

The study on the Printability of Hanji through Sizing and Calendering

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1. Introduction

Hanji is a presentative paper with Korean tradition and has been recognized as an important vehicle for long preservation of Korean historical and informative media. In spite of the native fact, recognition on Hanji as a cultural paper has been recently reduced due to a lack of its essential understanding and industrially economical output. Hanji has many good properties such as air-penetration, flexibility, soundproof, heatproof and humidity control. Hanji has been traditionally used as a painting paper. In recent, it was also developed for a variety of applications such as packaging paper, name card paper, light-proof paper, wall paper and industrial art paper. In spite of the extension of use, the lagging of industrial demand and high price are still disturbing development of Hanji industry. Development of a new use, which can meet a large demand rather than multi-usage, has been necessarily required to loose an economical burden in Hanji industry. Meanwhile, increasing a preservation period of an informative document has attracted a strong attention due to the limit of general printing papers. Hanji is suitable to meet the needs owing to the excellent durability. Therefore, objective of this study is to estimate the printability of Hanji through sizing and calendering processes.

2. Materials and Methods

2.1 Materials

Machine-made Hanji (99.7 grammage) was obtained from Jirisan Hanji company. CMC (Carboxymethyl cellulose, HAYASHI), cornstarch (DAE SANG), PVA (Polyvinyl alcohol, YAKURI), AKD (Alkylketenedimer, 20%, HE-201) as sizing agents were used to improve the surface property and printability of Hanji.

2.2 Methods

2.2.1 Preparation of sized Hanji

The four agents were dissolved with distilled water. Particularly, PVA was dissolved at 80°C for 1 h, and cornstarch was gelatinized at 95°C for 30 h to increase dissolution of these sizing agents. The concentration of dissolved sizing agents was adjusted as shown Table 1. Sizing on the surface of Hanji was performed using a coater (PI-1210, Sangyo, Japan) and the speed was 13 mm/sec. The sized Hanji was dried in a convection dryer at 50°C for 10 min and employed for estimation of various properties.

Table 1. Concentration of sizing agents

Sizing agents	Concentration(%)
CMC	0.5, 1, 1.5
Corn Starch	1, 2, 3
PVA	1, 5, 10
AKD	0.05, 0.1, 0.15

2.2.2 Physical and surface properties of sized and calendered Hanji

The sized Hanji was put into a thermo-hygrostat (20±1°C, RH: 65.5%) for over 24 h. The physical and surface properties such as grammage, brightness, sized thickness, density, gloss, smoothness, air permeability, roughness, opacity, size degree, color degree (L*a*b*), ink printabilities (picking, typography ink density and

its show through, Inkjet ink density and its show through, and ink girth) were investigated to estimate an impact of the sizing agents. The Sized Hanji was also calendered using the calender (Beloit wheeler). The condition was: pressure, 0.5 and 1.0 kgf/cm² operation speed, 7.16 cm/sec; temperature, 45°C. The measurement of ink girth was made using an image analyzer.

3. Results and discussion

3.1 Physical properties of sized Hanji

The physical properties of sized Hanji were investigated without calendering treatment, but the results were briefly mentioned. The sizing weight, sizing thickness and density increased with increase of concentration of the applied sizing agents. In most case of the sizing agent with each different concentration, the brightness showed a slightly increasing trend. AKD (Alkylketenedimer), well-known as a neutral sizing agent, was the highest in brightness. The degree of gloss was improved by Cornstarch. It may mean that Cornstarch become a good agent for improvement of gloss of Hanji. CMC (optimum concentration: 1%) was superior to the other agents in smoothness. Sizing resulted in reduction of air permeability due to a narrow space among fibers. The roughness was little different from the original paper, comparing with the sized Hanji. AKD showed the most improved size degree. It was considered to be due to good penetration of AKD with relatively low molecular mass into an empty space among fibers. Therefore, AKD seems to be recommendable as an agent for improvement of size degree and brightness of Hanji. Color expressed as L*a*b* values changed in the similar trend with original paper.

3.2 Physical properties of calendered Hanji after sizing

The physical properties of Hanji after stepwise process of sizing and calendering were estimated. In general, calendering treatment improves the physical properties

of paper by balancing the thickness and surface. As calender pressure increases, thickness was significantly decreased, but the density increased as an expectable result. The slight increase of brightness and opacity and the predominant rise of gloss were observed. Cornstarch still contributed to improvement of gloss degree of Hanji. It represents, from the results of sizing and calendering, that Cornstarch may be recognized as a gloss-improving agent for a printable Hanji. Expectedly, the reduction of roughness and air permeability were considered to be due to the relative increase of density. 0.1% of AKD is likely to be desirable for an optimized sizing degree. $L^*a^*b^*$ values slightly reduced after calendering treatment. As a result, sizing and calendering gave a good effect on reforming the properties of Hanji to some extents.

3.3 Printability of sized and/or calendered Hanji

Printability of sized and/or calendered Hanji was estimated by measuring picking strength, typography ink density, typography show through, inkjet ink density, inkjet show through and inkjet ink girth.

