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Silk Finishing with Polyurethane Resin used for the Linen-like Finishing

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의마가공용 폴리우레탄 수지를 이용한 견직물의 가공

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Abstract

본 연구에서는 견직물에 강경한 촉감을 부여하여 한복지 뿐만아니라 현대의 패션경향에도 부합되는 소재를 개발하고자 하였다. 견직물에 강경성을 부여하기 위하여 의마가공용 폴리우레탄 수지를 이용하여 수지농도와 큐어링온도에 따른 수지부착율을 조사하였고, 여기에 수반되는 물리적 특성의 변화를 살펴보았다. 또한 가공된 견직물의 세탁에 대한 내구성도 살펴보아 동시에 실용가능성도 검토하였다.

이상의 연구를 통해 다음과 같은 결과를 얻었다.

1. 의마가공용 폴리우레탄 수지를 견직물에 처리할 경우 수지 농도가 증가할수록 수지 부착량이 증가하였다.
2. 열처리온도를 변화시켜 수지부착량의 변화를 살펴본 결과 열처리 온도가 증가할수록 수지의 부착량이 감소하여 본 실험에 사용된 수지의 적정 열처리 온도가 160–180°C인 것을 고려해 볼 때 견직물의 경우 170°C의 열처리 온도가 적절한 것으로 나타났다.
3. 수지 처리된 견직물의 역학적 특성치의 변화를 살펴본 결과 RT, EM, MIU값은 감소하는 경향을 가지며, LT, B, 2HB, G, 2HG, 2HG5값은 증가하는 경향을 나타내어 폴리우레탄 수지처리로 의마가공 효과를 갖는 견직물을 얻을 수 있었다.
4. 수지 처리된 견직물의 역학적 특성치는 물세탁 후에도 크게 변화가 없어 세탁에 대한 내구성을 지니고 있는 것으로 나타났다.

Key words: silk fabric, polyurethane resin, stiffness, durability; 견직물, 폴리우레탄 수지, 강경성, 내구성

I. Introduction

Silk fabrics have the advantage of beauty and hygiene, but they have the disadvantage of difficulty in laundering. However, silk as a high quality fabric has been in demand for Korean traditional clothes, *Hanbok*, because of characteristics such as brilliance, shade, ease of handling, and warmth. In the past, silk clothing was limited to formal wear, but recently the use of silks has expanded from outer garments to underwear such as shirts, slips, and panty hose. In addition, the influence of reactionism and the increasing interest in natural fabrics has led to the use of stiff raw silk in clothes. Raw silk fabrics are manufactured from unscoured silk. Since the raw silk contains a considerable amount of sericin, it is not smooth and brilliant. After the scouring treatment, which leaves some of the sericin on the fabric to maintain strength and stiffness, the beauty of *Hanbok* can be achieved(Sung, S. K., Kwon, O. K., & Kouh, J. O., 1989). In order to maintain the silk fabrics' stiffness, we have protected the sericin which is usually removed in the scouring. However, the protected sericin loses its stiffness after laundering, and produces wrinkles after dry-cleaning.

Therefore, the purpose of this study is to develop a material which corresponds to modern *Hanbok* fashion as well as to silk, which is stiff and easy to care for. To make them stiff, silk fabrics are treated with polyurethane by using concentrated resin under curing conditions. The polyurethane resin add-on of the treated silk was measured, and the mechanical properties were measured after the treatment. The durability of resin-treated silk fabrics after laundering was also studied by measuring the change of mechanical properties after water washing.

II. Experimental

1. Treatment of resin

The characteristics of silk fabrics used in this experiment are the following Table 1.

Table 1. Characteristics of silk fabric

Material	silk 100%
Yarn Number(denier)	16.5×32.7
Weave	Plain
Fabric Count(ends picks/5cm)	288.8×203.4
Thickness(mm)	0.203
Fabric Weight(mg/cm^2)	26.2

The used Hyrex RS-R is a linen-like finishing water polyurethane resin currently available from Bokwang Chemical Corporation Ltd.(Bokwang Chemical Corporation Ltd., 2000). Hyrex RS-R is supplied as a 30% aqueous solution which was used to make the 5%, 10%, 20%, and 30% polyurethane resin solutions, into which the silk fabrics were dipped for 10 minutes. After that, the rate of pick-up of silk fabrics was 100% in padding. The processed sample was stretched on a tenter and desiccated in a oven at 110°C for 4 minutes. It was then heat-treated at a curing temperature of 160, 170, or 180°C for 2 minutes. Finally, it was washed in distilled water and dried at 100°C for 2 hours. The dried sample was weighed, and the amount of attached resin was calculated from the following equation.

$$\text{Add-on of resin}(\%) = \frac{(B-A)}{A} \times 100$$

A : Weight of sample before resin processing
B : Weight of sample after resin processing

The surface of resin treated silk fabrics was observed by scanning electron microscope (HITACHI S-2350).

