나노형 폴리에스테르섬유 제조에 있어 전기방사의 응용

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Electrospinning Application for Production of Nano-type PET Fibers

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1. Introduction

With the introduction of high-tech industries, these days textile products used as advanced materials of semiconductor, transport and medical fields. It was concerned with environmental problem in textile industry lately. So the problem is receiving careful study for high effectiveness and high efficiency of filter media made by nonwoven fabric to get rid of a pollutant. PET filter media produced from conventional methods can not precisely filtrate small particles, because conventional PET filter media has too large pore size.

Thus, PET electrospinning method is considerably interested in academic and industrial fields. Electrospinning using PET polymer was tried by Chun[1]. But, this study was not enough to demonstrate effect of electrospinning condition on diameter of electrospun PET fibers with changing process parameters. On the other hand, surface area per the unit area of the nanofibers compared with the conventional fibers is considerably large. It is possible to precisely filtrate of gas and small powder particles due to small pore size.[1~3] Thus, based on the previous our research about electrospinning condition, in this study the morphological structure and the mean diameter of PET fibers were observed with various processing parameters such as spinning distance and electrical potential. Also, we have suggest that the electrospinning condition to produce nanoscale PET fibers was determined by controlling air pressure.

2. Experimental

2.1 Electrospinning system

The electrospinning apparatus in this study was designed and manufactured to ensure uniform electric field and the apparatus mainly consisted of the power supply, the collector, the spinning nozzle system and the air pressure control equipment.

2.2 Thermal and viscosity properties

Thermal properties of the PET were studied by Differential Scanning Calorimeter(DSC, Perkin-Elmer). To investigate the thermal properties of the sample, all samples heated to 300℃ and heating rate was 10℃/min. Also, to estimate the viscosity of PET solution, we used the Digital Viscometer made by Brookfield. The viscosity was measured an hour interval for 30 hours after the stirring for 24 hours.

2.3 Sample preparation

The concentration of PET solution was fixed 20wt.% and spinning distance was changed 15, 20, 25cm. Also, electrical potential was changed 10, 15. 20, 25kV and 12 samples were prepared to the experiment.

2.4 Morphological structure

The morphological structure of electrospun PET fibers was observed with a scanning electron microscope(SEM X-650, Hitachi. Co., Japan).

3. Results and Discussion

3.1 Thermal and viscosity properties

The thermal properties of PET showed crystallization temperature(around 130℃) and melting point(around 255℃). With the residence time, viscosity was gradually increased and it was completely solidification after 24 hours. When stirring time was 4~8 hours, viscosity was maintained as 100cPs. And viscosity was 120cPs in residence time for 11~20 hours.

3.2 Electrospinning condition

Figure 1 shows the morphological structure of samples manufactured with different spinning distance and electrical potential.

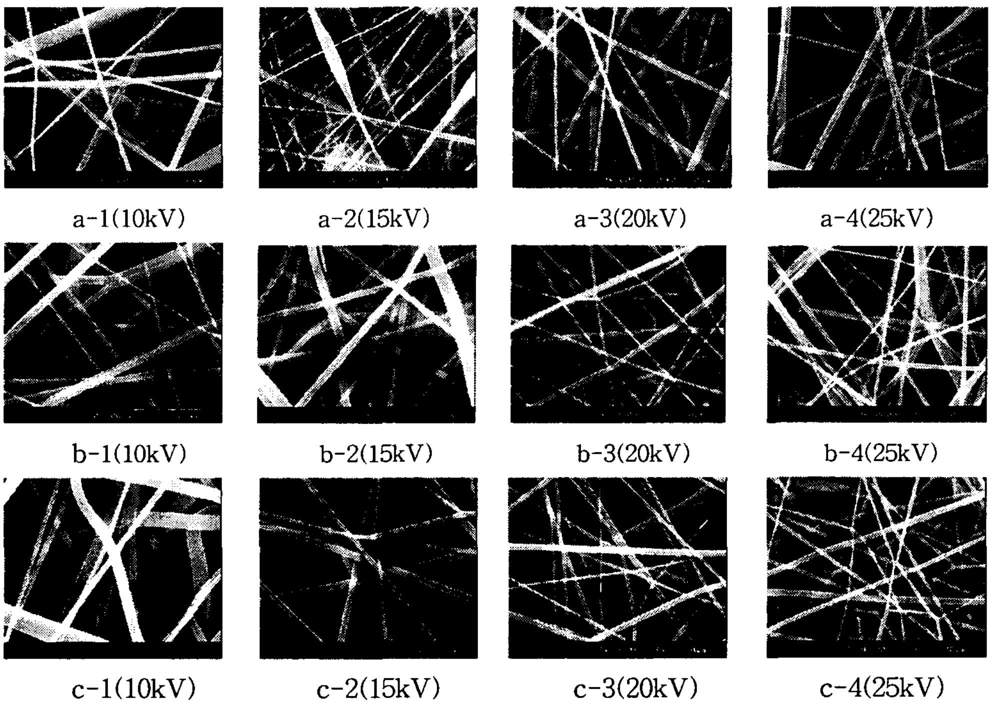


Figure 1. SEM microphotographs of electrospun PET fibers with variation of spinning distance and electrical potential.(a:15cm, b:20cm, c:25cm)

As the electrical potential between 10kV and 25kV gradually increased, the fiber morphology indicated that the uniform PET fiberweb was produced with some beads without regard to spinning distance. Also, based on these results(Fig. 1), we have investigated diameter distribution(Fig. 3) and mean diameter(Table 1) of the electrospun fibers. As the result, the average diameter continuously decreased with increasing electrical potential and the condition produced minimum mean diameter(0.934μm) was spinning distance of 15cm and electrical potential of 25kV. Also, the diameter distribution is narrow with increasing electrical potential. These results show that the increase of electrical potential improves the electric strength at the spinning region.

