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Preparation of porous ultrafine PGA fibers via selective dissolution of electrospun PGA/PLA blend fibers

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Abstract

In order to prepare porous ultrafine poly(glycolic acid) (PGA) fibers, ultrafine PGA/poly(L-lactic acid) (PLA) blend fibers were electrospun and then the PLA was removed via a selective dissolution technique with chloroform. PGA and PLA are immiscible and that a co-continuous phase morphology was developed during the electrospinning process. After extraction of the PLA, the resulting PGA fibers had three-dimensionally interconnected pores with a circular shape and the pore size distribution was very narrow.

Keywords: Poly(glycolic acid); Poly(L-lactic acid); Electrospinning; Selective dissolution; Porous ultrafine fibers

1. Introduction

Electrospinning is a unique technique for the preparation of ultrafine polymer fibers with diameters in submicrometers. Since electrospun ultrafine fiber mats have high specific surface area and high porosity, they can be applied for membranes, wound dressings, scaffolds, sensors, etc. [1–5]. Recently, electrospinning of biodegradable and biocompatible poly (glycolic acid) (PGA), poly(L-lactic acid) (PLA), and their random copolymers have attracted a great deal of attention particularly for drug delivery, surgical implantation, enzyme immobilization, tissue regeneration, prevention of post-operative induced adhesions, etc. [6–13].

In our previous study [14], porous ultrafine polyetherimide (PEI) fibers were prepared via selective thermal degradation of electrospun PEI/poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHBV) blend fibers. They were partially miscible and that the phase separation occurred during the electrospinning process. After the selective thermal degradation of PHBV in the ultrafine PEI/PHBV blend fibers at 210 °C, the remaining PEI fibers had highly porous surfaces. Porous ultrafine fibers can be also prepared via electrospinning of immiscible polymer blends, followed by selective thermal or photo degradation of one component. If two polymers are immiscible, a phase-separated composite structure can be formed during the electrospinning process. It was suggested that these porous ultrafine fibers have potential applications in nanofiltration and functional nanotubes [15–17].

In this study, biodegradable ultrafine PGA fibers with a highly porous structure were prepared via a selective dissolution technique. PGA/PLA blend solutions in 1,1,1,3,3,3-hexafluoro-2-propanol (HFIP) were electrospun and most of PLA was selectively extracted with chloroform. It is expected that ultrafine PGA fibers will show a different biodegradability according to their porosity.

2. Experimental

PGA (M_w = 14,000 − 20,000) and PLA (M_w = 450,000) were purchased from Purac Co. and Boehringer Ingelheim, respectively. HFIP and chloroform were purchased from Aldrich Co. and used as received. In order to prepare PGA/

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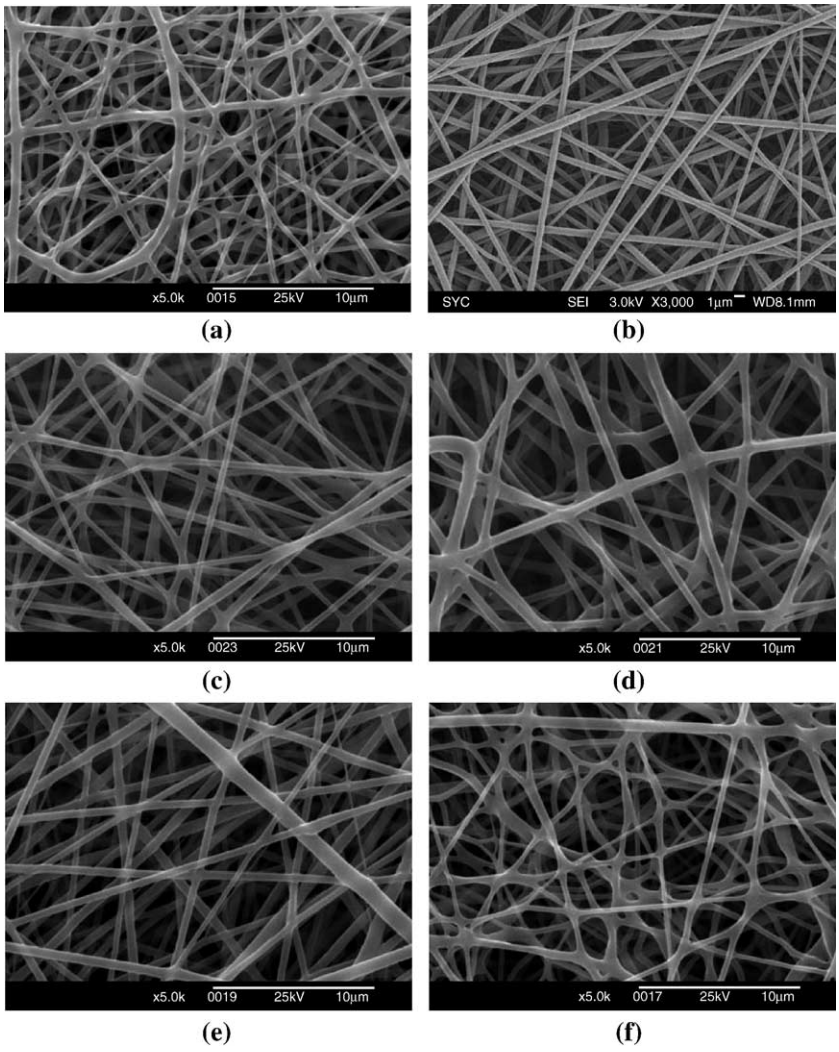