2. The measurement of mechanical properties

We measured seventeen mechanical properties that were major characteristics of six mechanical property groups. The mechanical properties of resin-processed silk were measured with KES-FB (KATO TECH CO LTD.) (Kawabata, 1980; Kawabata, Postle & Niwa, 1982).

3. Washing

The laundry method was based upon KS C 9608 and a home washing machine (LG Electronics, WF-J55N, Capacity: 5.5 kg) was used. The laundry intensity was set for wool, which the home washing machine maker selected. As washing water, tap water (hardness about 65 ppm $CaCO_3$) was used and the sample is re–washed 5, 10, or 20 times, respectively. After washing, the sample was subjected to the natural seasoning. After repeated washing, the specific mechanical properties of the resin-processed silks were measured and compared with those of the resin-processed silks before washing.

III. Results and Discussion

1. The effect of resin concentration and curing temperature on the %add-on of resin

Fig. 1 shows the effect of the concentration of polyurethane resin on the add-on. With increasing concentration, the add-on of resin is increased proportionally. A curing temperature of 170°C gave the highest %add-on.

Fig. 2 shows the change of the %add-on of resin under the various condition of heat treatment. In general, the process of heat treatment accomplishes the cross-linkage between the resin and the fabric, and the conditions of heat treatment are the process temperature, the process time, and the catalyst. In this experiment, the process time is fixed at 3 minutes, and the add-on of resin is measured after samples were treated at various temperatures of 160, 170, and 180°C. With increased temperature, the add-on of resin increases but decreases at some point. Considering that the suitable temperature(Bokwang Chemical Corporation Ltd., 2000) of heat treatment of resin used in this experiment is 160-180°C, the 170°C value is optimal in the case of silk fabrics.

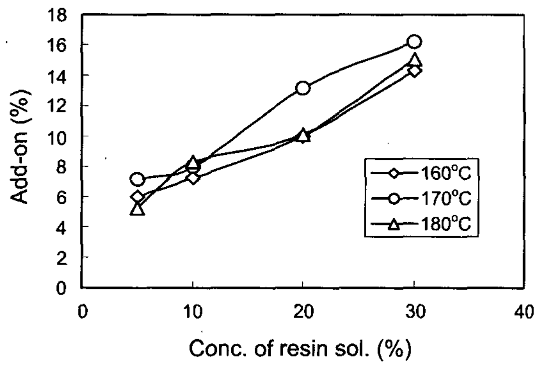

Fig. 1. Effect of conc. of polyuretane resin solution on the %add-on of resin to silk fabrics.

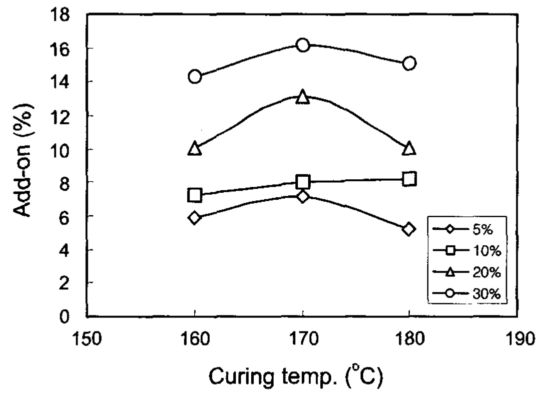

Fig. 2. Effect of curing condition on the %add-on of resin to silk fabrics for different resin solution concentrations.

Fig. 3 shows the surface of silk fabrics treated with resin. It is clear that with increased %add-on, the attachment of resin to the silk fabric increases.

2. The mechanical properties of resin-treated silk fabrics

Fig. 4 shows the effect of resin add-on on the linearity of load-extension(LT), the extensibility(EM), the tensile energy(WT), and the tensile resilience(RT). As the add-on of resin increases, LT values rises. WT and EM values of resin treated silk fabrics increase

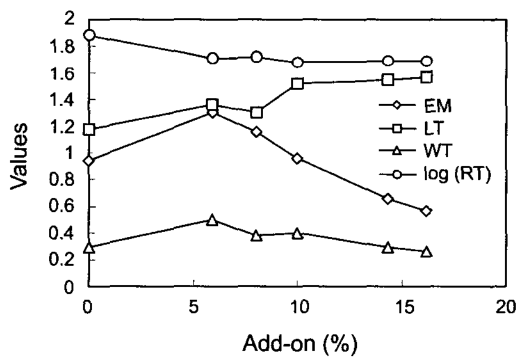

Fig. 4. Effect of %add-on on the tensile properties of resin treated silk fabrics.

