Chemical Treatment of Short Fiber Fraction of OCC for Retention and Drainage

Hye-Jung Youn*, Seong-Min Chin†, Ik-Sun Choi†, Hui Cho†, Yung Bum Seo‡ and Chang-Man Sohn§

*Assistant professor, †Graduate student
Dept. of Forest Sciences, Seoul National University, San 56-1, Sillim-Dong, Gwanak-Gu, Seoul, 151-921, Korea
‡Professor, Dept. of Forest Products, Chungnam National University, Daejeon, Korea
§Director, R&D Center, Hansol Paper Co., Ltd., Daejeon, Korea
* page94@snu.ac.kr

ABSTRACT

Use of recycled fibers in papermaking has been increased for economical and environmental reasons. Recycled papers are major fiber resources for brown grades and newsprints. Since the recycled fibers have disadvantageous properties as raw materials for papermaking it is of great importance to optimize the use of these recycled fibers. OCC (Old Corrugated Containers) is the major fiber source for linerboards and corrugating mediums that require diverse specification in strength properties. Many studies have been focused to overcome the problems of strength reduction of brown grades when recycled fibers are used as raw materials. The problem of strength loss for papers made from recycled fibers is closely associated with the increased amount of fines in recycled fibers and hornification of fibers. Fines contained in the recycled fiber resources cause problems not only in paper properties but also in process runnability. This shows that the optimal management and proper use of fines in recycling papermaking system are critical to get most benefits of using recycled fibers. In this study some approaches for optimal use of fiber fines in recycled paper mill have been investigated.

Stock samples, prepared in the laboratory and obtained from a recycling plant, were used. Fractionation of these samples was made using Sweco screen. And the effect of the addition of polyelectrolytes including cationic PAM and PEI on drainage and retention was evaluated. Different methods of polymer addition were compared to find the most effective ways of treating recycled fiber stocks with polyelectrolytes. Addition of polyelectrolytes to the short fiber fraction was most effective in retention and drainage. The influence of the charge and molecular weight of these two polymers has been examined and discussed.

INTRODUCTION

Many studies to make best use of OCC have been proceeded. Great improvement in our understanding on recycled fibers has been made during last several decades and successfully applied to improve the technological processes for effective and efficient use of fiber resources. But there is much to be learned to improve the recycling potential of these fibers since the quality of recycled fibers keeps deteriorating these days because of repeated recycling of fibers. For instance, the amount of fines contained in OCC has been increased up to 35%. And it is not rare to find 50% of fines in headbox stocks for corrugating medium. This indicates that optimum treatment strategies for these fines should be developed to improve physical properties of paper products made from the recycled fibers. Diverse methods including mechanical, chemical, and biological treatments of fibers have been introduced.

The effect of mechanical pretreatment consisted of compressive impact and shear action on OCC before refining was examined and showed that it increases the water retention value without shortening the fiber length. This resulted in improved strength properties without a loss in drainage (1). Mild mechanical treatment of OCC at high consistency improves the quality of recycled fibers (2). Pretreatment with various chemical agents can also be used to compensate the strength loss occurring during recycling of OCC. Nonionic polymers such as guar gums and enzymes have been found to improve the papermaking potential of recycled fibers (3, 4). Fractionation and selective mechanical treatment of the fractionated fiber has also been performed to increase the utilization of recycled fiber. It has been shown that selective refining of long fraction of OCC was helpful to reduce the refining energy and improve the physical properties (5, 6).

Not many studies, however, has been made on the strategic use of short fiber fraction of OCC. Since these fines impair the drainage and retention, which again decreases the operating efficiency or production rate of a paper machine, it is imperative to find optimal strategy of using fiber fines. Mechanical pretreatment of fines, however, would be improper to use since it generates much smaller fines that severely decrease drainage and retention. For improving drainage and retention, flocculation of fines into large flocs may be employed.

