UNIVERSITI TEKNOLOGI MARA

THE ELECTROCHEMICAL BEHAVIOUR OF METALLIC BIOMATERIALS IN SIMULATED HUMAN BODY FLUID

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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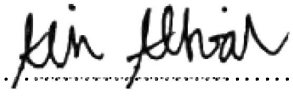
Signature of Student	:	
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ABSTRACT

The improvement of bio-implant applications in biomedical field grows together with the introduction of recently developed metals and alloys as bio-implant materials. However, the main concern for using metal alloy as an implantation is their tendency to corrode in physiological environment in the human body. Human body environment presents a corrosive that may lead to the rejection or implant failures. Therefore, the selection of most suitable implant material that is accepted by the living tissues is the major criteria to be focused on. Titanium, stainless steel and nickel titanium as basic metals were used in this study. The electrochemical tests performed in this study were open circuit potential (OCP) and potentiodynamic polarization on Ti-6Al-4V, 316L SS and Nitinol. These tests were performed with and without the addition of bovine serum albumin (BSA) to the phosphate buffer solution (PBS) with pH values of 5.2 and pH 7.4 at 37˚C. The results showed that the corrosion potential (E_{corr}) of 316L SS with the presence of BSA at both pH values are higher (pH 5.2= -652.0 mV, pH 7.4= -818.0 mV) than with no addition of BSA. Meanwhile, the corrosion resistance of Ti-6Al-4V at pH 7.4 and Nitinol at pH 5.2 increased without presence of BSA. The corrosion behaviour of Ti-6Al-4V, 316L SS and Nitinol under the concentrations of 0%, 2%, 4%, 6%, 8% and 10% of BSA at 37˚C were investigated using electrochemical methods. For Ti-6Al-4V, the potentiodynamic polarization graph showed the formation of TiO_2 layers are most stable in solutions that contain 0%, 2% and 8% of BSA. Meanwhile, the highest E_{corr} happened to 316L SS in the 8% of BSA. This shows that at 8% BSA, the proteins are most effective to decrease the corrosion rate of 316L SS by acting as a protective barrier from the initial stages of corrosion. For Nitinol in the solutions without proteins is most effective to decrease the corrosion rate of Nitinol alloy with the formation of TiO_2 layer at the initial stages of corrosion. By analyzing electrochemical impedance spectroscopy (EIS) measurements for Ti-6Al-4V and 316L SS, it can be seen that the most stable film formed on both alloys are in the solution that contain 8% of BSA. For Nitinol, at high impedance results indicated that all BSA concentrations showed almost similar behaviour which 0%, 2% and 4% followed by 8%, 10% and 6%, as the frequencies increases from −2 Hz to closely 6 Hz. From the equivalent circuit parameter, Nitinol alloy best perform with the presence of lower BSA (2% and 4%). All the three alloys were observed under scanning electron microscope (SEM) in order to analyze the changes in their surface morphology before and after the electrochemical tests. The brown colour appeared on the surface of samples were natural reaction to metal corrosion. The white products produced were due to the protein that adsorbed on the metal surface. 2D Raman spectroscopy is displayed as a contour map that allowed for the selection of an optimal time of conformational stability of proteins adsorption on the surface of the implant. It reveals that albumin in contact with the surface of Ti-6Al-4V surface after 30 minutes in BSA, while 316L SS and Nitinol took 60 minutes. Human serum albumin (HSA) achieves a stable configuration after only 15 minutes for Ti-6Al-4V, while 316L SS and Nitinol after 40 minutes resulted the time differences between both types of protein.

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