11th International Conference on Advanced Materials

ICAM 2009

Rio de Janeiro Brazil
September 20 - 25

Phase Transformations and Aging Heat Treatments of Ti-Mo-Sn Alloys for Biomedical Applications

F.F. Cardoso(1) *, C. Bronzoni(1), M. G. de Mello(1) and R. Caram(1)

(1) Department of Materials Engineering, University of Campinas, Campinas, SP, Brazil e-mail: rcaram@fem.unicamp.br

* Corresponding author.

Abstract – Materials that combine enhanced mechanical behavior, excellent corrosion resistance and high biocompatibility are of paramount importance in orthopedic applications. These features may be achieved by using β titanium alloys containing non-toxic elements. Mechanical behavior of β Ti alloys can be optimized by applying aging heat treatments. In this work, Ti-Mo-Sn samples were prepared, hot rolled and aged at 250-350ºC for different periods of time. Results obtained suggested that Sn added to Ti-Mo alloys changes Ti phase stabilities, favoring β stabilization and also, suppressing ω phase precipitation and hence, altering materials mechanical behavior.

Currently, the development of titanium alloy to be applied as orthopedic biomaterials has been focused upon β Ti alloys, which are produced with non-toxic and non-allergenic elements, such as Mo, Sn, Nb, Ta and Zr [1]. β Ti alloys show low elastic modulus, which favors transfer of stress between implant and bone [2]. Mechanical behavior of β Ti alloys can be changed and optimized by applying aging heat treatments.

In this work, Ti-8Mo and Ti-8Mo-6Sn (wt.%) samples were prepared in an arc-melting furnace under argon atmosphere. Samples were homogenized at 1000ºC/24h and furnace cooled. This was followed by hot rolling at 1000ºC, solution heat treatment at 1000ºC/1h and water quench (WQ). Following, aging heat treatments were carried out at 250-350ºC for 4 hours. Characterization involved microstructure analysis by using optical microscopy, Young's modulus measurements using standard through-transmission technique with coupled longitudinal and shear transducers, X-rays diffraction and Vickers hardness measurements.

Results obtained by using X-ray diffraction and optical microscopy showed that Ti-8Mo and Ti-8Mo-6Sn WQ samples presented microstructure formed by β phase and orthorhombic martensite. In addition, X-ray diffraction analysis confirmed precipitation of athermal ω phase in the Ti-8Mo WQ sample. These results suggest that Sn, when added to the Ti-Mo system, behaves as a β stabilizer element [3]. Also, it was observed that Vickers hardness decreased with the increase in Sn content. Based on Vickers hardness measurements, it was found that Sn works as a suppressor of ω phase precipitation, a behavior that has previously been reported in other systems [4]. Aging heat treatment was able to produce an increase in hardness and elastic modulus, which, probably, is due to α''→β reverse transformation and latter, by precipitation of isothermal ω phase [5]. Results obtained from X-ray diffraction combined with optical microscopy suggested that orthorhombic martensite was completely decomposed after aging for 2 h at 250ºC or 1 h at 350ºC (Fig. 1). This fact indicates that martensite decomposition depends on temperature and period of time of aging, as observed in other metallic systems [6].

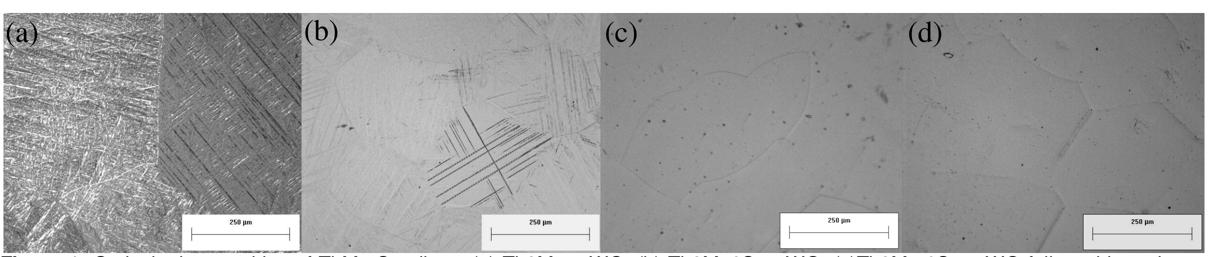

Figure 1: Optical micrographies of Ti-Mo-Sn alloys: (a) Ti-8Mo – WQ; (b) Ti-8Mo6Sn - WQ; (c)Ti-8Mo-6Sn – WQ followed by aging at 250ºC/2h and (d) Ti-8Mo-6Sn – WQ followed by aging at 350ºC/1h.

References

[1] D.J. Lin, J.H. Chern Lin, C.P. Ju, Biomaterial 23 (2002) 1723-1730.
[2] M.Niinomi. Journal of the Mechanical Behavior of Biomedical Materials I(2008) 30-41.
[3] Y.L.Hao, S.J. Li, S.Y. Sun and R. Yang. Materials Science and Engineering A 441 (2006) 112–118
[4] T. Ozaki, H. Matsumoto, S. Watanabe and S. e Hanada, S.Materials Transactions, 45-8 (2004) 2776-2779.
[5] Y. Mantani, M. Tajima. Materials Science and Engineering A438-440 (2006) 315-319.
[6] Y.L. Zhou, M. Niinomi. Journal of Alloys and Compounds 466 (2008) 535–542.