Abstract

Functional Polymer-Polymer Composites by Nano/Meso-Fiber Encapsulation: Applications in Drug Delivery Systems and Polymer Toughening

Ya Liang

Giuseppe R. Palmese, Ph.D.

Anthony M. Lowman, Ph.D.

This research focuses on developing functional polymer-polymer composites through fiber encapsulation. Two composite systems, poly(lactide-co-glycolide) (PLGA) – poly(vinyl alcohol) (PVA) and polypropylene (PP) – vinyl ester (VE), were investigated. The goal was to evaluate these systems for their potential applications in drug delivery and polymer toughening.

Sustained, controlled release of therapeutics and mechanical stability are desired in most drug delivery systems. This can be achieved by combining PLGA and PVA. The drug release rate mainly depends on the degradation rate of PLGA, while mechanical stability is maintained by PVA hydrogels. In this work, degradation behaviors of PLGA fibers and mechanical properties of PLGA-PVA composites were investigated during incubation in PBS (pH = 7.4) at 37°C. The size of nanofibers and the PVA matrix did not have a significant impact on the degradation rate. Degradation of PLGA fibers followed pseudo first-order kinetics. PVA matrix reduced mat shrinkage from 85% to 30% and maintained mechanical integrity of composites under incubation conditions. A gradual increase of tensile strengths and moduli of composites were observed after incubation for up to eight weeks, which was comparable to PVA hydrogels.

Thermosetting resins have good chemical and mechanical properties. However they are brittle, thus limiting their use in high performance composite materials. Rubber particles are usually used to toughen thermosetting resins, but they also greatly reduce mechanical properties. Rigid thermoplastic polymers have been investigated as toughening materials while limiting the

loss of mechanical properties. In this work, small diameter PP fibers were used to toughen VE resins. Results showed that PP greatly enhanced fracture toughness, but reduced mechanical strength of VE as voids were observed at the interface. Interfacial discontinuities of composites were improved after a plasma-based surface modification using vinyltrimethoxysilane (VTMS) was conducted on PP fibers. VTMS-grafting on PP did not significantly improve mechanical properties of the composite, but slightly increased fracture toughness by improving load transfer from VE to PP.

Overall, the PLGA-PVA system had a controllable degradation rate and desired mechanical stability for use in drug delivery systems, while the PP-VE system provided valuable information on toughening mechanisms of thermoplastic fibers and on toughening phase selection.