Microstructural Characterization of Biofunctionalized Titanium Foams

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Titanium and its alloys are widely used in orthopaedic and dental implants due to their mechanical properties and high corrosion resistance. It is known that porous metals can increase the in vivo lifetime of metallic implants by decreasing the effective Young's modulus of implant material to match that of bone as well as increasing the interfacial bond between living cells and implant materials via compositional or structural modification [1–4]. The present study aims at processing, biofunctionalizing and characterization of titanium foams having porosity from nano- to macro-scale. In order to reach that aim, first titanium foams were produced by powder metallurgy with space-holder technology. Powders of Ti and urea having average sizes of 32 and <500 µm, respectively, were blended in a planetary ball mill for 3h. The green compacts containing 30, 50, and 70 vol.% of urea (corresponds to 30, 50, and 70 vol.% of nominal porosity, respectively) were prepared by cold pressing in a stainless steel die under 350 MPa. After compacting, the space holder was removed by immersing the samples in water for 9, 10, and 11h for 30, 50, and 70 vol.% of nominal porosity, respectively. Finally, Ti foams were sintered at 1250 °C for 3 h under vacuum. The anodic treatment was performed at 200 V for 1 min in H₃PO₄ (1M). After processing, porosity values were determined by image analysis technique using Leica DM2500 OM and Image J 1.37v image analysis software and microstructures were investigated by FEI Nova 200 field emission gun scanning electron microscope (FEG-SEM), equipped with EDAX energy dispersive X-ray spectroscopy (EDS).

Samples produced with 30, 50, and 70 vol.% of nominal porosity exhibited 12.85, 27.61 and 59.11 vol.% actual porosity, respectively. The difference between the nominal and the actual porosity can be explained by the shrinkage that took place during the sintering. Microstructural examinations by SEM revealed that as the macro porosity on the foams increased, the sizes of the secondary pores induced by anodic treatment decreased (Figure 1). Besides, the SEM micrographs also showed that not just the surfaces of the samples, but also the inner pore cell walls were covered with an anodic oxide film. On the other hand, EDS analysis revealed that anodic treatment in H₃PO₄ resulted in incorporation of P ions into the anodic oxide film (Figure 2). Therefore, it is reasonable to suggest that biofunctionalization of Ti-foams can be obtained by anodic treatment.

Since corrosion and tribocorrosion are major clinical concerns on implant materials resulting in intense release of metallic ions and wear debris, electrochemical and triboelectrochemical characterization of biofunctionalized Ti foams are being studied [5].

References:

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