용융형 전기방사법에 의한 폴리에스테르섬유의 방사거동과 구조에 관한 연구

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Study on Spinning Behavior and Structure of Polyester Fibers by the Melt-type Electrospinning Method

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1. Introduction

The fiber formation of conventional melt spinning is extruded by forcing the polymer melt through a spinneret by pumping mechanism usually involving high pressure. This is followed by cooling, solidification and appropriate drawing of the fiber. The spinning process is broadly applicable to polyolefin, polyamide, polyester and indeed the whole range of fibers forming thermoplastic polymers.

In case of fiber spinning with the high molecular weight materials or with the materials having strong polar bonding, the conventional fiber spinning process is not suitable to produce the stability fibers for required characteristics. This would require the generation of marked elongational flow in the polymer melt. This may not be consistent with the design of conventional spinning because typically spinnerets tend to have a low length to diameter ratio and to have the polymer little chance to orient inside the spinneret. Furthermore, to generate extensional force field the high driving pressure that would be necessary can result in well known flow instability phenomena. Thus, it is necessary to study for alternative spinning methods that do not require the use of high pressure. Recently, electrospinning for this method is interested in fiber producers and textile researchers.

From literature survey, there was a few results related to electrospinning by melt-spinning method. Tayor[1]showed that ultrafine jet of monomeric liquids can be generated by applying high electrical potential. But, there were few studies for melt-electrospinning of polyester(PET) fibers.[2,3] Thus, in this study the melt-type electrospinning system of lab scale was designed and manufactured. From this, the spinning condition and spinning behavior of electrospun PET fibers have investigated. We have suggested the possibile approach of PET electrospinning by the melt spinning method to produce the fibers with having nano-size diameter.

2. Melt-type electrospinning apparatus

A schematic diagram of the melt-type electrospinning apparatus designed and manufactured in this study is shown in Figure 1. This apparatus is constituted to three parts such as power supply, spinning and winding units. In particular, spinning part includes heating equipment which can be melted polymer. The wall of heating system was surrounded by insulation jacket and plate in order to completely insulate between temperature sensor and heating equipment.

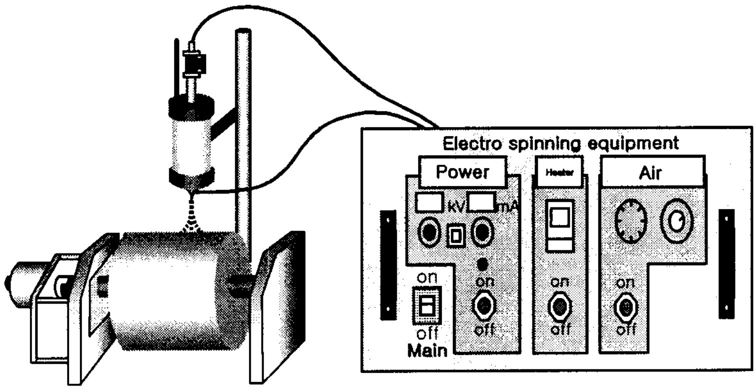


Figure 1. Schematic of a melt-type electrospinning apparatus.

3. Experimental

3.1 Sample preparation

Raw materials were used the regular PET chip having the melting point of 258℃. The samples were prepared with different conditions such as spinning temperature(265~295℃), electrical potential(15~30kV) and spinning distance(10~16cm). During the preparation of samples, the air pressure was constant as 100 mmH_2O. And then, the produced samples were dried for 24 hours at 120℃ in order to thermally stabilize.

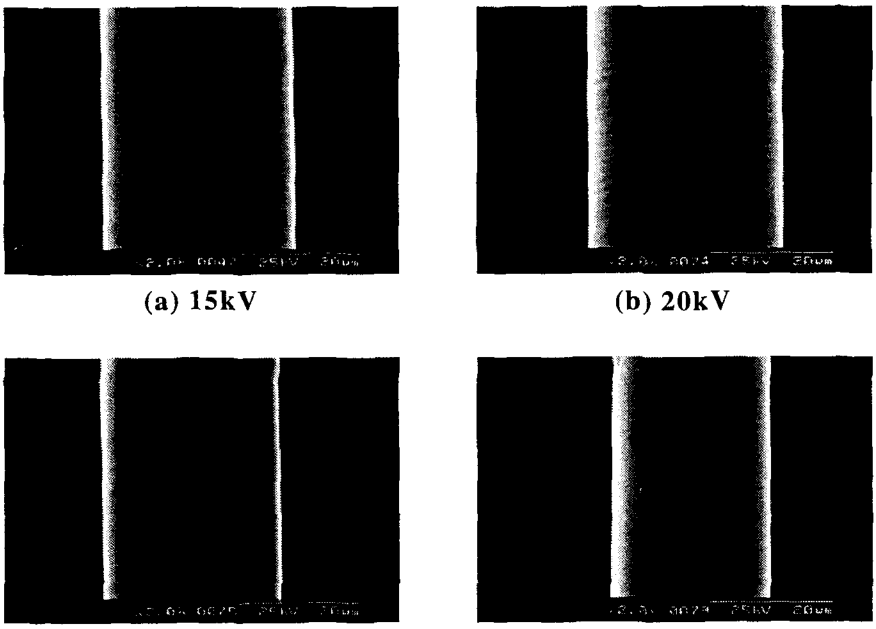
3.2 Morphological structure and diameter distribution

Morphological structure and diameter distribution of electrospun PET fibers by melt-spinning method were observed by SEM(X-650, Hitachi, Co., Japan) and the Image Analyzer(BMI plus).

