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A Study on the Fashion Accessary Product Development by Use of Korean Traditional Hanji (Part I) -Physical Properties of the Korean Traditional Paper(Hanji) Treated with Silcone resin-

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전통한지를 활용한 패션 악세서리 상품개발 (제1보) -실리콘 수지로 처리된 한지의 물성변화-

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Abstract

There are attempts to utilize Hanji for apparel material, but , the reason that the strength and durability of Hanji decrease to a great extent in the wet condition, restricts the usability of Hanji. In order to improve the resistance against water, Hanji was treated with silicone type water repellent agents. The treatment was carried out by conventional pad-dry-cure method. The optimum treatment condition was obtained by varying the concentration of repellent agent, curing temperature and time. Water repellency was tested by spray rating method. Wet and dry tensile strength, tearing resistance and abrasion resistance were examined after the treatment. Flexural stiffness and wrinkle recovery angles of hanji were also measured. In result, the optimum condition of treatment was at resin concentration of 40g/l, catalyst concentration of 20g/l(half of resin concentration), curing temperature of 160°C, curing time of 120 sec. Flexural stiffness of Hanji was hardly increased and wrinkle recovery angle of Hanji was improved a little by resin treatment. After the treatment, in dry condition, tensile strength and tearing resistance were little changed but abrasion resistance was improved. In wet condition, tensile strength, tearing strength and abrasion resistance were improved.

Key words: Hanji, Silicone resin, Water repellency, Physical properties; 한지, 실리콘 수지, 발수성, 물리적 성질

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I. Introduction

Korean traditional paper(Hanji) has known for its high qualities for more than thousand years. As compared to the western paper, Hanji is stronger, and has better durability, air permeability, flexibility, thermal insulation, soundproofs and UV absorbability. Also Hanji is able to control the humidity of environment because it absorbs or emits the moisture(Jeon, 2003). Utilizing these properties, Hanji has been used for handcraft such as workboxes, baskets, and vessels as well as for writing and painting(Lee, 2002).

Through the processes of the modernization and industrial development, Hanji was replaced with the mass produced western paper and also endangered because of the time-consuming production process and the lack of raw material(Choi & Cho, 1996).

Recently, with the tendency to find out and revive our traditional cultures, the production of Hanji starts to open again(Kim, 2000) and the applications of Hanji are extended to various areas such as wallpapers, upholsteries, etc(Lee, 2002). And there are new attempts to utilize for apparel material though they are not practically yet(Lee & Chae, 2003; Lee & Kim, 1999). In comparison with textile, Hanji created many wrinkles and creases easily, and had inferior dimensional stability. Particularly, the reason that the strength and durability of Hanji decrease to a great extent in the wet condition, restricts the usability of Hanji for apparel materials. But there are few attempts to enhance the resistance to water by finishing.

Thus, in this study, water repellent finish with silicone resin was applied on Hanji in order to improve the resistance against water. The optimum condition of the treatment was investigated. The effects of water repellent finish on physical properties of Hanji were examined in dry and wet condition after the treatment.

Table 1. Characteristics of the untreated Hanji

Weight(g/m^2)	Thickness(mm)	Wrinkle Recovery Angle(°)
38.6±3.1	0.13±0.01	68.3

Table 2. Physical properties of the untreated Hanji

Direction	Flexural Stiffness (mN)	Tensile Strength (kN/m)	Tearing Resistance (mN)	Abrasion Resistance (frequency)
Machine	0.161	24.68	453.4	38
Cross	0.058	10.01	877.6	28

Silcone Resin(Snotex WR 350) and catalyst(Snotex Cat-12) were also commercial prodducts from DaeYoung Chemicals Co.Ltd.

II. Experiments

1. Materials

As the samples, Commercial Hanji produced from Chonju was used without pretreatment. The characteristics and the physical properties of the untreated Hanji were summarized in <Table 1> and <Table 2>.

