NANOCOMPOSITE MEMBRANES OBTAINED BY A HOT PRESSING METHOD

EWA STODOLAK-ZYCH[1]*, ŁUKASZ SAS[2]

[1] DEPARTMENT OF BIOMATERIALS,
FACULTY OF MATERIALS SCIENCE AND CERAMICS,
AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, POLAND
[2] FACULTY OF ELECTRICAL ENGINEERING, AUTOMATICS,
COMPUTER SCIENCE AND BIOMEDICAL ENGINEERING,
AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, POLAND
*E-MAIL: STODOLAK@AGH.EDU.PL

[ENGINEERING OF BIOMATERIALS 138 (2016) 56]

Introduction

Bone defects are still a problem in orthopaedics and stomatology. A critical size of bone gaps required some biomaterials which can stimulate process of regeneration of suitable tissues [1]. This membrane implant should show such features as: porosity, bioactivity, defined degradation time and should be handy for surgeons. Commercial polymer membranes are characterized by weak osteoconductivity and osteoinductivity so they work as an inert barrier [2]. Porous polymer system can be functionalized by inorganic, organic and hybrid layers which can create new possibilities in membrane [1-3]. For example, modification of a polymer matrix by such particles as; BG, HAp, TCP lead to bioactive membrane [4]. The presence of MMT particles shortens degradation time comparing to the pure polymer. If the surface is covered by PRP or biological factors its biocompatibility will be higher than in a pure membrane. When the layer consists of biopolymer such as HA it is more suitable for cartilage tissue [2].
The work presents result of investigations on polymer-ceramic nanocomposite membranes which were obtained by hot pressing of porous granules of PLDLA. The polymer matrix was modified by ostoeconductive (SiO_2) and osteoinductive (TCP) particles.

Materials and Methods

Porous nanocomposite membrane based on resorbable poly-L/DL-lactide (PURASORB 80/20, PURAC) granules and ceramic nanoparticles; silica - SiO_2 (5-10 nm, Sigma Aldrich) and tricalcium phosphate - TCP (20-30 nm, Sigma Aldrich) were obtained by a hot pressing method. Porous granules (polymer and nanocomposite) were manufactured by salt leaching method ($NaH_2PO_4 \cdot 2H_2O$, Avator). Given portions of the polymer granules were distributed onto a glass holder and then heated up to 180°C and pressed under 0.6 kPa. Pore size distribution was determined by the mercury porosimetry (PoreMaster 60, Quantachrome Instruments). Microstructure of the nanocomposites was investigated using SEM/EDS (Nova NanoSEM). Thermal properties of the materials after the hot pressing and after nanoadditives were assessed by DSC thermal analysis. Bioactivity test were performed during immersion in SBF medium/7-14 days/37°C. Chemical and morfological changes were observed using SEM/EDS method and FTIR-ATR spectra (BIO-RAD FTS60V). Adhesion and cell spreading were observed in a fluorescence microscope (Olympus CX42) after acrylic orange dyeing.

Results and Discussion

All of manufactured membranes (polymer and nanocomposite) had porous microstructures. Size and shape of the pores strongly depended on salt used as a porogene during the granules preparation. The porosity of granules was independent of the nanofillers i.e.; SiO_2 or TCP. All membranes had similar thickness of 480 μm. Size of the pores present in the membranes were in the range 5-250 μm (FIG. 1). The highest porosity was observed in a pure polymer membrane (PLDLA) then in the membranes modified by SiO_2 and TCP (FIG. 2). The nanoparticles strongly influenced structure of the polymer matrix i.e.; crystallinity of the polymer decreased (DSC) and new bonds were observed in its FTIR spectrum. Both nanocomposite membranes were bioactive: after 7 days in SBF solution on their surface an apatite structure can be observed (SEM/EDS). The apatite structure was observed after 14 and 7 days of incubation in SBF solution on the membrane with n-SiO_2 and TCP, respectively. The biological studies showed that cells (NHOst) preferred spreading near pores. In all porous materials the cells well characterized by proper morphology after 7 days.

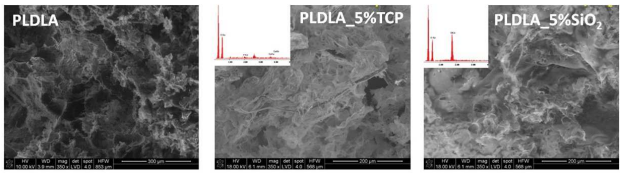

FIG. 1. Morphology of pure polymer, and PLDLA/TCP and PLDLA/SiO_2 nanocomposite membranes.

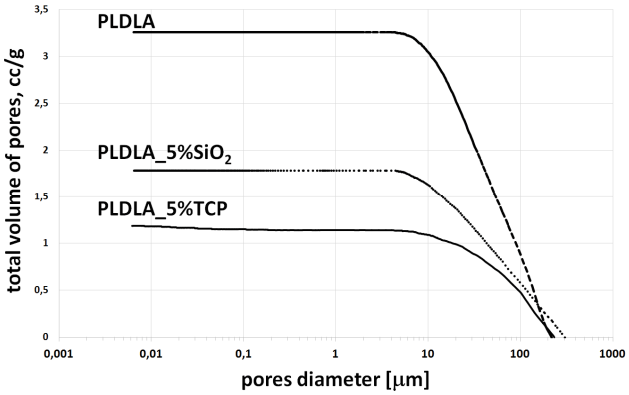

FIG. 2. Pore size distribution of the membranes.

Conclusions

Hot pressing method is a simple and cheap way to produce membrane materials. It guarantees repeatability of materials with similar weight, size of pores and total porosity. Nanocomposite membrane materials based on PLDLA and modified with SiO_2 or TCP give possibility to design such material features as; bioactivity and biocompatibility. It means that nanocomposite membranes can be potential materials for space making implants in a bone tissue defect.

Acknowledgments

This study was performed within the framework of funding for statutory activities of AGH University of Science and Technology in Krakow, Faculty of Materials Science and Ceramics (11.11.160.616).

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