Processes of obtaining hydroxyapatite nanoparticles of various morphology for biomedical application

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Abstract

Hydroxyapatite (HAp) is a calcium orthophosphate that is stable in the environment of the human body. It does not exhibit toxicity and integrates with human tissues. Due to its chemical and structural similarity to the biological apatite and the fact that it builds the bones and teeth of vertebrates, hydroxyapatite is the most important biomaterial in replacing damaged hard tissues in medicine and dentistry. Visible demand on HAp results in exploring new efficient methods to synthesize HAp. The first goal of the presented research was to develop continuous precipitation of HAp nanoparticles (nHAp) and nanoparticles modified with lecithin (nHAp-LE). The next step involved increasing the scale of the process in BOX reactors obtained in 3D printing. Particles were characterized in terms of crystallinity, size, morphology, characteristic functional groups, and zeta potential.

Another goal was to develop a new nHAp precipitation/remodeling reaction system to obtain nHAp of the rod and plate morphology. Another goal was to determine the forms of calcium phosphates formed during the formation of nHAp and the kinetics of nHAp remodeling. Crystallinity, size, morphology, characteristic functional groups, and chemical composition were determined. The kinetics of the remodeling process was based on measuring the concentration of calcium ions in the liquid phase surrounding the remodeled nanoparticles.

The last goal was to demonstrate the practical use of the obtained materials (spherical particles, rods, plates) in biomedical applications. Spherical nHAp were used as a drug carrier, and rod-shaped and plate-shaped nHAp as a component of composite materials. Toxicity and cellular uptake of spherical particles modified with lecithin and sodium alendronate were determined, which is the basis for assessing the application potential. The conducted research confirmed the assumed effect of lecithin on increasing the internalization of nanoparticles by cells. Surface-modified rod- and plate-shaped nanoparticles were used to improve the integration of polymer/ceramic composite materials. The mechanical properties of composites obtained by 3D printing technology depend on the surface modification of sodium stearate and ceramic content in the composite.

Keywords: nanohydroxyapatite, precipitation, continuous synthesis, scale up, remodeling, surface modification, drug delivery systems, tissue engineering

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