SYNTHESIS AND CHARACTERIZATION OF POLYURETHANE-BASED BIOMATERIALS FOR ORTHOPAEDIC APPLICATIONS

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Introduction

Polyurethanes (PUs) are important biopolymers in clinical practice. PUs were introduced as potential biomaterials in the late 1990's. Since then polyurethanes were applied as bone cements, scaffolds or drug delivery systems. They are (co)polymers containing soft and hard segments. The soft segments are composed of polyester, polyether or polycarbonate diols, while the hard segments are formed by reaction between a chain extender and a diisocyanate. By varying the symmetry and chemical structure of the diisocyanate, the molecular weight and type of the polyol, the soft/hard segment ratio, the polymerization method and the crystallisation ability of the soft and hard segments, the physical and mechanical properties can be tuned to the target values for specific biomedical applications. Because many factors need to be considered to achieve the perfect properties for a specific biomedical application, morphology, structure, mechanical and thermal properties relationships are of crucial importance. In this context, the main goal of the research is to manufacture and characterize bioactive, biodegradable polymeric bone cements based on non-toxic PUs and polysaccharides [1-4].

Materials and Methods

Polyurethane-based materials were obtained in a two-step as well as one-step bulk polymerization method using poly(ethylene glycol) (PEG) with average molar mass 2000 and 1,6-hexamethylene diisocyanate (HDI). PUs have been synthesized with BDO (1,4-butanediol) and starch as a chain extender. All reagents were supplied from Sigma-Aldrich and were used as received without further purification. PEG was applied to absorb the exothermic heat of the PU polymerization reaction and thus to prevent a significant increase of temperature within the cement system. Before starting the synthesis of bone cement, PEG was dried under vacuum at the temperature of 110°C for 2 h. Samples were prepared with both BDO and starch and without BDO or starch. Scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FT-IR), differential scanning calorimetry (DSC), thermogravimetry (TG) techniques and tests of mechanical properties were used for characterization of the obtained PUs.

Results and discussion

In the first stage, characterization of all used raw materials was performed, followed by elaboration of a methods for obtaining polymer bone cements. The structure of the received PU was confirmed by FTIR technique – FIG. 1. The characteristic absorption band at 1102–1095 cm^{-1} is caused by asymmetric stretching vibrations of -C-O-C-. The band located in the range 3333-3319 cm^{-1} proves presence of NH stretching vibrations. Band at 2929-2922 cm^{-1} and 2861- 2858 cm^{-1} was assigned respectively to asymmetric and symmetric vibrations of CH_2 group. As it can be seen (FIG. 1) there is no significant shift in location of vibration bands in the samples modified with BDO and starch. Results of measurements of heat of phase transitions and temperature of melting by DSC method are presented in FIG. 2. One can see from FIG. 2 that the highest heat of phase transition was observed for the sample PU_1:BDO.

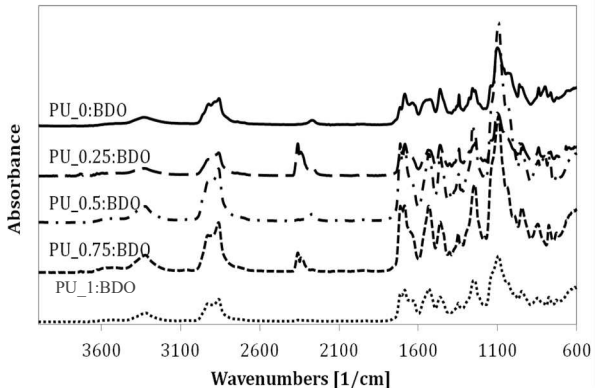

FIG. 1. FT-IR spectra of PUs samples (one-step bulk polymerization method).

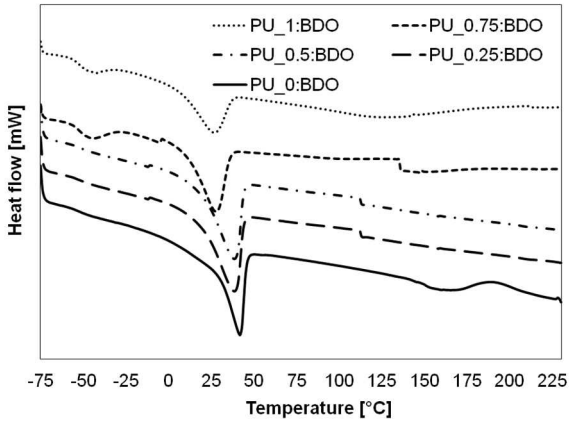

FIG. 2. DSC profiles of PUs samples (one-step bulk polymerization method).

Conclusions

Polyurethane-based materials modified with starch and BDO were obtained by applying one- or two-step bulk polyaddition method. The structure of the obtained PUs was confirmed by FTIR technique. An increase of starch content in PU materials cause a drop of heat of phase transition and an increase in the melting temperature. The obtained materials have a high potential for their further use in medicine as multifunctional bone cements.

Acknowledgments

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