

ELECTROCHEMICAL CHARACTERISATION OF TITANIUM ALLOYS FOR BIOCOMPATIBLE APPLICATIONS

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INTRODUCTION: Titanium alloys are regarded as highly biocompatible materials and are hence widely employed in the fabrication of prostheses. Their high corrosion resistance is due to the spontaneous formation of a protective oxide film, the integrity of which has been strongly correlated to the chemical and mechanical stability of implants. Despite the fact that total hip arthroplasty is a successful and world-wide accepted modern surgical operation, every year up to 20 % of human patients require revision surgery due to complications. These are often associated with the formation of a synovial-like tissue at the interface between the bone and the implant in response to the interaction of mechanical, electrochemical and biological processes. In this work [1], the electrochemical properties of Ti, TiAlV and TiAlNb were investigated under experimental conditions resembling the *in vivo* biological environment. Particular focus was placed on TiAlV, the currently more frequently employed alloy for hip prostheses.

METHODS: The electrochemical properties of the Ti samples were investigated using potentiodynamic, AC impedance and photoelectrochemical techniques. The experimental conditions selected consisted of buffered simulated body fluid solutions, thermostatted at 37°C. The effects of parameters such as pH, temperature and time were studied as well as the effects of different ionic species contained in simulated body fluid.

RESULTS: The influences played by the composition of the electrolyte solution on the formation and growth of the oxide film on TiAlV and modifications in the latter, as a result of selective ion inclusion or adsorption was investigated. Of particular interest were the effects of calcium and phosphate ions, as these ions are thought to be the first ions to interact with the metal surface amongst the different ions contained in body fluid. *In situ* measurements were carried out employing AC impedance and photo-electrochemistry in order to monitor changes at the metal-electrolyte interfaces and in the electronic properties of the semi-conductive oxide layer. AC impedance studies showed that these ions interact with the surface and change the passive film with time. This could be best monitored from changes in the phase diagrams

with time. In fact the appearance of a second overlapping phase shift was observed with time in the presence of either calcium ions or phosphate ions in electrolyte solutions containing 0.14 M NaCl. In the absence of added ions, only one phase shift was observed irrelevant of the time of exposure of the sample to the solution. Changes in the phase shifts in the presence of calcium and phosphate ions were not observed at room temperature. Photoelectrochemical experiments revealed an absorption at 250 nm in all simulated body solutions tested, but the photocurrents measured varied quite considerably in the presence of calcium and phosphate ions compared to NaCl. Differences were also observed between the three different metal samples investigated.

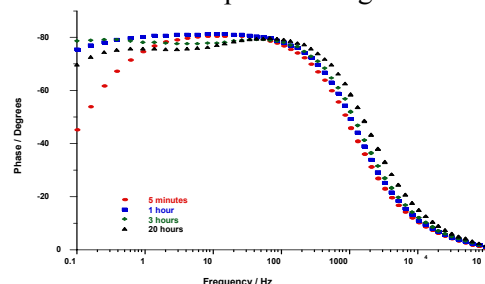


Fig. 1: AC phase shift spectra of TiAlV in 0.14 M NaCl containing 10 mM KH_2PO_4 adjusted to pH 7.4; $T = 37^\circ\text{C}$; $E_{\text{Pol}} = E_{\text{Corr}} \pm 10 \text{ mV}$.

DISCUSSION & CONCLUSIONS: Upon placing a metal implant in a biological environment, changes in the properties of the metal oxide film may occur as a result of interactions between the two environments. First results have shown that the use of *in situ* techniques such as AC impedance and photoelectrochemistry enable the monitoring of changes in the passive film with time under different simulated conditions. It was found that calcium and phosphate ions are both responsible for interacting with the Ti surfaces and altering the passive film shortly after contact. Other ions contained in body fluid do not appear to have the same effect. Surface modifications, however, appear to occur to a different extent or mechanism on pure Ti and on the two Ti alloys investigated.

REFERENCES: ¹ A.W.E. Hodgson, Y. Müller, D. Forster, S. Virtanen, *Corr. Sci.* submitted.

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