In this study, the effect of polymeric treatment of OCC fines with cationic PAM and PEI on drainage and retention has been examined. We evaluated the ability of polyelectrolytes to form flocs by measuring the turbidity change after polymer addition. Qualitative analysis of floc images was also carried out using handsheets. The influence of fractionation ratio and the type and amount of addition of polyelectrolytes on drainage and retention was also evaluated.

EXPERIMENTAL

Evaluation of flocculation

Raw materials

OCC stocks were prepared by disintegrating commercial corrugating mediums made of KOCC (Korean Old Corrugated Containers) in a laboratory. Fractionation of this stock was made using Sweco screen equipped with 100-mesh wire. Table 1 shows the properties of two fractions, that is, long fiber fraction (retained stock) and short fiber fraction (passed stock).

Table 1. The properties of two fractions prepared in a laboratory

	Long fiber fraction	Short fiber fraction
Fiber length, mm	1.20	0.22
Fines content, %	10.2	90.7
Ash content, %	-	32.4

Four types of cationic PAM and PEI were used as flocculants. The properties of cationic polyelectrolytes are shown in Table 2.

Table 2. Properties of cationic polyelectrolytes

Type		Molecular weight, x 10^6	Charge density, meq/g	Viscosity, 25℃, 0.1% cPs	Structure
C-PAM	A	1~2	0.58	35.30	Branch
	B	8	0.80	45.80	Branch
	C	8	0.91	91.80	Linear
	D	8	1.88	97.50	Linear
PEI		0.6	6.89	3.50	Branch

Measurement of flocculation and shear stability

Flocculation of short fibers by polymer was evaluated by measuring turbidity of stocks (7). The change of turbidity with polymer addition was continuously measured using an apparatus which consisted of DDJ, rpm controller, peristaltic pump and turbidimeter (Fig. 1). Stirring speed was kept at 400 rpm and flow rate by peristaltic pump was 150 mL/min. Addition level of polymer into stocks were 0.03, 0.06, and 0.09% by weight percent based on O.D. short fibers.

The ability to form flocs was evaluated as RT_a (average relative turbidity) shown in Eq. [1] (7).

$$RT_a = \frac{T_a}{T_0} \qquad [1]$$

where,

T_0 : average turbidity before addition of polymer,

T_a : average turbidity after addition of polymer.

To examine shear resistance of flocs, shear rate was controlled at 400 rpm during 90 sec after adding polymer and then increased to 800 rpm. Stability of floc against shear was represented by SI (Stability index) in Eq. [2]. Lower SI means that the formed flocs show better shear resistance.

$$SI = \frac{T_{p,HS} - T_{p,LS}}{T_0 - T_{p,LS}} \qquad [2]$$

where,

T_0 : average turbidity before addition of polymer,

$T_{p,LS}$: turbidity after addition of polymer at low shear,

$T_{p,HS}$: turbidity after addition of polymer at high shear.

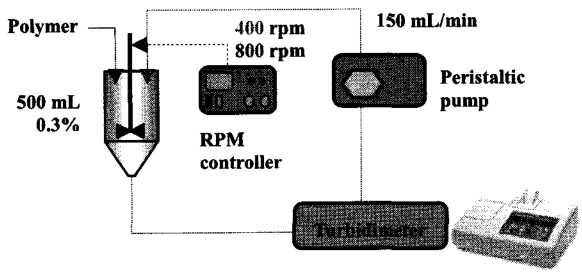


Fig. 1. Schematic diagram of turbidity measurement.

Evaluation of retention and drainage

Raw materials

KOCC stocks were obtained from duplex board mill to investigate the effect of chemical treatment of short fiber fraction on retention and drainage. For simulating stocks fractionated by multifractor in a mill, fractionation was made with Sweco screens with different wire mesh sizes, i.e., 100-mesh and 40-mesh. Table 3 represents two fractionation ratios based on weight percentage and fines content for each stock.

Table 3. Fines contents of fractionated stocks

Fractionation ratio (Accept : Reject)	Fines content, %	
	Accept	Reject
35:65	64.5	7.8
70:30	59.6	4.6

Chemical treatment of short fiber fraction

Cationic polyelectrolytes were added by two different methods (Fig. 2). One was that polymer was added to short fiber fraction and then treated short fiber fraction was mixed with long fiber fraction. The other was a conventional treatment that polymer was added to whole fibers stock. C-PAM B, C-PAM D and PEI were compared and dosages of polymer were 0.03, 0.06, and 0.09% based on O.D. short fibers.

