

THERMAL BEHAVIOUR OF FUNCTIONALLY GRADED SODIUM-CONTAINING CALCIUM PHOSPHATES

A. GONCHARENKO, D. ROKHIMISTROV, Z. ZYMAN

PHYSICS OF SOLIDS DEPARTMENT, PHYSICS FACULTY,
V.N. KARAZIN KHARKIV NATIONAL UNIVERSITY,
4 SVOBODA SQUARE, 61022 KHARKIV, UKRAINE

Abstract

Hydroxyapatite (HA), β -tricalcium phosphate (β -TCP) and their mixtures have been successfully applied in orthopedic, oral and maxillofacial surgery [1]. Calcium phosphate (CP) bioactive ceramics based on HA is usually fabricated of appropriate powders. Unfortunately, mechanical properties of such material are in general worse than those of human bone. Therefore, there is a necessity for development of new ceramic CP composites with improved characteristics.

An effective biomaterial must simultaneously possess various, often contradictory, properties [2]. A functionally graded material (FGM) with gradients in composition, phase and microstructure from the surface to the interior can better satisfy such combined requirements. Recently, FGM's of sodium-containing calcium phosphates were prepared expecting them to have improved circumstances for bone formation and bonding [3-4].

The aim of this work was to study the thermal behavior of FGM's of sodium – containing calcium phosphates prepared by an original route.

The initial powder was prepared by a simple one-step precipitation using $\text{Ca}(\text{NO}_3)_2$ and Na_3PO_4 reactants. The synthesis reaction resulted, besides HA, in the by product NaNO_3 . However, the latter was not washed out of the precipitate but rather used as a source of sodium for ceramics preparation. An original molding step was used resulted in gradient distribution of NaNO_3 in compacts. They were sintered under usual conditions.

It has been found that the linear (or volume) shrinkage and the density slightly changed in the fired compacts below 1100°C . However, the consolidation abruptly increased at 1100°C . The poor sintering is associated with NaNO_3 decomposition during heating and firing at temperatures below 1100°C . At higher temperatures, reactions between HA particles and products of NaNO_3 decomposition occurred and diffusion processes were intensified. Due to the gradient distribution of NaNO_3 in the compacts, the indicated thermal processes resulted in formation of functionally graded ceramics (having in particular a phase gradient from the surface to the interior as $\text{Na}_3\text{Ca}_6(\text{PO}_4)_5 \rightarrow \beta$ -rhenanite $\rightarrow \text{Na}^+$ solid solution in HA).

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POLYLACTIDE – CARBON NANOTUBES NANOCOMPOSITES AS MEMBRANES FOR GUIDED NERVE REGENERATION (GNR)

E. STODOLAK-ZYCH, A. FRĄCZEK-SZCZYPTA, M. BLAZEWICZ

AGH - UNIVERSITY OF SCIENCE AND TECHNOLOGY,
FACULTY OF MATERIALS SCIENCE AND CERAMICS,
DEPARTMENT OF BIOMATERIALS,
30 MICKIEWICZA AVE, 30-059 KRAKOW, POLAND

Abstract

New generation of membrane materials can play role in regeneration process in living organism e.g. creation of optimal conditions for regeneration of bone tissue (GBR/GTR technique) or defected peripheral nerve (GMR technique).

However, biodegradable polymeric materials which are now widely used in GNR technique (PLA, PCL, collagen) does not have satisfactory mechanical properties such as strength (RM) or Young's modulus (E) because it is difficult to control their porosity [1,2]. Materials suitable for nerve regeneration should exhibit electrical properties which stimulate the regeneration [3]. The main idea of the guided nerve regeneration is utilisation of a membrane separating two tissues i.e. defected nerve tissue and connective tissue. Inside the defected nerve tissue surrounded by the membrane should be present factors influencing the regeneration process such as: ECM protein, neurotrophic factors. On the other hand, the membrane should act as a barrier for fibroblast cells inflowing into the defected area.

The work presents results of investigations on porous nanocomposite materials basing on bioresorbable aliphatic polyesters i.e. poly-(L/DL)-lactide and carbon nanotubes (CNT). All materials i.e. nanocomposite foils and porous materials were prepared using synthetic co-polymer of L/DL-lactide with L/DL ratio of 80/20 from Purac®. The polymer had the FDA attestation confirming its biocompatibility. As the nanofillers, two types of CNTs produced by Nanostructured and Amorphous Materials (Inc. Huston, USA) were used: MWCNTs (multi-wall carbon nanotubes; diameter 10-30 nm and length 1-2 μm) and SWCNTs (single-wall carbon nanotubes; diameter 0.7-2 nm and length 15-30 μm). Nanocomposite membrane materials (PLDLA/0.5% wt. MWCNTs and PLDLA/0.5% wt. SWCNTs) were prepared using combined methods: phase inversion and freeze-drying. Porous microstructure of the nanocomposites was investigated using SEM/EDS. It was found, that the presence of the CNT influenced shape, size (5-50 μm) and distribution of pores in the material (total porosity of PLDLA/MWCNTs was about ~65% and PLDLA/SWCNTs was about ~35%). The nanoadditives increased mechanical properties of the membrane materials. For example addition of the SWCNTs increased the membrane strength (RM) from 16 to 24 MPa. Physicochemical properties of the materials surface were investigated by means of wettability and surface energy measurements. It was shown that dispersion part of surface free energy decreased when SWCNTs were used as additives (from 4.5 mm/mJ PLDLA membrane to 0.7 mm/mJ PLDLA/SWCNTs), while in the case of the