2. Methods

The treatments of silicone resin were carried out by the conventional pad-dry-cure method. The samples were cut into 30×30cm^2 and immersed in the bath containing resin and catalyst for 30minutes. The liquor ratio was 1 : 30. The excess solution was removed through a laboratory wringer to reach an average wet pickup of 200%. The impregnated samples were fixed on the pin frames and dried at 100°C for 10 min and then cured.

To obtain the optimum condition of the treatment, silicone resin concentration, catalyst concentration, curing temperature and time were varied. Physical properties were measured by the followed methods based on Korean Industrial Standards.

Water Repellency was evaluated by spray test method based on KS K 0590.

Flexural Stiffness was calculated with the length measured by flexometer method based on KS K 0539

Wrinkle Recovery Angle was expressed as sum of machine and cross direction measured by Monsanto tester based on KS K 0550,

Tensile strength was measured in machine and cross direction by constant rate of the elongation method by instron(model 1130, Instron Corporation) according to KS M 7015.

Tearing Resistance was measured in machine and

cross direction by elmendorf tester based on KS M 7016.

Abrasion Resistance was shown in machine and cross direction as frequency of abrasion under the weight of 300g, using the tester described in KS M 7062

For dry condition, the samples were stored at standard condition more than 24 hours, and for wet condition, the sample was immersed in distilled water during 20 min at room temperature, after that excess water was removed by blotting with the filter papers.

III. Results and Discussion

1. Effect of the Treatment Condition on Water Repellency

<Fig. 1> showed the change of the water repellency and add-on of the resin on Hanji according to the resin concentration. The ratio of catalyst concentration and resin concentration was 1:1. When the resin concentration increased, water repellency increased until 30g/l and leveled off. The highest water spray rating was 90. Add-on of the silicone resin on Hanji also increased until 40g/l resin concentration and then leveled off. It was assumed that the sites of absorption for resin on the Hanji surface were saturated. And It was also seemed that resin molecules were congregated each other at high resin concentration and the chance to react between the resin and the pulps were restricted(Park & Ryu, 1997). The higher add-on of the silicone resin was, the better water repellency was.

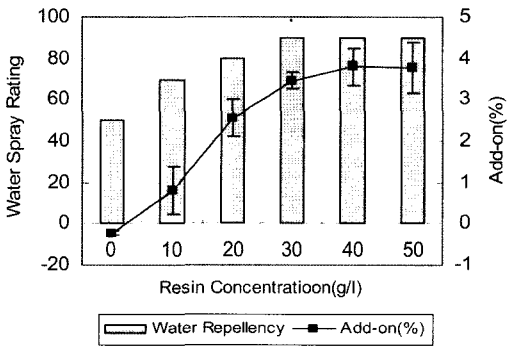

Fig. 1. Effect of the resin concentration on add-on

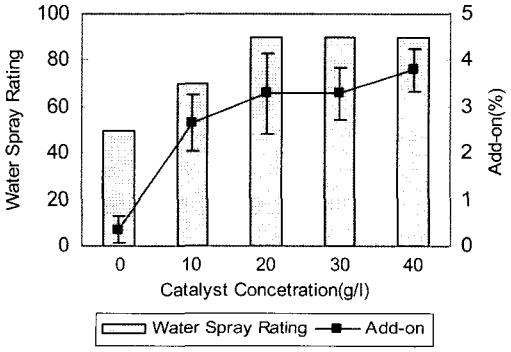

Fig. 2. Effect of the catalyst concentration on add-on and water repellency

Water repellencies and add-on on Hanji according to the cataltyst concentration were shown in <Fig. 2>. The resin concentration was fixed at 40g/l. Water repellency increased until 20g/l catalyst concentration(That is half of resin concentration) and then leveled off. Add-on of the resin on Hanji showed similar tendency to water repellency.

Table 3. Effect of the curing temperature and time on the water repellency

Time(sec)	30	60	120	180	300
135°C	70	70	80	80	90
160°C	80	80	90	90	90
185°C	80	80	90	90	90

Water repellencies of samples treated at the various curing temperature and time were shown in <Table 3>. At the curing temperature 135°C, 300 seconds needed to obtain 90 spray rating. At 160°C and 185°C, water repellency reached 90 spray rating in 120 seconds, and after that leveled off. Hanji was yellowed when the curing time was longer than 120 seconds at 185°C.

