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Synthesis of cellulose–nanohydroxyapatite composite in 1-*n*-butyl-3-methylimidazolium chloride

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Abstract

In this study cellulose–nanohydroxyapatite composite was fabricated for bone tissue engineering applications. In this composite a natural biopolymer was reinforced with bioactive nanohydroxyapatite for replacement or healing of bone. The ionic liquid 1-*n*-butyl-3-methylimidazolium chloride (BmimCl) was used for dissolution of cellulose.

Nanohydroxyapatite (n-HAp) powder was characterized by X-ray diffractometry (XRD), scanning electron microscopy (SEM) and FT-infrared (FTIR) spectroscopy. Thermogravimetric analysis (TGA) as well as MTT assay of nanocomposite was conducted to assess the thermal stability and cytotoxicity of the samples.

The results of XRD showed the formation of hydroxyapatite crystals and also SEM images indicated that n-HAp powder was nanocrystalline. The composite was thermally less stable than native cellulose. Also native cellulose had higher decomposition rate and mass loss. Results of biological test showed that the samples were biocompatible with no toxicity. Also, SEM observations demonstrated that human osteoblast cells can attach to the surface of the nanocomposite samples and this composite can be used as bone tissue engineering.

Keywords: Cellulose; Nanohydroxyapatite; Ionic liquid

1. Introduction

A variety of materials have been used for replacement and repair of damaged or traumatized bone tissues [1–3]. These materials include metals, ceramics, polymers (natural and synthetic) and their combinations. Metals and ceramics have two major disadvantages for tissue engineering applications: they are lack of degradability in a biological environment, and their processability is very limited [4]. In contrast, polymers have great design flexibility because the composition and structure can be tailored to specific needs. They are therefore attractive candidate. Biodegradability can be imparted into polymers through molecular design [5]. However, polymers have lower modulus and strength as compared to metals and ceramics [6]. For the mechanical reinforcement of polymers or for certain applications such as bone regeneration, composite materials of biopolymers and bioceramics have been produced for bone tissue engineering [7]. The most frequently used bioceramic material is hydroxyapatite (HAp). It is bioactive, osteoconductive, non-toxic and non-immunogenic [8]. Many efforts have been made to modify HA by polymers since the natural bone is a composite mainly consisted of nano-sized, needle-like HAp crystals (accounts for about 65 wt% of bone) and collagen fibers [9,10].

Natural biodegradable polymers have been used in tissue engineering [11,12]. One important category of natural biopolymers is polysaccharides. Cellulose is an abundant renewable polysaccharide consisting of a linear chain of (1,4) linked β-D-glucopyranose units aggregated to form a highly ordered structure due to its chemical constitution and spatial conformation [13] (Fig. 1).

The individual cellulose chains are joined by a network of inter-and intra-molecular hydrogen bonding and van der waals forces. The crystalline structure of cellulose, due to hydrogen bonds, in combination with the high molecular weight, gives it unique properties like chemical stability and mechanical strength. In the biomedical field, cellulose and its derivatives have been extensively used for decades [14].

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