Zn/HA Coating on the Ti-xNb Alloys after Nanotube Formation for Dental Implant

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Abstract: Zn/HA coating on the Ti-xNb alloys after nanotube formation for dental lmplant was researched using various experimental methods. Due to good biocompatibility and osteoconductivity, hydroxyapatite (HA) coatings on metallic biomedical implants were widely employed in orthopedic and dental applications. To improve biocompatibilities, Zinc (Zn) plays very important roles in the bone formation and immune regulations. The nanotube formed Zn-HA films were characterized with X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM), energy dispersive X-ray spectroscopy (EDS).

1. Introduction

Commercially pure titanium (CP-Ti) and Ti-6Al-4V alloys are the most common used as implants and orthopedics, dentistry due to their good biocompatibility, good resistance to corrosion, excellent mechanical properties, and workability. Especially, the Ti-6Al-4V alloy (α + β type), is the most widely used material due to its reported that the biocompatibility and hemocompatibility result from a thin titanium dioxide-based layer that is always present on the metal surface. The addition of alloying elements, such as Al and V, improved the mechanical properties of titanium. However, there are some problems of the alloy such as that alloy has properties of high elastic modulus and toxicity of V element and Alzherimer's disease of Al element, when compared with that of bone and potential adverse human effects. To improve the problem, new Ti alloys with nontoxic elements such as zirconium (Zr), niobium (Nb), and Tantalum (Ta) elements would be recommended. Some researchers have focus on Ti-Nb, Ti-Ta binary system with controlling the contents of Nb, Ta elements. Especially, Nb element of 4d transition metallic element is one of the most effective titanium β-stabilizer.

Nano-scale surface TiO_2 layer and diameter modulation of Ti alloys can be obtained function of improvement of cell adhesion, and It should be possible to control the nanotube size for biomedical implant use by controlling the applied voltage, alloying element, current density, anodization time, and electrolyte. Titanium and titanium alloys is generally considered to be bio-inert, and cannot bond directly to bone tissue. Therefore various surface modifications on Ti implants have been carried out to improve their bioactivity.

Recently Ti alloy are commonly coated with hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$, HA], that important to improve the cell adhesion and proliferation. Some of studies have been developed for HA coatings with good corrosion properties on Ti alloys for dental implant application. Zn element very important roles in the bone formation and immune regulations also in the most abundant trace element in bone. It has been demonstrated that titanium surfaces chemically modified with ZnO could significantly reduce the viability of five streptococcus bacterial strains.

2. Experimental

In this work, Ti-xNb binary alloys contained from 10 wt. % to 50 wt. % contents were manufactured by vacuum arc-melting furnace. The ingots of Ti-xNb alloys were homogenized in Ar atmosphere at 1000 ℃ for 2 h followed by quenching into 0 ℃ water. The formation of nanotubular film was conducted by electrochemical method in mixed electrolytes with 1 M H_3PO_4+ 0.8 wt.% NaF electrolyte. The anodization potential was 30 V and time was 1 h by DC supply. Electrochemical deposition of pure HA and Zn doped HA were conducted at 85 ℃ in an electrolyte containing (HA) 5 mM $Ca(NO_3)_2 \cdot 4H_2O$ + 3 mM $NH_4H_2PO_4$ and 4.95 mM $Ca(NO_3)_2 \cdot 4H_2O$ + 0.05 mM $Zn(NO_3)_2 \cdot 4H_2O$ + 3 mM $NH_4H_2PO_4$ in distilled water (Zn-HA); the Ca/P ratio for the electrolyte was 1.67 ratio. Precipitation of pure HA and Zn-HA was performed on the bulk Ti-xNb alloy surfaces using a potentiostat. The surface morphology and chemical composition was observed with a (FE-SEM) and energy dispersive X-ray spectroscopy (EDS) and mapping analysis. The crystal phase of the deposit was examined using a thin film X-ray diffractometer (TF-XRD, X' Pert Pro, and Philips, Netherlands). TF-XRD analysis is done using a XRD with Cu Kα incident radiation.

3. Conclusions

It was observed that the changed α phase to β phase with Nb content. The nanotubes formed on the Ti-xNb alloys surface were transformed from the anatase to rutile structure of titanium oxide. The EDS and mapping analysis rustle of nanotube formed Zn-HA films for elements are to the desired conditions to the results of the composition. (Supported by NRF: 2013 R1A1A 2006203 & NRF:No.2008-0062283).

Reference

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