Coatings for Biomedical and Healthcare Applications
Room Sunrise - Session D2

Bio-corrosion, Bio-tribology, and Bio-tribocorrosion

Moderator: Anna Igual Munoz, Ecole Polytechnique Federale de Lausanne

10:20am **D2-2 Evaluation of Tribocorrosion Kinetics and Biocompatibility of Electrochemically Induced Tribolayer for Hip Implants**, *M Lyvers, D Bijukumar,* University of Illinois College of Medicine at Rockford, IL, USA*; A Moore,* Winnebago High School, USA*; P Saborio,* Rush University Medical Center, USA*; D Royhman,* Rush University Medical Center and Northwestern University, USA*; M Wimmer,* Rush University Medical Center, USA*; K Shull,* Northweswtern University, USA*; **Mathew T. Mathew,*** University of Illinois College of Medicine at Rockford and Rush University Medical Center, USA

As the number of annual Total Hip Replacement (THR) surgeries continues to increase, the longevity of metal based hip implants is a major concern. Tribochemical Reactions cause the Cobalt-Chromium-Molybdenum (CoCrMo) hip implant to release wear debris that interacts with decomposed proteins to form a tribolayer. We conducted an electrochemical investigation in order to understand the role of molybdenum in the stability of the tribolayer under mechanical wear and electrochemical corrosion. Tribolayers made of a bovine calf serum (BCS) and bovine calf serum with sodium molybdates (BCS-Mo) were electrochemically deposited on high carbon CoCrMo discs and subjected to corrosion and tribocorrosion experiments under potentiodynamic conditions in a hip-simulator . Cyclic-polarization, Electrochemical Impedance Spectroscopy (EIS) tests and surface characterization techniques were carried out. The results indicate an increased resistance to corrosion under mechanical wear by BCS-Mo coated surface which is more distinct when Mo is added into the electrolyte. In addition, biocompatibility evaluation using MG63 osteosarcoma cells on BCS and BCS-Mo coated samples did not show any statistically significant difference in cell growth compared to uncoated CoCrMo discs. These findings suggest a pre-formed electrochemical tribolayer with sodium molybdates may be a promising pre-implantation treatment of THRs to extend the longevity of implants *in vivo*.

10:40am **D2-3 Tribocorrosion from Nano to Macroscale – the Effect of Proteins on Friction of CoCrMo Biomedical Alloy**, ***Nuria Espallargas,*** NTNU, Norway **INVITED**

The tribocorrosion performance of CoCrMo biomedical alloy has been widely studied in many different electrolytes (mainly simulated body fluids) and in the presence of proteins (mainly bovine serum albumin). In a recent review it was pointed out that the main outcome of the tribocorrosion of CoCrMo biomedical alloys exposed to simulated body fluids is the increase in wear as the electrode potential increases from cathodic to anodic. This is a very important conclusion that highlights the importance of the combination of electrochemistry with the mechanical action in biomedical bearing implants. However, it is still unclear what is the role played by proteins in this scenario. Indeed, it is very well stablished that proteins significantly affect the electrochemical performance of CoCrMo biomedical alloys, specially altering the cathodic kinetics and enhancing passive dissolution. However, the role played in friction and ultimately wear is still an open and interesting discussion. Therefore, in an attempt to investigate this phenomenon from a different perspective, I will present a nano-scale tribocorrosion set-up. These results will be compared with the classical macro-/micro-tribocorrosion results.

11:20am **D2-5 Fretting Corrosion of Biomaterials Dedicated to Dental Implants: Quantitative and Qualitative Insights**, *P Corne, A Vaillant-Corroy, P De March, F Cleymand,* Institut Jean Lamour, France*; **Jean Geringer,*** Mines Saint Etienne, France

600,000 dental implants are implanted in France every year; it is a question of more than 1 million all over the world. The total implants lifetime is about 10 years nowadays. Unfortunately during these 10 years 15-20% of implants did not succeed. Some combinations of biomaterials are available in order to mimic the anchorage process of teeth. A study based on fretting corrosion investigations has been performed. In order to be so close as possible to the actual conditions, some biomaterials used for manufacturing dental implants have been tested in human saliva. The targeted combination is around the dental implant and the abutment. Ti-6Al-4V, pure Ti, zirconia stabilized with Yttria, PEEK (PolyEtherEtherketone) are the studied materials.

The device is a Fretting corrosion machine that has been developed by Mines Saint-Etienne and Bose Company. The sliding conditions were: a sinusoidal displacement of 80µm during 16 and 4 hours. The contact stress has been estimated from the actual junction between implant and abutment (Astra™ TX4.5, Dentsply™/Atlantis™ titanium abutment) from modeling investigations (Finite elements). The average contact stress was considered of 130 MPa.

After tests, the total average wear volume of titanium was the highest against zirconia material. At the opposite the lowest titanium wear volume has been reached thanks to PEEK counter material. Thus the Open Circuit Potential (OCP) evolution has been precisely checked. The lowest decrease at the beginning of the fretting test has been highlighted by Ti-6Al-4V against PEEK material. Additionally some investigations with SEM high resolution have been performed in order to show different wear mechanisms.

11:40am **D2-6 Mechanical and Anti-Corrosive Properties of Various Titania/Silica Hybrid Composite Film as the Interlayer of a Diamond-Like Carbon Deposited Ti6Al4V Substrate by Sol-Gel Technique**, *N Wu, **Wen-Hsien Wu**, C Chou,* National Taiwan Ocean University, Taiwan*; R Wu,* National Institute for Materials Science, Japan*; J Lee,* Ming Chi University of Technology, Taiwan

Ti6Al4V alloy is one of the most popular implant material in the bio-medical application. In order to enhance the implant's wear resistance and anti-corrosion capability under the physiological environment, a diamond-like carbon (DLC) film with an amorphous silicon (a-Si) interlayer is the most popular coating system implemented on the Ti6Al4V substrate. However, many clinic failures of the implants caused by the crevice corrosion and delamination of the a-Si interlayer were reported after years of operation. In this study, titania/silica hybrid composite ($TiSi_xO_y$) films were built on Ti6Al4V alloy by sol-gel dip coating technique. The compositions of the films were changed by adjusting the Ti/Si ratios of the precursor solutions, and then, sintered at 650 °C under an argon atmosphere. A DLC outmost layer was deposited on these samples by radio frequency plasma enhanced chemical vapor deposition. An a-Si coated sample was also prepared as a benchmark. The surface and mechanical properties of $TiSi_xO_y$ films were evaluated by using scanning electron microscopy, atomic force microscopy, micro-scratch test, and nano-indentation. The composition and structure of $TiSi_xO_y$ films were investigated by using thermogravimetric analysis, X-ray diffraction spectroscopy, Fourier transform infrared spectroscopy, and X-ray photoelectron spectroscopy. The phase and structure of the DLC film was identified by a Raman spectroscopy. Corrosion resistance of Ti6Al4V substrates coated with only an interlayer or the whole DLC system was evaluated by electrochemical impedance spectroscopy. The results showed that an appropriate Ti/Si ratio of the $TiSi_xO_y$ interlayer can increase the hardness and, in the meantime, significantly promote the adhesion and anti-corrosion capability of the DLC-coated Ti medical alloy compared with the traditional a-Si coated one.

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