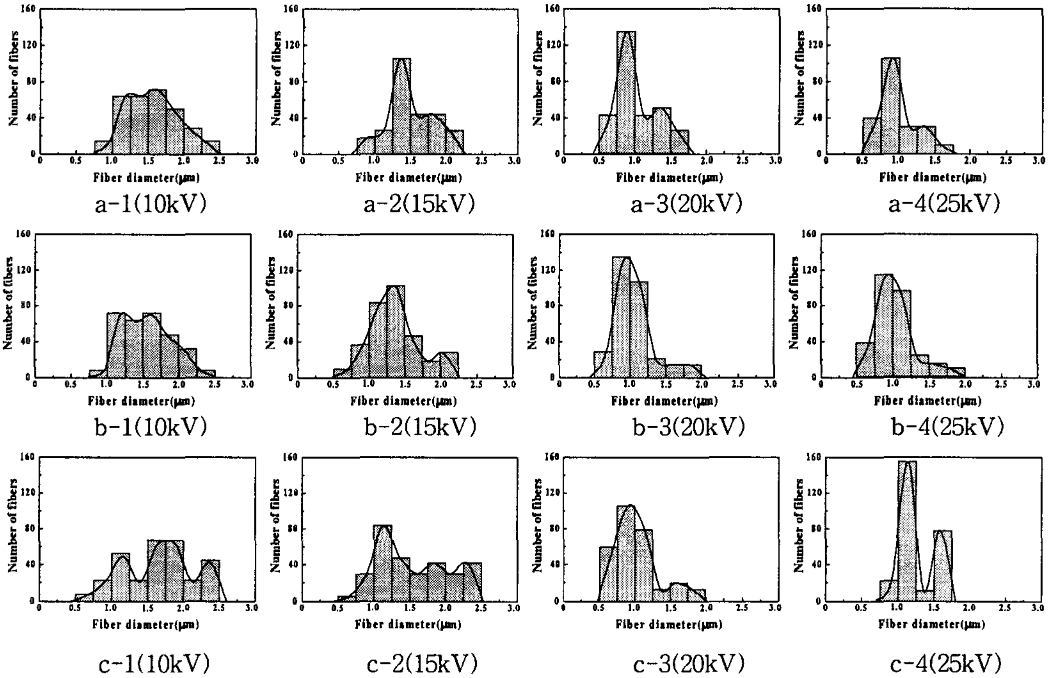


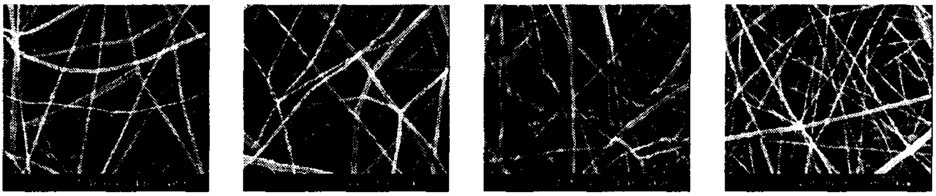
Figure 2. Diameter distribution of electrospun PET fibers with variation of spinning distance and electrical potential.(a:15cm, b:20cm, 25cm)

Table 1. Average diameter of PET samples with variation spinning distance and electrical potential

Electrical potential(kV) \ Spinning distance(cm)	15	20	25
10	1.531	1.551	1.634
15	1.294	1.324	1.504
20	0.993	0.998	0.996
25	0.934	0.952	0.978

3.4 Effect of air pressure

To obtain a nanofiber of PET electrospun fibers, we observed the variation of optimum spinning condition(15cm, 25kV) in addition to supply different air pressure(25, 50, 75, 100mmH_2O). Figure 3 shows the photograph of morphological structure with different air pressure. Also, Figure 4 shows the result of the mean diameter and diameter distribution of Figure 3. The mean diameters of each conditions(a, b, c, d) in shown Fig.3 were 0.92, 0.78, 0.65 and 0.63㎛, respectively. These results are due to draw the PET fibers by electric strength between tip of spinneret and collector and air pressure applied to spinning process. And, it is possible to produce the PET ultrafine fiber at the spinning condition(15cm, 25kV) and air pressure (100mmH_2O).



(a) (b) (c) (d)

Figure 3. SEM microphotographs of electrospun PET fibers with spinning distance of 25cm.(a)25mmH_2O, (b)50mmH_2O, (c)75mmH_2O, (d)100mmH_2O

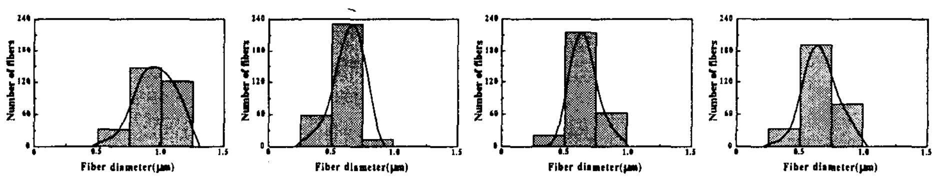


Figure 4. Diameter distribution of electrospun PET fibers with different air pressure.(a)25mmH_2O, (b)50mmH_2O, (c)75mmH_2O, (d)100mmH_2O

4. Conclusion

1. The average diameter of PET electrospun fibers was 0.93㎛ at 15cm of spinning distance and 25kV of electric potential. As the result of spinning behavior, we have found that the increased electric force led to increase draw ratio of electrospun PET fibers, especially when it has short spinning distance and large electrical potential.

2. In case of using air pressure for manufacturing ultrafine fibers as PET electrospinning, we found that mean diameter of electrospun PET fibers could be reduced to nanosize.

5. References

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