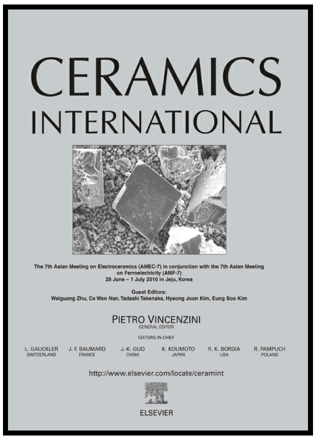

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PII: S0272-8842(17)32949-8
DOI: https://doi.org/10.1016/j.ceramint.2017.12.242
Reference: CERI17122

To appear in: *Ceramics International*

Received date: 6 November 2017
Revised date: 29 December 2017
Accepted date: 30 December 2017

Cite this article as: Jinlei Wang, Junmin Qian, Weijun Xu, Yaping Wang, Guanghui Hou, Tiantian Sun and Lin Luo, Effects of Sr^{2+}/Zn^{2+} co-substitution on crystal structure and properties of nano-β-tricalcium phosphate, *Ceramics International,* https://doi.org/10.1016/j.ceramint.2017.12.242

Effects of Sr^{2+}/Zn^{2+} co-substitution on crystal structure and properties of nano-β-tricalcium phosphate

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Abstract:

The incorporation of therapeutic ions like Sr^{2+}, Si^{4+}, Zn^{2+} and Li^{+} into biomaterials has become a promising approach to promote bone regeneration. However, the effects of Sr^{2+} and Zn^{2+} co-substitution on the crystal structure and properties of β-tricalcium phosphate (β-TCP) have not been elucidated well. In this study, Sr^{2+}-/Zn^{2+} co-substituted β-tricalcium phosphate (SrZnTCP) nano-powders with different extents of substitution (0-4.8 mol%) were synthesized by poly(ethylene glycol)-assisted co-precipitation and subsequent heat treatment. The as-synthesized SrZnTCP nano-powders were characterized by x-ray diffraction, Fourier transform infrared spectroscopy, elemental analysis, Rietveld refinement and differential scanning calorimetry. The results showed that the conversion of calcium-deficient apatite to β-TCP was achieved after heat-treatment above 800 °C. The *a*-axis and *c*-axis lattice parameters gradually decreased with increasing level of Sr^{2+}/Zn^{2+} co-substitution in β-TCP lattice. Sr^{2+} and Zn^{2+} preferentially occupied the ninefold coordinated Ca (4) sites and the sixfold coordinated Ca (5) sites, respectively. The co-substitution of Sr^{2+}/Zn^{2+} for Ca^{2+} significantly improved the thermal stability of β-TCP. The release rate of Zn^{2+} from SrZnTCP depended on Ca^{2+} concentration over 63-day immersion in PBS solution while that of Sr^{2+} was not affected by Ca^{2+} concentration. The amount of Sr^{2+} released increased with increasing Sr^{2+} content in SrZnTCP. Collectively, SrZnTCP showed great promise as a Sr^{2+}/Zn^{2+}-releasing biomaterial for bone repair, although no obvious mineralization was observed on β-TCP and SrZnTCP disc samples during 56 days of immersion in simulated body fluid.

Keywords: β-tricalcium phosphate; Therapeutic metallic ions; Rietveld refinement; Thermal stability; Release behavior

1. Introduction

Bone tissue engineering aims to repair bone defects and involves a combination of osteoconductive scaffold, osteoinductive growth factors and osteogenic cells [1]. The seeding of osteoconductive scaffold with stem cells often offers little or no benefit in increasing both regenerated bone volume within the scaffold and rate of callus formation [2]. To overcome this problem, various growth factors like bone morphogenetic protein-2 have been used to endow scaffolds with osteoinductivity to enhance healing of bone defects. However, these growth factors may rapidly lose bioactivity due to their short biological half-life and instability, which leads to limited therapeutic efficacy in bone regeneration [3]. Genetic modification of scaffolds is considered a promising strategy to improve bone regeneration over the past decade, but its extensive application is restrained by either potential