폴리비닐리덴플루오라이드섬유의 구조와 직경에 있어 전기방사 조건의 영향

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Effect of Electrospinning Conditions on the Morphological Structure and Diameter of PVDF Fibers

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1. Intruduction

The technical development of nonwoven industries for past 30 years with economic growth has contributed to create new end-use covered the wide field of industries. Recently, new concept of textile technology has studied and developed for cost reduction of production and high added value of products. Whereas the structure of nonwovens produced by conventional production methods have various pore size, and it is not suitable to filtrate gas and small powder particles. Therefore, electrospinning method has recently received considerable attention from both academic and industrial fields as an effective way to produce the ultrafine fibers.[1)~3)]Fibers produced by electrospinning is widely applied to functional materials such as high efficiency filter media, conductivity media and biocompatible media, because of having high surface area per unit area than conventional fibers.

Thus, in this study, based on previous study for optimum electrospinning condition of polyvinylidene fluoride(PVDF), we have observed the morphological structure and distribution of average diameter as changing process parameters such as spinning distance and electrical potential. Also, we have established the spinning conditions to produce the ultrafine PVDF fibers with and without external force, i.e., air pressure. As a result, the fiber web can applied to advanced media for EMI(electromagnetic interference) and dustproof mask demanded conductivity fibers.

2. Experimental

2.1 Electrospinning System

The electrospinning system was mainly consisted of the high power supply unit to supply electrical potential, the collector, the spinning nozzle system to feed the polymer solution and the air pressure control equipment for controlling spinning rate.

2.2 Thermal and viscosity properties

Melting point of PVDF was measured with a Perkin Elmer DSC-7 equipment system. The heating rate used in this study was 10℃/min. After agitation of PVDF polymer solution for 24 hours, the viscosity of PVDF solution was measured every hour for 30 hours. The used viscometer was Model Viscostar-R type made by the Brookfield.

2.3 Preparation of sample

On the PVDF concentration of constant 20wt.%, the sample was produced with different spinning distance(10, 15, 20cm) and different electrical potential(9, 12, 15kV). The total 27 of samples were prepared to experiment.

2.4 Morphological structure

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

3. Results and discussion

3.1 Viscosity and thermal properties

After 1 hour at the atmosphere temperature, the viscosity of PVDF solution is rapidly increased up to 3 hours, and after then the viscosity is a little increased according to increasing residence time. The proper viscosity for electrospinning is 3700cPs and the residence time for spinning is 4 to 14 hours. As the result of DSC experiment, the melting point of used PVDF polymers are 175℃.

3.2 Electrospinning condition

Figure 1 is shown morphological structure of samples produced according to various spinning distance and electrical potential. In case of spinning distance of 10 and 15cm, with increasing electrical potential from 9 to 15kV, spinning jet is formed unstable and sprayed fiber with rotation rapidly. There are beads in electrospun fibers in this condition. But in case of spinning distance of 20cm, there are beads at 9kV because of reducing electric force applied between spinneret tip and collector with increasing spinning distance. And beads are reduced at electrical potential of 12kV.

Figure 2 is shown the diameter distribution of electrospun PVDF fibers with different production conditions. In general the diameter distribution is broad with increasing electrical potential and spinning distance owing to the instability of electric strength in spinning region. On the other hand, Table 1 showed average diameter of electrospun fibers. Average diameter is reduced as spinning distance decreases and electrical potential increases.

3.3 Effect of air pressure

At the spinning distance of 10cm, PVDF fiber is not formed, since the spinning distance is too short to perfectly evaporate PVDF solvent. But, it is possible to produce electrospun PVDF fibers above the 15cm of spinning distance.

