

The Extraction of Co-PET from Non-Woven Fabrics of Nylon/Co-PET Sea-island Type Composite Microfiber

Myung Soo Park¹⁾, Jong Ho Yoon²⁾ and Dae Hyun Cho³⁾

1) Dept. of Textile & Fashion, Kyungil University, Kyungsan, Korea

2) Dept. of Industrial Chemistry, Kyungil University, Kyungsan, Korea

3) Taegu Metropolitan City, Daegu, Korea

Abstract : To find a suitable condition in this process examined, we investigated the main control factors, such as, the NaOH concentrations, such as, the NaOH concentrations, the heat treating times, and the heating temperatures. The resulting mechanical properties of the fabrics also studied. The samples used were Nylon/Co-PET sea-island type composite microfiber (Co-PET content: 35%) non-woven fabric. The conclusions obtained were as follows. 1. For the complete extraction of Co-PET from the sample non-woven fabric in the dry hot air process, 160°C of air temperature, 15 min. of treatment time, and around 30% of NaOH concentration were required. On the other hand, in the wet hot air process, 140°C of air temperature, 3.5 min. of treatment time, and around 30% of NaOH concentration were required. 2. The mechanical properties of the continuous processed samples showed that the WT, B, and WC increased with increasing the weight reduction ratio. However, the G, decreased with increasing the weight loss ratio. Note that, particularly in B, it increased drastically when the weight deduction ratios exceeded 30%. 3. As increasing the wet hot air temperature from 130 to 140°C, B appeared to increase, however, WT, G, and WC appeared to decrease. 4. The best condition found in this continuous process to extract Co-PET is the wet hot air temperature of 140, NaOH concentration of 28% or above, and the treatment time 2-4 min.

Key words : Co-PET extraction, microfiber, WT(tensile energy), RT(tensile resilience), B(bending rigidity), weight reduction

INTRODUCTION

Natural suede has been known to have many excellent physical properties in, such as, the tactility, the durability, and the insulation, and even in the appearance. Therefore, natural suede has a great value as a material for closing as well as many non-closing products. Nonetheless, natural suede has various shortcomings. It is easily contracted decolorized after washing and hardened by heat. Above all, particularly in these days the production as well as the finishing of natural suede has been considered as environmental pollution related industries. As such, a demand to substitute natural suede has appeared. Studies to substitute natural suede have been done particularly in these twenty years. As a result in Japan they now commercially produce man made suede.

They are making the man made suede with synthetic fibers such as PET/Co-PET and Nylon/Co-PET sea-island type composite microfiber. They are easier to care, lighter than natural suede. In Korea they also have developed a technology to produce man made suede with syn-

thetic fiber. However, the technological level is not satisfactory in comparison to that in Japan.

The sea-island type composite microfiber, which is the main material to produce man made suede, has the cross-section structure as follows. In the structure several islands of one component embedded within a sea of another component. As an island component PET or Nylon is used and as a sea component Co-PET is generally used (Okamoto, 1993). Non-woven fabrics is made by needle punch of the composite microfiber, followed by chemical extraction of Co-PET. In fact, only after the extraction of Co-PET, Nylon or PET, the sea component is microfibrized.

The chemical extraction of Co-PET is generally performed by using a NaOH solution. Most widely accepted Co-PET extraction process is the non-continuous batch process performed in NaOH bath (Okamoto, 1993). However, the use of the batch process, particularly for non-woven fabrics, has some disadvantage. Because of the heavy nature of the non-woven fabrics and the discontinuous nature of the batch process, the productivity is too low and the even control of the quality become very difficult.

In order to avoid the disadvantage, we examined the possibility of using a continuous Co-PET extraction process. With the continuous Co-PET extraction process we expect to increase the productivity and control the prod-

Corresponding author; Myung Soo Park
Tel. +82-53-850-7205, Fax. +82-53-850-7605
E-mail: mspark@bear.kyungil.ac.kr

uct with ease. To find a suitable condition in this process examined, we investigated the main control factors, such as, the NaOH concentrations, the heat treating times, and the heating temperatures. The resulting mechanical properties of the fabrics processed by the continuous process were also examined. Examined were the tensile properties, the bending properties, the shearing properties and the compressional properties.

