

전기방사 나일론 66 섬유웹의 특성화

이영수, 최성신, 이충중*, 주창환
충남대학교 섬유공학과, *(주)크린에어테크놀러지

Characterization of Electrospun Nylon 66 Fiberwebs

Young Soo Lee, Sung Shin Choi, Chung Jung Lee and Chang Whan Joo
Department of Textile Engineering, Chungnam National University, Daejeon, Korea
*R&D Center, Clean Air Technology Corporation, Cheonan, Korea

1. Introduction

Nylon was the first commercialized synthetic fiber. It is a polyamide, derived from a diamine and dicarboxylic acid. The nylon fiber has outstanding durability and excellent physical properties such as stiffness, wear and abrasion resistance, friction coefficient and chemical resistance. Due to these properties of nylon 66, nano-sized fibers are produced by electrospinning method in this study. During the past years the nylon 66 fibers have been prepared by conventional melt spinning. This technique relies upon the pressure driven extrusion of a viscous polymer fluid and produce fibers that typically range from 10 to 500 μ m in diameter. But electrospinning is unique method as a fiber spinning process because it can produce fibers ranging from 50 to 500nm.¹⁾⁻³⁾ On the other hand, nanofibers produced by electrospinning method have the problem on the application of the filter media. Because the produced nylon 66 nanofibers have no self-bonding among the nanowebs. Thus, in this study, the microwave and ultrasonic bondings among the nonwoven bonding methods are used to improve bonding force in the fiber assemblies. As the result, we observed the morphological structure and investigated the bonding force and pore characteristics of the nylon 66 fiberwebs treated by high frequency.

2. Experimental

2.1 Thermal and viscosity properties

Thermal properties were carried out with Perkin-Elmer DSC 2910 instrument. About 5mg of samples was hermetically sealed in an aluminum pan for this measurement. The samples were heated from 0 to 200 $^{\circ}$ C at a heating rate of 20 $^{\circ}$ C/min. After nylon 66 solution was agitated for 24 hours, the viscosity of nylon 66 solution was measured every hour for 12 hours. The used viscometer was Model Viscostar-R type made by the Brookfield.

2.2 Preparation of sample

The fibers were electrospun from nylon 66 solution of 30wt.% with formic acid. Nylon 66 solution was fed at 2.3ml/h through a stainless steel syringe needle. Fibers were collected on the electrically grounded aluminum target placed below the syringe tip. The distance between syringe and target and electrical potential were 10cm and 35kV, respectively.

2.3 Fiber bonding treatment

The treatment time was 420, 540 and 660sec on the fiber bonding by using the microwave. On the other hand, Table 1 shows preparation condition of ultrasonic bonding process. The used frequency and feed speed were constant. On the other hand, to observe the bonding force, we changed pressure from 0 to 4.5bar.

Table 1. Ultrasonic bonding condition of nylon 66 nanowebs.

Frequency(kHz)	Feed speed(cm/min)	Pressure(bar)
15	50	3.0
		3.5
		4.0
		4.5

2.4 Morphological structure

The surface morphology of electrospun fibers was observed by scanning electron microscope (SEM, Hitachi S-2350). And the diameter of nylon 66 fibers was measured by Kanscope program.

2.5 Physical properties

The bonding force of produced samples was performed with tensile tester(Instron 4467). The sample size was 15mm×50mm. Crosshead speed was 8mm/mim, and the used load cell was 5kgf.

2.6 Air permeability and pore size

Capillary flow porometry(CFP-34RTE-3A-3-6-14, Porous material. INC) used to analyze the pore structure. The pore size, air permeability and pore distribution of fiberwebs were determined by the measured data.

3. Results and discussion

3.1 Effect of the microwave

Figure 1 shows the morphological structure of nylon 66 nanosized fiberwebs bonded by dielectric heating. In case of the untreated sample, there is nearly no self-bonding in the nylon 66 fiberwebs. When the treatment time increased, bonding region of the fibers steady increased. These results are due to melt of fiber surface by microwave heating. Figure 2 shows the stress-strain curves of nylon 66 fiberwebs. When the treatment time increased, the bonding force increased. The maximum bonding force at 660sec was 2 times higher than that of untreated sample. But, the breaking strain at 660sec reduced because the debonding immediately appeared on reaching the maximum stress.



Figure 1. Microphotographs of dielectric bonded nylon 66 nanosized fiberwebs.
(a: untreated, b: 420sec, c: 540sec, d: 660sec)

3.2 Effect of the ultrasonic

Figure 3 shows the morphological structure of nylon 66 nanowebs according to applied pressure. As the pressure was increased, the bonding region increased. Specially, at the pressure of 4.5bar, the bonded area formed nearly film-like shape. On the other hand, the hole is generated

on the nanoweb at the pressure above the 4.5bar. Figure 4 shows stress-strain curves of untreated and treated samples by ultrasonic bonding. As the applied pressure raised up to 4.5bar, stress and strain increased.

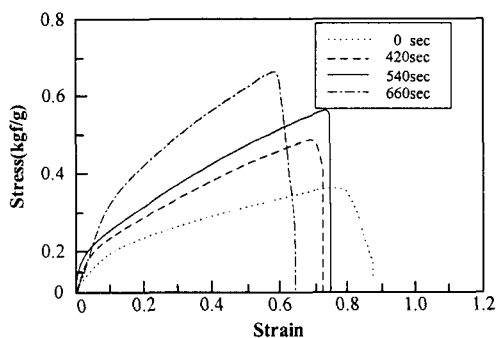


Figure 2. S-S curves of nylon 66 nanosized fiberwebs by dielectric heating.

