IIIa08-006

Microstructure and selected mechanical properties of a novel high entropy alloy for potential use as an implantable material

Torrento, J.E.M.(1); Sousa, T.S.P.(1); Afonso, C.R.M.(2); Grandini, C.R.(1); Correa, D.R.N.(3);
(1) UNESP; (2) UFSCar; (3) IFSP;

High entropy alloys (HEAs) have been developed for many high-performance applications, such as aeronautic, infrastructure industries, and biomedicine. HEAs are recognized for their superior strength, ductility, and corrosion resistance, in a simple crystal structure material (such as BCC and FCC). In the biomedical area, the current research effort is looking for the development of HEAs with properties compatible with use as implantable materials. This project aims to design, process, and characterize the structure, microstructure and selected mechanical properties of a novel HEA, composed of non-toxic elements (Ti, Nb, Zr, Ta, and Mn) for possible application as biomedical implants. In this study, TiNbZrTaMn and TiNbZrTaMo alloys were produced in non-equiatomic proportions, following some ab initio design predictions. The alloys were cast by arc melting and subjected to a heat treatment for microstructural homogenization. Then, thermal aging treatments were performed at 300 ºC, 400 ºC, and 500 ºC for 6 hours. The samples were characterized by density, EDS, chemical mapping, XRD, optical, scanning electron and transmission electron microscopy, elastic modulus, and Vickers microhardness measurements. The chemical characterizations indicated a good quality of the samples produced, and the structural characterization indicated the majority of BCC crystalline structure, as predicted by the ab initio design parameters, with the secondary phase precipitation with a hexagonal structure in the TiZrNbTaMo alloy. In the microstructural characterization, both alloys in the as-cast condition showed an irregular formation. After the heat treatments, it is possible to observe grain boundaries, characteristic of the BCC crystalline structure. For the TiZrNbTaMo alloy, in the boundary region, it is also noted some acicular structures indicated some microstructural modifications, which was confirmed by transmission electron microscopy, besides a third phase, possibly orthorhombic, which could be identified by this technique. The studied samples showed a low elastic modulus (around 80 GPa). The TiZrNbTaMo alloy showed substantial variation in elastic modulus that may be related to the precipitation of secondary phases in the microstructure after heat treatments. Both HEAs showed high Vickers microhardness to some commercial biomedical biomaterials (SS 316L, CP-Ti grade 2, and Ti-6Al-4V ELI). This study produced new HEAs, and the TiZrNbTaMn alloy showed the best potential for use in the orthopedical area, grouping low elastic modulus and high microhardness. (Financial support: FAPESP, CNPq, and CAPES)