

COMPARATIVE STUDY OF THE MICROSTRUCTURE AND ELASTIC/MECHANICAL PROPERTIES OF Ti-Zr-Cu-Pd-(Nb) AND Ti-Zr-Fe-(Hf) ALLOYS

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Ti-based metallic glasses are particularly promising lightweight metallic materials for biomedical applications because of their high strength, excellent corrosion resistance and good biocompatibility. However, there are still some limitations e.g. lack of plasticity, which have to be considered in order to use these alloys for implants. Recent reports on Ti-based composites have demonstrated that desired mechanical properties combining high strength, tensile ductility and excellent fracture toughness can be achieved by proper alloy design and microstructure control. The aim of our work is to find alloys with the mechanical properties close to those of bone, containing neither toxic nor allergic elements and possessing large hardness and low Young's modulus values, thus favoring their biomechanical compatibility with bone.

In this work, the microstructure, elastic and mechanical behavior of two groups: (i) *amorphous* Ti₄₀Zr₁₀Cu₃₈Pd₁₂ and β-Ti phase/amorphous matrix of Ti₄₀Zr₁₀Cu₃₄Pd₁₂Nb₄ and (ii) *crystalline* Ti-30Zr-20Fe and Ti-20Zr-20Hf-20Fe alloys have been compared. Ti₄₀Zr₁₀Cu₃₈Pd₁₂ is completely amorphous, while additive elements like Nb cause changes in the microstructure of that group, causing the occurrence of some β-Ti phases. In turn, the microstructures of Ti-30Zr-20Fe and Ti-20Zr-20Hf-20Fe compositions of both alloys are similar and consist of several different phases. Nanoindentation and acoustic measurement experiments reveal that the Ti-Zr-Cu-Pd/(Nb) alloys present comparable values of Young's modulus as those of crystalline Ti-Zr-Fe/(Hf) alloys:

- A) Ti-Zr-Cu-Pd [$E_r = 104\text{GPa}$]; Ti-Zr-Cu-Pd-Nb [$E_r = 125\text{G Pa}$]
B) Ti-Zr-Fe [$E_r = 92\text{GPa}$]; Ti-Zr-Fe-Hf [$E_r = 104\text{GPa}$]

Concerning the hardness, the values for all alloys are comparable.

- A) Ti-Zr-Cu-Pd [$H = 8.7\text{GPa}$]; Ti-Zr-Cu-Pd-Nb [$H = 10.1\text{GPa}$]
B) Ti-Zr-Fe [$H = 8.7\text{G Pa}$]; Ti-Zr-Fe-Hf [$H = 8.7\text{GPa}$]

Moreover, in order to check the toxicity of Cu and Pd, extraction test was performed on Ti-Zr-Cu-Pd alloy. Over 7 days of immersion the sample in simulated body fluid (Hank's solution), the release of the above-mentioned elements to the testing solution was measured and compared to the EU standard [1], in order to assess the possible use of this alloy in the orthopedical area.

[1] (FprEN 1811:2010) The document prepared by Technical Committee CEN/TC 347 "Methods for analysis of allergens".

Acknowledgments: The authors wish to thank the BioTiNet ITN (No.264635) FP7 Marie Curie project and the MAT2011-27380-C02-01 project from the MINECO (Spain).