THE INFLUENCE OF PHASE CHANGE MATERIAL (PCM) ON SELECTED PROPERTIES OF POLYURETHANE/MAGNETITE SYSTEMS

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[ENGINEERING OF BIOMATERIALS 153 (2019) 95]

Introduction

Polyurethanes (PUs) can be defined as the group of polymers which contain urethane linkages [1]. Depending on chemical composition, polyurethanes can exhibit a variety of properties, which can be adjusted to the specific purposes. Therefore these materials are widely investigated nowadays. Due to their good biocompatibility, PUs are considered to be good materials for biomedical applications [2].
Typically polyurethanes are synthesized using three compounds: long-chain polyol, isocyanates and chain extender [2]. Either one- or two-step polymerization can be employed according to the desired properties of the obtained polyurethane. The latter allows better control of the final composition of the product. During the first step, a prepolymer is formed and then it reacts with a chain extender during the second step as shown in FIG. 1.

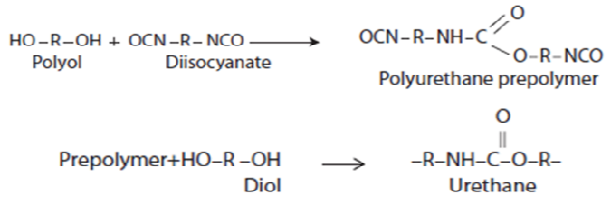

FIG. 3. Reactions during a two-step polymerization of polyurethanes [1].

Phase change materials (PCMs) can store thermal energy during phase transition, due to their high enthalpy of fusion. One of the representatives of PCMs is poly(ethylene glycol), a semi-crystalline polymer which exhibits high degree of crystallinity. Melting temperature and heat of fusion change according to the molecular weight of PEG. Incorporation of PEG PCM material into polyurethane matrix can be utilized to store latent heat of polymerization of PU. This is important in applications as injectable bone cement, where very high temperatures during polymerization can cause necrosis of surrounding tissues [3].

Materials and Methods

Poly(ethylene glycol) (PEG) with M_w = 2000 g/mol *(Sigma Aldrich)*, 1,6-hexamethylene diisocyanate (HDI) *(Fluka Analytical)*, dibutyltin dilaurate (DBTDL) *(Aldrich Chemistry)* as a catalyst, 1,4-butanediol (BDO) *(Sigma Aldrich)* as a chain-extender and sodium alginate (SA) *(Sigma Aldrich)* as a crosslinker have been used in polyurethane preparation. As additives micro magnetite particles (Fe_3O_4) *(Aldrich Chemistry)* and poly(ethylene glycol) (PEG) with different concentration and molecular weight *(Sigma Aldrich)* were used.

One day before the synthesis PEG 2000 was dried at 90°C under vacuum conditions for 2 h. About 2 h before the synthesis, it was placed into an oven at 60°C in order to melt the polymer. Magnetite was dried at 110°C for 12 h. Melted polyol was placed into a three-neck flask to which nitrogen inlet, the cooler and the mechanical stirrer were connected. Temperature was set and kept around 50°C using the heater and the catalyst was dropped. Next, HDI was added. During the reaction, temperature was kept below 60°C for 40 minutes.
Meanwhile, other components: BDO, SA, magnetite and PEG were mixed together in order to obtain a paste.
After 40 minutes, the prepolymer was put into a polypropylene container and the paste was added. The components were mixed and placed into an oven set at 80°C for 2 h. Afterwards, the temperature was decreased to 60°C and the obtained products were kept at these conditions for 12 h.
Microstructure, porosity and in vitro chemical stability in PBS and Ringer solution as well as bioactivity in SBF solution by Kokubo method have been investigated.

Results and Discussion

All the samples exhibit porous structure which was shown in FIG. 2.

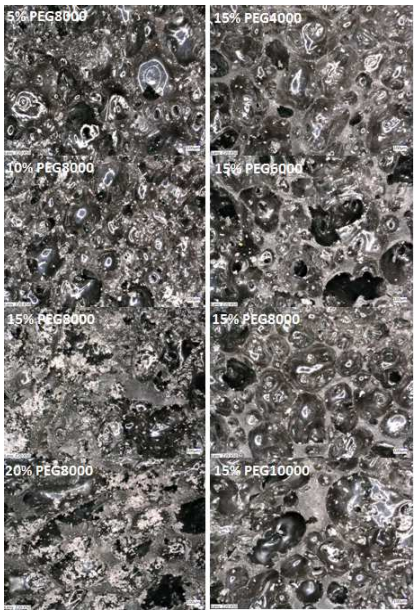

FIG. 2. Pictures of manufactured samples made using digital microscope at 50x magnification.

Porosity of the samples depends on concentration and type of added phase-change material. For the lowest concentration (5%) sample was highly porous.

Conclusions

Polyurethane-based bone scaffolds modified with phase change material (PCM) with different concentration and different molecular weight are multifunctional materials with controlled porosity that can be applied for bone regeneration.

Acknowledgments

Authors are grateful to the Polish National Science Centre for financial support under the Contract No. UMO-2016/22/E/ST8/00048.

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