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Microstructural Characterization of the Ti-30Nb Alloy Synthesized by Powder Metallurgy

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Mechanical alloying (MA) has been applied to a wide variety of materials: metals, ceramics, polymers, and composite materials. It is a non-equilibrium process that can be defined as "a powder processing metallurgical technique that involves cold welding, fracture, plastic deformation and re-welding of powder particles in high-energy mills". This technique has been positioned as an alternative for the production of new materials due to its multiple advantages, thus allowing binary alloys to be obtained at low temperatures, from chemical elements immiscible in the solid-state, supersaturated solid solutions, intermetallic compounds, amorphous alloys, and nanocrystalline materials[1]. Selecting materials for different components in implant prostheses depends on several factors, including the design and required strength of the system in the application. Moreover, long-term studies have found that insufficient load transfer from an artificial implant to an adjacent remodeled bone may cause bone resorption and eventual loosening of the prosthetic device, a phenomenon called ‘‘stress shielding effect’’. This so-called stress shielding effect is caused directly by the mismatch in the stiffness of the implant material with that of the surrounding natural bone. Several solutions to this problem have been found, including more flexible designs and the use of materials with relatively low moduli. Recently developed biocompatible titanium-based alloys have tended to include relatively large amounts of Nb, Zr, and/or Ta. With respect to the elastic modulus, Davidson reported that an Nb content in the range of 35-50 mass% favors attaining a relatively low elastic modulus.[2] Although Ti-6Al-4V alloy is being widely used as an implant material, studies have shown that the release of aluminium and particularly vanadium ions from the alloy might cause some long-term health problems, such as peripheral neuropathy, osteomalacia, and Alzheimer. Some developed biocompatible (Al and V free), low modulus β or near- β phase titanium alloys, such as Ti-13Nb-13Zr, Ti-11.5Mo-6Zr-2Fe, and Ti-15Mo, have demonstrated their great potential for implant application. Some developed α phase Ti-7.5Mo alloy has shown an even lower modulus.[3] In this work, the microstructural characterization and chemical analysis are presented the Ti-30Nb alloy was synthesized for 20 h by MA. The raw material used was: Titanium (Ti) as the main element and Niobium as a betagene element [4]. In the X-ray study, the crystalline structures of the elements and the microstructural changes in the mechanical alloying were identified through diffractograms. The aliquots were analyzed in an X-ray diffractometer, Brand: STOE, Model: STADI-MP, Max kV: 40 mA Max: 30, Radiation 1.54060 λ (Å) Cu. Reading conditions: By Transmission, 2 Theta with angles from 10° to 100°, measurement time 15 min., Step = 2.1. The morphology was analyzed by means of scanning electron microscopes (SEM), while the chemical composition was evaluated by means of energy dispersion spectroscopy (EDS).

Figure 1 shows the X-Ray results of the alloy. It is possible to observe the presence of different peaks, which correspond to the Ti-β, Nb, Ti6 O, and (Zr Y) O elements. The Match program was used to determine the phases of the elements.

Figure 2a shows the morphology of the particles analyzed by SEM. It can be observed a different morphology of the particles; the average size is ranking 10 µm. The chemical composition of the particles can be observed in figure 2b where the stoichiometric distribution of the elements is seen, the homogeneous distribution of titanium, and the agglomerations of niobium is observed, in addition to the presence of the elements that made up the grinding medium.