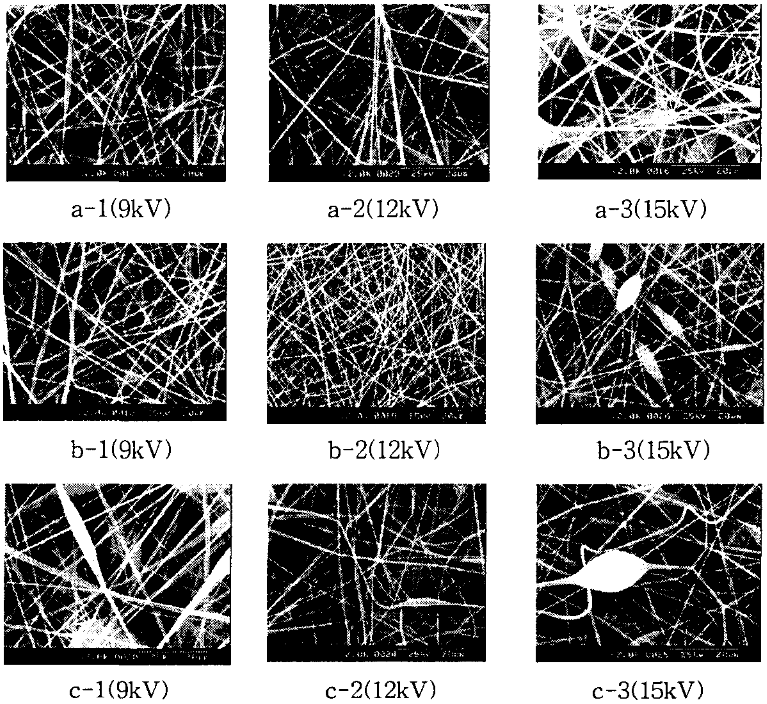


Figure 1. SEM microphotographs of electrospun PVDF fibers with variation of spinning distance and electrical potential.(a:10cm, b:15cm, c:20cm)

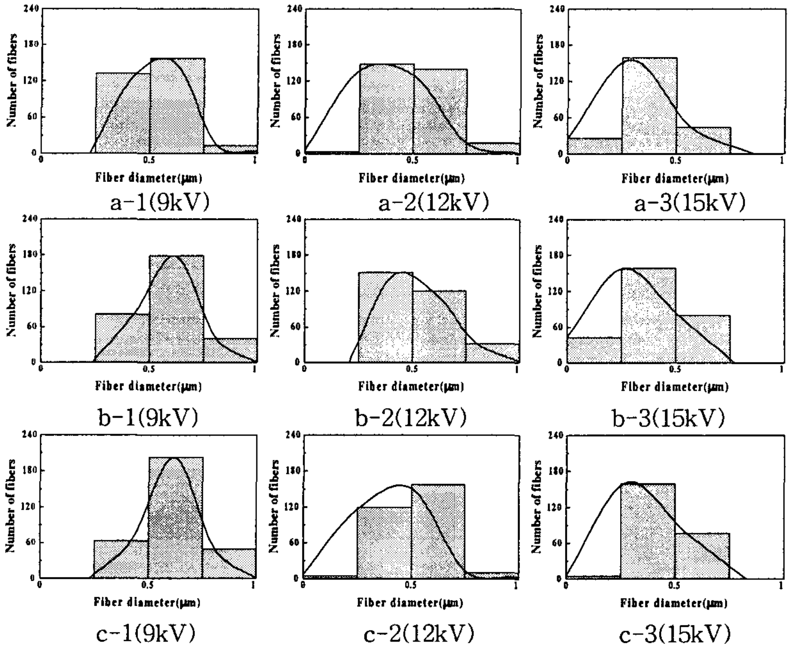
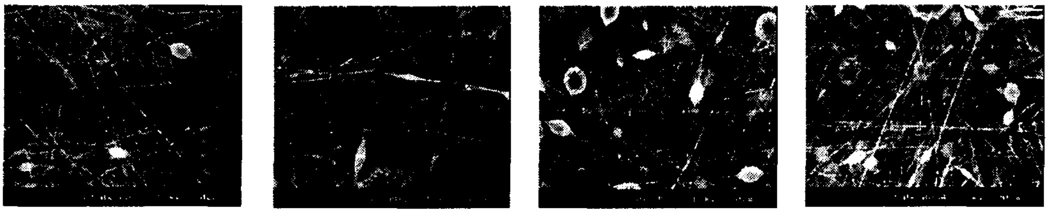


Figure 2. Diameter distribution of electrospun PVDF fibers with variation of spinning distance and electrical potential.(a:10cm, b:15cm, 20cm)

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

Spinning distance(cm) / Electrical potential(kV)	10	15	20
9	0.53	0.59	0.61
12	0.50	0.52	0.56
15	0.38	0.41	0.43

Figure 3 showed the morphological structure of electrospun fibers with changing air pressure. The average diameter of PVDF fibers at 25mmH_2O was 0.166㎛, at 50mmH_2O was 0.136㎛. Also the average diameters of electrospun fibers at 75mmH_2O and 100mmH_2O were 0.129 and 0.120㎛, respectively. As increase air pressure, the fiber diameter is reduced by increasing draw ratio of fibers.



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

Figure 3. SEM microphotographs of electrospun PVDF fibers.(×2000)

4. Conclusion

1. In case of spinning distance of 10cm and electrical potential of 15kV, average diameter is the smallest value of 0.38㎛ because of increasing electric force applied between spinneret tip and collector. This is caused by the reduction of spinning distance and the increase of electrical potential.

2. As applying air pressure of 100mmH_2O, average diameter of PVDF fiber is shown the smallest 0.12㎛ because of drawing electrospun fibers by air pressure.

5. References

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