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Influence of Zr content in Ti-40Nb-xZr alloys on microstructure and elastic modulus and microhardness

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The scenario of using alloys in implants has changed in recent years. Today, either due to earlier receiving of the implant or simply because they live longer since life expectancy has increased, the implanted patient lives much longer with the implant than decades ago. In this way, new challenges have arisen in recent years, in order to offer a product that promotes an increase in the life expectancy and quality of these patients. Currently, either due to cost or the ease of obtaining the alloys, considering alloys applied in other areas, such as, the chemical or aeronautical industry, respectively, in the case of stainless steel and Ti-6Al-4V alloy. These alloys have two main problems. They contain toxic elements in their composition. for example, in Ti-6Al-4V alloy, aluminum is associated with Alzheimer's disease, while vanadium is associated with respiratory problems. In the case of stainless steel, it is even worse, Ni can present a carcinogenic effect. Finally, when there is a large difference between the elastic modulus of the bone (30-40 GPa) and that of the implant material (Ti-6Al-4V - 120 GPa and stainless steel 304L 210 GPa), a well-known problem of stress shielding occurs. As mechanical stress, tension while walking and exercising, for example, is not transmitted properly to the bone, a phenomena called osteopenia occurs, which can lead to implant loosening or even a new fracture. Thus, the search for new alloys with an elastic modulus closer to that of the bone and free of toxic elements to the human body has intensified in recent years. Therefore, the objective of this work is to analyze in Ti-Nb-Zr alloys the influence of Zr in Ti-40Nb-xZr alloys, where x = 0, 20, 30, and 40% (wt.%). Thus, Ti-40Nb (0Zr), Ti-40Nb-20Zr (20Zr), Ti-40Nb-30Zr (30Zr), and Ti-40Nb-40Zr (40Zr) alloys were produced in an arc melting furnace using a copper mold, under a protective argon atmosphere. These alloys underwent microstructural characterization, which consisted of X-ray diffraction (XRD), optical microscopy (OM), scanning electron microscopy (SEM), as well as semi-quantitative analysis via SEM-EDS. Vicker microhardness (HV) was also determined through the average of 15 measurements, with the application of a load of 0.5 kgf for 15 seconds, as well as the elastic modulus of the alloys through impulse excitation using Sonelastic ATCP equipment. All Ti-40Nb-xZr alloys showed dendritic microstructure, composed of the Beta-Ti (bcc) phase. The 20Zr alloy showed an elastic modulus of 88 GPa and a microhardness of 206 HV, while the 30Zr showed 85 GPa and 239 HV and, finally, the 40Zr alloy showed 77 GPa and 237 HV. These results indicate that the addition of Zr, despite increasing the microhardness, can be effective in order to reduce the elastic modulus of the alloys.