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CHEMICAL, BIOLOGICAL AND MECHANICAL CHARACTERIZATION OF Zr-25Ta-5Ti ALLOY

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ABSTRACT

Life expectancy has increased by 31.1 years since 1940. With this increasing aging of the population, the demand for biomedical materials that can repair or replace functions of the human body has increased too. Zirconium, together with titanium, has been widely used in biomedical applications due to its physical, chemical, and biological properties. Zirconium, present in greater quantity in the alloy understudy, has chemical and physical properties similar to titanium. It has two crystal structures. It is more stable in the compact hexagonal phase known as α. At higher temperatures, its crystalline structure is a body-centered cubic, β phase. With the addition of other elements, it is possible to change the allotropic transformation temperature to modify the phase volume fractions.

Tantalum added to zirconium is excellent for biocompatibility and β-phase stabilization. Titanium aids in biocompatibility and is a β stabilizer. Studies in the literature show that alloys with a predominance of β-phase have more excellent mechanical compatibility with human bone. This work aimed to prepare and characterize a new zirconium alloy containing 25 wt% of tantalum and 5 wt% of titanium for biomedical applications. The ingot was included in an arc melting furnace; already cast, it was subjected to heat treatment at 1000 °C for 24 hours in a vacuum of 10^{-7} torr to relieve the residual melting stresses, The sample underwent a hot-rolling process, heated up to 1000 °C,

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approximately, and then it was air cooled, finished with approximately 4 mm of thickness. For chemical analysis, density and chemical composition were made. The alloy's structural and microstructural characterizations were performed using X-ray diffraction and optical (OM) and scanning electron (SEM) micrographs images. Microhardness and modulus of elasticity measurements were also performed under the three alloy conditions for the mechanical characterization. Lastly, MTT and crystal violet tests were performed to assess the cytotoxicity and cell adhesion of the alloys. After the hot-rolling process, the analyses of structural and microstructural characterization show that the produced alloy has the β phase and the α phase. The hardness of the alloy is superior to titanium and zirconium, but after the hot-rolling process, the value has become more viable for biomedical applications. The modulus of elasticity shows that the addition of tantalum decreased the modulus because of the β phase that has a minor density, compared with Ti-cp and other commercial alloys such as cobalt and chromium alloy. The biological tests indicated that the alloys are not cytotoxic, demonstrating properties of alloys with potential for future biomedical applications.

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