Development of Nonwoven from Fibrillated PVA

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1. INTRODUCTION

Polyvinyl alcohol (PVA) has been a popular subject for researchers due to its superior properties such as water-solubility and high strength. Recently PVA is used to produce fibrillating fiber, which was already patented. However, the effects of solution and spinning conditions had not been researched in systematical manner.

In this study, the optimum condition for the fibrillation was studied.

2. EXPERIMENTAL

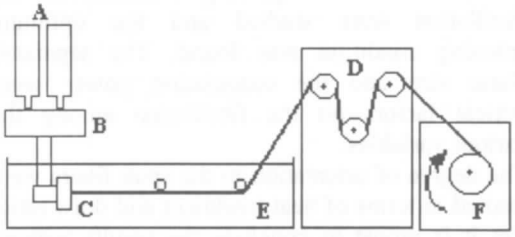
2.1 Material

In this study, two kinds of PVA (polyvinyl alcohol) were used for spinning solution. The major properties of the PVA were summarized in Table 1.

	Degree of Polymerization	Degree of Saponification
PVA I	500	96 mol %
PVA II	1000	96 mol %
PVA III	1000	86 ~90 mol %
PVA IV	2600	99.4 mol %

2.2. Spinning Apparatus

Figure 1 shows the spinning machine used in the study. All parts were kept at 90 °C during the spinning process. Methanol was used for coagulation solution. The temperature of the coagulation bath was controlled with several levels (-30, -40 °C and room temperature).



A: Spinning solution reservoir, **B:** Gear pump, **C:** Nozzle, **D:** Feed roller, **E:** Coagulation bath **F:** Winding roller

Figure 1. Apparatus of Spinning Machine

2.3. Spinning Solution

The spinning solution was made from the mixture of the two PVA's with several blending ratios. The mixtures of the polymer powders were solved in water using Autoclave at 90 °C for 2 hours. The solution was kept for over-night at 90 °C before the spinning.

2.4 Spinning conditions

Gel Spinning

Polymer : PVA I and PVA II
Bath temperature : -30, –40 °C
Solution concentration : 20, 25 and 30 %
Ratio of PVA I to PVA II : 0, 10, 20, 30, 40, 100 %

Wet spinning

Polymer : PVA III and PVA IV
Bath temperature : room temperature
Solution concentration : 20, 25 and 30 %
Ratio of PVA III to PVA IV : 20, 25 %
Concentration of DMSO : 0, 20, 30 40 %

3. RESULTS AND DISCUSSION

3.1 Preliminary experimental results

Several spinning conditions were examined to find out the optimum condition for fibrillation. However, most of the spinning condition did not showed satisfactory fibrillation. When the temperature of the coagulation bath was set at –30 and –40 °C, the spun fiber was frozen into solid state. However, due to the low coagulation power, the solvent (water) in the fiber could not be extracted enough to solidify the fiber. The fiber turns into a gel state solution under room temperature.

To improve the coagulation power, the solution was spun into the bath at room temperature. However still the spun fiber did not show fibrillation either. We assumed that the phases of each PVA's were not separated into adequate size. The size of separated phase need to be controlled for fine fibrillation.

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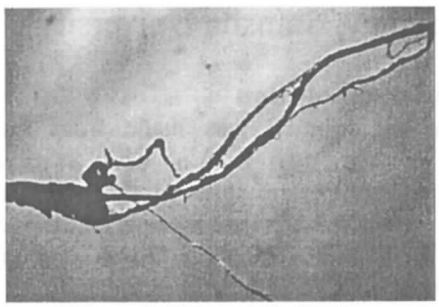

Figure 2. Fiber Fibrillation

The optimum condition found is
Solution concentration : 25 %
PVAIII / PVA IV : 30/70
Bath temperature : room temperature
DMSO concentration : 20%

3.2 Phase separation

Figure 3 showed a microscopic photo of phase separation. To figure out the phase separation, the film was cast from the spinning solution and methanol and heat were treated. That resulted that the solubility of PVA III gets lower than PVA IV in the film. When water was treated, the PVA IV was solved out, that could be observed using microscopy.

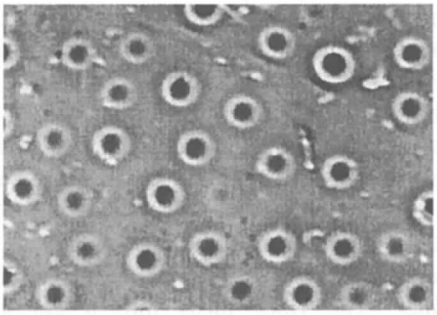

Figure 3. Phase Separation of PVA Film

3.3 Degree of Orientation

Table 2 shows the effects of draw ratio and heat treatment condition on the fiber diameter and the degree of orientation. It is inadequate to withdraw conclusion from the result because the data were measured one time. Nonetheless, it was found that the diameter decreased with draw ratio, while the birefringence index increased.

The effect of heat treatment on the degree of orientation could not be explained yet. Further study need to carry out for more

Table 2. Effects of Heat treatment of degree of orientation

Temp. (°C)	Time (min.)	Draw ratio	d (μm)	Δn
90	1	x1	382.2	0.801
		x3	269.5	NA
		x5	156.8	NA
	3	x1	377.3	1.31
		x3	215.6	7.41
		x5	171.5	NA
	5	x1	372.4	1.31
		x3	147	10.27
		x5	196	NA
120	1	x1	335.1	0.84
		x3	259.7	7.75
		x5	191.1	NA
	3	x1	284.2	1.79
		x3	249.9	8.00
		x5	161.7	NA
	5	x1	318.5	1.86
		x3	245	7.54
		x5	161.7	NA
180	1	x1	294	4.06
		x3	196	11.37
		x5	186.2	NA
	3	x1	313.6	3.49
		x3	279.3	8.61
	5	x1	196	NA
Without heat treatment		x1	284.2	0.50
		x3	220.5	6.96
		x5	225.4	NA

4. CONCLUSIONS

The effects of the spinning condition on the fibrillation were studied and the optimum spinning condition was found. The separated phase size and the coagulation power seem critical factors on the fibrillation among the various variables.

The degree of orientation in the spun fibers were studied in terms of heat treatment and draw ratio. Yet it is unjust to conclude the results without further study.