Examining the Interaction of Chemistry and Mechanics on Surface Behavior: Applications of Corrosion Related to Biological and Non-Biological Materials

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This presentation is directed towards understanding the surface behavior of a corrosive environment on a welded aluminum alloy and a method to prevent corrosion of a titanium alloy. Corrosion is ultimately the flow of electrons from an electron donor, usually a metallic alloy, to an electron acceptor, whether that is chemically, such as water, or biologically, such as white blood cells. Understanding how corrosion affects the metallic alloy, weakening it due to metal dissolution or hydrogen embrittlement, can lead to the creation of methods to prevent it, such as coatings that separate the metal from the environment. In the case of titanium, a coating can also encourage the incorporation of the implant into the surrounding bone, helping to extend the life of the implant and reduce secondary surgeries due to loosening. This presentation will first cover the corrosion of a commonly used aluminum alloy, followed by the characterization of a bioactive coating on titanium.

Welded aluminum 6061 is used in many different applications, including in the wings and fuselages of airplanes, in automobiles, and in yachts and SCUBA tanks. Determining how the yield strengths of three different weld production types, low, nominal, and high, are affected by a corrosive environment is of utmost importance in the continued use of welded aluminum in its various applications. The research presented here will first cover the determination of an appropriate accelerated corrosion environment by comparing the weld yield strength over 240 hours after exposure to either a 5 wt.% sodium chloride and acetic acid solution or a 5 wt.% sodium chloride and 0.3 vol.% hydrogen peroxide solution. After the corrosion environment has been determined, the three weld types will be exposed to the accelerated immersion environment over 336 hours. During the 336 hours, samples were removed at various time intervals to determine how the environment affected the yield strength of the weld. For all weld conditions, a decrease in weld strength was seen, until between 96 and 168 hours, after which an increase in weld strength was seen. The likely cause of the increase in weld strength was the formation of aluminum oxide surrounding the weld, which increased the weld strength, as aluminum oxide has a higher yield strength than aluminum 6061.

In addition to reducing corrosion, coatings also have the ability to improve the interface between bone and implants, increasing the osseointegration and stability of an implant. Titanium coupons were first characterized chemically, using X-Ray Photoelectron Spectroscopy, to follow two reaction series to determine if the reactive ends remained following the initial deposition and if the reactions were taking place as hypothesized. After chemical characterization, the coatings were subjected to nano-indentation, to ensure that the coating properties were unchanged, and to tensile testing, to determine how strongly the coatings were adhered to the titanium alloys. Lastly, the coatings were exposed to bone cells, to determine if the bone cells would adhere to the coatings and grow across the surface. The results of these studies demonstrated that the reaction series progressed as expected, producing tightly bound coatings. The mechanical properties coatings were unchanged as a result of the reaction series, the bone cells adhered to the coatings equal to or better than the control, and the cells increased in number over seven days. A brief overview of future research will also be presented.