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Titanium-Niobium alloys covered by electrospinning technique to applications in bone implants

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Introduction

Recently, to avoid toxic metals in the human environment, there are many efforts to produce alloys containing titanium Ti and niobium Nb. Nb is a powerful stabilizer of beta-titanium phase[1]. Depending on the composition of a binary TiNb alloy the elastic modulus can be more suitable to the osseous tissue (lower modulus and higher hardness are desired). There are few studies about binary alloys with higher niobium percentages. Some authors mention that one of the reasons is economic viability. Nb, unlike Ti, is a rare and expensive metal from the international community point of view [1,2]. However, this is not the Brazilian reality. The objective of this work was analyzed substrate of produced TixNb alloys (x = 50, 80, and 90%) mechanically and create a cover using electrospinning technique using PVA/propolis solution.
The treatment aims to reach adequate characteristics to improve the interaction of implant surfaces with bone tissue through the use of a biocompatible and hydrophobic polymer (PVA). In addiction, propolis have properties that help the process of healing. The results showed that the crystalline phases of the alloys are cubic. Hardness H and modulus of elasticity E measured of the alloys with 80%, 90% of Nb, and pure niobium presented similar behaviors, whereas the alloy with 50% showed considerably less E and greater H (more suitable to bone implant application). The PVA/Propolis coating produced on the alloys are well-adhered presenting a promising way to accelerate the healing process.

Methods

- Titanium (cp grade 2) 99% and Niobium 99.8% were alloyed to produce alloys with 50%, 80% and 90% wt. of niobium and pure niobium were used as samples.
- Crystalline Phases: X-ray diffraction technique. The measurements were made using CuKα radiation, in bragg-brentano geometry.
- Nanoindetation tests: Elastic modulus E and hardness (H) were measured by instrumented indentation technique using a UNAT Nanoindenter (Zwick-Roell/Asmec), employing the Quasi-Continuous Stiffness Method (QCSM) and a Berkovich diamond tip. The maximum force was 500 mN. A sampling of 49 indentations was obtained in each surface.
- Electrospinning: 10 kV of voltage was applied in the process with a distance between the needle and the samples.

Results

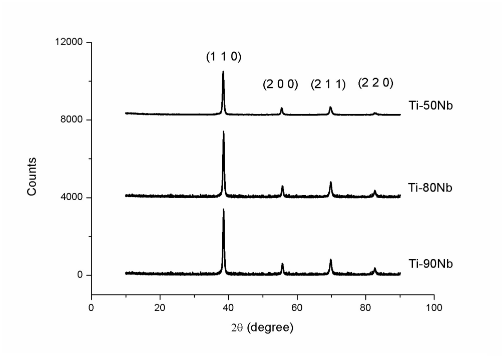

Figure 1: *X-ray pattern of the TixNb alloys (x=50%, 80%, and 90%)*

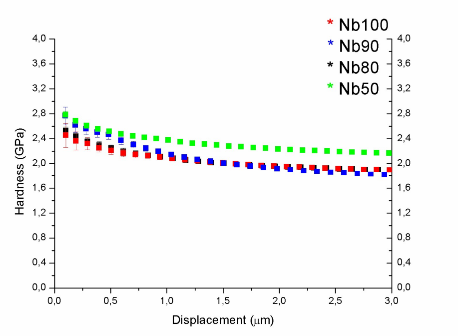

Figure 2: *Hardness of the alloys.*

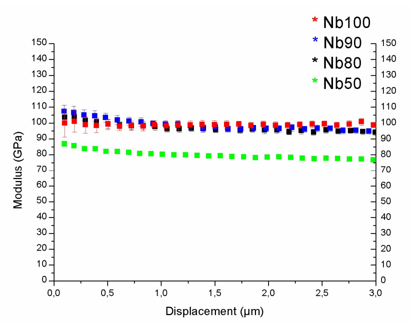

Figure 3: *Elastic modulus of the alloys.*

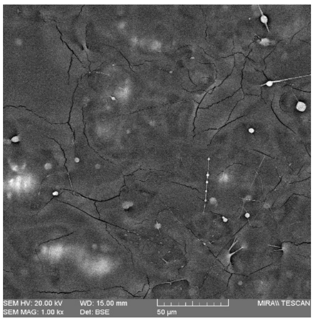

Figure 4: *Sem Image of Nb50 alloy after electrospinning*

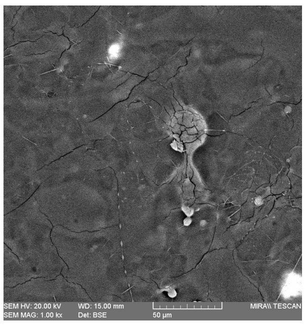

Figure 5: *Sem Image of Nb80 alloy after electrospinning*

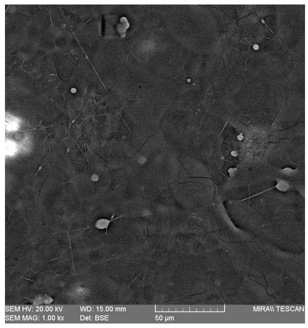

Figure 6: *Sem Image of Nb90 alloy after electrospinning*

Conclusion

- The crystalline phases of the alloys are only cubic
- The alloys with Nb 80%, 90% contained, and pure niobium presented similar Hardness and modulus of elasticity.
- The alloy with 50% showed considerably less elastic modulus and greater hardness (more suitable to bone implant application).
- The PVA/Propolis coating produced by electrospinning on the alloys seems well-adhered on alloys surface.

References

[1] Q. Chen, G. a. Thouas, Metallic implant biomaterials, Mater. Sci. Eng. R Reports. 87 (2015) 1–57. doi:10.1016/j.mser.2014.10.001.
[2] M. Niinomi, Recent metallic materials for biomedical applications, Metall. Mater. Trans. A. 33 (2002) 477–486. doi:10.1007/s11661-002-0109-2