charged bacterial cell surface. Upon their subsequent adsorption, QAC molecules replace Ca^{2+} or Mg^{2+} ions from the cytoplasmic membrane in order to maintain charge neutrality in the membrane. The replacement of Ca^{2+} and Mg^{2+} ions by QACs destabilizes the intracellular matrix of a bacterium, as the hydrophobic tail interdigitates into the hydrophobic bacterial membrane causing leakage of intracellular fluid and loss of turgor pressure. Antimicrobial efficacy of QACs remains preserved when QAC molecules are immobilized on a substratum surface. It is difficult to envisage how immobilized QAC molecules can exert the same mechanism of antimicrobial activity as do QACs in solution. Immobilized QACs, especially after adsorption of a protein film as developing rapidly in the human body, are strongly hindered in their search for heterogeneously distributed negative charges on bacterial cell surfaces which is crucial for their efficacy in solution. Hence, it has been often hypothesized that QAC molecules immobilized to a substratum surface possess other generic mechanisms of action than QACs in solution, but these have never been elucidated. Immobilized QACs do not cause directly visual membrane damage. Instead, the strong adhesion forces arising from immobilized QACs enter bacterial adhesion forces into the lethal regime, i.e. where the stress exerted on the bacterial cell membrane is causing killing.

11:40am **MB+BI-ThM12 Combinatorial Discovery of Materials That Resist Bacterial Adhesion**, ***A.L. Hook***, *C. Chang, J. Yang,* University of Nottingham, UK*, R. Langer, D.G. Anderson,* Massachusetts Institute of Technology*, S. Atkinson, P. Williams, M.C. Davies, M.R. Alexander*, University of Nottingham, UK

Biofilm formation leads to a 1000 times increase in antibiotic tolerance compared with planktonic bacteria and is associated with 80% of hospital acquired infections, resulting in $3.0 billion in excess health-care costs each year in the U.S alone. Thus, new materials that prevent biofilm formation would offer enormous benefits to the health industry and improve patient welfare. However, the limited understanding of bacteria-material interactions restricts the rational design of such materials. Polymer microarrays are emerging as a key enabling technology for the discovery of new biomaterials[1] and have been utilised to identify novel polymers that resist bacterial attachment.

Polymer microarrays were formed as previously described.[2] This platform enabled a large combinatorial space to be rapidly screened by a biological assay to identify new materials that fulfil a given performance criterion.[3] In the present study a bacterial attachment assay was developed using green fluorescing protein (GFP) tagged bacterial strains (*Pseudomonas aeruginosa, Staphylococcus aureus and Escherichia coli)* where the attachment of bacteria to each material was quantified by measuring the fluorescnce after incubation for 72 h.

Due to the large combinatorial chemical space available to the polymer micoarray format a strategy was devised to rapidly identify the optimal polymer composition that resists bacterial adhesion. This utilised a multi-generation microarray approach where the 'hits' from one array feed into the design of a subsequent array. Initially, an array was formed from 22 monomers with varied chemistry that were mixed to form 488 unique material compositions. Hit compositions were chosen from this array to produce a focussed second generation array containing unique materials where the hit compositions were varied incrementally. The resulting hit compositions were all amphiphilic containing both hydrophobic and hydrophilic moieties.

A methodology has been developed to screen the vast combinatorial chemical space within polymer chemistry for optimised compositions that produce novel materials with inherent resistance to bacterial adhesion. Key to this approach was the use of multi-generation microarrays.

References

[1] Hook AL, Anderson DG, Langer R, Williams P, Davies MC, Alexander MR. Biomaterials 2010;31:187-198.

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[3] Mei Y, Saha K, Bogatyrev SR, Yang J, Hook AL, Kalcioglu ZI, Cho SW, Mitalipova M, Pyzocha N, Rojas F, Van Vliet KJ, Davies MC, Alexander MR, Langer R, Jaenisch R, Anderson DG. Nature Materials 2010;9:768-778.