From the above results, the optimum condition of the treatment was at resin concentration 40g/l, catalyst concentration 20g/l(That is half of resin concentration), curing temperature 160°C and curing time 120 sec.

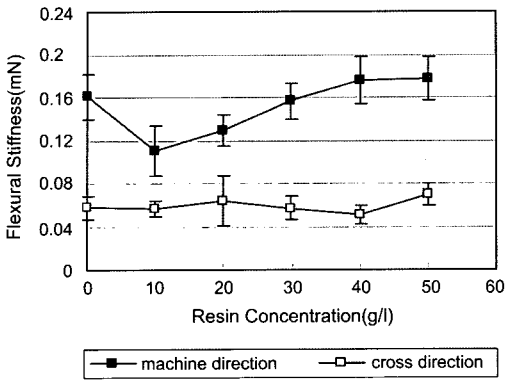

Fig. 3. Effect of the resin concentration on flexural stiffness

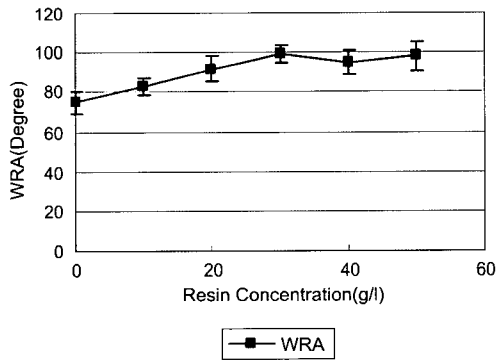

Fig. 4. Effect of the resin concentration on wrinkle recovery angle

2. Effect of the Resin Concentration on Physical Properties

<Fig. 3> showed the Flexural stiffness of Hanji according to the resin concentration. Flexural stiffness of machine direction was reduced at 10g/l resin concentration, and after that increased until 40g/l. It was considered because at low resin concentration, silicone resin acted as a softener, but at high resin concentration, adhesion of silicone resin on pulp increased and made Hanji stiff. But the treatment did not make Hanji much stiffer than the untreated. Flexural stiffness of cross direction was hardly affected by the resin concentration. Flexural stiffness of cross direction was hardly affected by the resin treatment.

<Fig. 4> showed the change of Wrinkle recovery angle with the increasing resin concentration. Wrinkle Recovery angle increased until 30g/l, then leveled off. It seemed that though the changes were smaller than in case of anti-crease agent, the elastic and flexible silicone chains attached on the pulps made wrinkle recovery improve to some extent.

