World Academy of Science, Engineering and Technology
International Journal of Bioengineering and Life Sciences
Vol:14, No:10, 2020

Corrosion Study of Magnetically Driven Components in Spinal Implants by Immersion Testing in Simulated Body Fluids

Authors : Benjawan Saengwichian, Alasdair E. Charles, Philip J. Hyde

Abstract : Magnetically controlled growing rods (MCGRs) have been used to stabilise and correct spinal curvature in children to support non-invasive scoliosis adjustment. Although the encapsulated driving components are intended to be isolated from body fluid contact, in vivo corrosion was observed on these components due to sealing mechanism damage. Consequently, a corrosion circuit is created with the body fluids, resulting in malfunction of the lengthening mechanism. Particularly, the chloride ions in blood plasma or cerebrospinal fluid (CSF) may corrode the MCGR alloys, possibly resulting in metal ion release in long-term use. However, there is no data available on the corrosion resistance of spinal implant alloys in CSF. In this study, an in vitro immersion configuration was designed to simulate in vivo corrosion of 440C SS-Ti6Al4V couples. The 440C stainless steel (SS) was heat-treated to investigate the effect of tempering temperature on intergranular corrosion (IGC), while crevice and galvanic corrosion were studied by limiting the clearance of dissimilar couples. Tests were carried out in a neutral artificial cerebrospinal fluid (ACSF) and phosphate-buffered saline (PBS) under aeration and deaeration for 2 months. The composition of the passive films and metal ion release were analysed. The effect of galvanic coupling, pH, dissolved oxygen and anion species on corrosion rates and corrosion mechanisms are discussed based on quantitative and qualitative measurements. The results suggest that ACSF is more aggressive than PBS due to the combination of aggressive chlorides and sulphate anions, while phosphate in PBS acts as an inhibitor to delay corrosion. The presence of Vivianite on the SS surface in PBS lowered the corrosion rate (CR) more than 5 times for aeration and nearly 2 times for deaeration, compared with ACSF. The CR of 440C is dependent on passive film properties varied by tempering temperature and anion species. Although the CR of Ti6Al4V is insignificant, it tends to release more Ti ions in deaerated ACSF than under aeration, about 6 µg/L. It seems the crevice-like design has more effect on macroscopic corrosion than combining the dissimilar couple, whereas IGC is dominantly observed on sensitized microstructure.

Keywords : cerebrospinal fluid, crevice corrosion, intergranular corrosion, magnetically controlled growing rods
Conference Title : ICBBB 2020 : International Conference on Bioengineering, Biomaterials and Biopolymers
Conference Location : London, United Kingdom
Conference Dates : October 22-23, 2020