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Characteristic Features of Plasma Electrolytic Treated Layers in Na_3PO_4 Solution

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Abstract

Plasma electrolytic oxidation (PEO) treatment of Ti6Al4V (Ti) using various concentrations of Na_3PO4 (NAP) has been carried out. Based on the PEO process, characteristics of the treated layers, such as structure, chemical composition, phases, roughness, hardness and porosity level were investigated. Irregular micro-channel spots were found on all treated surfaces. Larger pores were more evident on the PEO treated with NAP-7.5 g/L, and are considered to be related to the high intensity of micro-arc discharges on Ti surface. XRD analyses revealed that the surfaces of treated layers are composed of Ti, TiO_6 and anatase. The Profilometry test depicted that the surface roughness of PEO treated layers is significantly higher than bare Ti. The thickness and hardness of PEO-treated layers increased with increasing NAP concentration and found to be highest with sample processed with NAP-10 g/L. Among all the NAP concentration used, 5 g/L showed the least level of porosity. Reflection on the results portends that the PEO treated with 10 g/L concentrations could serve a potential candidate for clinical purposes.

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Keywords: Plasma electrolytic oxidation; Na_3PO_4; Ti6Al4V; roughness; hardness

1. Introduction

Plasma electrolytic oxidation (PEO), also known as micro-arc oxidation has been gaining popularity as a novel electrochemical surface treatment to produce porous and adherent layer on light materials [1,2]. The PEO layer provides improved corrosion resistance, wear resistance and biocompatibility. Generally, application of PEO process on light materials is expected to produce a complex phase owing to an extremely high temperature of the local surface which can reach up to 5000 ^oC [3], and thereby modify the surface structure.

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Titanium and its alloys (Ti) have a good corrosion resistance, high strength to weight ratio and passive oxide film chemical stability [4]. Nevertheless, plasma electrolytic oxidation treatment of these materials can be carried out in a benign electrolyte solution to harden and improve their surface properties against aggressive environments [5]. Among electrolyte reagent grades for PEO processing, sodium phosphate has been extensively used owing to its ability to ionise easily in water and good conductivity [6]. Khan et. al [6] investigated the effect of pulse current on the structural characteristics of PEO coating using the Na_3PO_4 compound. They reported that the coatings consisted of amorphous and rutile phase structure with a content range of 17-25 wt. %. Recently, Sandhyarani et. al [7] studied the performance of Zr using Na_3PO_4 compound solution under different processing time. They found that the produced coatings consisted of high dense oxide films with uniform thickness ranging from 3 to 14 µm. These studies indicate that PEO treatment carried out in Na_3PO_4 electrolyte solution demonstrated improved properties for light materials. However, the influence of Na_3PO_4 concentration on light materials has not been investigated especially on Ti substrate. Therefore, it will be of great interest to study the associated effect on the surface morphology of Ti. This preliminary study examines features of Ti treated with different concentration of Na_3PO_4. The effect of Na_3PO_4 concentration on the structure, chemical composition, phases, roughness, hardness and porosity level was evaluated and discussed. The findings will lead to the selection of an appropriate concentration for the hydroxyapatite (HA) deposition in the future study.

2. Experimental

2.1 Materials and method

Ti6Al4V plates (Ti) of dimension 20 mm x 10 mm x 2 mm were used as the substrates. Prior to PEO treatment, the substrate surface was ground with metallographies abrasive SiC paper (800-2500 grit size) and then cleaned with acetone and distilled water in an ultrasonic bath. A DC power supply unit (Keysight Technologies Deutschland GmbH, Model No: N8957A, Germany) of 1500 V/30 A capacity was employed to carry out the PEO process. The electrolyte solution was prepared by dissolving reagent grade Na_3PO_4 (NAP) in distilled water. The Ti coupons were then treated with aqueous electrolyte solutions containing a concentration of 5 g/L, 7.5 g/L and 10 g/L NAP at a constant current density of 5 $mAcm^{-2}$ and 10 min deposition time. The voltage and distance between the electrodes were fixed at 300 V and 1.5 cm respectively. During the PEO process, the Ti samples were used as the anode while stainless steel was used as the cathode. The electrolyte bath was cooled by a water cooling system to keep the temperature below 35 ^{o}C. After the PEO treatment, the coated samples were cleaned with distilled water and air dried at room temperature. Fig. 1 shows the PEO system used in the present study.

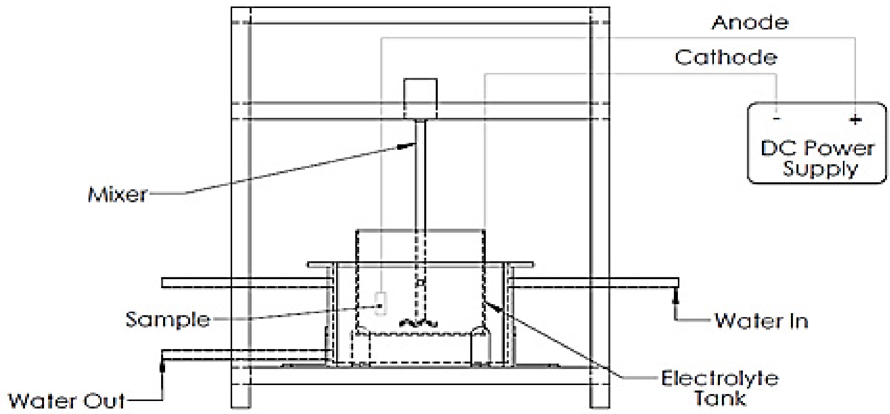

Fig. 1. Schematic representation of plasma electrolytic oxidation setup.