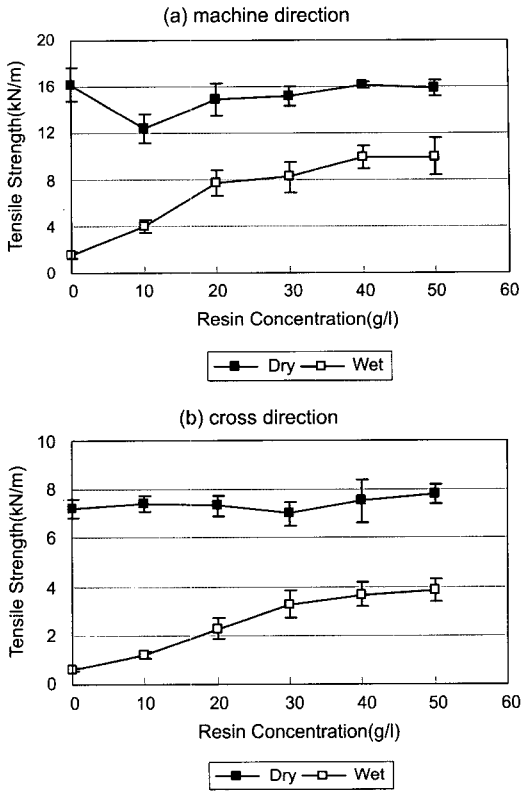

Fig. 5. Effect of the resin concentration on tensile strength

The effect of the resin concentration on tensile strength of Hanji was shown in <Fig. 5>. And (a) and (b) are in machine and cross direction. In dry condition, tensile strength of machine direction was reduced at 10g/l resin concentration, then increased and leveled off. It was considered that at the low resin concentration, silicone resin acted as a softener and reduced the friction and hindered the adhesion between the pulps of Hanji, therefore the tensile strength was decreased. When the resin concentration increased, adhesion of silicone resin between pulps increased and resulted in the decreasing of softener effect and rather supported the tensile strength. Tensile strengths

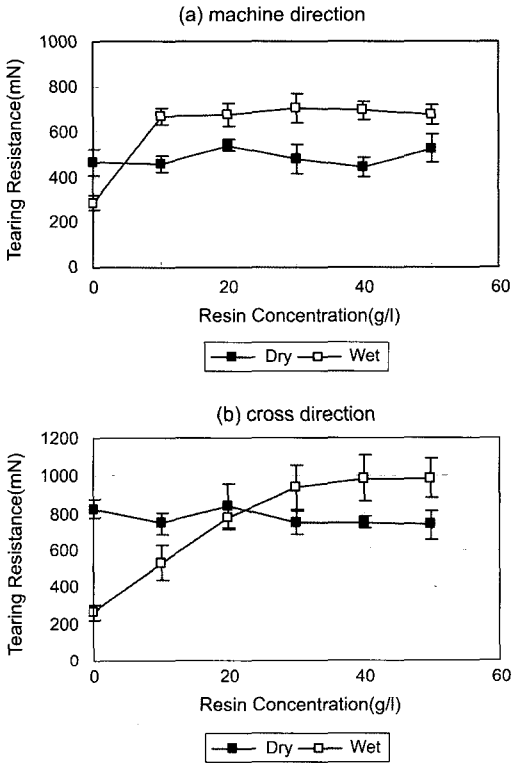

Fig. 6. Effect of the resin concentration on tearing resistance.

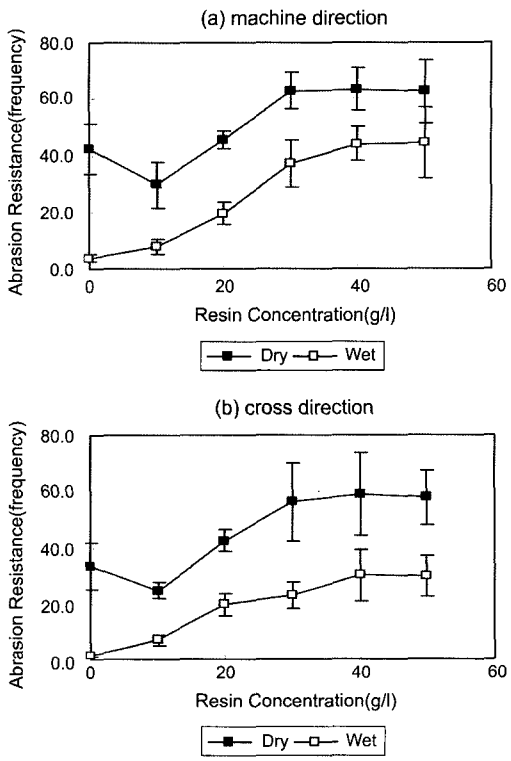

Fig. 7. Effect of the resin concentration on abrasion resistance

of the cross direction were not affected largely by the resin concentration.

In wet condition, tensile strengths of both directions showed a similar tendency to the add-on of the resin on Hanji. It was considered that the adhesion between Hanji pulps in dry condition was dissociated in wet condition and did not function properly. Tensile strength was affected by the silicone resin adhered between the pulps, and depended on the add-on of the resin. The effect of the water repellent resin on tensile strength was greater in the machine direction than in the cross direction. The pulps of Hanji were oriented along the machine direction rather than the cross direction. It can be assumed that the adhesion between Hanji pulps in the machine direction is greater than that in the cross direction.

