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Synthesis, characterization, in vitro biocompatibility and antibacterial properties study of nanocomposite materials based on hydroxyapatite-biphasic ZnO micro- and nanoparticles embedded in Alginate matrix(Article)

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The paper presents the results of studies of biocompatibility and antibacterial properties of multiphase nanocomposite materials based on HA-Alg-ZnO (hydroxyapatite‑sodium alginate-biphasic zinc oxide) and HA-ZnO (hydroxyapatite‑zinc oxide), which were synthesized from the analytically pure calcium nitrate tetrahydrate, ammonium hydrophosphate, hydrous ammonia, zinc nitrate hexahydrate and calcium chloride. The samples' antimicrobial activity assessment was carried out on Gram-negative (E. coli, P. aeruginosa) and Gram-positive bacteria (S. aureus and S. epidermidis) test cultures by the co-incubation and modified “agar diffusion” methods. The murine fibroblast cells were used for the biocompatibility tests and cytotoxicity evaluation. It was shown that synthesized nanocomposite material has a multiphase nanoscale architecture, where ZnO nanocrystals are represented by two lattices: cubic and hexagonal. The possible explanation of ZnO nanocrystals' phase transition is given. At the same time, a partial replacement of Ca2+ ions by Zn2+ ions in the HA lattice possibly occurs due to processing of composite by US radiation. The replacement was evidenced by the non-stoichiometric Ca/P ratio < 2.16, O𝑑P𝑑O lines' shifting on FTIR spectrum and TEM analysis. The studied composite demonstrate a pronounced antibacterial activity due to the incorporation of ZnO particles into sodium alginate and moistened powder of hydroxyapatite. Both forms of HA-ZnO (suspension) and HA-Alg-ZnO (beads) are biocompatible. An interpretation of the process of Zn ions' embedding into hydroxyapatite and alginate matrix is given, as well as their influence on the biomimetic composite properties is discussed in details. Statement of significance: A number of studies have shown that Zn effectively inhibits the growth and development of bacteria and yeast fungi. Zinc plays an important role in the creation of new antimicrobial agents, and zinc-doped hydroxyapatite will find further application in biomedicine. In this regard, the phase states of zinc oxide, as well as the processes of calcium replacement by zinc in calcium apatite and in alginate should be explored fully. Nowadays we have lack of information and the study's results about those interactions. The present study provides data of the multiphase morphology, antimicrobial activity, biocompatibility and cytotoxicity of the biomimetic nanostructured composite materials, such as sodium alginate/hydroxyapatite/ZnO based granules and hydroxyapatite/ZnO based hydrogel, and the establishing Zn ions' behavior patterns with another composite components. 