Surface Characterization of 316L Stainless Steel to Determine Effect of Surface Treatment on Biocompatibility

Steve Trigwell¹, Guna Selvaduray², and John Turn³

¹Electrostatics and Surface Physics Laboratory
Mail stop: YA-C2-T, NASA
Kennedy Space Center, FL 32889
Ph: 321-867-1222
trigws@ksc.ems.ksc.nasa.gov

²Department of Chemical and Materials Engineering
San Jose State University
One Washington Square, San Jose, CA 95192
Ph: 408-924-3874
gunas@email.sjsu.edu

³CTC-United Defense
1205 Coleman Avenue
Santa Clara, CA 95050
Ph: 408-289-0331
john_turn@udlp.com

Abstract

The ability of 316L stainless steel to maintain biocompatibility is critical to its effectiveness as an implant material. The critical surface tension has been shown to correlate with the thrombogenicity, where a range of critical surface tension (γₖ) of 20 – 30 mJ/m² is considered to be the zone of biocompatibility; however, the biocompatibility is dependent upon the surface characteristics of the material. In this study, the surface of mechanically polished (MP) and electropolished (EP) 316L stainless steel coupons were studied by contact angle measurements at 37 °C, X-ray Photoelectron Spectroscopy (XPS), and Atomic Force Microscopy. The critical surface tension of the MP surface was 40 mJ/m² and the EP surface was 47 mJ/m², considerably higher than the zone of biocompatibility, even though the EP surface was considerably smoother than the MP surface (Ra = 607 Å vs. 1379 Å, respectively). The XPS data showed the EP surface had enhanced Cr:Fe and O:C ratios, typical of electropolished stainless steel, but the Cr was present more as Cr(OH)₃ on the EP surface, compared to Cr₂O₃ on the MP surface. The EP surface showed significant amounts of P, S, and Ca which were probably residues from the electropolishing process. It is well known that trace contaminants on a surface can greatly affect contact angles, and may have caused the high critical surface tension measurements for the EP. Work is in progress to further treat the 316L surfaces with Atmospheric Plasma Glow Discharge (APGD) to remove the contaminants and enhance the oxidation. This research is aimed at correlating surface characteristics, particularly the roughness and chemistry, to the critical surface tension and thereby to biocompatibility. The critical surface tension data obtained at 37°C will also be
compared with data obtained at room temperature so that the usability of published surface tension data, for purposes of determining biocompatibility, can be evaluated.