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Improvements in the Physical Properties of Hanji by Using Red Algae Pulp

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ABSTRACT

Hanji is a traditional Korean handmade paper, made of bast fibers of the paper mulberry. Its fiber furnish is much more expensive than wood fiber furnish. Hanji with a low basis weight requires additional opacity and smoothness for better writing and printing. Filler such as calcium carbonate can not be used to raise the opacity of Hanji because of its low retention in low basis weight paper and the high freeness of the Hanji fiber furnish. Addition of red algae pulp, which is prepared from marine red algae to the Hanji fiber furnish negated retention problems happening in the case of mineral filler addition, and produced a substantial improvement in the opacity and smoothness of Hanji. The higher retention was due to the much larger size of the red algae fibers compared to the mineral fillers. The improvement in opacity and smoothness were also due to the shape of the red algae fibers: that red algae fibers are narrower in widths and shorter in lengths than wood fibers results in increased surface area and smoothness.

Keywords: *Hanji, Red algae fiber, Opacity, Smoothness, Aging test, Wood pulp*

1. Introduction

Hanji is a traditional Korean handmade paper, which is known to last 1,000 years with strength and integrity. In addition to its excellent conservation properties, Hanji is known for its high brightness, smooth surface for calligraphic writing, and high strength[1~4]. Due to the high price of Hanji fiber furnish, approximately 10-20 times that of copy paper, high basis weight Hanji is not widely used. However, low basis weight Hanji is translucent and its surface is quite rough. Thin Hanji sheets may be folded and only the outside surfaces are used for calligraphic writing.

Red algae fibers are produced from marine red algae. For example, *Gelidium elegance*, one of thousands of red algae species, can be used as a raw material for making red algae fibers. The red algae is extracted at 100-130°C with the addition of small amounts of chemicals, and the solids after extraction are bleached to produce red algae fibers[5~7]. The average dimensions of the red algae fibers are 0.5-1.0 mm long, and 2-5 μm wide, respectively. We have used these red algae fibers to produce high-quality printing paper samples in the

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lab, and have demonstrated the very high smoothness[8] of red algae paper, e.g., 600 sec in a Bekk smoothness tester without coating.

Red algae fibers have other useful properties such as high opacity. Lee[6] demonstrated that red algae fibers have as high opacity as calcium carbonates, which are the most widely used fillers in the paper industry. For use as a fiber furnish in Hanji, conservation properties are also important, because one of the particular merits of using Hanji is its long-lasting quality[4,8,9]; use of Hanji currently has extended to historical and governmental appointment documents.

In this study, we applied red algae fibers to the Hanji bast fibers, and investigated the resulting changes in physical properties. Accelerated aging was used to evaluate the conservation properties of red algae fibers and Hanji, with varying amounts of added red algae fibers.

2. Materials and Methods

Hanji fiber furnish, consisting of 100% "Dak" fibers from paper mulberry, was provided by Chunyang Paper Co. (Junju, Korea). The fibers were prepared using traditional pulping and bleaching methods. Red algae fibers were provided by Pegasus Research Inc. (Daejun, Korea), which develops technologies for red algae utilization and holds multiple patents concerning red algae fibers.

The paper samples that were prepared are shown in Table 1. For comparison to wood fibers, a mixture of paper mulberry fibers and softwood bleached chemical pulp was prepared as "Hanji-wood 90". The samples were all handmade papers prepared in a traditional Hanji production facility located in Chunyang Paper Co. The basis weight was 20 ± 1 g/m2.

Micrographs of the surfaces of the paper samples were obtained using scanning electron microscopy (SEM). All of the physical properties of the samples were measured in a constant temperature-humidity room (20℃, 50% RH). The breaking length of the paper was measured using a Universal Testing Machine (UTM; Micro-350, Testometric Company Ltd., Rochdale, England) according to TAPPI Method T 494 om-01. The folding endurance was measured according to TAPPI Method T 423 cm-98. The smoothness was measured using a Bekk Smoothness Tester (Toyo Seiki Co. Ltd., Tokyo, Japan) according to TAPPI Method T 479 cm-99. Optical properties (opacity and brightness) were measured using a colorimeter (Color Touch; Technidyne Co., New Albany, IN, USA) according to TAPPI Method T 425 om-01 (opacity of the paper-89% reflectance backing and paper backing) and TAPPI Method T 425 om-02 (brightness of the pulp, paper, and backing).

