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Fabrication of Polyacrylonitrile Nanoporous Fibers via Electrospinning

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Abstract. This study provide several straightforward ways to fabricate nanoporous fibers with diameters in the rang from nanometers to several micrometers.The PAN nanoporous fibrous materials are unique in their ultrahigh specific surface and porous geometry and have the potential to meet emerging needs in advanced technical applications. PAN nanoporous fibers were electrospun in a single process by varying solvent compositions. Polyacrylonitrile (PAN) and Polylactide (PLA) bicomponent electrospun fibers, upon removal of the PLA by CF solvent extraction, became nanoporous. The surface morphology of the electrospun PAN fiber are investigated by a Scanning Electron Microscope (SEM).

Introduction：

Because of electrospinning is the most efficient technique to fabricate fibers with diameters ranging from nano-scale to microscale,it has attracted much attention[1]. The surface morphology of electrospinning fibers is crucial when considering end-use applications. Electrospinning fibers with high surface area,inter-fiber pores and unique properties have drawn interests in research for potential applications in diverse fields. Nanoporous fibers have shown to enhance application in filtration[2],tissue engineering[3],drug delivery system[4],catalysis[5],sensors[6],super hydrophobic surfaces [7] etc.

Electrospinning is a straightforward and effective method to fabricate nanoporous fibers and it has been demonstrated,often involving the use of high vapor pressure solvents [8-10] or the inclusion of additives in the solutions [11-13] followed by their removal in post electrospinning processes.In this study, PAN was dissolved in the different solvent systems,the effects of the solvent compositions on the characteristics of as-spun fibers such as fiber surface morphology was intensively investigated. Otherwise test the concept of phase separation by electrospinning mixtures of polyacrylonitrile (PAN) and Polylactide（PLA). PLA is expected to be selectively removed from bicomponent fibers by solution in chloroform. Porous fibers could be generated by electrospinning polymer blends, followed by selective dissolution.

Experiment Section

Materials. Polyacrylonitrile (PAN) with a degree of polymerization of 15,000 g/mol., Polylactide (PLA) with a degree of polymerization of 10,000 g/mol.N,N-dimethylformamide (DMF) ,Chloroform ($CHCl_3$), Acetone were purchased from Shanghai Chemical Reagent Co. Ltd. All materials were used as received.

Electrospinning. All solution concentrations reported were weight percentages. Nanoporous fibres were electrospun from these solutions at 15 kV with a high-voltage power generator (0–30 kV, DW-P303-1ACF0, Tianjin DongWen high-voltage power generator Co., LTD). and collected on a grounded aluminum target 15 inches from the orifice. The obtained fibrous membranes were vacuumed for at least 24 h to remove the remaining solvent.

Results and Discussion

The surface morphology of the electrospun PAN fiber were investigated by a Scanning Electron Microscope (SEM). Nanoporous materials for SEM analyzed are collected on a steel mesh, mounted on a SEM disc and sputter-coated with Platina. SEM micrographs are illustrated from figure 1 to 3.

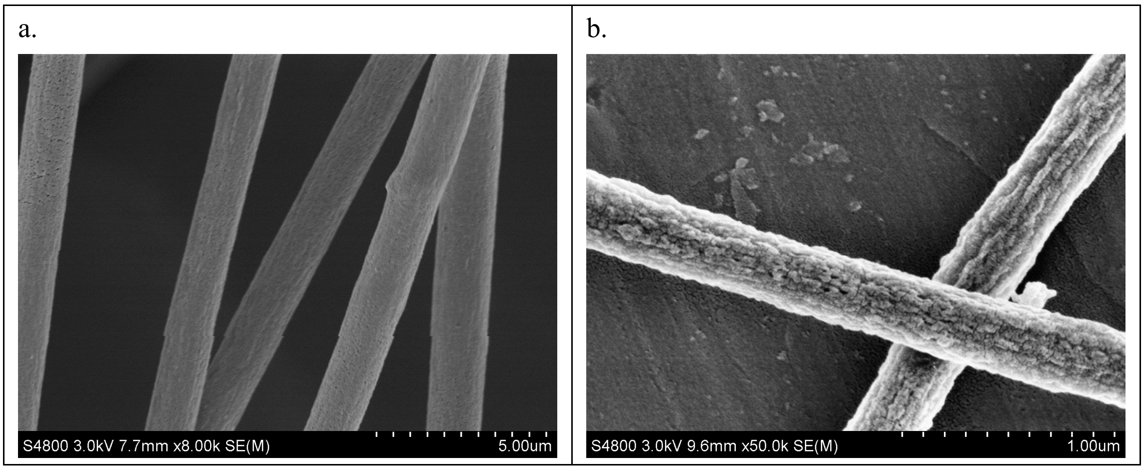

Fig. 1, a.SEM images of PAN fibers electrospun from DMF solutions
b.SEM images of PAN fibers electrospun from 8 wt% PAN solutions with weight ratios of Acetone/DMF:2/8

The surface of PAN fibers electrospun from DMF solutions is smooth and characterless as illustrated in Fig.a. The surface of PAN fibers appears some pores as illustrated in Fig.b. Non-solvent(Acetone) and solvent(DMF) mixtures for electrospinning PAN can have a dramatic effect on the morphological appearance of electrospun fibers.