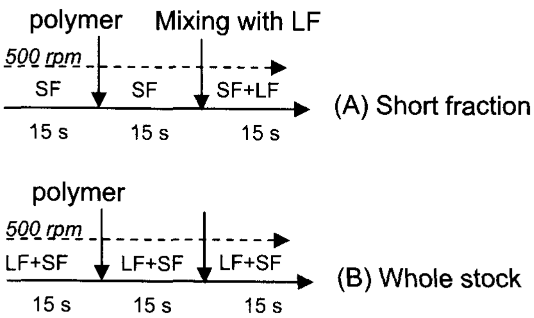


Fig. 2. Two methods of polymer addition.

Measurement of drainage and retention

Drainage was evaluated with the amount of drained water from DDJ during 10 s. And fines retention was also measured using DDJ. The experimental variables were type and addition level of polymer and addition method.

RESULTS AND DISCUSSION

Flocculation and shear stability

Turbidity of stock was decreased with the addition of polymer and it was dependent on type and addition level of polymer. Fig. 3 shows degree of flocculation expressed as RTa. Lower RTa means more flocculation. All of added polymers formed flocs of short fibers and flocculation tendency became greater with increase of polymer dosage. Especially PAMs formed much bigger flocs than PEI because of higher molecular weight. When PAM with branch structure was used, flocculation tendency was the greatest among used polymers and continuously increased until 0.06% of addition, but it has slowed above this dosage. But, linear PAM showed persistent flocculation with increase of polymer dosage. This result would be derived from the different molecular structure. As PAM with higher molecular weight or higher charge density was used as a flocculant, larger flocs of short fibers were produced.

Fig. 4 shows floc images of handsheet which basis weight was 30 gsm when polymer was added by 0.06%. As can be seen, C-PAM B which has high molecular weight and branch structure formed larger flocs than C-PAM D or PEI did. Consequently, molecular weight and structure are crucial factors to control flocculation of short fibers.

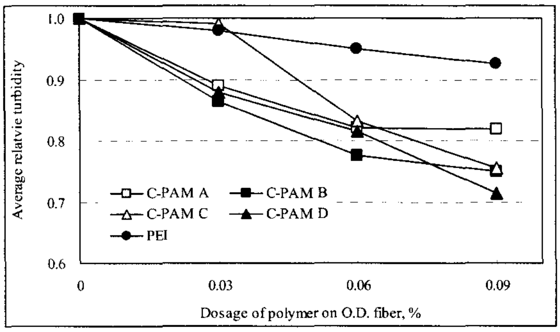
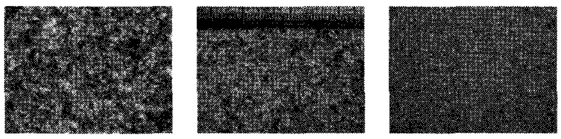


Fig. 3. Average relative turbidity of short fiber fraction with addition of cationic polymer.



C-PAM B C-PAM D PEI

Fig. 4. Images of flocs formed by addition of polymer to short fiber fraction (0.06% on O.D. short fibers).

For proper chemical treatment, not only more flocculation but also a resistance of floc on shear in process is very important. Weak flocs are easily broken by shear so it can make polymer addition ineffective. Fig. 5 showed the stability indices of flocs formed by C-PAM B, C and D. Despite of similar molecular weight, flocs formed by C-PAM B showed more resistant on shear. It seemed that molecular structure of polymer had a great influence on shear stability of flocs. And the less cationicity, the superior shear resistance. In case of PEI, the lowest shear stability was shown.

