

Preparation of ultrafine poly(sodium 4-styrenesulfonate) fibres via electrospinning

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Abstract. The ultrafine poly (sodium 4-styrenesulfonate) (NaPSS) fibres have been prepared for the first time by electrospinning. The spinning solutions (NaPSS aqueous solutions) in varied concentrations were studied for electrospinning into ultrafine fibres. The results indicated that the smooth fibre could be formed when the concentration of NaPSS was above 40 wt.%. The morphology of the fibres was shown by scanning electron microscope (SEM). The Fourier transform infrared spectroscopy (FTIR) indicated that the structure of NaPSS did not change after electrospinning.

Keywords. NaPSS; ultrafine fibre; electrospinning; SEM; FTIR.

1. Introduction

The electrospinning technique has been proved to be a facile and effective method for manufacturing micro/nanoscale polymer fibres and polymer/inorganics composite fibres (Huang *et al* 2003; Xia *et al* 2003). The basic requirements for electrospinning are a polymer source, a high voltage supply, and a collector (Fong *et al* 1999). When a strong electrostatic force is applied to the capillary containing a polymer solution, the solution is ejected from the capillary and deposited as a nonwoven fibre mat on a collector serving as the ground for the electric charges (Lannutti *et al* 2007). The micro/nanofibres produced by electrospinning method have shown amazing characteristics such as very large surface area-to-volume ratio and high porosity with very small pore size (Park *et al* 2004). Many polymers have been spun into fibres by electrospinning (Kim *et al* 2005; Zhou *et al* 2006; Gupta *et al* 2005; Ohkawa *et al* 2004; Son *et al* 2005). However, as a typical polyelectrolyte, the electrospinning of sodium polystyrene sulfonate have never been reported.

In this study, the ultrafine NaPSS fibres were successfully prepared by electrospinning technique. The results were characterized by scanning electron microscope (SEM) and Fourier transform infrared spectroscopy (FTIR).

2. Experimental

2.1 Materials

Poly(sodium 4-styrenesulfonate) (NaPSS, Mw = 100,000) was purchased from XZL Chemicals Co., Ltd (China). Distilled water was used as solvent.

2.2 Instruments

The scanning electron microscopy (SEM) measurements were recorded on a SHIMADZU SSX-550 microscope. FT-IR spectra were recorded on a Nicolet Instruments Research series 5PC Fourier transform infrared spectrometer.

2.3 Preparation of ultrafine NaPSS fibres

The NaPSS aqueous solution of various concentrations (20, 29, 40 and 49 wt.%) were collected and stirred for 6 h at room temperature. The electrospinning experiments were performed at room temperature. The polymer solution was placed into a 2 ml glass syringe with a tip inner diameter of 1 mm. A clamp connected with high voltage power supplier (0–30 kV) was attached on the glass syringe. A piece of aluminum foil was placed towards the tip at a distance of 17 cm as grounded collector. The polymer jets generated from the tip by high voltage field to the grounded collector and formed the ultrafine fibre mesh. The apparatus for the electrospinning experiments was similar to previous report (Gupta *et al* 2005).

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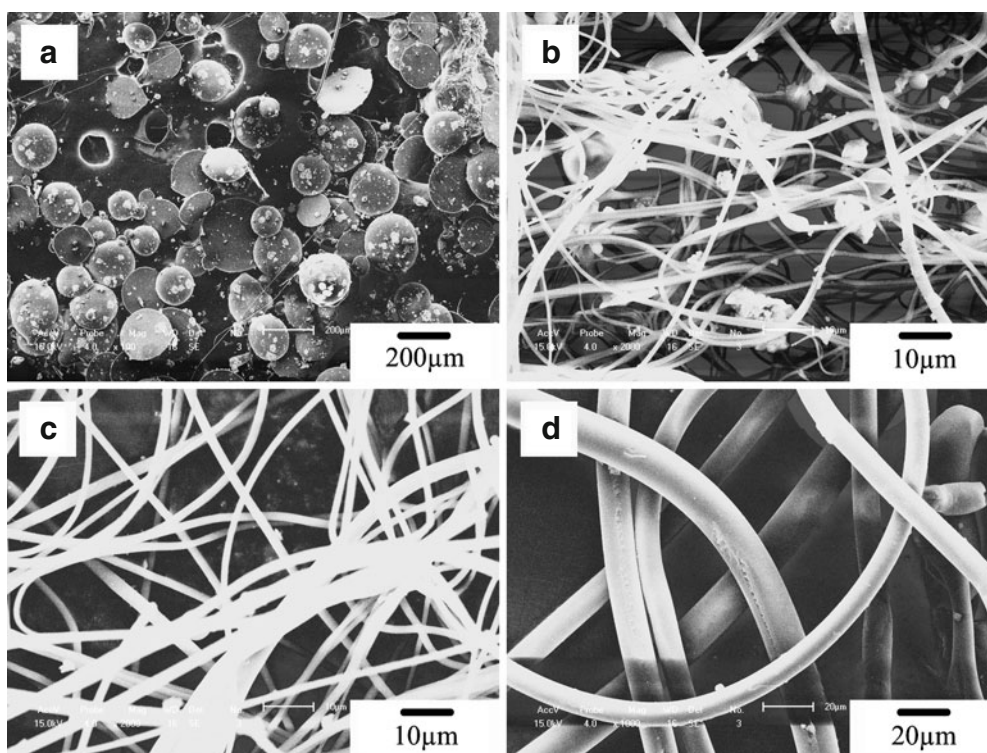