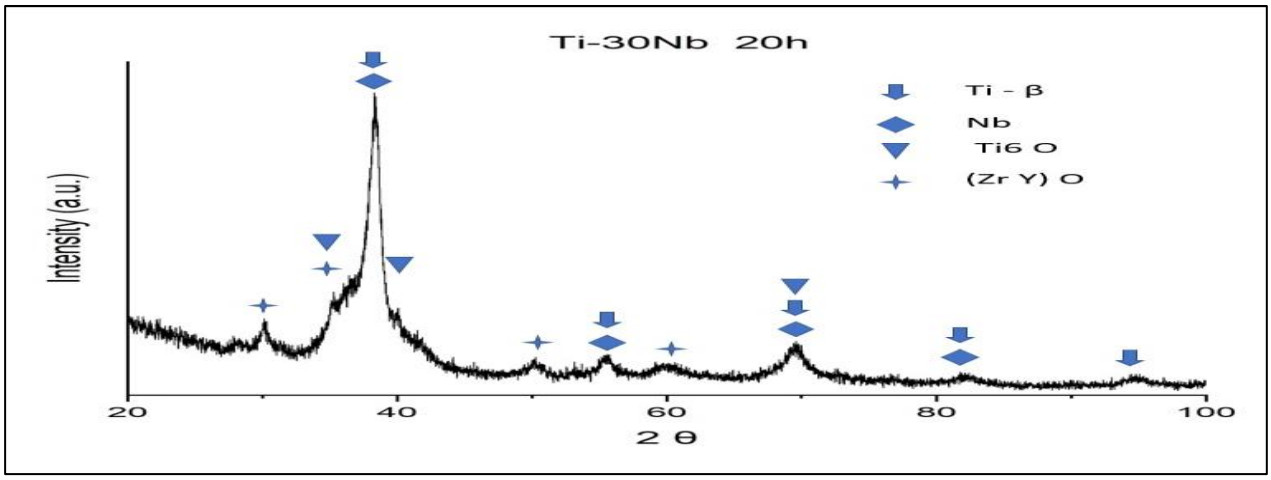
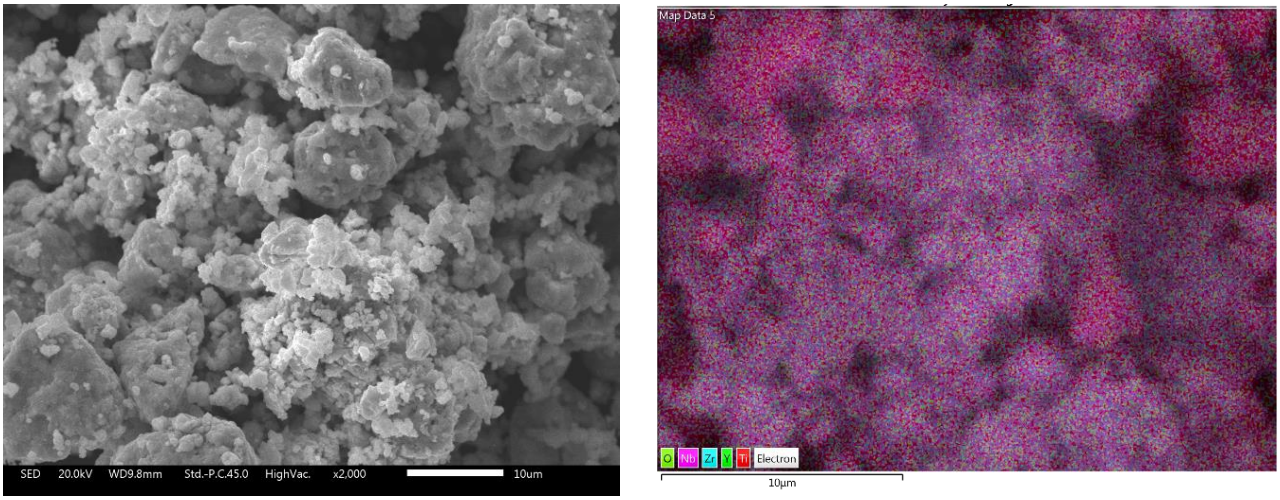


Figure 1. XRD analysis of Ti-30Nb %at alloy milled for 20 h



a) b)

Figure 2. Ti-30Nb alloy milled for 20 h a) SEM image and b) EDS

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