Biofilms and Biofouling: Marine Medical Energy Focus Topic
Room: 23 - Session MB+BI-ThA

Marine Biofouling

Moderator: D.E. Barlow, Naval Research Laboratory

2:00pm **MB+BI-ThA1 The Role of Oxygen in Microbiologically Influenced Marine Corrosion**, ***B.J. Little***, *J.S. Lee, R.I. Ray*, Naval Research Laboratory **INVITED**

Two microbiologically mediated processes dominate the literature on microbiologically influenced corrosion (MIC) in natural marine environments – ennoblement and sulfate reduction that leads to sulfide derivitization. Both are global phenomena and both depend on the presence of oxygen for aggressive attack. Marine biofilms cause a noble shift, or ennoblement, in corrosion potential (E_{corr}) for most passive alloys. E_{corr} ennoblement increases the probability for pitting and crevice corrosion initiation and propagation for those passive alloys where E_{corr} is within a few hundred millivolts of the pitting potential (E_{pit}) (e.g. 304L and 316L stainless steels). Numerous researchers have shown that increased cathodic oxygen reduction reaction (ORR) rates accompany ennoblement of E_{corr}, but do not agree on a universal mechanism for acceleration of ORR by biofilms. The role of oxygen in accelerating marine sulfide influenced corrosion has not been precisely defined. Past experiments have demonstrated that dissolved oxygen (DO) in stagnant natural seawater (8 ppm) exposed to corroding carbon steel will be depleted to the detection limits of an electrochemical probe (100 ppb) within 48 h due to aerobic microbial respiration and corrosion reactions. Furthermore, most solid surfaces in contact with seawater are anaerobic because the rate of microbial respiration within a biofilm is greater than the rate of oxygen diffusion. Even in an oxygenated bulk environment, sulfate-reducing bacteria (SRB) dominate anaerobic niches in marine biofilms and produce aqueous sulfides that can derivitize some metals and alloys (e.g., carbon steel and copper-based alloys). In the absence of oxygen, corrosion will slow or cease as bare metal, surface oxides and metal ions are derivatized forming protective surface metal sulfides. Whereas in the presence of oxygen, the protective surface-bound sulfides are oxidized thus allowing more corrosion reactions can take place. In addition, introduction of oxygen (e.g., flow after stagnation) dramatically increases instantaneous corrosion rates owing to metal sulfides being more efficient oxygen reduction cathodes compared to metal oxides. The end result is deeper metal penetration when compared to strictly anaerobic environments. More recent experiments have demonstrated that even transient DO in the bulk medium can influence the microflora and corrosion rates of carbon steel. Using optical DO probes (detection limits 4 ppb) bulk concentrations of DO in the bulk medium are being correlated with corrosion rates and pit depths in carbon steel. Persistence of aerobic bacteria at ppb DO is being followed.

2:40pm **MB+BI-ThA3 3D-Tracking of Biofouling Microorganisms with Digital In-Line Holographic Microscopy**, ***S.M. Stuppy***, University of Heidelberg, Germany, *A. Rosenhahn, T. Schwartz,* Karlsruhe Institute of Technology, Germany, *T. Ederth,* Linköping University, Sweden, *J.A. Callow, M.E. Callow,* University of Birmingham, UK, *B. Liedberg,* Linköping University, Sweden, *G.W. Swain,* Florida Institute of Technology, *M.H. Grunze*, Karlsruhe Institute of Technology, Germany

Digital in-line holographic microscopy, based on Gabor´s initial idea of a lensless microscope[1], is an imaging technique which allows to track microorganisms in three dimensions. A so-called "source wave" interferes with the wave scattered off the swimming objects and forms an interference pattern (Hologram) on the detector which contains three-dimensional information of the objects investigated. To obtain real space information from the Hologram, a reconstruction algorithm is applied[2]. The reconstructed data provides 3D trajectories of single spores with a 10 Hz time resolution and thus allows a qualitative and quantitative analysis of swimming behavior and settlement kinetics of microorganisms such as marine biofoulers or pathogen bacteria down to a lenght of 1-2 µm.

In our recent work the swimming and settlement behavior of *Ulva linza* zoospores as a common motile biofouling organism was investigated in the vicinity of surfaces with different chemistry[3-5]. We analyzed the effect of fast and abnormal settlement of *Ulva* spores on a charged Arginin containing oligopeptide surface[6] by digital holography to study the exploration behavior and kinetics of the colonization of the surfaces. As step towards application of holography at ocean test sites in the field, we constructed a compact holographic setup and tested it at the FIT test site and studied the swimming behavior of small marine organisms in their native environment.

