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Poly(propylene fumarate) Copolymers with Phosphonic Acid-based Monomers Designed as Bone Tissue Engineering Scaffolds

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Abstract : In order to heal bone disorders, the conventional methods which involve the use of autologous and allogenous bone grafts or permanent implants have certain disadvantages such as limited supply, disease transmission, or adverse immune response. A biodegradable material that acts as structural support to the damaged bone area and serves as a scaffold that enhances bone regeneration and guides bone formation is one desirable solution. Poly(propylene fumarate) (PPF) which is an unsaturated polyester that can be copolymerized with appropriate vinyl monomers to give biodegradable network structures, is a promising candidate polymer to prepare bone tissue engineering scaffolds. In this study, hydroxyl-terminated PPF was synthesized and thermally cured with vinyl phosphonic acid (VPA) and diethyl vinyl phosphonate (VPES) in the presence of radical initiator benzoyl peroxide (BP), with changing co-monomer weight ratios (10-40wt%). In addition, the synthesized PPF was cured with VPES comonomer at body temperature (37oC) in the presence of BP initiator, N, N-Dimethyl para-toluidine catalyst and varying amounts of Beta-tricalcium phosphate (0-20 wt% ß-TCP) as filler via radical polymerization to prepare composite materials that can be used in injectable forms. Thermomechanical properties, compressive properties, hydrophilicity and biodegradability of the PPF/VPA and PPF/VPES copolymers were determined and analyzed with respect to the copolymer composition. Biocompatibility of the resulting polymers and their composites was determined by the MTS assay and osteoblast activity was explored with von kossa, alkaline phosphatase and osteocalcin activity analysis and the effects of VPA and VPES comonomer composition on these properties were investigated. Thermally cured PPF/VPA and PPF/VPES copolymers with different compositions exhibited compressive modulus and strength values in the wide range of 10–836 MPa and 14–119 MPa, respectively. MTS assay studies showed that the majority of the tested compositions were biocompatible and the overall results indicated that PPF/VPA and PPF/VPES network polymers show significant potential for applications as bone tissue engineering scaffolds where varying PPF and co-monomer ratio provides adjustable and controllable properties of the end product. The body temperature cured PPF/VPES/ß-TCP composites exhibited significantly lower compressive modulus and strength values than the thermal cured PPF/VPES copolymers and were therefore found to be useful as scaffolds for cartilage tissue engineering applications.

Keywords : biodegradable, bone tissue, copolymer, poly(propylene fumarate), scaffold
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