UNIVERSITI TEKNOLOGI MARA

THE EFFECTS OF SINTERING TEMPERATURE ON THE PHYSICAL PROPERTIES OF Ti-Nb-Sn WITH HYDROXYAPATITE COMPOSITES FOR BIOMATERIAL APPLICATION

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ABSTRACT

Titanium (Ti) composites have been extensively used and rapidly progressed in the development of metallic medical instrumental and surgical implant for decades. Studies on Ti-35Nb-2.5Sn-15HA composite have been revealed to be a potential material for biomedical application. However, it only focuses on dense cortical bone structure with 10-20 GPa and used ball mill that are the main cause for contamination of mixing process in powder metallurgy. Hence, targeting on cancellous bone of basic requirement of 0.01 to 3 GPa with 30 to 80% porosity and to eliminate the contamination from ball milling were done through mixing with no ball mill via conventional powder metallurgy process. The fabrication of Ti-35Nb-2.5Sn-15HA composite was prepared by using 2 wt% stearic acid, mixing duration of 10 minutes, uni-axial compaction pressure of 111 MPa and heating rate of 10°C/min in a vacuum furnace. Varying sintering temperature was done at 900°C, 1000°C, 1100°C, 1200°C and 1300°C. The XRD analysis result shows new phases other than the element being developed in the composites after sintering. The peaks of the XRD patterns have been identified as belonging to the phases of β-Ti, TiO_2, NbSn, NbO, $CaTiO_3$ and $CaNb_2O_6$. Higher sintering temperatures promote better sintering in the sintered composite resulting in high densification, Vickers microhardness and compressive strength. The result indicated that optimum sintering temperatures of green compacts were found at 1000°C whereby at this sintering temperature produced better microstructure, physical and mechanical properties of the sintered composites with highest densification, lowest total porosity, Vickers microhardness, compressive strength and elastic modulus of 26.25%, 73.75%, 469.02 HV, 14.81 MPa and 1.48 GPa respectively. Bioactivity test was done by Kokubo method. From the FESEM observation, it shows that various precipitation shapes of CaP apatite formation grown were scattered from tiny to big globular furry like shape at the sample surface. From the EDX analysis, it is confirmed that the precipitation shapes on the sample surface consist of calcium and phosphorus rich phase, CaP. Due to these results, it indicates that Ti-35Nb-2.5Sn-15HA is a promising Ti composite for biomaterial application.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Titanium (Ti) and Ti alloys have been widely used as implanting metallic biomaterials due to their excellent mechanical properties and high corrosion resistance [1-5]. Furthermore, Ti and Ti alloys are well known for their superior biocompatibility and non-cytotoxicity to cellular tissue that gives advantageous for biomaterials [6].

Attempts have been made to develop new Ti alloys to achieve better performance in terms of biochemical compatibility by including the non-toxic and non-allergic elements such as Nb, Sn, Ta, Zr and Mo [7, 8]. It is noted that Sn acts as a β stabilizing elements in the β phase of Ti alloys in a manner similar to Nb [9]. Moreover, Sn was selected as the first additional element to increase strength and Nb was added to obtain a partial β-structure which contributes to decrease the bulk elastic modulus of the alloy required for biomaterial implants [10, 11].

However, like all metallic biomaterials, Ti alloys have poor biological activity which means that they cannot effectively interact with the surrounding tissues while they are implanted [12, 13]. While retaining the advantages of high strength and high endurance of metallic materials, highly biofunctional of metallic biomaterials can be achieved by combining Ti alloys with bioactive ceramics [14] such as calcium hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$) or HA that are excellent in biofunction. HA is a well known Ca phosphate based bioceramic inorganic material that can be considered to be an important bioactive ceramic material. This is because it resembles the biological apatite and can be prepared as a dense or porous body with excellent biocompatibility for bone bonding and osteoconductivity due to its ability to form strong chemical bonds with host material. Thus, it has been recognized as a potential graft material [15, 16].

Numerous studies have shown that under osseointegration conditions of the titanium implant, a bone tissue structure analogous to the mother bone is formed