

CHARACTERIZATION OF THE ELASTIC MODULUS OF METALLIC BIOMATERIALS ASSESSED BY DIFFERENT TECHNIQUES: A COMPARATIVE STUDY

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Abstract

Advances in the quality of life and, consequently, in the life expectancy of Brazilians, along with the increase of the traffic accident rates, have provided the development of new materials. In particular titanium alloys free of allergenic and cytotoxic elements such as V and Al, respectively. Besides the search for biotolerable elements, one of the main motivations regarding the development of metallic biomaterials is the development of alloys with low modulus of elasticity. The present research project aims to deepen the current knowledge about the methodologies to measure the elastic modulus of metallic biomaterials such as AISI-316L stainless steel (ASTM F138), Co-Cr alloys, Ti-6Al-4V alloys and Ti-β alloy Ti-35Nb-4Sn.

Key words:

Biomaterials, Modulus of elasticity, Mechanical properties

Introduction

The possibility of fabrication of structural metal implants free of toxic and allergenic elements makes some β-type titanium alloys very attractive due to their high specific mechanical strength, as well as high corrosion resistance and excellent biocompatibility¹.

With the intention of deepening the current knowledge regarding the methods of measurement of the modulus of elasticity, the objective of this research proposal is to characterize samples of stainless steel AISI-316L (ASTM F138), Co-Cr alloy, Ti c.p., Ti-6Al-4V alloy and Ti-β Ti-35Nb-4Sn alloy. Several analytical techniques were applied in the characterization of the elastic modulus as tensile, compression and bending tests to be performed in a universal testing machine in addition to nanoindentation characterization and ultrasonic techniques.

Results and Discussion

In order to obtain an initial reference for the comparison of the elastic modulus, mechanical tests were realized. All tests were performed in a universal test machine. In the tensile test a cylindrical specimen of a useful length of 25 mm and a diameter of 5 mm was used. For the bending test a sample of identical characteristics was chosen. Finally, for the compression test a cylindrical specimen of a diameter of 2 mm and length of 4 mm was used. The mechanical assays experimentally prove the fact that the titanium β alloys have modulus of elasticity much lower than the commercial alloys. This phenomenon can be particularly evidenced when the results of the tensile test presented in image 1 and chart 1 are analyzed.

The nanoindentation test was performed with variable loads of 5, 10, 100, 300 and 500 mN. Ten indentations were produced for each specified load. From these initial data it can be affirmed that the modulus of elasticity obtained by the nanoindentator presents better reliability when configured with the load of 300 mN. For the ultrasound technique, the elastic modulus was determined through a pulse-echo acoustic emission

technique using a Panametrics-NDT 5072PR pulse-receiver equipped with transducers operating at a frequency of 5MHz.

Image 1. Curves Stress VS Strain (Tensile Test)

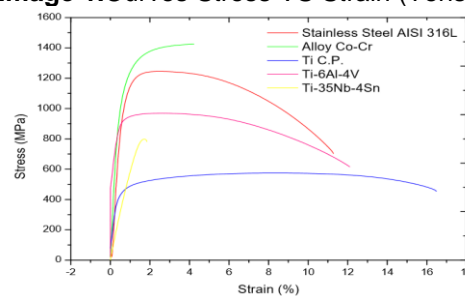


Chart 1. Comparison – Modulus of Elasticity (Tensile Test)

Sample	Modulus of Elasticity (MPa)
AISI 316L	205,15 ± 26,81
Alloy Co-Cr	243,45 ± 11,39
Ti C.P.	105,40 ± 16,79
Ti-6Al-4V	105,40 ± 16,79
Ti-35Nb-4Sn	66,16 ± 5,04

Conclusions

The titanium β alloys showed lower modulus of elasticity than those found in commercial alloys. In addition, other unique characteristics should also be emphasized as: high biocompatibility, mechanical strength and conformability. Therefore, these alloys are an important alternative for future biomedical applications.

Acknowledgement

My sincere thanks to my tutor PhD. Éder Sócrates Najar Lopes for always encouraging me and the CAPES / CNPq foundation for the support during the realization of this research project.

¹ HANAWA, T. Research and development of metals for medical devices based on clinical needs. Science and Technology of Advanced Materials. v. 13, pp. 1-15, 2012.