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Study on the Characteristics of PP/PET Blended Nonwovens Produced by Needle-punched Methods

권 오 혁, 이 래 연, 주 창 환
충남대학교 섬유공학과

1. INTRODUCTION

Among the production technologies of nonwoven fabrics, a needle punching technique has one of the long history and holds still important place[1~2]. At the present time, it is used not only for scrimming with woven or knitted fabrics and other nonwoven fabrics, but also for applying the special fibers blending nonwovens at the web forming process in order to manufacture economical and high value added-products such as home furnishing, industrial and technical purpose[3~4]. However, in recent, the raw material of nonwoven fabrics is limited to use PP or PET fibers. There is a few study about blending with functional fibers and it is necessary to study these fibers for applying the requirement of special end-uses, such as separation, filtration, heat insulation, and reinforcement etc[5].

In this study, we have experimentally examined the effect of blend ratio between PP fibers and three functional PET fibers on the dimensional and structural properties of nonwovens. And, by varying only a parameter in needle punching, it is very difficult to achieve the thickness and air permeability of products according to the required specifications[6]. Thus we have heat treatment with two calendering conditions using PP/LM, PP/SD blending needle-punched fabrics. And then compared with and without heat-treatment blending needle-punched fabrics on the view point of thickness, pore diameter and air permeability.

In addition, we have analyzed the blending needle-punched fabrics and PP100 needle-punched fabric with the view points of basic properties(thickness, basic weight(GSM)), tensile properties, pore diameter and air permeability to observe the effect of functional fibers blending.

2. EXPERIMENTAL

2.1 Materials and production condition

The features of PP and three functional PET fibers such as BP, LM, SD fibers used in this study were given in the Table 1.

Table 1 Sample identification

Sample fiber		Sample ID	Fineness (denier)	Fiber length (mm)
PP fiber		PP	2	47.5
PET	Anti-bacterial fiber	BP	6	41
	Low melting fiber	LM	4	51
	Stretch fiber	SD	2.5	51

For manufacturing the blending needle-punched fabrics with different blend ratio of PP and PET fibers such as 85/15, 70/30, 55/45, the fibers were opened in a blender followed by intermediate opener and stored in a mixing bin. After storing in the mixing bin, the materials were fed to the worker-stripper type card via a chute feeding system. Then the webs were cross-lapped and needled. Needle punching line was arranged in such a way that the 1st, 2nd, and 4th punching machines are placed to needle punching from the top side downwards and the 3rd punching machine is placed to needle punching from bottom upwards. In addition, the heat-treatment of needle-punched fabrics blended PP fibers with LM fibers and SD fibers on the calender rollers was carried out at the two conditions(120℃ and 128℃), respectively.

2.2 Structure and property tests

We observed the cross section of raw materials with optical microscope extended 500 times. Also, the needle-punched fabrics were dyed with Resolin Blue BGLS® to observe the blended PET fibers.

The blending needle-punched fabrics were tested in terms of thickness, basic weight(GSM), breaking stress, breaking strain, pore diameter, and air permeability according to the ASTM standard procedures.

The pore characteristics of needled fabrics, such as maximum, minimum and mean pore diameter, were tested with PMI Automated Perm-porometer(Porous materials Inc.) tester using ethyl-alcohol as a wetting liquid. And air permeability was measured to use Frazier type(Model: AP-360) tester.

3. RESULTS AND DISCUSSION

The cross section of all raw material fibers is circular except LM fibers which have the bicomponent structure in ellipse cross section; The core part was composed of common PET while the sheath part is low melting point PET.

Figure 1 shows photographs for the surface view of PP/SD needled fabrics with different blending condition. Observing the photographs of each blending condition, we found that PP and PET fibers were blended homogeneously at each blending condition.

(a) PP100 (b) PP/BP(85/15) (c) PP/BP(70/30) (d) PP/BP(55/45)

Figure 1 Photographs for surface view of PP/SD fabrics with different blend ratio.

In the result of needle-punched fabrics with different fiber blends, both weight per unit area and thickness were obtained slightly higher than PP100. However, when the blend ratio of functional PET fibers was increasing, there was no high variation in them. But after heat-treatment with calender rolls, fabric density of needle-punched fabrics increased with increasing PET fibers content. Therefore, calendering of the needle-punched material is regarded to be helpful in achieving the compactness and fabric density.

Tensile properties show that breaking stress at the cross direction(CD) has higher than at the machine direction(MD). Because the blended fabrics were prepared using cross-lapping process where more fibers were oriented towards the cross direction. Then, less resistance was offered to inter-fibers movements in machine direction. Figure 2 shows the tensile curves of LM fibers blended nonwoven fabrics. Breaking stress and breaking strain have decreased with increasing blend ratio.

Figure 3 represented the variation of breaking stress at 120℃ and 128℃ calendering conditions in the case of the LM fibers, breaking stress has highly increased with the calendering.