4. Results and discussion

4.1 Morphological structure

Figure 2 shows the morphological structure of electrospun PET fibers with different electrical potential. PET fibers were spun filament shape rather than the spray shape which was formed usually electrospinning behavior. And the diameter of electrospun PET fibers generally decreased with increasing electrical potential. That was due to fiber drawing during spinning process by strong electrical force between the spinneret tip and collector.



(a) 15kV (b) 20kV

(c) 25kV (d) 30kV

Figure 2. SEM microphotographs of electrospun PET fiber by melt-type electrospinning with electrical potential.(×2000)

4.2 Spinning behavior

In particular, PET fibers were electrospun filament type by simply electrical force without the supply of air pressure. Also, the spinnability improved with increasing electrical potential. On the other hand, the spinnability decreased with increasing spinning distance due to the reduction of electrical force with increasing spinning distance. In this study, the suitable spinning temperature of electrospun PET fiber was 235 to 295℃ and electrospun PET fibers could not spin above 29 5℃, because of increasing the number of fiber breaks.

4.3 Diameter distribution

Figure 3 shows average diameter of electrospun PET fibers with different spinning condition. As the result, average diameter was steadily decreased with increasing the spinning temperature and the electrical potential. Whereas, with decreasing spinning distance the average diameter of PET fibers were increased.

That was due to fiber drawing with increasing the electrical force between spinneret tip and collector. And average diameter of electrospun PET fibers showed from 15 to 45㎛ ranges.

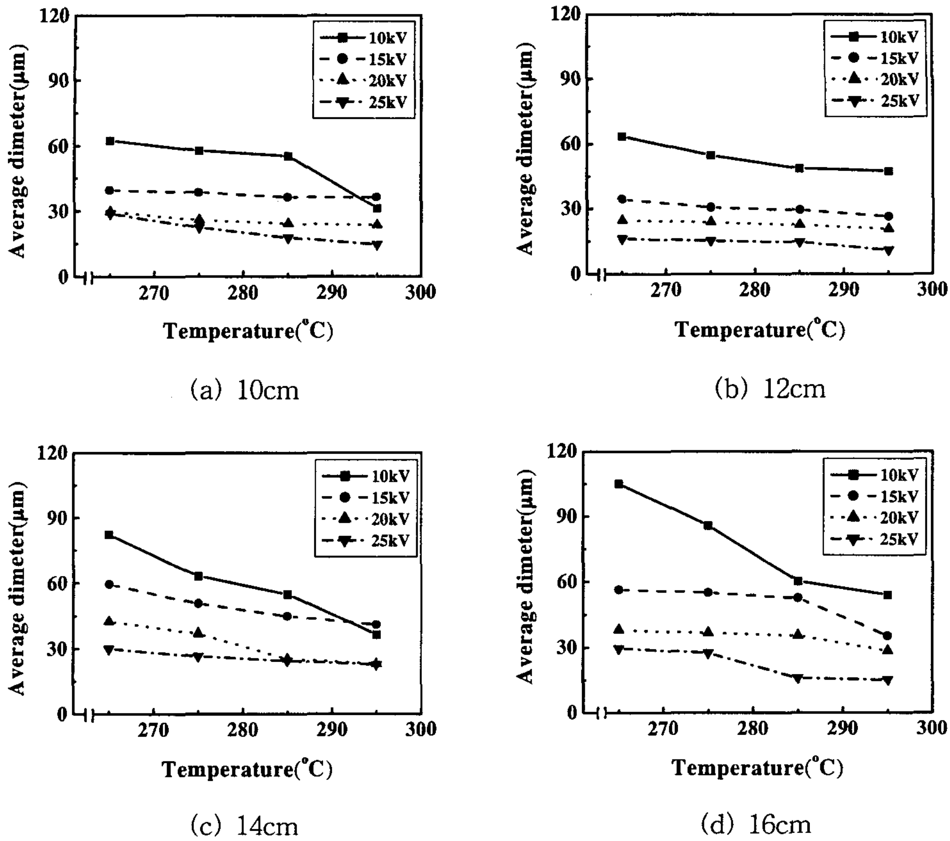


Figure 3. Effect of spinning temperature on the average diameter of electrospun PET fibers.

5. Conclusion

The melt-type electrospinning apparatus of lab-scale was newly designed and manufactured. As the result of the spinning behavior of the system, PET fibers were spun filament type rather than spray shape by only electrical force without external pressure. The fiber diameter of electrospun PET fibers were generally decreased with increasing electrical potential and spinning temperature. And the average diameter of electrospun PET fibers showed from 15 to 45㎛ ranges in this study.

6. References

1. G. Taylor, Proc. R. Soc. A. V(313), 453~475(1969)
2. L. Larrondo, St. John Manley R., J. Poly. Sci., Polymer Physics Edition, V(19), 909~920(1981)
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