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Preparation and Characterization of the Electro-spun Polyethylene Terephthalate Fibrous Membrane

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Abstract

In this study, the electro-spun PET (polyethylene terephthalate) fibrous mats with fiber diameters ranging from 400 nm to 6 μm were produced with the different settings of the polymer solution concentration, spinning voltage and receiving distance. The morphological properties and structure of the fibrous membrane were evaluated for the investigation of the effects of the electro-spinning parameters on fiber properties using Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD) respectively. The experimental results showed that the continuous PET fibers without beads can be spun with the following settings: spinning voltage at 20 kv, receiving distance at 15 cm, and concentration of polymer solution 10%-16%. The electro-spinning process can be controlled well at a spinning voltage of 16-22 kv. The effects of receiving distance on the fiber diameter and morphological structure were not obvious; however, the crystallinity of the PET fibers was relatively lower than other spinning methods.

Keywords: Electro-spinning; Polyesters; Microstructure; Crystallinity

1 Introduction

Poly (ethylene terephthalate) (PET) fiber has high breaking strength and elastic modulus, good elastic resilience, and excellent thermal stability. In addition, it also has good heat, abrasion, light and corrosion resistance etc. Therefore it can be used for a wide range of industrial applications. Due to its biostability, PET material has been successful used as vascular prostheses for some artificial grafts. Moreover, its processability into fibrous structures is suitable for the structural designing. PET material has been electro-spun to nano/micro fibers in recent years, widely applied in various fields due to its advantageous mechanical properties, biocompatibility and cost-effectiveness [1, 2].

Among those techniques developed for the fiber assembles, the electro-spinning is a simple method for the manufacturing of fibers with diameters ranging from few hundred nanometers to few microns, so that it can improve and optimize the performance of traditional PET fibers [3] For example, the fiber at nano-scale has a relatively large specific surface area, so the non-woven

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PET fabric composed of nanofibers can be used as filtration materials, also can be used as tissue supporting materials of the cell and the medical treatment materials of the skin [4].

Many researchers have made some systematic investigations on the development of electro-spinning technology, but few reports could be found about the study of the effects of the electro-spinning settings on the properties of the PET fibers. Chi Lei [2] has reported her work on the spinning of PET fibers by treating tetrachloroethane (VCM) / phenol as solvent, and given a discussion about the characterization of the fiber properties. However, dissolving the PET with tetrachloroethane (VCM) / phenol require the heating process and the conductive rate of the PET spinning dope is very low. Wang Peijie [4] studied the influence of different solvents on the spinnability of polyester solutions, and found that the electro-spinning process could be optimized by the selection of trifluoroacetic acid/methylene chloride as solvent. Electro-spun nylon 6 nanofibrous membrane has been investigated by GB Yin [5] in the paper. Electro-spun PAN nanofibers, electro-spun spider silk and electro-spun polycaprolactone have also been studied by different researchers [6-8] However, no researches have been done for the comparison of the electro-spun and melt spun PET fibers in terms of crystallinity and morphology.

Based on previous studies [1, 2, 4], this paper presents a set of self-developed electrostatic spinning device and the PET fibers were electro-spun using the solvent of trifluoroacetic acid/methylene chloride with the volume for the 4:1. The feasibility of producing PET membrane with different fiber diameters from nanometer to micrometer ranges was investigated by varying the process parameters, particularly concentration of polymer solution, electrostatic spinning voltage and receiving distance. We also attempted to produce various fiber diameters and crystallinity by varying the electrospinning process parameters and identifying the effect of these parameters on their characteristics.

2 Materials and Methods

2.1 Electrospinning Process

The PET chips were supplied by Shanghai Far Spinning Co. LTD. Three fluorine acetic acid (TFA) and methylene chloride (DCM) were supplied by Enterprise Group Chemical Reagent Co. LTD. All the chemicals used here were reagent grade without any further purification.

A self-developed electrospinning set-up (Fig. 1) was used to produce nano/micro fibers. The main parts of this set-up were: a high voltage power supply (ES-203), a 5 ml syringe connected to a stainless steel needle gauge (CI-II), and finally a stainless steel rotating drum (8 cm diameter, 30 cm length).

PET was dissolved in TFA/DCM (4:1) mixture in various polymer solution concentrations such as: 10%, 12%, 14% and 16% (w/v). The solution was loaded into 5ml syringe and discharged by a syringe pump at a constant speed. All concentrations were spun with receiving distance ranging from 6 to 10 cm and a voltage of 16-22KV which produced uniform and beadless fibers.

2.2 PET Fiber Diameter Measurement

The test samples were mounted on the SEM holders and gold-platinum coated for 2 min. S-3400N