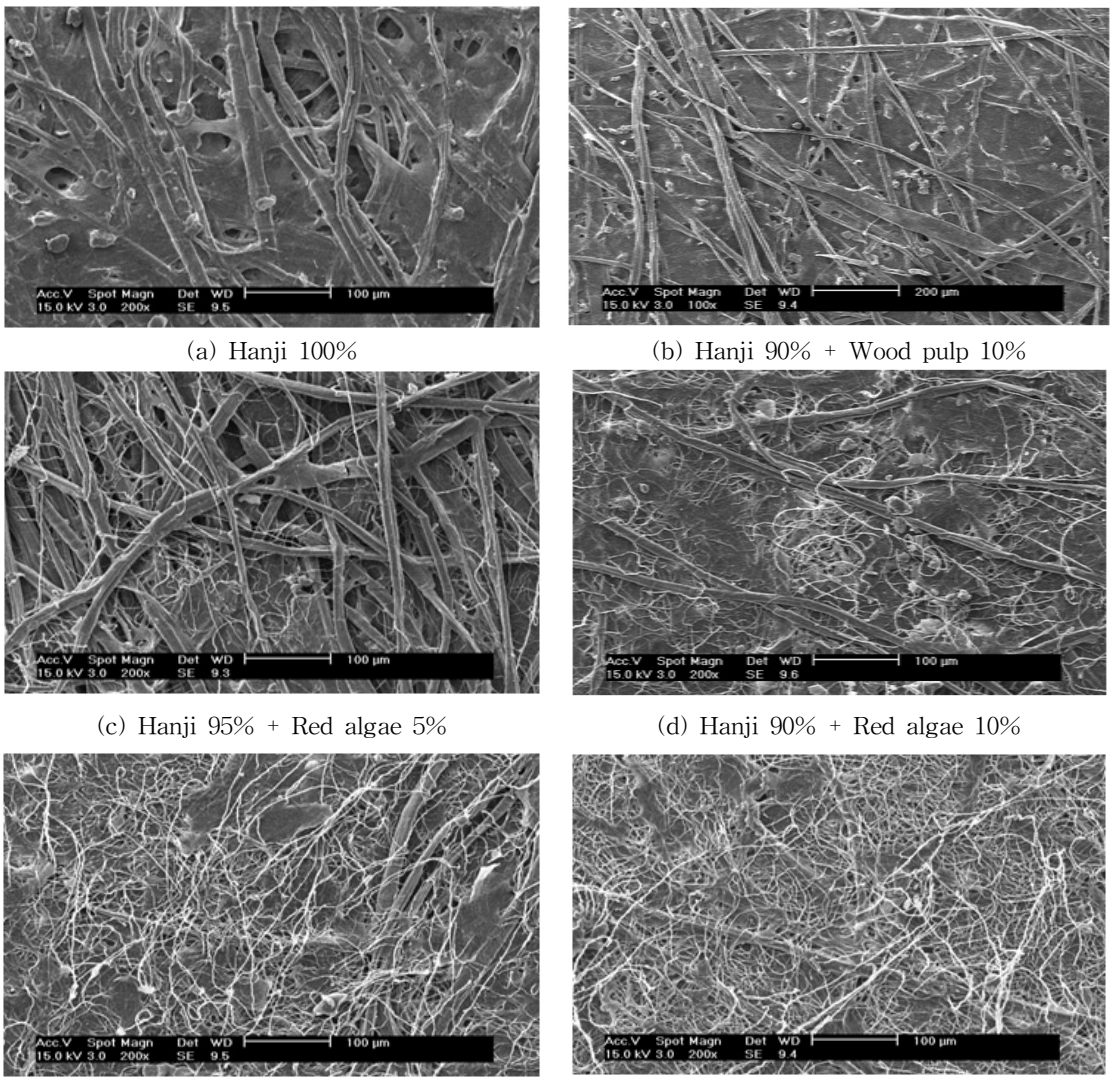
3. Results and Discussion

SEM micrographs of the samples listed in Table 1 are shown in Fig. 1. When the red algae fiber content was more than 10%, a smoother surface than the other furnishes, including 100% Hanji, was apparent.