EXPERIMENT

Preparation of sample non-woven fabrics

The non-woven fabric samples used for the continuous process were 30×350 cm in size cut from a supplied non-woven fabrics (needle-punched, thickness: 1.3 mm, width: 152 cm, density 320 g/m²). The non-woven fabrics is composed of a Nylon/Co-PET (Co-PET content: 35%) composite microfiber. For the physical property examination the processed non-woven fabric samples were cut into 20×20 cm in size.

Extraction of Co-PET

In order to simulate the extraction of Co-PET in a continuous process we used a padding extraction apparatus designed by us shown in Fig. 1. As can be seen in Fig. 1 the samples were continuously padded and bathed in NaOH solution.

In order to increase the extraction efficiency we adopted 4 nip system. After bath in the apparatus, the samples were continuously heat treated in a curing machine. The NaOH solutions used were 16, 20, 24, 28, 32, and 34%. The padding nip pressure used was atmospheric pressure. For the heat treatment we cut the processed samples into 30×35 cm each and applied dry hot airs and wet hot airs (steam; RH 70%). The dry hot airs used were 140, 150 and 160°C and the wet hot airs used were 120 and 130. The heat treating times were 5~10 min. in the dry hot air case and 2~10 min. in the wet hot air case. Fact is that during this heat treatment most of Co-PET is chemically extracted. After the extraction we finished the sample fabrics by neutralizing in a weak acid

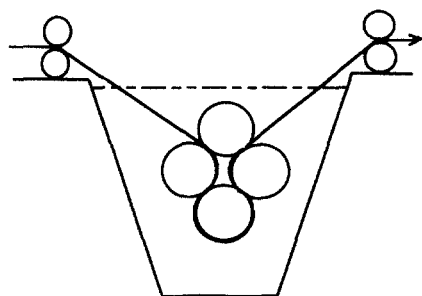


Fig. 1. Testing of padding (4 nip) apparatus.

solution and washing. The finished samples were then dried at 80°C for 1 hr. and kept on silicagel for 48 hrs. for the complete dryness. The Co-PET extraction ratios were estimated by weighing the weight loss ratio of the samples according to the weight loss equation

$$\text{Weight loss(\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

W_1 = Original sample weight

W_2 = Finished sample weight

The surface states of sample

The Co-PET extracted states of the finished sample surfaces were observed by polar microscope (CARL ZEISS, X 200).

The measure of the mechanical properties

The mechanical properties of the finished non-woven fabric samples were measured according to KEB-FB method (Kawabata, 1975; Kawabata, 1980). The measured were the tensile properties, the bending properties, the shearing properties and the compressional properties.

RESULTS AND DISCUSSION

Co-PET extraction

In Fig. 2, the weight loss ratio (thus, Co-PET extraction ratio) changes of the sample with respect to the heat treatment time at various NaOH concentrations and under various temperatures (a: 140°C, b: 150°C, c: 160°C) of dry hot air were shown. The general trend is that the weight reduction ratios increase with increasing the treatment time and the increment is more significant with increasing the NaOH concentration and the temperature. However, in the data set of over 10 min. of treating time and under 160°C of dry hot air condition, the increasing trend obviously diminished. This diminish seemed due to the almost completion of the Co-PET extraction from the samples. From this, we may state that in the dry hot air treatment process the necessary condition for the complete removal of Co-PET from the sample fabric is 160°C of air temperature, 15 min. of treatment time, and around 30% of NaOH concentration.

