Electrospinning of Polystyrene-Polyisobutylene-Polystyrene Triblock Copolymers

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Statement of Purpose: High performance thermoplastic elastomers (TPEs) with good solvent resistance, elasticity, tear strength and flex fatigue properties have found a wide range of applications in medicine such as tubing and implants. TPEs, while being macroscopically homogenous, phase separate on a microscopic (nanometer scale). Polyisobutylene (PIB)-based block copolymers are TPEs which possess a unique combination of properties: good heat, chemical and environmental stability due to the saturated nature of the PIB segment, coupled with good processability and outstanding barrier properties. (Puskas JE. J Polym Sci. A. Polym Chem. 2004; 42: 3091- 3109.) Linear triblock polystyrene-*block*-polyisobutylene-*block*-polystyrene (PS-PIB-PS) is considered to be the first generation of PIB based TPEs. These first generation block copolymers were confirmed to be biocompatible and infection-free in ultra-long term endoluminal or vascular device applications and are currently used as a polymeric coating on the medicated Taxus® coronary stent. (Boston Scientific Corp. 1 Boston Scientific Pl. Natick, MA 01760)

Electrospinning is a process to produce polymeric nano- to micro- scale fibers. The technique involves the generation of a strong electric field between a polymer solution in a reservoir such as a syringe with a needle or a pipette, and a metallic collection plate. At a critical voltage value, the charge overcomes the surface tension of the deformed drop formed on the tip causing an electrically charged jet to be produced. We explored the possibility of electrospinning PIB-based TPEs for controlled release, drug delivery and tissue engineering applications. In this work, we report the effect of the processing parameters on the size and uniformity of the fibers electrospun for PS-PIB-PS linear triblock copolymer.

Method

Materials: Semicommercial SIBS under the trade name of SIBSTAR® was obtained by courtesy of Kaneka Co., Osaka, Japan (073T, 31 wt. % polystyrene; M_n-66700 g/mol). Tetrahydrofuran (THF), Dimethyl formamide (DMF) and Toluene (Aldrich) were used as received.

Method: The polymer was dissolved in THF:DMF (95:5) and THF:Toluene (95:5) (w/w). An electric potential of 30kV was used to produce the jet and the distance between the glass pipette tip (tilted a few degrees from the horizontal) and the grounded copper sheet was 30 cm.

Characterization and Analytical Procedures: Silver sputtered electrospun fibers, loaded on aluminum stubs, were examined by Scanning Electron Microscopy (JEOL-JSM5310 SEM). The average fiber diameter and its distribution were determined from 100 random measurements of fibers collected in each spinning condition.

Results/Discussion: Figure 1 depicts the relationship between the fiber diameter and polymer solution concentration.

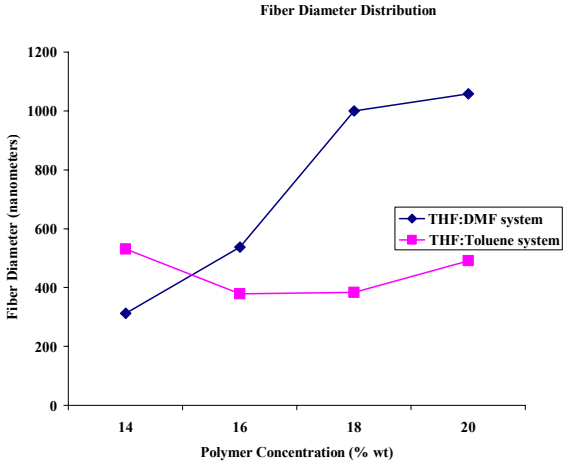
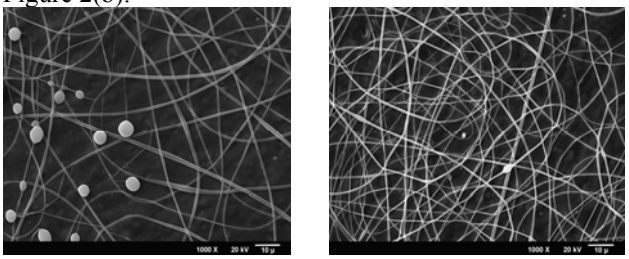


Figure 1. Fiber Diameter v/s Polymer concentration

In the THF:DMF system, fiber diameter steadily increased with concentration, similarly to other electrospun polymers. (Fong H. Polymer 1999; 40:4585-4592) Interestingly, in the THF-Toluene system, fiber diameter was nearly independent of concentration.

Beaded fibers were observed with both solvent systems at 14 and 16 wt% (Figure 2(a)). However, 18 and 20 wt% polymer solutions yielded fibers with 1000 nm ± 563 (THF:DMF system) (18% wt) and 383 nm ± 108 (THF:Toluene system) (18% wt) diameter shown in Figure 2(b).



(a) (b)

Figure 2. Scanning electron micrographs of Electrospun fibers obtained for the THF:Toluene system (a) 14% wt (b) 18% wt

Conclusion: Nonwoven fibers of PS-PIB-PS linear triblock copolymer were successfully fabricated by electrospinning. Surprisingly, the fiber diameter was independent of polymer solution concentration in the THF:Toluene solvent system. Future work includes electrospinning of dendritic (arborescent) PS-PIB-PS copolymers, new potential biomaterials.