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Preparation and Surface Characterization of TiO_2 Layers on Ti-6Al-4V by Anodic Oxidation Technique

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Abstract – Titanium and titanium alloys are widely used in a variety of biomedical applications because of a natural oxide formation. In this study, TiO_2 films were produced on Ti-6Al-4V substrates (bars and plates) by anodic oxidation technique with H_2SO_4 solution as electrolyte at voltages ranging from 10V to 100V. The microstructure, phase structure and phase composition of the films produced were analysed depending on applied voltage and microstructure of the substrate.

Titanium and titanium alloys are widely used in a variety of biomedical applications due to their corrosion resistance and biocompatibility. A protective passive titanium dioxide film covers the surface of the Ti and its alloys in ambient conditions. This natural oxide is 2 to 7 nm thick, and it is one of the principal responsible for the success as an implant material [1]. TiO_2 films can be produced on Ti-6Al-4V substrates by several techniques, like: thermal oxidation [2, 3], anodic oxidation [3, 4], sol-gel process [3], etc.

In this study, TiO_2 films were produced on Ti-6Al-4V substrates by anodic oxidation technique, using 1M H_2SO_4 solution as electrolyte at different voltages (from 10V to 100V) during 1 min. Pieces of substrate come from a bar and plates with different thermo-mechanical treatments. The microstructure, phase structure and phase composition of films produced under different voltages were determined by scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), and X-ray diffraction (XRD) operated with glancing angle geometry with an angle of incidence of 1°.

Different colours of interference were obtained depending on the applied voltage and they are according to those mentioned in the literature [3] (Fig. 1).

The oxide layers produced on Ti-6Al-4V at low voltages up to 50V are smooth and amorphous. Moreover, there is a selective oxidation of alpha and beta phases of the alloy used as substrate, this effect becomes more important when the microstructure of the substrate has texture, just like it is observed on the plates of Ti-6Al-4V. A spark discharge occurs, at voltages larger than 60V, producing porous and crystalline coatings (Fig. 2). Crystalline phases of TiO_2, anatase and rutile, were obtained at high voltage and by thermal treatment of amorphous oxides. Each of these morphologies and structures of the coatings are suitable to different biomedical applications and devices.

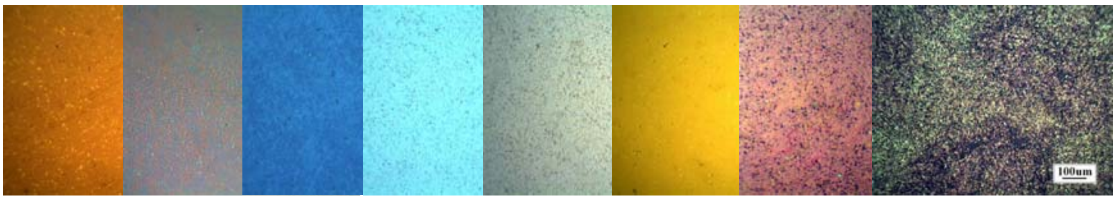

Figure 1: Optical micrograph of TiO_2 coatings obtained at 10, 20, 25, 30, 40, 50, 60 and 100 V on bar of Ti-6Al- 4V.

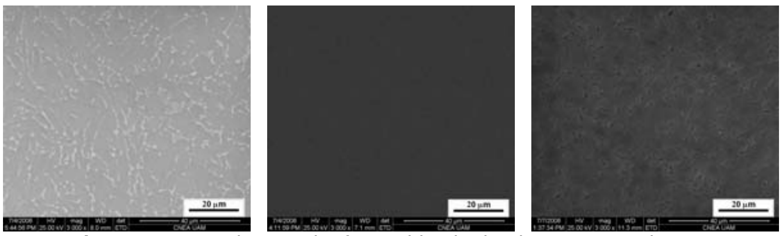

Figure 2: SEM micrograph of an oxide obtained at 10, 50 and 100 V.

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