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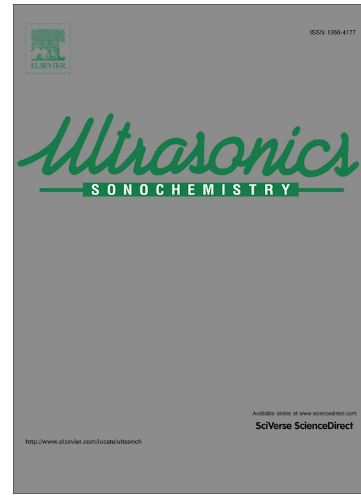

Structural features of hydroxyapatite and carbonated apatite formed under the influence of ultrasound and microwave radiation and their effect on the bioactivity of the nanomaterials

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Structural features of hydroxyapatite and carbonated apatite formed under the influence of ultrasound and microwave radiation and their effect on the bioactivity of the nanomaterials

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ABSTRACT

The samples of hydroxyapatite and carbonate substituted hydroxyapatite (CHA) were obtained under the influence of physical factors, namely ultrasound (US) and microwave (MW) radiations. The results of Fourier transform infrared spectroscopy and X-ray diffraction analysis have proved the formation of the calcium deficient hydroxyapatite and B-type CHA with the Ca/P ratio in the ranges 1.62 – 1.87. *In vitro* studies have showed the increased bioactivity of the samples, synthesized under the influence of physical factors as compared to the standard ones. The samples of both groups, synthesized under the influence of 600 W MW, have shown the greatest stability in biological environment. *In vivo* tests confirm that obtained under US and MW radiations hydroxyapatite-based biomaterials are biocompatible, non-toxic and exhibit osteoconductive properties. The usage of US and MW radiations can significantly shorten the time (up to 5-20 minutes) of obtaining of calcium deficient hydroxyapatite and B-type CHA in nanopowder form, close in structure and composition to the biological hydroxyapatite.

1. INTRODUCTION

Despite the different approaches to the substitution of bone tissue by bone transplant or other synthetic biomaterials (BM), the problem of developing such BMs still exists [1]. Modern approaches with the use of computer design for physical objects modeling, tissue engineering and 3D printing opens new horizons for innovative clinical procedures. However, their clinical usage is still very limited due to the multiple reasons: high prices of equipment, licensing, medical limitations, etc. Thus, many researches focus on more effective application of classic BMs, especially calcium phosphate ceramics (CPC), biodegradable polymers, porous-structured metals [2, 3].

Hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$ (HA) is the closest material to the bone mineral due to its chemical and crystallographic parameters. Many different methods were developed to obtain HA-based BMs with osteoconductive and osteoinductive properties [4-14]. Among them are solid-state synthesis [15]; mechanochemical method [16]; conventional chemical precipitation [17]; wet chemistry [18]; hydrothermal [19]; sol-gel and emulsion methods [20, 21]; chemical synthesis under the influence of ultrasound (US) and microwave (MW) radiations [22-29]. One of the drawbacks of the last one is considerable time, which is overlapped by the exceptional effectiveness of the transformation of radiation energy into the heat of reacting system that leads to the fast homogeneous nucleation.

Normal heating mechanism of reacting system includes radiation and convection: the heat is distributed from the hot surface to the relatively cold volume by the flow of the substance, which takes significant time. In case of the MW radiation, the electric field polarizes simultaneously all molecules of the material leading to the rapid conversion of electromagnetic energy into heat, resulting in the super-fast heating of the entire material. Physical effects of US influence occur due to the sound cavitation (formation, growth and implosionary collapse) that leads to the formations of hot spots with temperature of ~5000 K and pressure of ~1000 bar