In Fig. 3, similar data sets but treated under wet hot air (a: 130°C, b: 140°C) conditions were shown. The general trend of the weight loss ratio changes is very much alike with Fig. 2. However, the obvious diminish of the increase of weight loss ratio appeared in a rather milder conditions. Under 130°C of wet hot air condition it appeared from around 5 min. of treatment time. And under 140°C condition it appeared from as early as 2.5 min. of treatment time. From this we noticed that the necessary condition for the complete removal of Co-

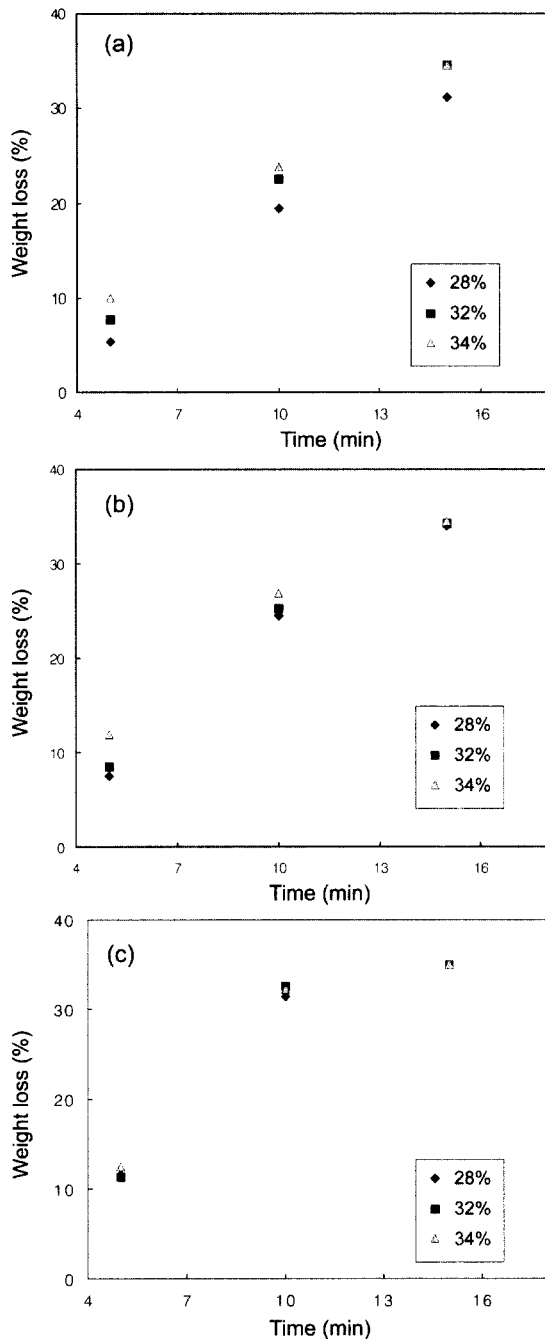


Fig. 2. Weight loss of sample against treated time at various concentration of NaOH in dry-hot air apparatus. (a) 140°C; (b) 150°C, (c) 160°C

PET from the sample fabric in the wet hot air treatment process is 140°C of air temperature, 3.5 min. of treatment time, and around 30% of NaOH concentration.

