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Microstructure-Mechanical Properties Correlation in a Ti-12Mo-13Nb Biocompatible Alloy

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Abstract –This work correlate the specific hardness / Young Modulus with phases precipitated in the Ti-12Mo-13Nb alloy submitted to different mechanical/thermal treatments. The phases were characterized by transmission electron microscopy (TEM). The mechanical characterization was carried out by using the Vickers microhardness test and Young's modulus measurements. Among the different conditions, the 500º C /24h aging showed the highest hardness/ modulus ratio.

Several corrosion-resistant Ti-based alloys such as Ti-Mo, Ti-Nb, Ti-Nb-Ta-Zr have been developed for biomaterials applications. β-type titanium (Ti) alloys with non-toxic elements have been developed to achieve lower Young's modulus and higher mechanical strength. The microstructure of β titanium alloys can be controled by thermomechanical process (heat treatment and quench from the β phase field and aging) and two types of precipitates, α and ω phases can appear during aging [1-3]. Generally, a refined α phase results in high strength.

In this work, the Ti-12Mo-13Nb alloy was produced by arc-melting, homogenized via heat-treatment, cold forged, treated (950 ºC for 1 h) and then aged at 500 for 10 min, 4 h and 24 h followed by quenching. The microstructures were analyzed by transmission electron microscopy (TEM), Vickers microhardness tests and Young's modulus measurements by nanoidentation technique. As a barometer to evaluate the performance of biomaterials with low Young's and high hardness (associated with mechanical strength) for bone implants, the ratio of hardness to modulus was calculated.

Figure 1 show TEM micrographs (bright field) with the selected area diffraction (SAD) pattern of Ti-12Mo-13Nb aged to 500 °C for 10 min, 4 h and 24 h. Figure 1a and 1b show ω phase precipitated in a β matrix and the presence of a small amount α phase in a β matrix, respectively. Increasing aging time, we can observe the dissolution of ω phase and in the increase of the volumetric fraction of lamellas α phase (Fig. 1c and 1d).

Figure 2 shows the hardness to modulus ratio of Ti-12Mo-13Nb alloy in the mentioned conditions including data for commercially pure (cp Ti) and a commercial Ti-6Al-4V alloy. The highest value for hardness to modulus ratio was obtained for the sample aged at 500 °C for 24 h that presented higher volumetric fraction of α phase.

From the current research, the alloy aged at 500 °C by 24 h seems to be a promising candidate for an implant material due the combination of lower modulus and higher microhardness as consequence of the controlled microstructure.

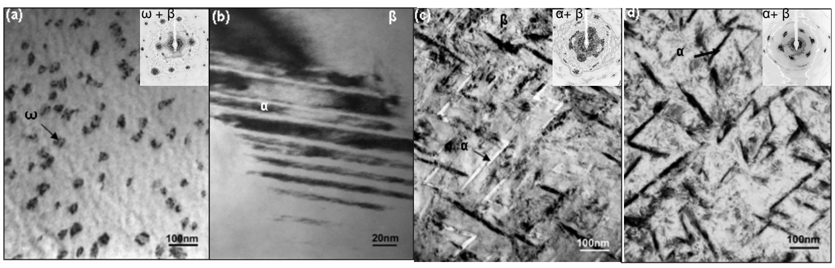

Figure 1: TEM bright-field image and SAED pattern of Ti-12Mo-13Nb alloy in conditions: **a, b)** aged 500°C/10min **c)** aged 500°C/4h and **d)** aged 500°C/24h.

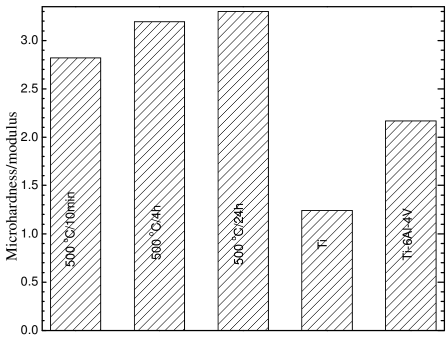

Figure 2: Ratio of hardness to Young's modulus of the Ti-12Mo-13Nb alloy in different conditions, commercially pure (cp) Ti and Ti-6Al-4V.

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References

[1] Y. Zhou, M. Niinomi, Journal of Alloys and Compounds. 466 (2008).
[2] B. Wang, Z. Liu, Y. Gao, S. Zhang, X. Wang, Journal of University of Science and Technology Beijing. 14 (2007).
[3] S. L. Raghunathan, A. M. Stapleton, R. J. Dashwood, M. Jackson and D. Dye, Acta Materialia. 55 (2007).