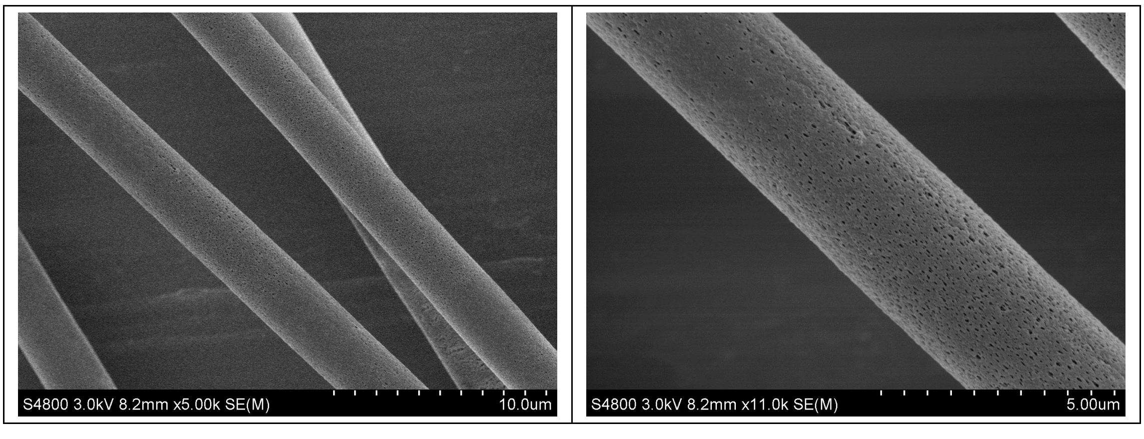

Fig. 2 , SEM images of PAN fibers electrospun from 8 wt% PAN solutions with weight ratios of CF/DMF:1/9

Nanoporous fibers has been demonstrated often involving the use of high vapor pressure solvent. Fig.2 shows PAN nanoporous fibers from 8wt% PAN solutions with high vapor pressure solvent. In the electrospinning process, the CF solvent evaporated in combination with high fiber stretching under the electrical force, the concentrated polymer- rich phase solidified into the matrix, whereas the solvent-rich phase eventually transformed into the pores as solvent dried out,then fabricate the nanoporous fibers as shows in Fig.2.

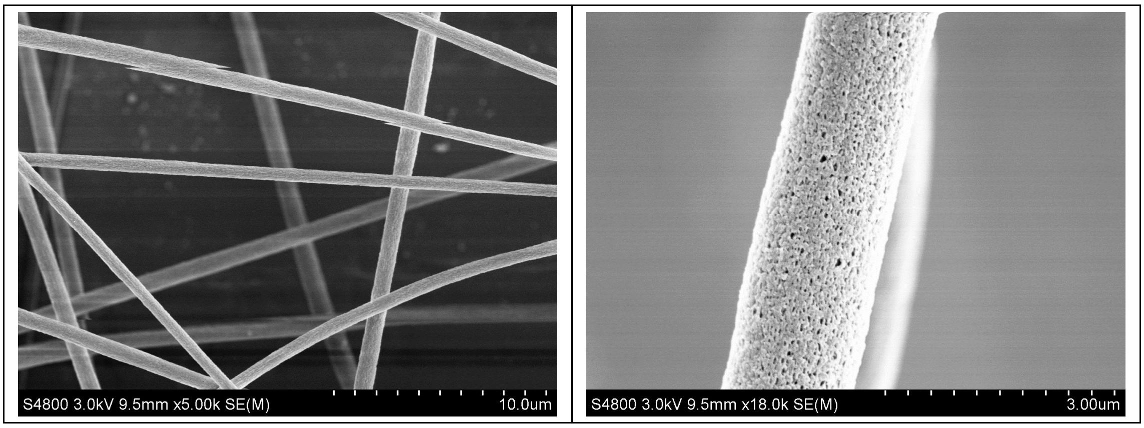

Fig. 3,SEM images of PAN/PLA (4/1)fibers from DMF solution after the extraction of PLA using CF.

Both PAN and PLA are easily soluble in DMF to form clear and homogeneous solutions.Ultrafine bicomponent polymer fibers were fabricated by electrospinning the 10%mixture of PAN and PLA at 4/1 mass ratio. PLA removed from bicomponent fibers by solution in chloroform. As Fig.3 shows stable pores formed after extraction of PLA by CF .The concept of phase separation was coupled with electrospinning to produce polyacrylonitrile (PAN) and Polylactide (PLA) bicomponent electrospun fibers, upon removal of the phase-separated PLA domains by solvent extraction, became nanoporous.

Conclusion

The obtained experimental results show that PAN nanoporous fibers can fabricated via different solvent compositions and mixture polymer phase separation . Non-solvent and solvent mixtures for electrospinning PAN can have a dramatic effect on the morphological appearance of electrospun fibers. In the electrospinning process ,the high vapor pressure solvent evaporated in combination with high fiber stretching under the electrical force, then the solvent-rich phase eventually transformed into the pores as solvent dried out. Polyacrylonitrile (PAN) and Polylactide (PLA) bicomponent electrospun fibers, upon removal of the PLA by CF solvent extraction, became nanoporous.These nanoporous PAN fibrous materials are unique in their ultrahigh specific surface and porous geometry and have the potential to meet emerging needs in advanced technical applications.

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