Morphology of Nano-Phase Mg-doped Hydroxyapatite Films Formed by Electrochemical Deposition

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Commercially pure titanium (CP-Ti) and Ti alloys have been intensively studied for the applications of orthopedic and dental implants because its excellent mechanical properties, corrosion resistance, and outstanding biocompatibility. However, being bio-inert metallic implant, they cannot bond to living bone directly after implantation into host body. Hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$, HAp) is materials mainly known for its special ability to contact bone tissue. HAp coated implants, mainly prepared by plasma spraying have shown to increase the quality of adhesion of structural prostheses and to reduce particle release from the metal surface. However, the in vivo tests of these coatings have shown lack of bonding strength to the metallic bio-inert substrate or resorption. It is well-known that natural HAp contains lot of trace elements which play very important roles in the biological process. Functional elements doped in HAp can be easily fabricated by adding the related ions into the reactions, such as Mg, Mn, Zn, Si, and Sr.

In this study, we prepared Mg doped nano-phase HAp film on the TiO_2 nano-network surface using the electrochemical deposition method. The deposition process involved two steps, 1) TiO_2 nano-network on Ti alloy was formed at high current in NaOH solution; 2) electrochemical deposition method was carried out in electrolyte for Mg doped nano-phase HAp deposition on TiO_2 nano-network surface. The range of lateral pore size of the network specimen was about 10–120 nm on Ti surface by anodized in 5 M NaOH solution at 0.3 A for 10 min. Nano-network TiO_2 surface were formed by this anodization step which acted as templates and anchorage for growth of the HAp during subsequent pulsed electrochemical deposition process at 85℃. High purity $Ca(NO_3)_2$, $Mg(NO_3)_2$ and $NH_4H_2PO_4$ were used as starting materials.

The morphology and crystalline structure of Mg doped nano-phase HAp on the TiO_2 nano-network surface was characterized using a thin film X-ray diffractometer (TF-XRD) and field emission scanning electron microscopy (FE-SEM). Elemental analysis was performed using an energy dispersive X-ray spectroscopy (EDS). To examine the bioactivity, the pure HAp film, Mg doped HAp film and untreated Ti alloys (control) were immersed in SBF for 4 and 7 days.

A multilayer TiO_2 nano-network was produced rapidly on Ti surface a simple electrochemical anodized treatment. The enhancement of the HAp-forming ability arise from TiO_2 nano-network surface, which is formed the conversion of the sodium titanate gel on the electrochemical anodized treatment [1]. The phase and morphologies of deposits HAp were influenced by the Ti surface morphologies, current density and Mg ion concentration.

It is therefore expected that Ti and Ti alloys having a high biocompatibility can be obtained by applying the Mg doped nano-phase HAp deposition after the electrochemical anodized treatment. (Supported by NRF: 2013 R1A1A 2006203; hcchoe@chosun.ac.kr).

[1] K. Lee, Y. M. Ko, H. C. Choe, and B. H. Kim, Formation of Nano-phase Hydroxyapatite Film on TiO_2 Nano-network, J. Nanosci. Tech. 12, 822 (2012).