11th International Conference
on Advanced Materials

ICAM 2009

Rio de Janeiro Brazil
September 20 - 25

Preparation, structural characterization, and biocompatibility of Ti-Ta alloys used as biomaterial

S.L.M. Ruiz(1), T.A.G. Donato(2), C.R. Grandini(1) and A.P.R.A. Claro(3)

(1) UNESP, Grupo de Relaxações Anelásticas, 17.033-360, Bauru, SP, Brazil,e-mail: samlea@fc.unesp.br
(2) USP, Depto. de Biologia Celular e do Desenvolvimento, 05.508-900, São Paulo, SP, Brazil
(3) UNESP, Faculdade de Engenharia de Guaratinguetá, 12.516-410, Guaratinguetá, SP, Brazil
* Corresponding author.

Abstract - Titanium and some of its alloys have been largely used in the production of prostheses and special devices in the medical and odontological areas due to their properties as of low values of elasticity modulus, corrosion resistance, and biocompatibility. Many studies have also been made with materials that present smaller elasticity module values, higher mechanical strength, greater corrosion resistance, and biocompatibility. It is known that alloys that present tantalum as a substitutional element compose promising materials for such application. This paper presents the preparation, structural characterization, and biocompatibility of Ti-Ta alloys with different tantalum contents.

Nowadays, titanium is used in several areas due to their properties as excellent resistance strength/density relation, high corrosion resistance, and good behavior to high temperatures. It is well used in the chemical and aerospace industry. Its use was expanded in the biomaterials field due to excellent biocompatibility, that associated to the corrosion resistance, low density, and low values of elasticity modulus (when compared with stainless steel, for example), characterizes this element as one of the most promising metals for production of articulated prostheses, dental implants, and other medical devices. Today, only 5% of the titanium production in the metallic form are destined to the production of biocompatible alloys [1]. In this way, many studies have been made with the objective to characterize and to understand the behavior of new alloys that present similar mechanical strength (or still better), smaller elasticity modulus of and larger biocompatibility than the used alloys. Ti-6AL-4V alloy is the most used in orthopedic implants. However, it is known that the aluminum ions causes neurological disorders and vanadium ions are associated with enzymatic disorders, among other problems [2]. Recent studies have been made with metallic biomaterials that present niobium, zirconium, molybdenum, hafnium and tantalum as substitutional elements added to titanium and the Ti-Ta alloys have shown promise for this application [3]. In this sense, many efforts have been made to characterize and to understand the behavior of Ti-Ta alloys, and this paper presents the preparation, structural characterization, and biocompatibility of Ti-Ta alloys with different tantalum content.

The samples used in this study constitute polycrystals of the Ti-Ta system, produced by arc-melting in an argon atmosphere in the UNESP, Faculty of Engineering, Guaratinguetá, Brazil. The chemical analysis showed the main elements that compose the alloy to be in good agreement with the stoichiometry (10 and 20 weight % Ta). After melting, the samples were characterized by X-ray, optical, and scanning electron microscopy measurements, after swaging to obtain cylindrical bars with an approximately 3-mm diameter and 30-mm length. Mechanical spectroscopy measurements were made using a torsion pendulum operating with oscillation frequency among 0.5 and 30 Hz, with a temperature range of 100–700 K at a heating rate of 1 K/min and a vacuum better than 10^{-5} mBar. With mechanical spectroscopy measurements, the dynamical elasticity modulus can be obtained and the behavior of interstitial and substitutional elements present in the alloy studied [4].

The mechanical spectroscopy measurements showed complex relaxation structures, which were decomposed into their constitutive relaxation processes. These relaxation processes may be caused by stress-induced ordering of heavy interstitial elements around elements of the alloy, representing the interaction of substitutional and interstitial elements present in the alloys. The elasticity modulus obtained showed that this alloy is a promising material for use as orthopedic implants. In direct or indirect cytotoxicity tests, the studied alloys presented no cellular toxicity, indicating good *in vitro* biocompatibility.

The authors wish to thank the Brazilian agencies CNPq and FAPESP for their financial support.

References

[1] M. Geetha, A. K. Singh, R. Asokamani, A. K. Gogia, Progress in Materials Science 54 (2009) 397-425.
[2] J. Black, Biological performance of materials – Fundamentals of Biocompatibility, Marcel Dekker, New York, 1992.
[3] Y.-L. Zhou, M. Niinomi, Journal of Alloys and Compounds 466 (2008) 535-542.
[4] A. S. Nowick, B. S. Berry, Anelastic Relaxation in Crystalline Solids, Academic Press, New York, 1972.