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Ti-based Alloys for Biomedical Applications

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Editorial

During the past decades, several works have been reported on the study of nanomaterials due to their potential applications (energy storage, environment, solar cells, aerospace, food, cancer therapy, etc). Among these nanomaterials we can site titanium-based alloys which are mainly applied in the biomedical and dental fields. These materials have interesting properties, when compared with stainless steel and Co-based alloys, such as high corrosion resistance, high biocompatibility; relative low modulus; good fatigue strength, low densities, which give high specific strength. The limitation of Ti-based alloys is their poor wear and tribological behavior that requires improvement.

Since 1940, Ti-based alloys were used as alternative orthopedic implant materials, and they showed excellent biological properties. Indeed, several methods have been used for the fabrication of porous Ti-based alloys include high energy mechanical milling or mechanical alloying, sintering, cold and hot working, casting, machining, etc. However, it is difficult to synthesize Ti-alloys from the liquid state. Mechanical alloying (MA) is the most used technique because of its simplicity, its low cost and having the ability to fabricate nanomaterials with desirable properties and a desired microstructure.

However, the Ti6Al4V alloy (GRADE 5, with Young's Modulus of 110 GPa) is the most widely used and promising material in medical implants, because of its high mechanical properties. The reduction of grain size (from micro to nanoscale) can lead to enhanced tribological behavior and biocompatibility of Ti6Al4V alloy. Further studies show that aluminum and vanadium ions can cause serious problems including cytotoxic effects, allergic reaction and potential neurological disorders [1]. In order to overcome these limitations, recent works have been devoted to replace Ti6Al4V alloy by other titanium alloys composed of non-toxic elements such as Zr, Ta, Nb, Mn, Sn, etc.

On the other hand, TiAlNb alloys (Ti15Al33Nb and Ti21Al29Nb) were fabricated by hot rolling followed by heat treatment [2]. It has been found that the wear resistance of these alloys was greater than that for Ti6Al4V alloy. Likewise, their fatigue strength and lives are comparable to that for Ti6Al4V. The effect of milling on the microstrcutural evolution of Ti-30Nb-13Ta-2Mn alloy has been studied [3]. Thus, Ti-β solid solution was formed after 20 hours of milling. Prolonged milling time (greater than 50 hours) lead to the formation of amorphous and nanocrystalline particles (Ti-β, Nb-FCC, $NbTi_4$, Mn_2Ti, MnTi). In the recent works [4,5]. Ti-Mn alloys (with Mn content higher than ~ 12 wt%) were synthesized by powder metallurgy techniques (mechanical alloying and spark plasma sintering) for biomedical applications. It has been found that the addition of manganese to the titanium metal reduces the alpha (α) to beta (β) transformation temperature. In

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addition, the increase in the Mn content (from 2 to 12 wt%) results in an increase of hardness (from 2.4 to 5.28 GPa) and the elastic modulus (from 83.3 to 122 GPa), while the ductility decreases from 21.3 to 11.7 %. In addition, a new Ti7MnxNb alloys (with Nb content from 0 to 10 wt%) were produced by using powder metallurgy process from elemental powders of Ti, Mn and Nb [6]. It has been reported that the microstructure is composed of two phases (α and β), and the increase of niobium content improve the stability of the β phase. It has also been observed that the compressive strain increased significantly while the elastic modulus decreased with increasing niobium content.

Ti-Nb based alloys are also promising materials thanks to their low elastic modulus and good biocompatibility. Recently, TixNb (x = 18.75, 25, and 31.25 at%) alloys were synthesized by using SPS and conventional powder metallurgy processes [7]. The Young's modulus of these alloys is about 90 GPa. They also showed excellent biocompatibility.

We intend this special issue of Current Scientific Research in Biomedical Sciences to provide up-to-date information about the applications of Ti-based alloys in biomedical. The focus of the special issue is on the recent developments that have improved function and life time of an implant in the human body.

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Conflict of Interest

The author declares that there is no conflict of interest.

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