The surface state

In Fig. 4~6, the surface states of the sample non-woven

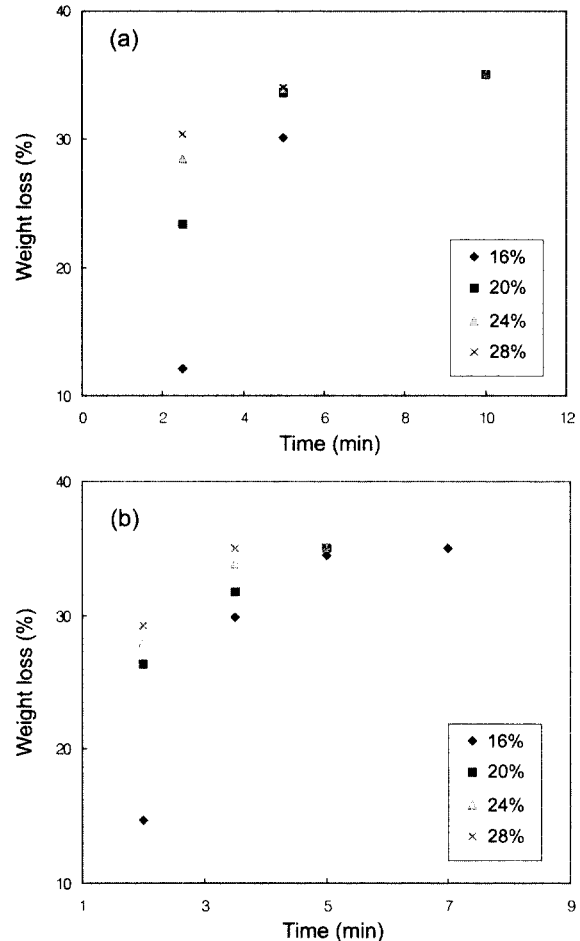


Fig. 3. Weight loss of sample against treated time at various concentration of NaOH in wet-hot air apparatus. (a) 130°C, (b) 140°C

fabrics at various weight loss ratios (0~35%) were shown. As can be seen in these figures, the island components, i.e., Nylon, gradually exposed to form to their microfibr state as the sea component Co-PET is extracted from the original composite fiber with increasing the weight loss ratio. In Fig. 6-b, at 35% of weight loss ratio, one visually can see the complete microfibrized state of the non-woven sample fabrics. One thing to note here is the appearance of many crimps on the exposed microfibr in Fig. 6, which are absent in Fig. 4 and 5. in the lower weight loss ratio cases. The crimps seemed to appear because the completely exposed microfibr is under heat.

The tensile property

Fig. 7 showed the tensile energy (WT) change with respect to the change of the weight loss ratio. As can be seen in Fig. 7, WT increased with increasing the weight loss ratio. This tendency seemed due to the

Fig. 4. Microphotograph of sample.
(a) untreated sample, (b) weight loss 5.4%

increased number of crimps, which may tangle the exposed microfiber each other and required some excess WT (Dringra, 1981; Dringra, 1989). Comparing 130°C data with 140, one easily notices that WT under 130°C is slightly higher than that under 140°C. One should notice that the fabrics treated under 130°C had been tolerated some longer heating time more crimps were formed. The rather steep increases of WT under 140°C from the weight loss ratio of 30% also believed to be the same reason.

Fig. 8 showed the tensile resilience (RT) change with respect to the change of the weight loss ratio. Here, it clearly showed that RT decreased with increasing the weight loss ratio. This RT tendency is due to the consumed excess WT due to the crimps. It is believed that the excess WT due to the crimps is not recoverable. Therefore, the 130°C treated samples has less RT than 140°C treated samples. This means the samples treated under 140°C is more stable in RT.

The bending property

Fig. 5. Microphotograph of sample.
(a) weight loss 13%, (b) weight loss 24%

In Fig. 9, the bending rigidity (B) changes with respect to the weight loss change were shown. In Fig. 9, it clearly showed the increasing tendency of B with increasing the weight loss ratio. From the weight loss 25% a drastic increase of B is observed. When the weight loss exceeds 25% it is believed that a significant amount of microfiber is exposed from the composite fiber. The exposed microfiber under heat may cause the contraction of the microfiber to increase the stiffness. Moreover, the increased number of microfiber may create many folding contact points. It is believed that these two effects together may give rise to the drastic increase of B over the weight loss of 25%.

In Fig. 10, the hysteresis of bending moment (2HB) change with respect to the weight loss ratio change. As shown in Fig. 10, 2HB increases with increasing the weight loss ratio. When the weight loss ratio exceeds 25% the increase of 2HB is not significant. Under 130°C 2HB values appeared slightly higher than under 140°C 2HB values. This seemed related to the appearance of the crimps, which cause many slip phenomena between exposed microfiber (Postleand Jong, 1981).

