PREPARATION AND CHARACTERIZATION OF TITANIUM-ZIRCONIUM ALLOYS

Guilherme Ramos Costa, Daniela Maria Cerqueira Leite, Cristiano Stefano Mucsi,
Jesualdo Luiz Rossi*
Instituto de Pesquisas Energéticas e Nucleares - IPEN Brazil
* Corresponding author: jelrossi@ipen.br

Keywords: titanium alloys; zirconium; biomaterials; mechanical properties

Introduction and objective

The alloys used for making dental implants must display properties such as biocompatibility, biofunctionality and corrosion resistance. The titanium alloys are the most widely used due to their higher strength-to-density ratio, superior biocompatibility and corrosion resistance, good mechanical properties, low tensile modulus when compared to other metallic biomaterials. The main objective of this work was the preparation of titanium-zirconium alloys for implant dentistry. The work aimed to compare the results of melting during the various stages of furnace preparation and the corresponding mechanical and microstructural characterization of the obtained titanium-zirconium alloys.

Methodology

A casting of two implant candidate alloys was carried out (Ti14%Zr and Ti20%Zr by mass). The used vacuum melting furnace, an electric arc furnace fitted with tungsten non consumable electrode and billets with 200 g mass were cast. The experimental alloys were chemically characterized using a scanning electron microscope fitted with an energy dispersive spectrometer. The gas analysis was carried out. The microstructure was characterized using optical and scanning electron microscopy. The mechanical properties were assessed using instrumented microhardness testing.

Results and discussion

The resulting melting microstructure observed using optical microscopy, a microstructure in the form of slats or lamellae, also described as basket-weave, can be easily discerned. All microstructures showed the coarse melting microstructures with Widmanstätten lamellae that were related to the inherent anisotropy of the hexagonal crystalline structure of the α phase. With increasing Zr content in Ti-Zr alloy, Widmanstätten lamellar structures became coarser.

Titanium reacts easily with other elements, mainly gases, such as hydrogen, nitrogen and oxygen, dissolving quickly in liquid or solid metal at temperatures above 400 °C, resulting in samples with less ductility or more brittle. The as casted laboratory samples with the addition of 14% zirconium and 20% titanium resulted in increased hardness as compared to commercial sample.

Conclusion

The prepared alloys showed a low carbon contamination, less than 0.03% by mass, indicating that clean melts can be obtained in the electric arc furnace with non-consumable electrode. Samples fused in the laboratory with the addition of 12% and 20% zirconium to titanium caused an increase in microhardness when compared to the commercial sample, which also has about 12% Zr.

References

1. Costa, G.R., Master Dissertation, Instituto de Pesquisas Energéticas e Nucleares - IPEN, Universidade de São Paulo, 2016. (In Portuguese)
2. Leite, D.M.C., et al., Modifications of titanium and zirconium alloy surfaces for use as dental implants. MATERIALS SCIENCEFORUM (ONLINE), v. 1012, p. 477-482, 2020.