(a) untreated silk fabric

(b) resin treated silk fabric (5.95% add-on)

(c) resin treated silk fabric (16.3% add-on)

Fig. 3. Scanning electron micrographs of the surface of resin treated silk fabrics.

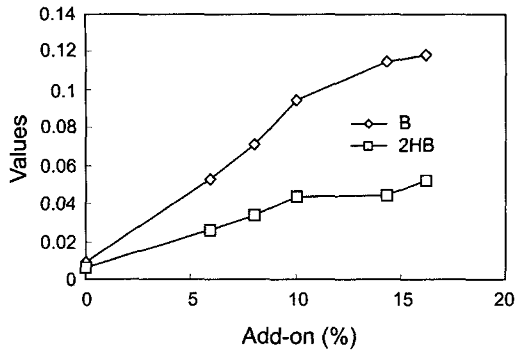

Fig. 5. Effect of %add-on on the bending properties of resin treated silk fabrics.

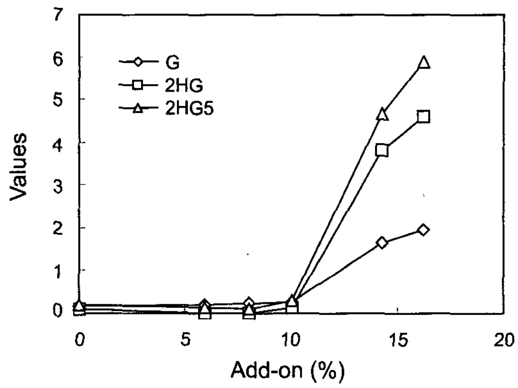

Fig. 6. Effect of %add-on on the shearing properties of resin treated silk fabrics.

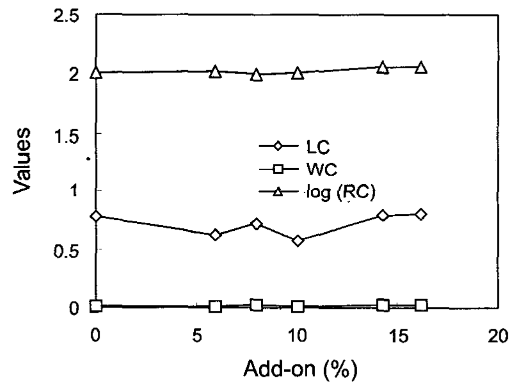

Fig. 7. Effect of %add-on on the compression properties of resin treated silk fabrics.

slightly below 5% resin add-on, but they decline as the add-on of resin increases above 5%. Taking into account that as the add-on of resin increases, RT tends to be slightly decreased, the form stability of the resin-treated silk fabrics lessens. It means that the resin-treated sample gets stiffer and tends not to be loose.

Fig. 5 shows the change of the bending rigidity(B) and the hysteresis of bending moment(2HB) of the resin-processed silk fabrics. B and 2HB, which are the important elements in the drape and the form stability, increase as the add-on of resin does. Because the fibers are connected together by the resin, its flexibility decreases, the movement of fibers and yarns becomes unnatural, and the bending resistance increases. It means that the resin-treated sample has a larger measurement in B and 2HB, similar to ordinary linen(Park & Ryu, 1997).

Fig. 6 shows the change of the shear stiffness(G) and the hysteresis of shear force (at 0.5 of shear angle: 2HG or at 5 of shear angle: 2HG5) of resin-treated silk. As the add-on of resin increases, the values of G, 2HG and 2HG5 also increase. The shearing property of fabric affects the flexibility and the handle of fabrics. This is determined by the slide rigidity, the elastic modification in the crossing of warp and weft, and the bending modification of yarn. 2HG and 2HG5 are especially related to the coefficient of friction, the cover factor, and the density of warp and weft. The attachment of resin affects the rigidity of friction or the pressure of touch in warp and weft direction, and therefore makes the shearing modification difficult.

Fig. 7 shows the change of the linearity of the compression-thickness curve(LC), the compressional energy(WC), and the compressional resilience(RC) of silk fabrics after the resin processing. After resin processing, LC, WC and RC values tend to be slightly increased because of the attachment of resin on the surface.