Fig. 6. Microphotograph of sample.
(a) weight loss 30%, (b) weight loss 35%

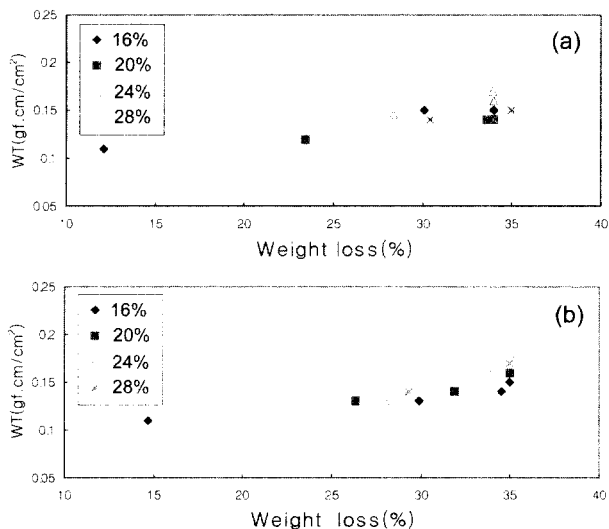


Fig. 7. Tensile energy (WT) of sample against weight loss at various concentration of NaOH in wet-hot air apparatus.
(a) 130°C, (b) 140°C

Shearing property

In Fig. 11, the shear stiffness (G) change with respect to the

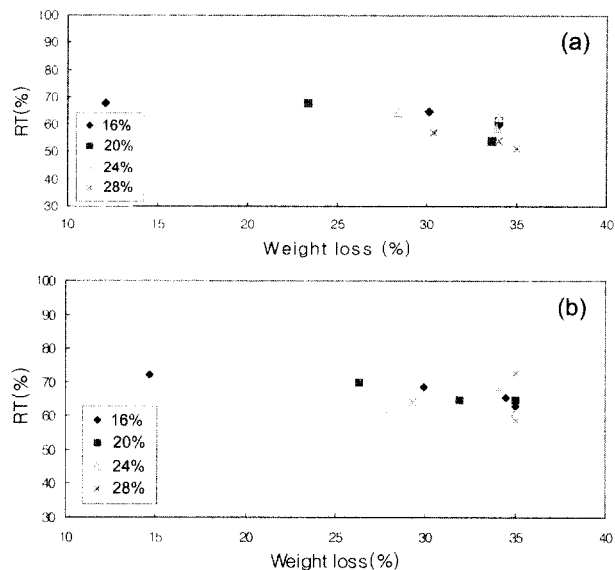


Fig. 8. Tensile resilience (RT) of sample against weight loss at various concentration of NaOH in wet-hot air apparatus.
(a) 130°C, (b) 140°C

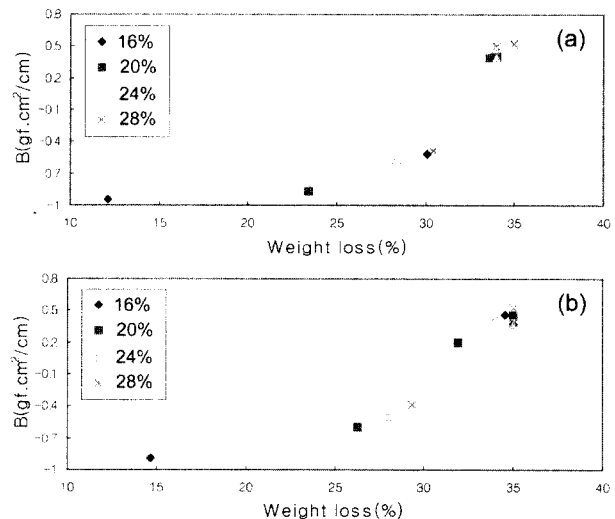


Fig. 9. Bending rigidity (B) of sample against weight loss at various concentration of NaOH in wet-hot air apparatus.
(a) 130°C, (b) 140°C