The furnish with 5% red algae had a breaking length lower than the other samples. Bekk smoothness increased

Table 1. List of paper samples

	Type
Hanji 100	Paper mulberry fiber 100%
Hanji-wood 90	NBKP 10% + Paper mulberry fiber 90%
Red algae 5	Red Algae fiber 5% + Paper mulberry fiber 95 %
Red algae 10	Red Algae fiber10% + Paper mulberry fiber 90%
Red algae 20	Red Algae fiber 20% +Paper mulberry fiber 80%
Red algae 30	Red Algae fiber 30% +Paper mulberry fiber 70%



(a) Hanji 100% (b) Hanji 90% + Wood pulp 10%

(c) Hanji 95% + Red algae 5% (d) Hanji 90% + Red algae 10%

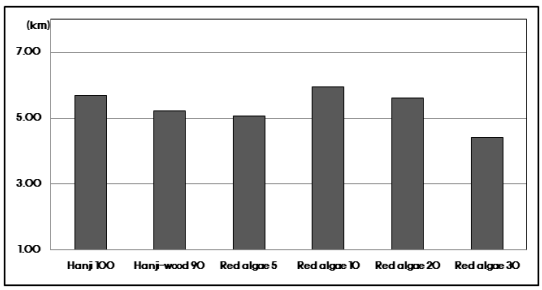
(e) Hanji 80% + Red algae 20% (f) Hanji 70% + Red algae 30%

Figure 1. SEM micrographs of Hanjis samples mixed with wood pulp and red algae fibers

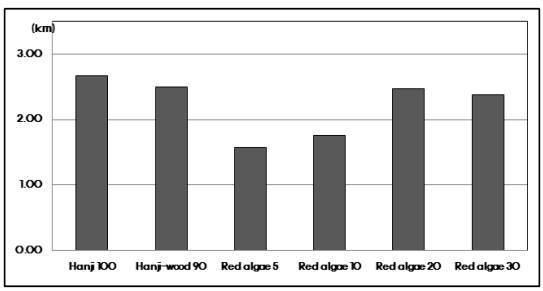
in proportion to the increase in red algae content on both the wire and felt sides (Fig. 3). These results are consistent with the images shown in Fig. 1.

Opacity is very important for low basis weight pa per for writing and print grades. Fig. 4 shows the improvement in the opacity of the Hanji samples in proportion to the amount of red algae fibers included. The brightness of the samples showed the same trend (Fig. 5). When 10% by weight wood pulp (softwood bleached kraft pulp, SwBKP), was added, improvement in the opacity and brightness of the Hanji samples was negligible compared to 10% addition of red algae fibers.

The aging test is important, because one of the merits of Hanji has is its conservation properties. Aging of each sample was conducted for 6 weeks in a 105^{o}C oven dryer, and changes in the sample prop

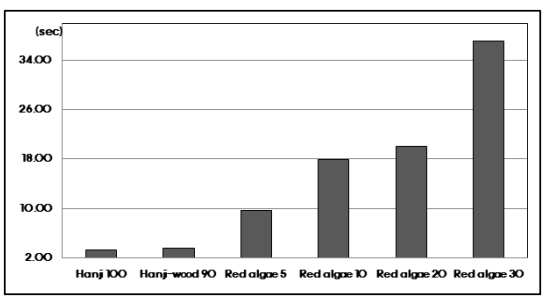


(a) MD breaking length

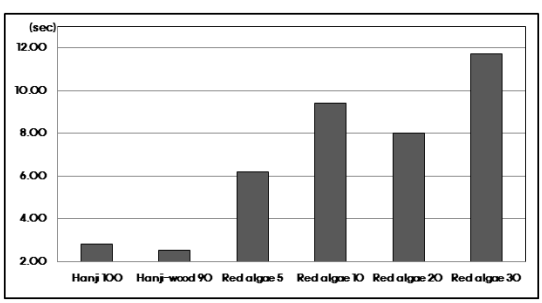


(b) CD breaking length

Figure 2. Breaking lengths of the samples.



(a) Bekk smoothness measured on felt side



(b) Bekk smoothness measured on wire side

Figure 3. Bekk smoothness of the samples.

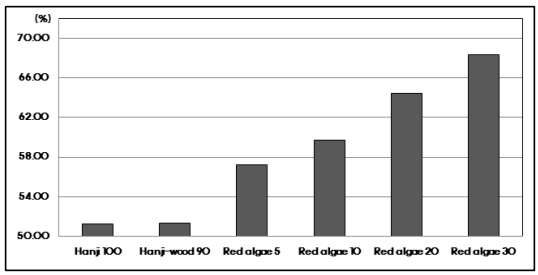


Figure 4. Opacity of the samples.