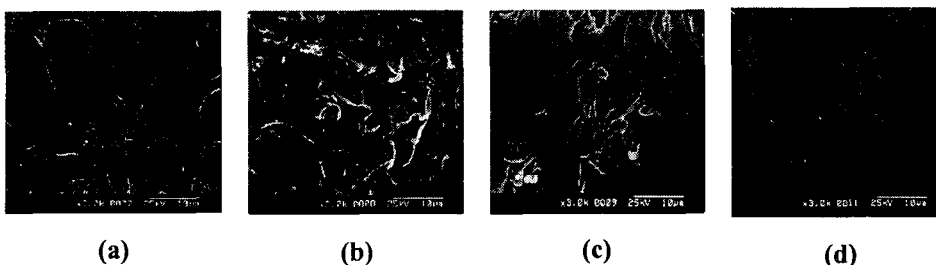


Figure 3. Microphotographics of the bonding area with different pressure. (a: 3.0bar, b: 3.5bar, c: 4.0bar, d: 4.5bar)

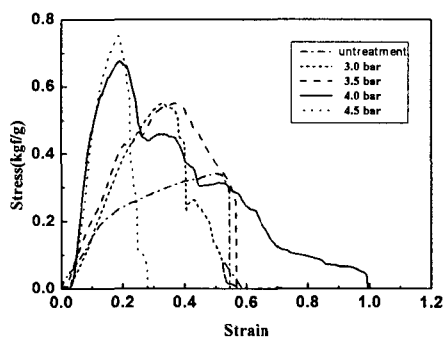


Figure 4. S-S curves of nylon 66 nanosized fiberwebs by ultrasonic method.

3.3 Air permeability and pore size

Table 2 shows the air permeability and pore size of the base material (PP meltblown) and nanoweb/MB nonwoven produced by electrospinning on the PP meltblown during the 300sec. The treatment time of microwave bonding was 660sec and applied pressure on ultrasonic bonding was 4.5bar. The air permeability decreased a little due to the formation of fiberwebs network. The air permeability of nanoweb/MB nonwovens bonded by ultrasonic techniques is $15.5\text{cm}^3/\text{cm}^2/\text{sec}$ smaller than that of other samples. On the other hand, Figure 5 shows the pore size distribution

of produced sample with various bonding techniques. In case of the untreated nanowebs/MB, pore size distribution is very broad because it is easy to tear by the used air flow on the pore size experiment owing to no bonding in the fibers. Also, the mean pore size of the untreated nanowebs/MB was $12.6\mu\text{m}$ but that of the produced nanowebs/MB by ultrasonic bonding was the smallest $4.3\mu\text{m}$ due to the formation of the strong bonding at the interface between nanoweb and PP meltblown.

Table 2. The air permeability and pore size of nanowebs/MB nonwoven.

Classification	PP meltblown			Untreatment			Microwave			Ultrasonic		
Air permeability ($\text{cm}^3/\text{cm}^2/\text{sec}$)	31.2	28.6	30.4	22.2	22.5	21.6	18	19.8	20.6	15.7	14.2	16.7
Pore size(μm)	18.2			12.6			8.1			4.3		

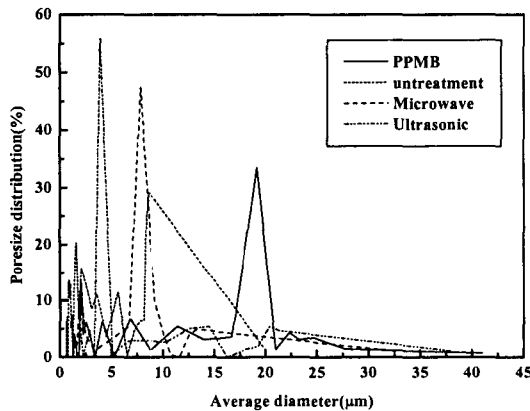


Figure 5. The pore size distribution of nanowebs/MB nonwovens with different treatments.

4. Conclusions

1. The nylon 66 nanosized fiberwebs were bonded by microwave and ultrasonic techniques. The bonding force of fiberwebs by the microwave method has about twice greater than untreated fiberwebs. On the other hand, the bonding force by the ultrasonic method has about three times greater than untreated fiberwebs.

2. The air permeability of nanowebs/MB by ultrasonic and microwave treatments is smaller than that of the untreated nanowebs/MB due to the strong bonding in the fiberwebs.

3. The pore size of nanowebs/MB remarkably reduced by ultrasonic and microwave treatments and their pore size distributions are narrow due to the formation of fiberwebs network.

***Acknowledgement:** This study was supported by Clean Air Technology Co. Funds.

5. References

1. H. Fong, I. Chun and D. H. Reneker, *Polymer*, V(40), 4585~4592(1999)
2. Buer, A., Warner, S., *Textile Research Journal*, V71, 323-328(2001)
3. I. D. Reneker and M. Shaker, *Synthetic Metals*, V(114), 109~114(2000)