We also applied holography to study motile biofilm forming bacteria. Using a large CMOS sensor, we were able to resolve and track rod shaped bacteria with a length of 2 µm, namely the pathogen *Pseudomonas aeruginosa*. We will show the first three-dimensional trajectories for a free swimming *Pseudomonas aeruginosa*.

1 Gabor, D. *Nature***161**, 777 (1948).

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6 Ederth, T. *et al.Biofouling***24**, 303-312, doi:Doi 10.1080/08927010802192650 (2008).

3:00pm **MB+BI-ThA4 A Multidisciplinary Approach to Tackling Microbiologically Influenced Corrosion**, ***S.A. Wade***, *P.R. Stoddart, E. Palombo, M.M. Hlaing, M.A. Javed, D. Marić, D. Eldridge, S.L. McArthur*, Swinburne University of Technology, Australia

Microbiologically influenced corrosion (MIC) can lead to localized material degradation rates that are orders of magnitude higher than would normally be expected from standard, abiotic corrosion. This can lead to the premature failure of a wide range of important structures that can not only be costly to repair, but in some cases can have fatal consequences.

Studies of MIC require expertise from a wide range of fields such as material science, microbiology, chemistry and engineering. However, much of the past work that has been undertaken on MIC has been performed with a discipline-specific focus. This is somewhat understandable in a historical research context and may help to explain some of the observed discrepancies between MIC studies undertaken in the laboratory and field observations. In order to overcome some of these issues and develop solutions to the problems caused by MIC a multidisciplinary approach is required.

We have assembled a multidisciplinary team to investigate two specific aspects of MIC, namely the composition of bacterial consortia implicated in MIC and the associated physicochemical processes that drive MIC.

With respect to bacterial identification work is being carried out using a variety of techniques, including the relatively novel application of MALDI-TOF and Raman spectroscopy to MIC. The latter technique is particularly attractive as it potentially allows single bacteria to be identified at different stages of their life cycle, as well as in biofilm. Initial work in this area has required the development of data analysis techniques in order to remove background fluorescence signals in a consistent manner. MALDI-TOF potentially allows rapid routine identification from large numbers of samples. Initial results obtained with this technique will be presented.

The second area of interest includes work undertaken to look at how changes in field conditions can affect the likelihood of MIC. Metal coupon corrosion tests using seawater samples obtained from different field locations have been performed. A range of metallurgical, chemical and microbiological measurements were made to investigate differences observed for samples tested in two different seawater solutions and also for replicate samples tested using seawater from the same location.

Although progress remains challenging, the multidisciplinary approach reported here is showing great promise, with chemists, metallurgists and physical scientists working closely with microbiologists to understand the full complexity of the underlying biological processes.

3:40pm **MB+BI-ThA6 Bioinspired Surfaces with Dynamic Topography for Active Control of Biofouling**, ***X.H. Zhao***, *G.P. Lopez, D. Rittschof*, Duke University

Biofouling of ship hulls and propellers increases drag and power usage and decreases fuel efficiency. Biofouling costs the US Navy alone approximately one billion dollars per year, and the decreases in fuel efficiency further increase green-house gas emissions. Traditional antifouling coatings, relying primarily on biocidal organics and metals, have negative environmental impacts, while newer polymer-based coatings are easily damaged and ineffective in long-term applications.

On the other hand, nature has created an enormous number of biological surfaces that can effectively clean themselves via active deformation and motion. For example, tiny hairs called cilia on the surfaces of respiratory tracts constantly move back and forth, pushing inhaled foreign particles out of our lungs. The ciliary cleaning has also been used by molluscs, corals and many other marine organisms for active antifouling.

Inspired by active biological surfaces found in nature, we have developed a novel active-antifouling technology by harnessing dynamic deformation of polymer coatings in response to external stimuli. We discover that the surfaces of silicone-based coatings can be significantly deformed by applying a direct-current voltage across the coatings. The deformation is on-demand, dynamically switching the coating surfaces between patterned and flat states as the applied voltage is on and off. The on-demand deformation can actively and effectively detach various biofouling organisms such as bacterial films and barnacles adhered on the polymer coatings. The new technology can be readily integrated with existing or newly-developed polymer coatings, combining the advantages of various state-of-the-art antifouling technologies. This new active-antifouling system is environmentally friendly, autonomous, highly effective, and potentially durable over long-term applications. Next, we will further discuss the fundamental effect of active surface deformation on marine organism-surface interactions. A new theory for biofouling detachment caused by substrate deformation, instead of external forces, will be presented.

