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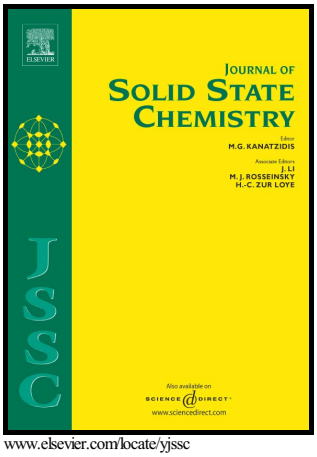

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Fast synthesis of La-substituted apatite by the dry mechanochemical method and analysis of its structure

Natalia V. Bulina [a,*], Marina V. Chaikina [a], Igor Yu. Prosanov [a], Dina V. Dudina [b,a], Leonid A. Solovyov[c]

[a] *Institute of Solid State Chemistry and Mechanochemistry SB RAS, Kutateladze street 18, Novosibirsk 630128, Russia*
[b] *Lavrentyev Institute of Hydrodynamics SB RAS, Lavrentyev avenue 15, Novosibirsk 630090, Russia*
[c] *Institute of Chemistry and Chemical Technology SB RAS, Federal Research Center "Krasnoyarsk Science Center SB RAS", Akademgorodok 50/24, 660036 Krasnoyarsk, Russia*

Abstract:

Compared to pure apatite, La-substituted apatites have improved thermal, mechanical and biological characteristics. In this article, a fast synthesis of La-substituted apatites by a dry mechanochemical method is presented. Structural studies by X-ray diffraction and Fourier transform infrared spectroscopy indicated the formation of a single-phase nanosized product after 30 min of high-energy ball milling of the reaction mixtures. The dry mechanochemical method is technologically attractive for the preparation of La-substituted apatites, as it allows reducing the processing time down to half an hour and does not require prolonged high-temperature annealing normally used in the synthesis practice of the substituted apatite. As the mechanochemically synthesized samples are nanosized, it is difficult to determine details of their crystal structure by the Rietveld refinement method. Therefore, a series of the mechanochemically synthesized samples with different concentrations of lanthanum were annealed at 1000 ^{o}C for 5 h. It was found that the annealed powders are microcrystalline La-substituted apatites $Ca_{10-x}La_x(PO_4)_6O_x(OH)_{2-x}$, where $0 \leq x \leq 2$. In their structure, the Ca^{2+} ions are replaced by the La^{3+} ions localized near the Ca2 sites, and the OH^- groups are replaced by the O^{2-} ions in the hexagonal channels.

Keywords: substituted apatite, lanthanum, mechanochemical synthesis

1. Introduction

The structure of hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$) offers possibilities for substitution (doping) in the cation and anion sublattices, which alters the physical and chemical properties of the compound and expands the range of its applications. In recent years, a number of articles dealing with substitution of lanthanides for calcium in the structure of hydroxyapatite have been published. The synthesized compounds are promising as materials for medicine [1-4] and luminescent materials [5-7]. There are studies, in which substitution of one [8] or more [9] trivalent metals for calcium has been implemented. Simultaneous substitution of lanthanides for calcium and silicate for phosphate is also possible [10-12].

The La-substituted apatite (HA-La) has a higher thermal stability, a higher flexural strength and a lower dissolution rate than the stoichiometric hydroxyapatite. The cytotoxicity of the non-substituted apatite and La-substituted apatite is comparable. However, the La-substituted apatite has a positive effect on the function of osteoblasts [1]. The morphology of osteoblasts (spindle-like shape with long mini-filopodias spreading, higher cell density) formed on the HA-La substrate indicates that the incorporation of La into the apatite promotes the prolifiration and adhesion of osteoblasts that stimulate the growth of new bone tissue [1].

* Corresponding author. Tel.: +7 383 233 24 10; fax: +7 383 332 28 47.

E-mail address: bulina@solid.nsc.ru (N.V. Bulina)