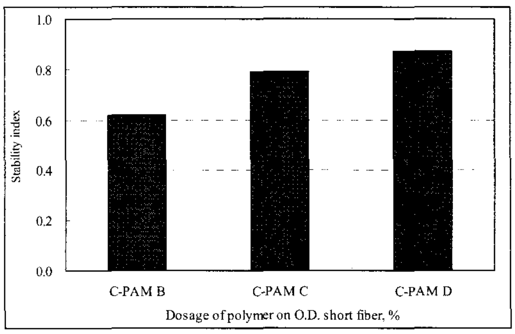


Fig. 5. Stability index of flocs formed by C-PAM B, C and D.

Drainage

Addition of polymer on short fiber fraction increased the amount of drained water (Fig. 6). Though C-PAM B formed the biggest flocs, the greatest improvement of drainage was obtained by C-PAM D due to higher cationic charge. PEI has the highest charge density but shows little increase of drainage. It is because PEI with low molecular weight formed smaller and weaker flocs. Fig. 7 represents effect of the addition level of polymer and addition method. As the amount of polymer increased, drainage was improved. Compared with conventional treatment which polymer added to whole fiber stock, selective treatment of short fiber fraction showed better drainage.

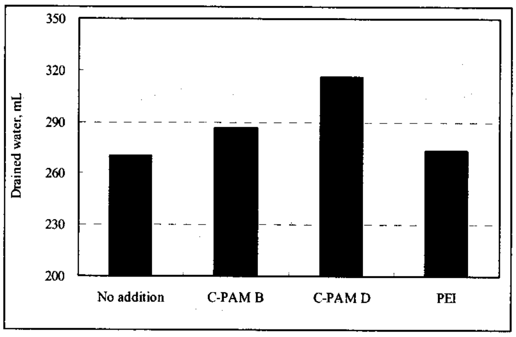


Fig. 6. Volume of drained water after addition of different cationic polymers to short fiber fraction (fractionation ratio of stock is 35:65).

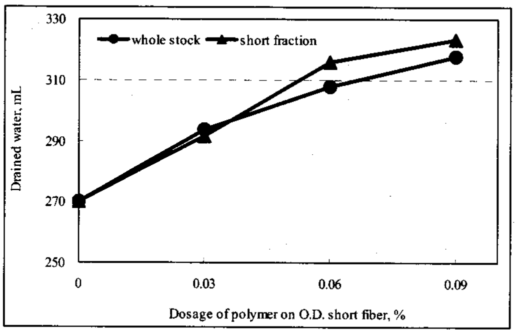


Fig. 7. Effect of addition method of C-PAM D on drainage.

Retention

Fig. 8 represented the fines retention after addition of cationic polymer with dosage of polymer. Stock treated by C-PAMs showed higher fines retention than PEI (Fig. 8) because of a better ability to flocculate.

Especially, addition of polymer to short fiber fraction gave higher fines retention compared with conventional addition (Fig. 9). Before mixing with long fiber fraction, short fibers were selectively treated by cationic polymers. The chemical treatment like this is effective in retention and drainage because most of fines could be attached onto fibers or filtered in the form of flocs by polymer. Stock with fractionation ratio of 35:65 showed a drastic increase of fines retention (Fig. 10).

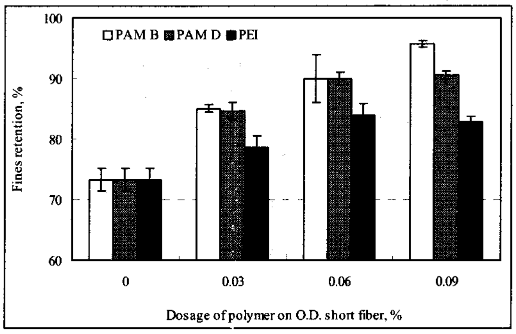


Fig. 8. Fines retention after addition of different cationic polymer to short fiber fraction (Fractionation ratio is 35:65).