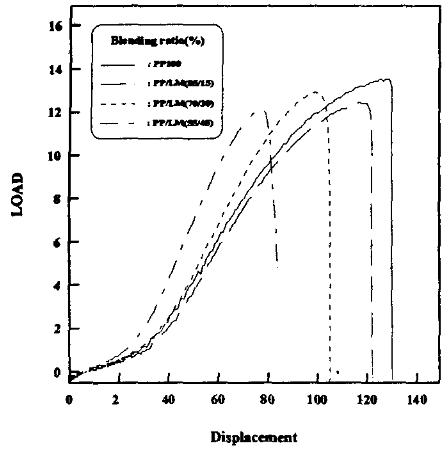

Figure 2 Load-extension curves of PP/LM on needle-punched fabrics with . different blend ratio.

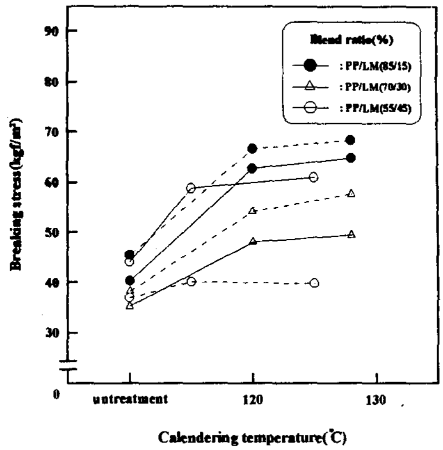

Figure 3 Effect of calendering temperature on the breaking stress of nonwovens with PP and LM blended fibers.
MD: ———— CD: - - - - - -

Also, with the increase of calendering temperature, breaking stress was slightly changed and breaking strain tended to decrease; This explained the breaking stress with the calendering condition made to improve the inter-fibers compactness, but partly the inter-fibers melting made the connection with fiber to fiber and breaking strain has lower.

The mean pore diameter increased with blend ratio in the needle-punched fabric with PP/BP and PP/LM as shown in Figure 4. But, pore diameter of PP/SD nonwoven fabrics increased slightly. This noted the effect of the blending fibers. BP and LM fibers had a larger denier than PP fibers, but SD fibers had similar denier with PP fibers.

Figure 5 represented the effect of the mean pore diameter with the calendering conditions in the case of PP/LM nonwoven fabrics.

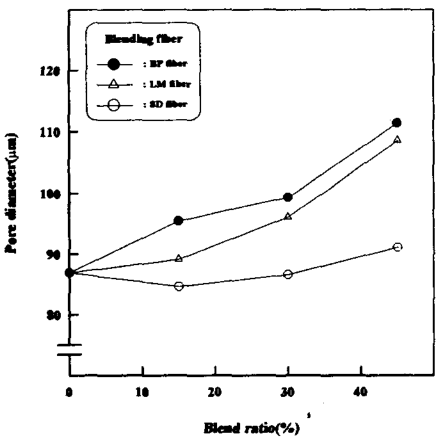

Figure 4 Pore diameter of the nonwoven fabrics made from PP and variable PET fibers.

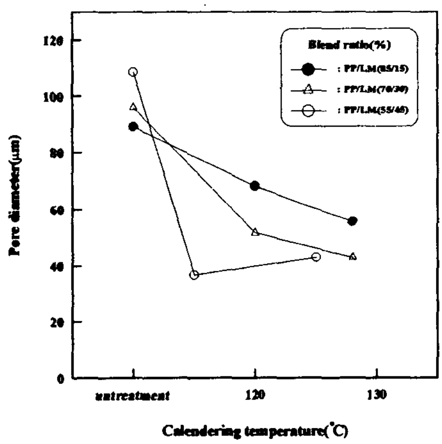

Figure 5 Effect of calendering temperature on the pore diameter of nonwovens with PP fibers and LM fibers.

When the blend ratio of LM fibers was higher, the mean pore diameter was highly decreasing. This showed that the assembly of fibers had more packed because the PET fibers were partly melting and the pore diameter was lower.

Therefore, calendering helps greatly in achieving the specification in respect of pore diameter and air permeability. However, the pore diameter and air permeability increased after high temperature calendering condition. Because during the calendering individual fibers shrinks in the fabric and creates more voids in the structure, then there by increasing the air permeability. In addition, we can find that the pore diameter and air permeability showed a close interrelations.

4. CONCLUSION

We had investigated the effect of fiber blend ratio on the properties of PP100 and three functional PET blended nonwoven fabrics manufactured by a needle punching machine, and also calendered in the two conditions with PP/LM, PP/SD blended nonwoven fabrics. From this study, the following results can be obtained:

1) Fabric density of needle-punched fabrics with increasing blend ratio of PET fibers had little change and when PP/LM, PP/SD needled fabrics calendered in two conditions, the fabric density had rapidly increased.
2) Breaking stress and strain in the tensile experiment showed higher values at the cross direction than at the machine direction. And with increasing the blend ratio of PET fibers, the breaking stress and strain of blending needle-punched fabrics generally showed lower than PP100 condition. However, in the case of calendered nonwoven fabrics, breaking stress increased and breaking strain decreased.
3) With the increase of blend ratio in BP and LM fibers, pore diameter and air permeability of PP/BP, PP/LM nonwoven fabrics have increased. And, in the case of calendered nonwoven fabrics, two properties have a decreasing trend.

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