Fig. 1. SEM images of ultrafine PGA/PLA fibers: (a) PGA, (b) PGA/PLA (90/10), (c) PGA/PLA (70/30), (d) PGA/PLA (50/50), (e) PGA/PLA (30/70), and (f) PLA.

PLA blend solutions, 8 wt.% PGA and 5 wt.% PLA solutions in HFIP, respectively, were first prepared and then mixed at predetermined ratios (PGA/PLA=90/10, 70/30, 50/50, 30/70, *w*/*w*). The electrospinning setup used in this study consisted of a syringe and needle (ID=0.495 mm), an aluminum collecting plate, and a high voltage supply (Chungpa EMT) [18–20]. The PGA/PLA solutions were electrospun at a positive voltage of 17 kV and a working distance of 7 cm (the distance between the needle tip and the collecting plate). The mass flow rate of the PGA/PLA solutions was 4 mL/h. The electrospinning processes were carried out at 25 °C. The morphologies and pore structures of the electrospun PGA/PLA fibers and the residual PGA fibers were observed by a field emission scanning electron microscope (FE-SEM, JSM-6335F, JEOL). Prior to the observation, SEM specimens were coated with platinum by ion beam sputtering for a few seconds. Differential scanning calorimetry (DSC) measurements were conducted with a Perkin-Elmer DSC-7 under nitrogen atmosphere. About 10 mg of sample were sealed in an aluminum pan for the measurement. In order to remove thermal history, the samples

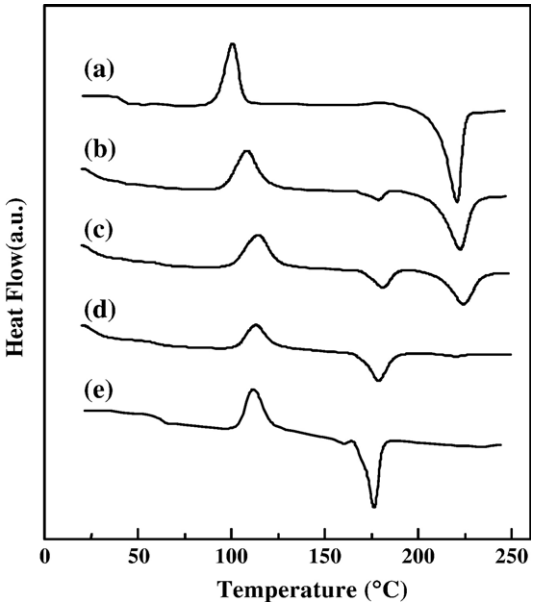

Fig. 2. DSC thermograms of ultrafine PGA/PLA blend fibers: (a) PGA, (b) PGA/PLA (70/30), (c) PGA/PLA (50/50), (d) PGA/PLA (30/70), and (e) PLA.