BIODEGRADABLE TRICALCIUM PHOSPHATE/POLY(3-HYDROXYBUTYRATE) SCAFFOLDS FOR BONE TISSUE REGENERATION

Szymon Skibiński[1]*, Piotr Pańtak[1], Ewelina Cichoń[1], Maciej Guzik[2], Joanna Czechowska[1], Anna Ślósarczyk[1], Aneta Zima[1]

[1] Faculty of Materials Science and Ceramics, AGH University of Science and Technology, Al. Mickiewicza 30, 30-059 Krakow, Poland
[2] Jerzy Haber Institute of Catalysis and Surface Chemistry Polish Academy of Sciences, Niezapominajek 8, 30-239, Krakow, Poland
*e-mail: skibinski@agh.edu.pl

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Introduction

Bioceramic scaffolds based on tricalcium phosphates (TCPs), despite their outstanding biological properties, exhibit low compressive strength and high brittleness. The fabrication of ceramic scaffolds in combination with degradable polymers may result not only in improved mechanical properties but also opens their potential application as carriers of biologically active substances supporting tissue regeneration [1]. Among different polymers used in tissue engineering, polyhydroxyalkanoates (PHAs) are of special interest as they are biocompatible, biodegradable and their degradation products (aliphatic (*R*)-3-hydroxy acids) are naturally present in cells that metabolize fats. To date, however, most research has focused on the use of PHAs in the soft tissue engineering [2]. In contrast, this research show the potential application of one of the PHAs, i.e. poly(3hydroxybutyrate) (P(3HB)) as a component of TCP/P(3HB) scaffolds for bone tissue regeneration.

The aim of this study was to obtain biodegradable TCP/P(3HB) composite scaffolds with different pore architecture. The influence of the polymeric coating on physicochemical properties of materials has been examined.

Materials and Methods

In our study, bioceramic scaffolds were prepared by a foam replication method. Three types of polyurethane matrices with different pore architectures were immersed in ceramic slurry (consisting of β-TCP powder, distilled water, Dispex A4040 and methylcellulose), dried and sintered at 1150°C. Then scaffolds were treated with 10% (w/v) aq. solution of citric acid for 3 minutes, thoroughly washed with distilled water and dried. Materials with small (TCP-S), medium (TCP-M) and large pores (TCP-L) were produced. The obtained ceramic specimens were infiltrated with 5% (w/v) P(3HB) chloroform solution, dried at room temperature for 7 days and subjected to further studies. The developed scaffolds were investigated by X-ray diffraction (XRD), scanning electron microscopy (SEM), hydrostatic weighing and compression tests. To evaluate the P(3HB) degradation, composites were incubated in distilled water at 37°C up to 180 days. Afterwards, extracts were analyzed *via* UHPLC-MS.

Results and Discussion

XRD analysis revealed that bioceramic scaffolds consist of one crystalline phase i.e. β-TCP. In the case of composites, β-TCP reflexes along with amorphous halo originated from P(3HB) were noticed. The obtained materials possessed open porosity around 65 vol% with spherical pores from 209 ± 87 to 714 ± 211 μm. SEM observations (FIG. 1) demonstrated that TCP scaffolds were uniformly covered with the polymer. Observed microporosity of P(3HB) layer is connected with fast chloroform evaporation and crystallization of the polymer. Composites possessed higher comprehensive strength (up to 4.5 ± 0.5 MPa) and surgical maneuverability in comparison to uncoated scaffolds (FIG. 2). Moreover, P(3HB) degradation products were identified by UHPLC-MS as (*R*)-3-hydroxybutyric acid and its oligomers, which can be beneficial for the surrounding tissues *in vivo* [3].

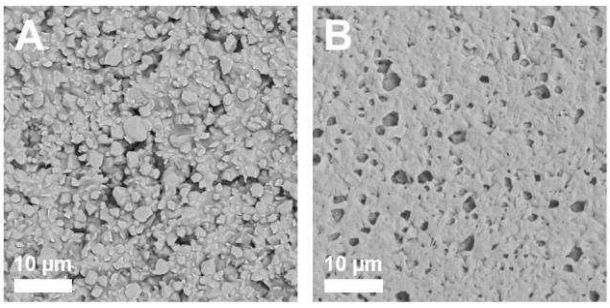

FIG. 1. Microstructure of materials: A) TCP-M and B) TCP-M/P(3HB).

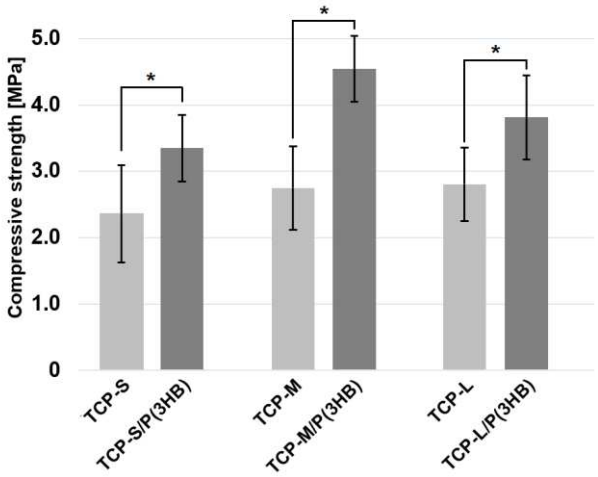

FIG. 2. Compressive strength of the scaffolds. Statistically significant differences are indicated by * $p \leq 0.01$.

Conclusions

The macroporous TCP and TCP/P(3HB) scaffolds with different pore architectures were successfully obtained. Polymer infiltration did not significantly affect open porosity of materials but improved their comprehensive strength. Moreover, degradation products of P(3HB) may be beneficial for the surrounding tissues as they can act as the nourishing agents. Thus, obtained composites were found to be promising bone substitutes for use in low-load bearing applications. Further *in vitro* studies are necessary.

Acknowledgments

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