Synthesis of Nano-Fluorohydroxyapatite Thin Films by Sol-Gel Method

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ABSTRACT It is realized that the surface of biomedical metallic implants covered by fluorohydroxyapatite, [Ca10(PO4)6(OH, F)] (FHA) can create bioactivity of the implant and shorten healing time. In this work FHA, in the form of powders and of thin films on titanium substrates, were synthesized by sol-gel spin coating method, using calcium nitrate tetrahydrate (Ca(NO3)2.4H2O), phosphorous pentoxide (P2O5) and ammonium fluoride (NH4F) to provide Ca-precursor, P-precursor and fluorine reagent, respectively. The FHA powders were calcined and thin films were fired at temperatures ranging from 500-800°C. The constituent of both powders and thin films were confirmed as FHA using X-ray diffraction (XRD) and Fourier transform Infrared spectroscopy (FTIR). The thermal stability of FHA powders was studied by differential thermal analysis (DTA). The optimized calcination and firing temperature was 600 °C. Transmission electron microscopy (TEM) results with Debye-Scherrer equation gave the size of the FHA particles in nano-scale range. The films were found to be quite uniform and dense by SEM.

Keywords: Sol-gel, fluorohydroxyapatite, thin films, spin coating

INTRODUCTION

The clinical applications of calcium phosphates constitute an interesting field of research and development in the production of useful biomaterials for implant fabrication and/or fixation. Biomaterials in general and bioceramics in particular allow replacement of several parts of our body [1,2]. The most used calcium phosphate in implant fabrication is hydroxyapatite [HA, Ca10(PO4)6(OH)2], since it has similar characteristics as the mineral component of bones. It exhibits good properties as biomaterial, such as biocompatibility, bioactivity, osteoconductivity and direct bonding to bone [3].

HA, which has the similar chemical composition and the crystal structure to apatite in the human skeletal system, has attracted much interest as an implant material in clinical applications [4]. Bone tissue can rapidly grow along the surface of the HA implant in the presence of a rich calcium and phosphorous environment, forming firm chemical bonds between HA and bone tissues without any intervening soft tissue layer [5,6]. Despite its excellent biocompatibility and efficacious biological fixation to bony tissues, HA has poor mechanical properties in bulk form such as ductility and toughness, and this has restricted its use in load bearing applications [7]. HA is now often coated on a metal substrate such as Titanium (Ti) and its alloys constituting a new implant which combines the superior mechanical performance of the metal component with the excellent biological responses of the HA ceramic [8,9]. Metallic biomaterials, such as Ti and its alloys, have enjoyed clinical success because of their superior strength, biocompatibility, durability, and resistance to corrosion in physiological environment [10]. The high mechanical strength and toughness of these bio-metals are the most important advantages over bioactive ceramics, which are inherently weak and brittle [11].

Ti and its alloys have long been used as implant materials in dental and orthopedic applications [12]. To improve the implant-tissue osseointegration, much effort has gone into the modification of the Ti-surface [13-15]. Among the various attempts, made to improve osseointegration, HA coatings on Ti implants have shown not only good fixation to the host bone and but also increased bone ingrowths to the implant [16]. The improved biocompatibility provided by the HA coatings is due its chemical and biological similarity to hard tissues, and its consequent direct bonding to host bones [17]. The bone in growth properties and implant fixation behavior need to be improved in order to shorten the implant-tissue osseointegration time [18]. However, pure HA suffers relatively high dissolution rate in simulated body fluid, which affects its long-term stability. High dissolution may lead to disintegration.
CONCLUSIONS

Fluorohydroxyapatite (FHA) has been successfully synthesized with NH₄F as the fluorine containing reagent by sol-gel spin coating method. XRD studies found that the apatite phase existed in powders and coatings with no impurity at 600°C. The size of FHA particles, estimated by Debye-Scherrer equation and TEM results, ranges from 21.6 to 39.2 nm. SEM results showed that the thin films were dense, uniform and had a thickness of about 1–1.5 μm.

REFERENCES