weight loss ratio change is shown. As shown in Fig. 11, G decreased with increasing the weight loss ratio and G under 130°C is higher than that under 140. It is obvious that the fineness (denier) of the fiber become higher at higher weight loss ratios (Shelton, 1976). This supplied many free spaces between microfibrils in the non-woven fabrics to decrease G. Under 140°C G values were found to be more stable than 130°C values to the change of the weight reduction ratio.

Compressional property

In Fig. 12, the compressional energy (WC) changes due

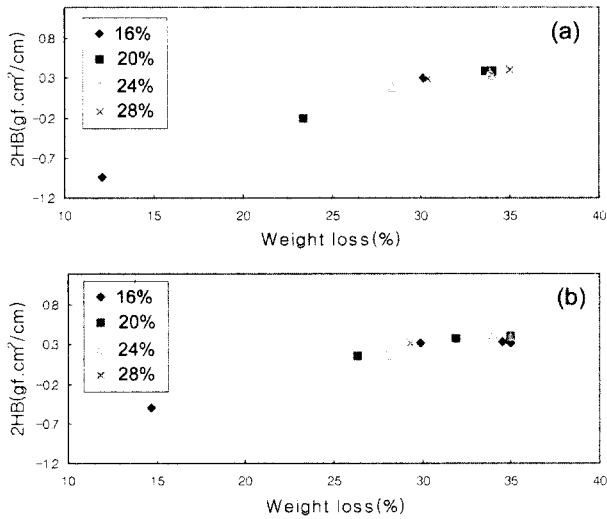


Fig. 10. Hysteresis of bending moment(2HB) of sample against weight loss at various concentration of NaOH in wet-hot air apparatus. (a) 130°C, (b) 140°C

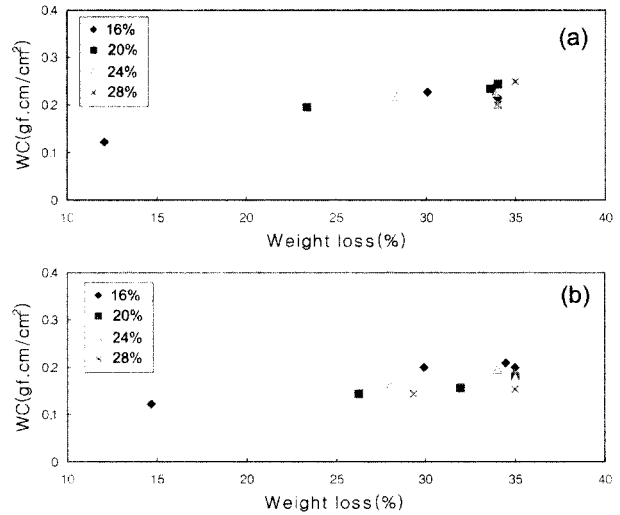


Fig. 12. Compressional energy (WC) of sample against weight loss at various concentration of NaOH in wet-hot air apparatus. (a) 130°C, (b) 140°C

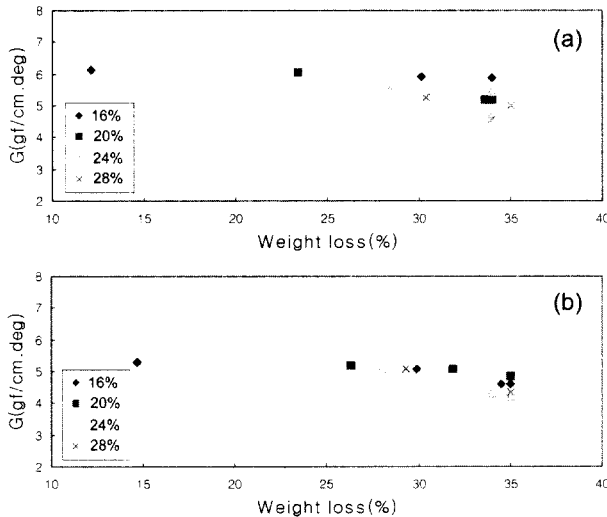


Fig. 11. Shear stiffness (G) of sample against weight loss at various concentration of NaOH in wet-hot air apparatus. (a) 130°C, (b) 140°C