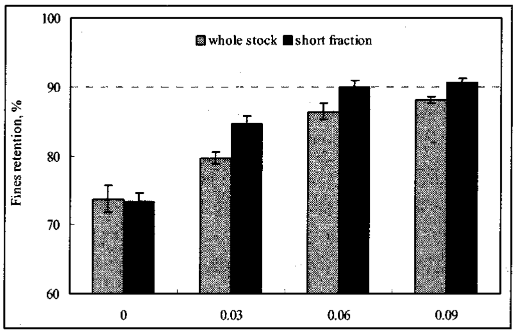


Fig. 9. Effect of addition method of C-PAM B on fines retention (fractionation ratio is 35:65).

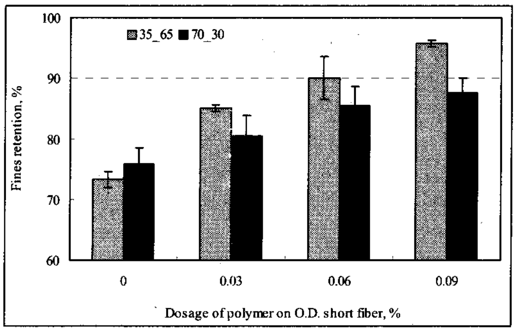


Fig. 10. Effect of fractionation ratio on fines retention.

CONCLUSIONS

Fines contained in the recycled fiber resources causes problems not only in paper properties but also in process runnability. This shows that the optimal management and proper use of fines in recycling papermaking system are critical to get most benefits of using recycled fibers. This study examined some approaches for optimal use of fiber fines in recycled paper mill.

Stock samples, prepared in the laboratory and obtained from a recycling plant, were used. Fractionation of these samples was made using Sweco screen. The effect of the addition of polyelectrolytes including cationic PAM and PEI on flocculation and shear stability was examined. Polymer with high molecular weight and branch structure formed much bigger flocs and branch structured polymer showed more resistance to shear.

In addition, the effect of chemical treatment on retention and drainage was investigated. Different methods of polymer addition were compared to find the most effective ways of treating recycled fiber stocks with polyelectrolytes. Addition of polyelectrolytes to the short fiber fraction was the most effective in retention and drainage. Polyelectrolyte with high charge density and high molecular weight could be chosen for drainage and with high molecular weight and branch structure was good for retention. Selective chemical treatment of short fiber fraction and proper type of polymer could be an approach for optimal use of recycling fines.

ACKNOWLEDGEMENT

This work was supported by Ministry of Commerce, Industry and Energy and partially by Brain Korea 21 Project, Korea Research Foundation. We are also deeply grateful to Prof. Hak Lae Lee for his advice on this study.

REFERENCE

1. Seo, Y.B., Choi, C.H., Seo, S.W., Lee, H.L. and Shin, J.H., Fiber property modification by mechanical pretreatment, Tappi J. 85(1):8-13(2002).
2. Lee, H.L., Youn, H.J., Lee, S.G., Huh, Y.D., Lee, J.J., Ryu, J.Y., Upgrade of recycled fibers by high consistency pulping, Proceeding of Spring Conference of K-Tappi, 202-206(2003).
3. Min, Z., Martin. A.H., Richard, A.V., and John, A.H., Effect of chemical pretreatments of never-dried pulp on the strength of recycled linerboard, 2001 Papermakers conference proceedings (2001).
4. Jaakko, P., Matti, S-A. and Liisa, V., Biomechanical pulping with enzymes: Response of coarse mechanical pulp to enzymatic modification and secondary refining, Tappi J. 83(5):1-8(2000).
5. Abubakar, S.M., Scott, G.M. and Klungness, Fiber fractionation as a method of improving handsheet properties after repeated recycling, Tappi J. 78(5):123-126(1995).
6. Lee, H.L., Youn, H.J., Kang, T.Y., Seo, M.S., Huh, Y.D. and Ryu, J.Y., Effects of fractionation of KOCC and mechanical treatments of its components on paper properties, Proceeding of Spring Conference of K-Tappi, 205-206(2002).
7. Lee, H.L., Youn, H.J., Lee, J.Y. and Ahn, H.M., Evaluation stock flocculation phenomena based on turbidity measurement, Proceeding of Fall Conference of K-Tappi, 273-282(2004).