Fig. 8 shows the change of the coefficient of friction (MIU), the mean deviation of MIU(MMD) and the mean deviation of geometrical roughness(SMD) in the resin-treated silk fabrics. As the add-on of resin increases, MMD values does not change a lot but MIU values decrease. This means that the attachment of resin makes the surface of silk fabric smooth. SMD values increase and decrease within a narrow band which may

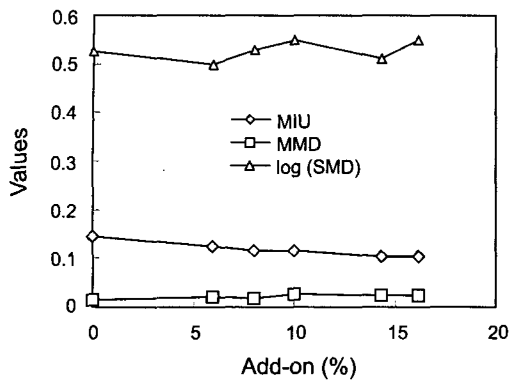

Fig. 8. Effect of %add-on on the surface properties of resin treated silk fabrics.

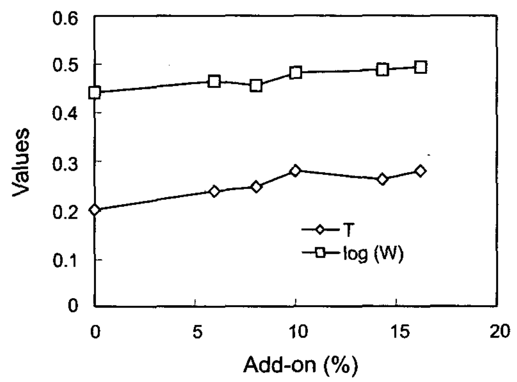

Fig. 9. Effect of add-on on the thickness and mass properties of resin treated silk fabrics.

indicate the error in the determination. This means that the attachment of resin is uneven.

Fig. 9 shows the change of the thickness and the mass of the resin-treated silk. The thickness and the weight tend to increase, as the add-on of resin increases.

Fig. 10 shows the ratio of mechanical properties of polyurethane resin-processed silk fabrics after 5, 10, and 20 washings to that of the pre-washed and untreated state. We select seven mechanical properties, which vary greatly after the resin finishing of silk fabrics. B and G tend to be slightly decreased because of the damage of resin on the surface. But most measurements of the mechanical properties do not change a lot after the repeated water washing. Even after repeated water washings, the resin-treated silk fabric maintains the effect of the linen-like finishing compared with the

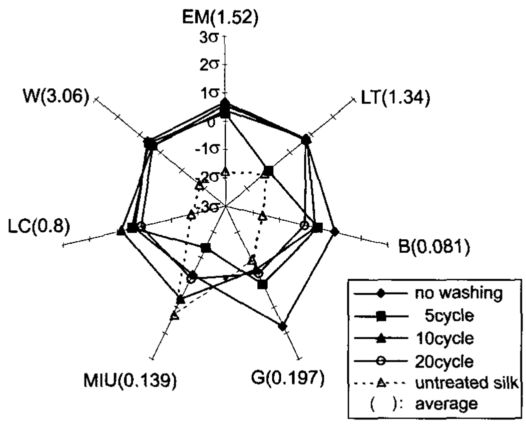

Fig. 10. The change of mechanical properties of resin treated silk fabrics after water washing.

resin-untreated one and shows durability against water washing.

IV. Summary and Conclusion

The purpose of this study was to investigate the effect of raw silk-like finishing of silk fabrics treated with polyurethane resin. A silk fabric was treated in an aqueous solution of polyurethane resin with varying concentrations and curing temperatures, and investigated in relation to %add-on of resin, change of mechanical properties and durability of processed silk against laundering.

The results obtained are summarized as follows.

1. The add-on of resin increased with the increase of the concentration of polyurethane resin solution.

2. The highest %add-on of resin on silk fabric was obtained at a curing temperature of 170. This was true for all the resin solution used.

3. RT, EM and MIU values of processed silk fabrics decreased and LT, B, 2HB, G, 2HG and 2HG5 values increased. It means that the processed silk fabrics have an effect of linen-like finishing.

4. Most measurements of the mechanical properties do not change substantially after the repeated water washing. The resin-treated silk fabrics maintained the effect of the linen-like finishing and showed durability against water washing.

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