to the change of the weight loss change were shown. As was shown in Fig. 12, the WC increases with increasing the weight loss ratio. This is due to the appearance of sift and bulky microfiber at increased weight loss ratios. Under 130°C WC values were appeared relatively higher that those under 140°C.

CONCLUSIONS

In this study we suggested a continuous Co-PET extraction process by using a padding extraction apparatus in

making a man made suede. It is believed that the use of the continuous process may have several advantages in comparison to the existing non continuous batch process in extracting Co-PET from the non-woven fabric which is an essential technique in making a man made suede, for the increased productivity, the better quality products, the saving of energy, and the reduction of the waste water.

The samples used were Nylon/Co-PET sea-island type composite microfiber (Co-PET content: 35%) non-woven fabric.

To find a suitable condition in this process examined, we investigated the main control factors, such as, the NaOH concentrations, such as, the NaOH concentrations, the heat treating times, and the heating temperatures. The resulting mechanical properties of the fabrics also studied. The conclusions obtained were as follows.

1. For the complete extraction of Co-PET from the sample non-woven fabric in the dry hot air process, 160°C of air temperature, 15 min. of treatment time, and around 30% of NaOH concentration were required. On the other hand, in the wet hot air process, 140°C of air temperature, 3.5 min. of treatment time, and around 30% of NaOH concentration were required.

2. The mechanical properties of the continuous processed samples showed that the WT, B, and WC increased with increasing the weight reduction ratio. However, the G, decreased with increasing the weight loss ratio. Note that, particularly in B, it increased drastically when the weight deduction ratios exceeded 30%.

3. As increasing the wet hot air temperature from 130 to 140°C, B appeared to increase, however, WT, G, and WC appeared to decrease.

4. The best condition found in this continuous process to extract Co-PET is the wet hot air temperature of 140°C, NaOH concentration of 28% or above, and the treatment time 2~4 min.

REFERENCES

- Berkowitch J.E. (1993) "In tomorrow's ideal and profits: polyester 50 years of achievement textiles institute". Manchester, p.112.
- Dhingra R.C., S. De Jong and Postel R. (1981) The low stress mechanical properties of wool and wool-blend woven fabrics. *Text. Res. J.*, **51**, 759.
- Dhingra R.C., Lui D. and Postel R. (1989) Measuring and interpreting low-stress fabric mechanical and surface properties part II: Application to finishing, drycleaning, and photodegradation of wool fabrics. *Text. Res. J.*, **59**, 357.
- Kawabata S. (1975) "The stanardization and analysis on hand evaluation" (first edition). *The Text. Mach. Soc. of Japan*, Osaka.
- Kawabata S. (1980) The stanardization and analysis oh hand evaluation (second edition). *The Text. Mach. Soc. of Japan*.
- Kawabata S., Postle R. and Niwa M. (1982) Objective specification of fabric quality: Mechanical properties and performance. *The Text. Mach. Soc. of Japan*, Osaka.
- Mitsuo M. and Masau M. (1992) Changes in the mechanical properties and fabric handle of polyester-fiber fabrics through the finishing stages. *J. Text. Inst.*, **83**, 144.
- Okamoto M. (1993) "In Tomorrow's Ideal and Profits: Polyester 50 Years of Achievement Textiles Institute" Manchester, p.108.
- Skelton J. (1976) Fundamentals of fabric shear. *Text. Res. J.*, **46**, 862.

(Received November 1, 2001)
