The Effect of Hyaluronic Acid on the Tribocorrosion of CoCrMo- and AHNS- Alloys in Simulated Inflammatory Environments

CATEGORY OR KEYWORD

Biotribology, Wear of Materials

AUTHORS AND INSTITUTIONS

Radice S.[1], Fullam S. [1], Fischer A.[1,2], Wimmer, M. A.[1]

[1] Rush University Medical Center, Department of Orthopedic Surgery, Chicago, IL, USA

[2] University of Duisburg-Essen, Materials Science and Engineering, Duisburg, Germany

INTRODUCTION

Metal implants from total joint replacements are locally exposed to particularly corrosive environments when, during joint inflammation, hydrogen peroxide (H_2O_2) is locally released into the synovial fluid. Electrochemical interactions among hyaluronic acid (HA) present in the synovial fluid, H_2O_2 and metallic surfaces are expected, which will play a role in the tribocorrosion behavior of the implant.

AIMS

This work aims to investigate corrosion rates and fretting corrosion behaviors of two different alloys from the orthopedic field, in relation to possible scavenging effects of HA with different amounts of H_2O_2.

MATERIALS AND METHODS

The tested alloys are a low carbon CoCrMo (ASTM F1537) and a nickel-free AHNS (Austenitic High Nitrogen Steel) (Fe-18Cr14Mn-3.5Mo-0.08C-0.88N). Non-destructive electrochemical measurements were run in triplicates, with the alloys exposed to a synovial model fluid containing albumin proteins and HA, with (3mM, 30mM) and without H_2O_2. The same electrolytes were used as lubricants for tests run in a custom-designed fretting corrosion set-up, equipped with a three-electrode cell for measuring the free potential; pins made of either CoCrMo- or AHNS-pins were laterally pressed against a Ti6Al4V rod with a contact pressure of 60 MPa; the rod was driven vertically to a reciprocating motion of amplitude ± 50 μm. Friction force measurements allowed to calculate the accumulated friction work for each test. Surface morphology and composition were analyzed by SEM/EDS. Wear scar depths were assessed by scanning white-light interferometry.

RESULTS AND DISCUSSION

The AHNS showed overall lower corrosion rates than CoCrMo; in the electrolyte with HA and without H_2O_2, corrosion rates were 0.33±0.14 μm/y (AHNS) *vs.* 1.3±0.5 μm/y (CoCrMo). HA did not show clear scavenging effects with 3mMH_2O_2. In 30 mM H_2O_2, the corrosion rate of CoCrMo was higher with HA than without HA (7.8±3.0 μm/y *vs.* 2.8±1.1 μm/y), while for the AHNS, the corrosion rate did not decrease (0.85±0.20 μm/y *vs.* 0.88±0.10 μm/y). Complexation of degenerated HA molecular chains with Cr-ions released from the CoCrMo-surface in 30 mM H_2O_2 may explain the effect of HA observed on the CoCrMo-alloy and not on the AHNS-alloy. Results from the fretting tests are not available yet.

CONCLUSIONS

The observed increase in corrosion rate of CoCrMo, due to electrochemical interactions between HA and H_2O_2 molecules has clinical implications, suggesting that HA accelerates corrosion of CoCrMo implants in

the presence of 30 mM H_2O_2. Our preliminary results encourage further research on the AHNS alloy for orthopedic applications. These conclusions will be revised on the base of the results from the fretting tests.