4:00pm **MB+BI-ThA7 Seasonal Study of Cathodic Current and Elucidation of Oxygen Reduction Enhancement Mechanism in Marine Biofilms**, ***M.J. Strom***, Naval Research Laboratory, *S.C. Dexter*, University of Delaware

The ability of a biofilm to influence the corrosion rates through the enhancement of cathodic currents is well known but what mechanisms cause this enhancement and how sustainable is it during seasonal variation? Enhancement of the oxygen reduction reaction has been shown to occur in Delaware Bay waters. Historically, enhancement of the oxygen reduction reaction by biofilms has been attributed to the presence of catalase in biofilms. However, recent work has indicated that manganese oxides may also provide a means for oxygen reduction enhancement in. The following investigation looks at the effect of seasonal variation of the sustainability of oxygen reduction enhancement and distinguishes between manganese and catalase based mechanisms

The following work used sacrificial anodes to provide a long-term cathodic current to biofilm-coated cathodes in Delaware Bay waters, in order to monitor seasonal variation of biofilm-coated cathodes under varying polarization intensities over a year. Manganese and catalase based oxygen reduction enhancement mechanisms were evaluated through the addition of glutaraldehyde or formaldoxime (FAD) treatments to the bulk solution of immersed galvanic couples.

Varying the polarization intensities of 6XN cathodes in a galvanic couple with a sacrificial anode has provided further evidence that the sustainable cathodic current enhancement found by biofilms of Delaware Bay is a result of oxygen reduction enhancement. Glutaraldehyde treatment experiments indicate that a catalase mechanism of oxygen reduction enhancement is not likely in at this location. FAD treatment experiments support the hypothesis that manganese oxides are the dominant catalysts in oxygen reduction enhancement in these waters. Seasonal studies of cathodic current enhancement show that cathodic current enhancement in Delaware Bay is seasonally dependent, with higher cathodic currents in the late spring to early fall. It is suggested that this variation is the result of the biological activity of the surrounding sediments providing a manganese resource into the water column during the warmer seasons.

4:20pm **MB+BI-ThA8 Tailoring Anode and Cathode Biofilms for Higher Current Production in Bioelectrochemical Systems**, ***J. Regan***, Penn State University **INVITED**

Bioelectrochemical systems (BESs) exploit the ability of some microbes to reduce an anode (exoelectrogenesis) or oxidize a cathode (exoelectrotrophy) for the generation of electrical current coupled with some biotransformation. There has been a lot of research in the past decade on improving the performance of BESs, primarily by addressing system features that allow reduced internal resistance. These design advancements have led to more than a six order of magnitude increase in power densities in that short time period. Moreover, a growing number of potential BES applications are being developed, including electricity production from wastes and sediments in microbial fuel cells for remote or centralized power, the production of fuels such as hydrogen and methane in microbial electrolysis cells, the recovery of value-added chemical products such as caustic and hydrogen peroxide, water desalination in microbial desalination cells, and microbial electrosynthesis for the production of organic products. Some design and operation parameters can have significant effects on anode and cathode biofilm architecture, composition, and functionality. For a given system configuration (e.g., electrode material, electrode spacing, membrane), there are only a few parameters that can be manipulated during operation. One of these operational variables is the external load or the applied potential in a potentiostatically operated system, which can significantly affect the microbial ecology of BESs as it influences the availability of the anode to serve as an electron acceptor for exoelectrogens and thereby controls the cooperation and competition among various community members in mixed-culture systems. This directly translates into performance effects, not only with respect to the time required to achieve a desired electron donor removal efficiency, but also with electron losses to competing metabolisms such as methanogenesis and aerobic respiration in an air-cathode system. This presentation will cover the mechanics of BESs, including some of the emerging designs and applications, as well as some of the parameters than can be manipulated to include microbial function, density, and productivity.

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