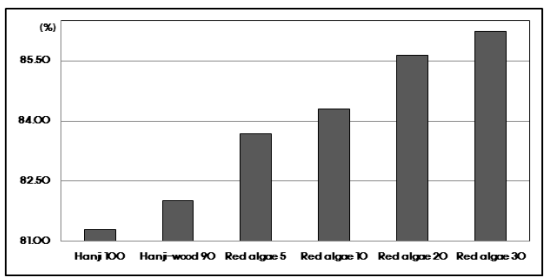


Figure 5. Brightness of the samples.

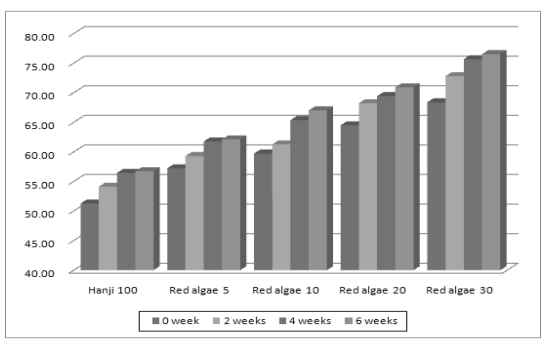


Figure 6. Opacity of the samples after the 6 week aging experiment.

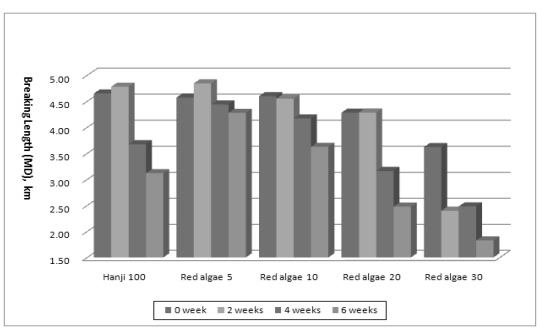


Figure 7. Breaking length of the samples after the 6 weekaging experiment.

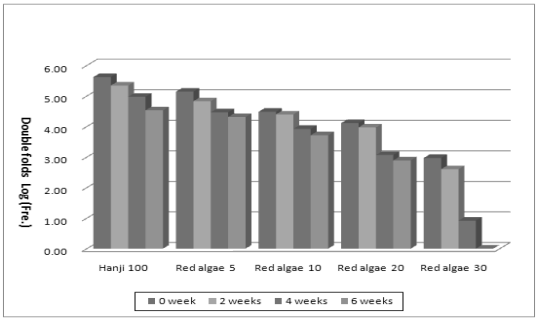


Figure 8. Double folds of the samples after the 6 week aging experiment.

erties were compared. Figs. 6-8 show the opacity, breaking length (MD), and double fold (MD) changes with aging, respectively. Opacity increased in proportion to the percentage of red algae fibers and aging time. Breaking length decreased as the aging time increased. Only the "Red algae 30" sample showed a large difference from the "Hanji 100" sample in breaking length. Double folds decreased in proportion to the amount of red algae and the aging time. Addition of 30% red algae again showed a large drop in double folds. The CD properties were very similar to the MD properties. These results suggest that red algae fibers can be added up to 20% if conservation properties are required.

Conclusions

Red algae fibers were added to traditionally prepared Hanji furnish to improve the physical and optical properties of low basis weight Hanji. The results demonstrated large improvements in essential properties of Hanji such as opacity and smoothness. It is very difficult to add fillers to low basis weight Hanji to improve opacity because of low retention. The surface of Hanji is not as smooth as modern copy paper, because it consists of long and stiff fibers. Dochim is a process for creating a smoother surface on Hanji, which is functionally similar to modern calendering, but does not produce as smooth a surface as copy paper. Red algae fibers have high opacity, and have a much larger size than fillers, which assists with higher retention. Red algae fibers are short and thin, and provide excellent formation and a smoother surface, which insures high smoothness. The conservation properties of red algae fibers were not as good as Hanji fiber furnish. However, it was shown that up to 20% addition of red alge to Hanji furnish did not result in significant deterioration in an accelerated aging test over 6 weeks.

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