The effect of the resin concentration on tearing resistance was shown in <Fig. 6>. In dry condition, the treatment of silicone resin had less effect on tearing resistance of Hanji. It seemed that the influence of the silicone resin on tearing resistance were much less than the physical adhesion between Hanji pulps. In wet condition, tearing resistance increased with the increasing add-on of the resin on Hanji according to the resin concentration. It seemed that the Hanji pulps were dissociated in wet condition, and tearing resistance depended on the silicone resin between and/or on the pulp of Hanji. The degree of the effect of resin concentration on tearing resistance was larger in the cross direction than in the machine direction because the Hanji pulps were oriented better in the machine direction.

<Fig. 7> showed the effect of the resin concentration on abrasion resistance of Hanji. In wet condition, abrasion resistances on both directions reduced at 10g/l resin concentration, after that increased and leveled off. It seemed that at the low resin concentration, the silicone resin on the pulp decreased the friction and hindered the adhesion between the pulps, and make the pulp dissociated easily, therefore the

abrasion resistance was reduced. But, when the add-on of resin on the pulp was increased, the flexible silicone resin covered the larger surface of the Hanji. In consequence, the surface of Hanji became smoother and the abrasion resistance was increased.

In wet condition, the abrasion resistances on both directions also increased with the increasing add-on of the resin. It seemed because of the same reason as tensile strength and tearing resistance. The influence of resin concentration on abrasion resistance was greater in the machine direction than in the cross direction.

IV. Conclusions

From the above results, we can have the conclusions as followed.

1. The optimum condition of treatment was at resin concentration of 40g/l, catalyst concentration of 20g/l (half of resin concentration), curing temperature of 160°C, curing time of 120sec.

2. The higher add-on of silicone resin on Hanji, the better water repellency was.

3. Flexural stiffness of Hanji was hardly increased by resin treatment.

4. Wrinkle Recovery Angle of Hanji was improved a little after the resin treatment.

5. In dry condition, flexural stiffness, tensile strength and abrasion resistance were decreased at resin concentration of 10g/l and after that, increased and leveled off. Tearing resistance was little affected by resin concentration in dry condition. In wet condition, tensile strength, tearing resistance and abrasion resistance increased as resin concentration increased up to 40 g/l. These showed similar tendency to add-on of the resin on Hanji.

6. In most cases, the effects of the silicone resin in the machine direction on mechanical properties were greater than that in the cross direction, except the tearing resistance

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요 약

한지를 의류용으로 사용하기 위한 시도들이 있었지만, 습윤상태에서 물리적 성질이 크게 감소한다는 문제점 때문에 많은 한계를 가지고 있었다. 따라서 한지의 습윤상태에서의 물리적 성질을 향상시키기 위해 내수성을 부여하고자, 실리콘 수지를 이용하여 한지에 발수가공을 행하였다. 패드-드라이-큐어 방법을 사용하여 처리하였고, 가공의 최적조건을 알아보기 위해 수지의 농도와 촉매의 농도, 큐어링 시간과 온도를 변화시켜 실험하였다. 한지의 발수도, 강연도, 방추도를 측정하였고, 습윤과 건조상태에서의 인장강도, 인열저항, 마찰저항을 비교하였다. 그 결과 한지의 발수가공을 위한 최적처리조건은 실리콘 수지농도 40g/l, 촉매농도는 수지농도의 1/2인 20g/l, 큐어링 온도 160°C, 큐어링 시간 120초였다. 가공 후에도 한지의 유연성은 크게 저하되지 않았으며, 방추도는 약간 증가하였다. 가공 후, 건조상태에서의 인장강도, 인열저항은 큰 변화가 없었으나 내마모도는 증가하였고, 습윤상태에서의 인장강도, 인열저항, 내마모도 모두 증가하였다.