STATE-OF-ART OF PREPARATION OF CARBON NANOFIBER WITH MULTIPLE TUBLAR STRUCTURE

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Introduction

Electrospinning has been shown to be a powerful and effective method for the preparation of ultra-thin fibers. Though the electrospinning technology was patented in 1934, the application area has been expanded recently, for high performance filters, scaffolds in tissue engineering and electrodes for electric double layer capacitors (EDLCs) [1]. Here, multi-tubular structures of carbon nano-fiber were prepared by electrospinning from incompatible blends of bicomponent polymers of with carbonizable and unarbonizable polymers.

Experimental

Two kinds of polymers were chosen: one was carbonizable polymer polyacrylonitrile (PAN) and another was a uncarbonizable polymer polymethylmethacrylate (PMMA). The immissible polymer blends were electrospun, stabilized, carbonized and finally graphitized. 10 wt.% PAN and PMMA were dissolved in DMF in the PAN/PMMA weight ratio of 3/7, 5/5, and 7/3. The solutions were spun into fiber web by using an electrospinning apparatus consisting of a 25 kV DC power supply equipped with the positively-charged capillary from which the polymer solution was extruded and with a negatively-charged drum winder to collect the fibers as webs. The electrospun fiber web was stabilized at 280 °C for 1 h under air, and then carbonized at 1000 °C for 60 minutes by supplying N_2 gas. The carbonized samples of these materials were subsequently heat treated at 3000 °C in high-purity argon gas for 1 h in a graphite resistance furnace.

Results and Discussion

Fig. 1 shows the viscosity effect on the skin/core position of the component. It is well known that, the polymer with higher viscosity tends be continues phase and the polymer with lower viscosity tends to be continuous phase structuring skin and core in the fiber forming process[5].

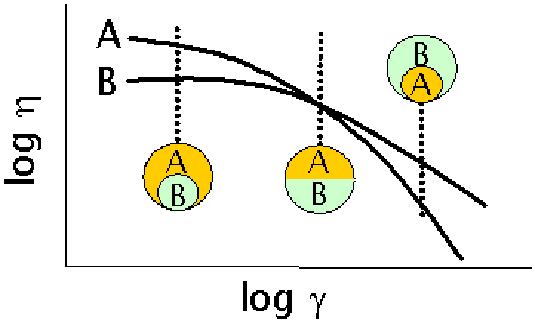


Fig. 1. Side-by-side configurations owing to viscosity differences.

The viscosities of PAN and PMMA and blends of PAN/PMMA are shown in Fig. 2. All the solutions exhibit Non-Newtonian behavior; shear-thinning as the shear rate is increased. The viscosity value increased as the concentration of the PAN solutions was increased.

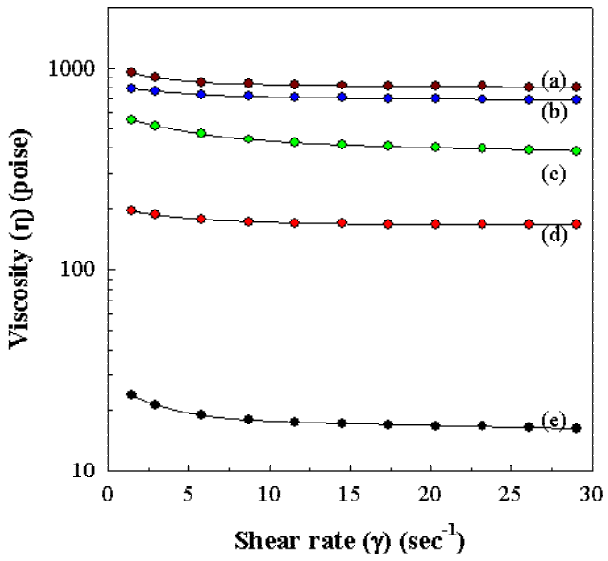
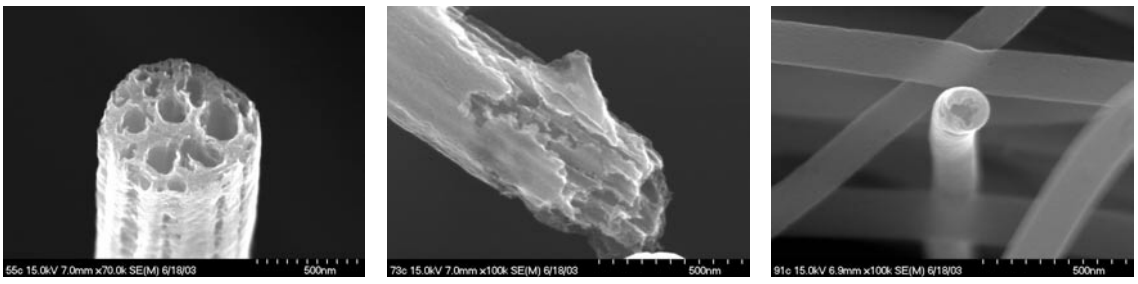


Fig. 2. Viscosity vs. shear rate of blend polymers at 30□; (a)PAN/PMMA= 10/0, (b)PAN/PMMA=7/3, (c)PAN/PMMA=5/5, (d) PAN/PMMA=3/7, and (e)PMMA/PAN=10/0.

On the basis of the viscosity behaviors of the blend solutions, we can predict the phase behaviors of the PAN and PMMA, dispersed phase of PMMA and continuous phase of PAN, in whole shear rate resign. The dispersed phase in the fibers is supposed to form tubular structure through decomposition during the stabilization and following carbonization.

Fig. 3 shows the FE-SEM micrographs of multi-tubular carbon nano-fiber at various precursor compositions. The tubular structures continued through the whole length of the fibers. The fiber diameter was ranged 100-500nm.



(a) **(b)** **(c)**

Fig. 3. FE-SEM images of nanotubular carbon fibers HTT at 1000□; (a) PAN/PMMA=5/5, (b) PAN/PMMA=7/3, (c) PAN/PMMA=9/1.

Conclusions

The nanotubular carbon fibers were prepared by electrospinning, stabilization and carbonization. The numbers of tube and tube diameter could be controlled by compositions of the blend polymers. Electrospinning method would be one key technology for designing of carbon nano-fibers with tubular structure.

References

[1] Kim C, Yang KS. Electrochemical properties of carbon nanofiber web as an electrode for supercapacitor prepared by electrospinning. Applied Physics Letters 2003;83(6):1216-1218.