Figure 1. SEM images from NaPSS aqueous solution with various concentrations: (a) 20 wt.%, (b) 30 wt.%, (c) 40 wt.% and (d) 50 wt.%.

3. Results and discussion

It could be seen that with the increment in the concentration of NaPSS solution, the results changed from spheres to fibres. When the concentration of NaPSS aqueous solution was 20 wt.%, the electrospinning productions were almost microsphere structures with large diameters (figure 1a). When the concentration was 30 wt.%, the electrospinning productions were fibres with many beads (figure 1b). Smooth fibre was formed when the NaPSS concentration was above 40 wt.%. At 40 wt.%, the diameter of the NaPSS fibres ranged from 1.3–3.5 μm , with an average fibre diameter of 1.8 μm (figure 1c). At 50 wt.%, the viscosity of NaPSS solution was too high, so electrospinning process was fitful, and only a few large diameter fibres (above 9.5 μm) could be obtained on collector (figure 1d). Therefore, 40 wt.% was a suitable concentration for attaining the smooth fibres compared to those at other weight concentrations.

In order to examine whether the structure of NaPSS changed in the electrospinning process, IR spectra of both the raw material of NaPSS and the electrospun NaPSS were measured. Figure 2 shows IR spectra of the raw material (A) and electrospun fibres (B). Both of them had peaks of NaPSS at 1184, 1130 and 1040 cm^{-1} (Yang *et al* 2002); where peaks at 1184 and 1040 cm^{-1} could be assigned to the SO^3 -group antisymmetric and symmetric vibrational adsorption peaks, respectively, and 1130 cm^{-1} to the in-plane skeleton vibration of benzene ring. It was concluded that the electrospinning process did not affect the structure of NaPSS.

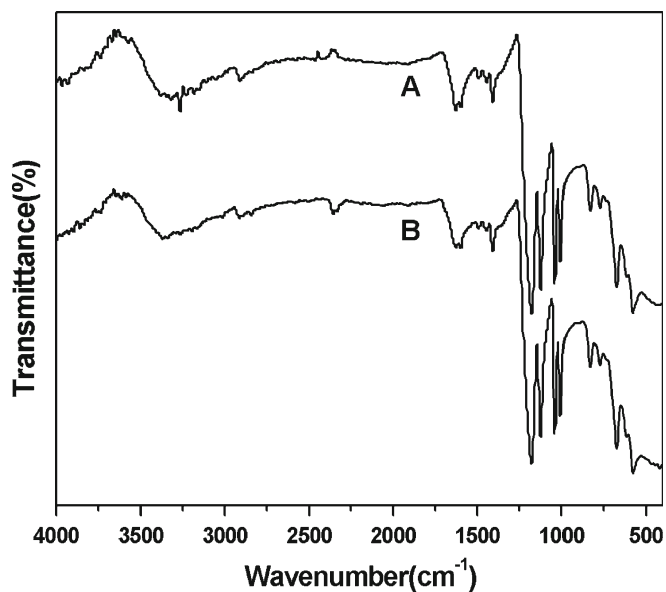


Figure 2. IR spectra of raw material of NaPSS (A) and electrospun NaPSS fibres (B).

4. Conclusions

The ultrafine NaPSS fibres have been successfully prepared by the electrospinning method. We found that water was a suitable solvent for the electrospinning of NaPSS fibres. With

the increment in the concentration of the NaPSS solution, results changed from spheres to fibres. 40 wt.% was a suitable concentration for attaining smooth fibres. The structure of NaPSS did not change in the electrospinning process.

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