HYDROXYAPATITE - CHITOSAN MATERIAL WITH SILVER NANOPARTICLES

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Introduction

Materials composed of nanoparticles as well as bio-inspired composites consisting of biomimetic apatite and natural polymers such as collagen and chitosan are considered as the promising future biomaterials. Recently, the attention has been drawn to hydroxyapatite-chitosan (HA/CTS) composite, which show promise in mimicking both, the organic and inorganic components of natural bone [1,2]. Although the composite materials are the subject of many studies, a number of both cognitive and applicational, issues have not been explored yet. The role of chitosan in creating the mechanical strength of the composite still has not been explained.

The aim of this study was to obtain homogenous HA/CTS and HA/CTS/Ag composites via a simple solution-based chemical method. Special emphasis has been made on combining in the developed materials relatively good mechanical strength with the desired microstructure. The influence of the addition of 0.1wt% silver nanoparticles on physicochemical properties of materials has been examined.

Materials and Methods

The new hydroxyapatite-chitosan (HA/CTS and HA/CTS/Ag) materials were synthesized via modified wet chemical method using $Ca(OH)_2$ (≥99.5%, Merck), H_3PO_4 (85.0%, POCH) as the sources of calcium and phosphorus ions, respectively. Medium molecular weight chitosan (around 100,000 kDa, DD ≥ 75.0%, viscosity 200–800 cups, Sigma-Aldrich) was applied as the organic component. The procedure, by which materials were prepared, has benn described previously [3]. After decanting HAp/CTS slurry, suspension of 0.1wt% of silver nanoparticles (US Research Nanomaterials, NC., USA) was added. The crystalline phases of the obtained materials were analyzed by powder X-ray diffraction with CuKα radiation (D2 Phaser, Bruker) in the 2θ range of 10°–60° at a scanning speed of 1°/min. The scanning electron microscope (SEM - Nova 200 NanoSEM, FEI Company) equipped with X-ray dispersive spectroscopy (EDS) was used to determine crystal morphology and chemical elemental composition in microareas of the samples. For the compressive strength testing, the cylindrical samples (6mm in diameter and 12mm high) were prepared from the synthesized filter cake and stored at 37 °C for 1week. The compressive strength was measured at a crosshead displacement rate of 1.0 mm·min−1 using universal testing machine Instron 3345.

Results and Discussion

During the synthesis of HA/CTS hybrid material via the modified solution-based method the electrostatic complexes between positively charged, protonated amine groups of chitosan and the negative phosphate species (HPO_4^{2-} and $H_2PO_4^-$) were formed. X-ray diffraction analysis revealed that the prepared samples consisted of only one crystalline phase – i.e. hydroxyapatite (FIG. 1). The characteristic reflections for non-stoichiometric apatitic structure of low crystallinity degree were detected in the patterns of studied materials.

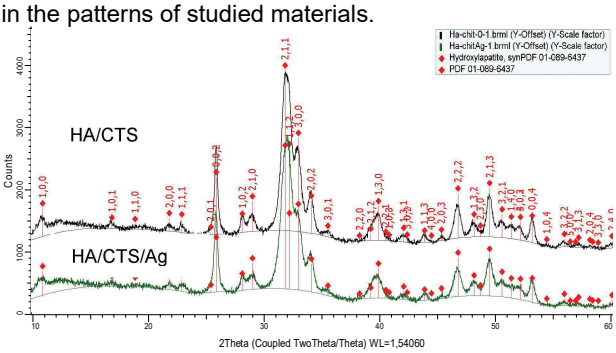

FIG. 1. X-ray patterns of HA/CTS and HA/CTS/Ag materials.

SEM observations demonstrated that the applied preparation method allowed obtaining materials with homogeneous microstructure (FIG. 2). The observed changes in the surface morphology were connected with the addition of A nanoparticles to the HAp/CTS materials.

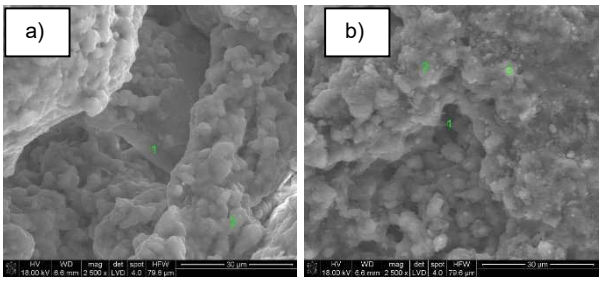

FIG. 2. Microstructure of material a) HAp/CTS and b) HAp/CTS/Ag.

Mechanical strength is usually the imperative criterion during the selection of bone substitutes for tissue engineering. Materials HAp/CTS and HA/CTS/Ag possessed compressive strength 22.4±7.4 MPa and 22,1.1±9.1 MPa, respectively. The addition of 0.1 wt.% of silver nanoparticles to HA/CTS material did not influence significantly on compressive strength.

Conclusions

Results of our studies have shown that it is possible to introduce chitosan and silver nanoparticles into the structure of hydroxyapatite via the wet chemical synthesis. This method allows us to obtain the ceramic-polymer composite with an interesting, promising mechanical and biological properties. X-ray diffraction analysis, revealed the presence of only one crystalline phase – i.e. hydroxyapatite in HA/CTS and HA/CTS/Ag materials. Introduction of chitosan and silver nanoparticles during the synthesis did not influence the distribution of hydroxyapatite. SEM observations demonstrated that the preparation method, allowed obtaining composite materials with homogeneous microstructure. The compressive strength of obtained materials was equal 22MPa. The obtained HA/CTS/Ag materials due to their interesting properties could be potentially used as a solid phase of bone cements.

Acknowledgments

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