

Novel Injectable GA/LA-Based Biodegradable Polymer Composites for Orthopedic Applications

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Introduction

Synthetic biodegradable polymers with ester linkages have been widely used in biomedical and pharmaceutical applications for decades [1-4]. Poly(glycolic acid) (PGA), poly(lactic acid) (PLA) and their copolymers (PGLA) are among the few biodegradable polymers with Food and Drug Administration (FDA) approval for human clinical use. Due to their biocompatibility and controlled degradability, these polyesters have been successfully used as suture materials for wound closure; implant devices for dental and orthopedic restorations; carriers for drug, protein and cell delivery; and tissue scaffolds for tissue engineering. However, most of these polymers are only available in their solid forms unless they are dissolved in chloroform or methylene chloride. Currently many applications in tissue engineering, especially in orthopedics and dentistry, require that biomaterials be shaped *in situ* to fit cavities/defects with complicated geometries in tissues. Although there are a number of studies dealing with development of *in situ* curable and deliverable systems, few among them are satisfactory in either strengths of the formed systems or viscosities of the polymer formulations. Therefore, there is a need in creating biodegradable materials with high strength and easy handling. In this study, we propose to develop a novel star-shape GA/LA-based oligomeric polyester methacrylate system for improved viscosity and mechanical strength for orthopedic and tissue engineering applications.

The objective of this study was to synthesize and characterize *in situ* polymerizable and biodegradable liquid oligomeric polyesters, use these novel oligomers to formulate the polymer networks and composites with bioabsorbable beta-tricalcium phosphate (beta-TCP) filler, and evaluate their mechanical, curing and degradation properties.

Materials and Methods

The hydroxyl-terminated 3-arm oligomeric polyesters were synthesized from GA and L-LA homopolymers or copolymers using a condensation polymerization technique, followed by methacrylation with methacryloyl chloride. After purification, the 3-arm oligomers were characterized using FT-IR, NMR, vapor pressure osmometry and viscometry. The purified oligomers were then used to formulate the biodegradable composites with beta-TCP in the presence of redox-initiators. Specimens were fabricated at room temperature following the published protocol [5]. Compressive, diametral tensile and flexural strengths, curing time,

degree of conversion, and exotherm of the materials were measured. Effects of molar ratio and filler content were also studied. *In vitro* degradation studies were conducted in PBS (pH = 7.4) solution at 37 °C, using compressive strength as an evaluation tool.

Results

We have developed a novel *in situ* polymerizable liquid 3-arm biodegradable oligomeric polyester system based on GA and LLA. The cured neat resins showed the initial compressive yield strength (YCS, MPa), modulus (M, MPa), ultimate strength (UCS, MPa) and toughness (T, KN-mm), ranging from 4.0-20.1, 201.5-730.2, 82.7-310.5 and 1.02-3.93. The cured composites with beta-TCP showed the initial YCS, M, UCS and T, ranging from 27.7-56.4, 1440-4870, 81.6-158.9 and 0.94-1.97. Increasing GA/LLA ratio increased all the initial compressive strengths of both neat resins and composites. Increasing filler content increased YCS and M but decreased UCS and T. Diametral tensile strength test showed the same trend as compressive strength test. There seems an optimal flexural strength for the composite at the filler content around 43%. Increasing molar ratio increased curing time but decreased degree of conversion (DC). Increasing filler content increased curing time but decreased exotherm and DC. During the course of degradation, all the materials showed a burst degradation behavior within 24 h, followed by an increase in CS. The PGA neat resin completely lost its strength at around Day 45. The composites completely lost their strengths at different time intervals, depending on their molar ratio and filler content. The degradation rate is found to be molar ratio and filler-content dependent.

References

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