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Rapid formation of hydroxyapatite nanostrips via microwave irradiation

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Abstract

Hydroxyapatite (HAp) nanostrips were rapidly obtained during a mild microwave heating method. Applying microwave irradiation to $Ca(NO_3)_2{\cdot}4H_2O$/CTAB/Na_2HPO_4 precursor solution, the HAp precipitation process was occurred directly and without common crystallographic transformations including dissolution and slow recrystallization. The cationic surfactant CTAB was used as a soft template to modify nucleation and growth process. TEM investigations showed that the fabricated nanostrips had a width and length of about 10 and 55 nm, respectively. The X-ray diffraction pattern revealed that the fabricated well-crystallized and high purity hydroxyapatite nanostrips had a pattern similar to the bone mineral. The FTIR spectrum of the synthesized HAp nanostrips confirmed the crystallization degree observed in X-ray diffraction pattern. Moreover, the effect of CTAB on formation mechanism of the fabricated nanostrips was investigated.

Keywords: Ceramics; Nanostructured materials; Chemical synthesis; Nanofabrication

1. Introduction

Recently, there have been great attentions to fabrication of one-dimensional (1D) nanomaterials due to their intrigue and fascinating physical and chemical properties [1,2]. Many reports have been focused on rapid, facile, low-cost and low-temperature synthesis methods available for fabrication of such nanostructures [3].

Hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$), is a primary constitute of the calcified tissues (i.e. bones and teeth) which has been extensively used as a implant material for bone and tooth substitute owing to its resemblance to mineral components of human hard tissues [4]. Also, it has a good bioactivity, biocompatibility and osteoconductivity with human body constituents [5]. Hydroxyapatite has been poorly crystallized in nanosize rod-like crystals in bone matrix [6]. The applications of the HAp components have been restricted to low load-bearings due to their poor mechanical reliability [2,5]. Previously, many efforts have been focused on the improvement of the mechanical properties of the HAp bioceramics [7,8]. Using one-dimensional HAp nanostructures (such as nanorods, nanowires, nanofibers and nanoneedles) as the building blocks for the fabrication of dense bioceramics is an attractive approach to increase strength and fracture toughness [9]. Various methods such as hydrothermal [9], mechanochemical [10], electrospinning [4], chemical precipitation [11] and microwave irradiation [12] can be effectively used for fabrication of one-dimensional (1D) HAp.

Even thought various synthesis methods have been used to fabricate nanosize HAp structures, there are intensive interests to find mild and rapid ways for synthesis of pure Hydroxyapatite nanoparticles. Mass production of high purity Hydroxyapatite is reported to be possible via time-consuming and tedious processes [13]. Microwave irradiation is an efficient method which solves this problem and provides rapid, facile and convenient synthesis procedures [12–21]. Increasing the yield of the precipitations, unique properties of the microwave irradiation can be successfully used for synthesizing of various nanostructured materials [18–21]. Also, there are several investigations which reported the microwave-assisted formation of well-crystalline HAp nanoarchitectures with high purity [12–17]. Effects of various surfactants such as sodium dodecyl sulphate (SDS) [22], triethanolamine (TEA), diethanolamine (DEA) [23], ethylenediamine tetraacetic acid (EDTA) [14] and Cetyltrimethylammonium bromide (CTAB) [24] on the

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