Picking results are given in Fig. 1. From the results of picking strength, CMC, Cornstarch and PVA with hydrophilic hydroxyl group showed high retention, comparing to AKD with long hydrophobic alkyl chain. This result represents that the three sizing agents, which can form hydrogen bond with cellulose and be mechanically retained due to the basic affinity, have strong picking strength, but AKD, which chemical reaction with hydroxyl group of cellulose to form a -keto-ester is main mechanism, requires at least high temperature above 50°C.

It supports that the mechanical factor such as calender pressure contributes to improvement of picking strength, as shown in Table 2.

Table 2. Effect of the surface strength

pressure(kgf/cm ²)	0	0.5	1
sizing agents			
0.5% CMC	8.4	0.2	0.1
1.0% CMC	N	N	N
1.5% CMC	N	N	N
1% Corn starch	7.5	N	N
2% Corn starch	N	N	N
3% Corn starch	N	N	N
1% PVA	N	N	N
5% PVA	N	N	N
10% PVA	N	N	N
0.05% AKD	1.7	1.8	2.0
0.1% AKD	0	0	0
0.15% AKD	0	0	0

0 : All picked, N : no picked, Base paper : 0

Unit : cm

Fig.1. Effect of typography ink density and its show through

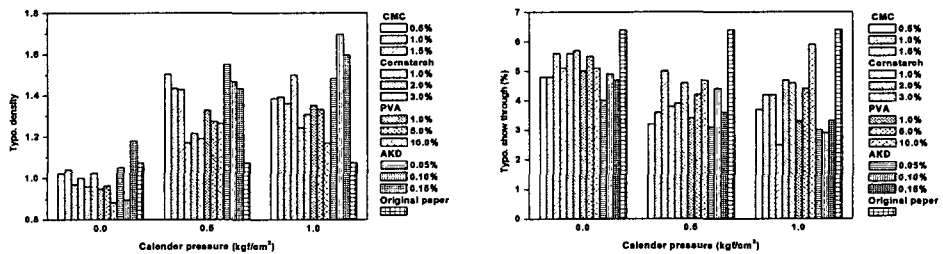
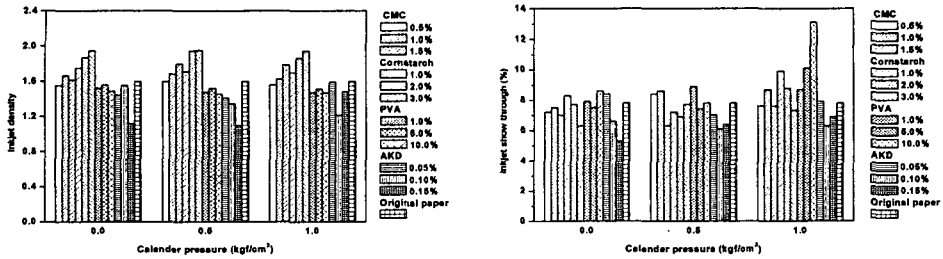


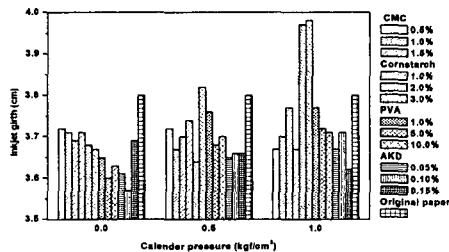
Figure 1 presents in typography ink density and show through. The typography ink density was improved with increase of calender pressure. The highest typography ink density and typography show through were observed as 1.70 and 2.9%, respectively, when 0.1% of AKD was applied under 1kgf/cm² of calender pressure. In typography, AKD may be acceptable as a good sizing agent for improvement of printability of Hanji.

Fig.2. Effect of inkjet ink density and its show through



Inkjet ink density and show through are given in Fig.2. In ink density, high value was observed in the case of cornstarch. In particular, Hanji sized with 3% of Cornstarch without calendering showed the highest ink density and show through. Therefore, 3% of Cornstarch seems to be a suitable sizing agent for printability of inkjet ink.

Fig. 4. Effect of Inkjet ink girth



Inkjet ink girth is given in Fig.2. In most case, the sizing agents tended to increase ink girth when calendered. Accordingly, calendering process in inkjet print is desirable to be avoided due to the significant increase of ink girth. Hanji treated with 0.1% of AKD showed the most improved ink girth and, in addition, Cornstarch could be considered as a suitable sizing agent of inkjet ink density. Consequently, 0.1% of AKD and Cornstarch were recommendable as a sizing agent for inkjet print.

4. Conclusion

The results could be summarized that

1) at 0.1% level, AKD (Alkylketenedimer) was a provisionally recommendable sizing agent for improvement of printability of Hanji in typography print, in spite of its poor picking strength. The picking strength can be improved by a drying temperature and a combination with polymeric sizing agents because AKD is a chemically reactive sizing agent and also low-molecular-mass substance. In on-going research, the defined heating condition is under investigation.

2) Cornstarch also contributed to improvement of gloss in all the treatments and inkjet ink density of printability of Hanji.