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Characteristics of White Water from Enzyme Deinking process for ONP at Low Alkalinity

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ABSTRACT

Old newspaper was deinked using commercial cellulolytic enzymes and a surfactant complex at low alkalinity. The properties of the deinked pulp(DIP) were evaluated and the suspended solids content, cationic demand, turbidity, and chemical oxygen demand(COD) of the process water were measured. The results can summarized as follows,

1. The brightness and yield of the DIP were improved using enzymatic surfactant complex deinking.
2. The amount of foaming during deinking with the enzyme surfactant complex was higher than that with synthetic surfactant deinking. However, it was not sufficient to cause process problem.
3. The pH and turbidity of the white water from deinking with the enzyme surfactant complex were similar to those of the white water from surfactant deinking.
4. The suspended solids content, cationic demand, and COD of the white water from deinking with the enzyme surfactant complex were improved compared to those of the white water from surfactant deinking.

Keywords: *enzyme deinking, white water, suspended solid, cationic demand, turbidity, COD*

1. Introduction

The paper recycling process includes a deinking step to remove ink particles prior to waste paper recycling. Deinking is a series of unit operations in which ink is detached from the pulp fibers and the dispersed ink is separated from the pulp slurry. To facilitate the use of paper made with wastepaper, wastepaper-based products must compete with virgin equivalents, perform well during conversion, and meet the same end-product specifications. Deinking is necessary to achieve the minimum brightness values required for printing- and writing grade papers. The conventional deinking method requires large quantities of chemical agents, such as sodium hydroxide, sodium carbonate, hydrogen peroxide, and surfactants. Many approaches have been suggested to solve the problems encountered using traditional deinking techniques.[1,2)]

Bio-active deinking has been proposed as an alternative, as it is known that enzymatic deinking is beneficial in decreasing the use of chemicals and water

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compared to conventional alkaline methods.[3-5] Alkaline actives cellulolytic enzymes have also been used for deinking of waste papers.[6-8] Neutral deinking methods have also been reported.[9] In contrast with conventional deinking at high pH, the neutral deinking method avoids alkaline contaminants and yellowing of pulps. Much smaller amounts of chemical agents are therefore needed to bleach the deinked pulp. In neutral deinking, all processes are performed at neutral pH. Therefore, the white water of neutral deinking processes should be clearer than that of alkaline processes. Thus, a neutral or low alkalinity deinking process has the advantage of low cost of waste- water treatment. The white water from a neutral deinking process can be easily recirculated without any other treatment. Evaluation of the chemical properties of white water is very important for successive reuse of process water.

In this study, old newspaper(ONP) was deinked u sing commercial cellulolytic enzymes and a surfactant at low alkalinity. The properties of the deinked pulp(DIP) were evaluated and the suspended solids content, cationic demand, turbidity, and chemical oxygen demand(COD) of the process water were measured.

2. Materials and methods

2. 1. Materials

The paper stock used in this study was old newspaper(ONP) published in Korea. The ONP was torn into small pieces(approximately 3 × 4 cm) by hand and stored in vinyl packaging.

Ethylene oxide and propylene oxide copolymer(EOPO surfactant, Shinyang chemical. Co., Busan, Korea) and Denimax BT(enzyme, Novo Nordisk, Bagsvaerd, Denmark)were used as deinking agents, and NaOH and Na2SiO3 were used as additives.

2. 2. Methods

2. 2. 1. Disintegration of ONP

Forty grams of ONP were adjusted to 4% consistency by using 55℃ tap water(pH 6.8) that contained 0.5% NaOH and 1% Na_2SiO_3. As a deinking agent, 0.2% enzyme-surfactant complex(ESC; enzyme : surfactant = 1 : 9, w/w) was added. As a control, 0.2% surfactant(SUR) was added. After soaking for 10 minutes, the ONP was disintegrated

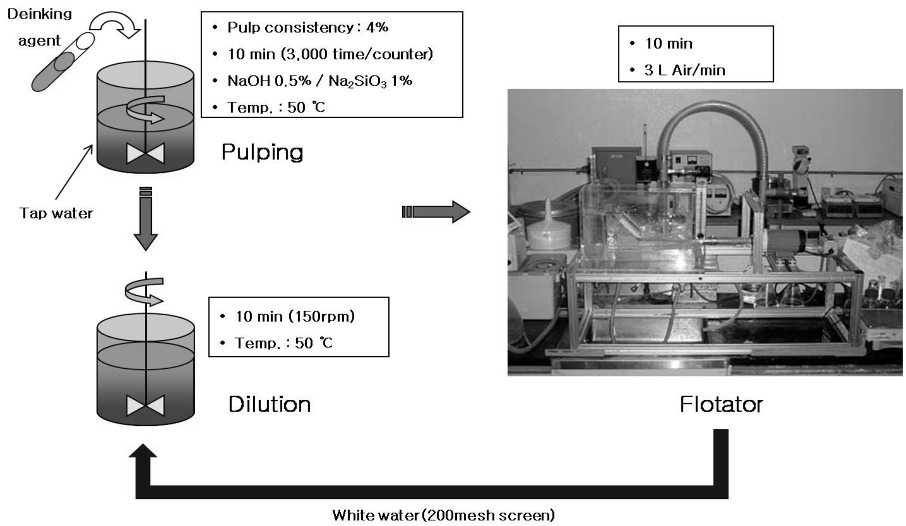

Fig. 1. Deinking process in the laboratory.

using a Canadian Standard laboratory-scale pulper. The disintegrator revolution was controlled to 3,000 times (Fig. 1).

2. 2. 2. Deinking of ONP

The ONP pulp slurry(conc. 1%) was deinked in a 3 L laboratory flotation cell (Fig. 1) for 10 minutes at 50℃ under an air flow of 3 L/min. Deinked pulp was dewatered and held in a refrigerator. Handsheets of deinked pulp were prepared according to TAPPI T 205. The brightness and yield of deinked pulp were determined using standard TAPPI methods.

2. 2. 3. Recycling of white water

After deinking, the pulp slurry was carefully screened with a 200 mesh screen. Almost 80% of the original water was collected using screen filtration (Fig. 1). The recovered white water was reused in flotation process for deinking 10 times successively.

2. 2. 5. pH

After every deinking, the pH of white water were measured.

2. 2. 6. Suspended solids(SS)

The suspended solids content of the white water was measured according to TAPPI T 656. The suspended solids content was calculated as follows:

$$Suspended\,Solids\,(mg/L) = (b-a) \times \frac{1,000}{V}$$

a : Weight of filter paper before filtration (mg)
b : Weight of filter paper after filtration (mg)
V: Volume of the sample (mL)

2. 2. 7. Turbidity

The turbidity of the white water was measured with a UV spectrometer at 280 nm.

2. 2. 8. Cationic demand

The cationic demand of the electric charge materials in white water was determined using a Zeta-meter(ZM 3+ 412, USA).

2. 2. 9. Chemical oxygen demand

Chemical oxygen demand content (COD)was measured by TAPPI T 281. The COD was calculated as below.

$$COD(mg/L) = (b-a) \times f \times \frac{1,000}{V} \times 0.2$$

a : 0.025N-potassium permanganate solution control titration (mL)
b : 0.025N-potassium permanganate solution sample titration (mL)
f : Factor of 0.025N-potassium permanganate solution
V : Volume of the sample (mL)

3. Results and discussion

3. 1. Brightness of the handsheets

The △-brightness of the deinked pulp handsheets is shown in Fig. 2. The △-brightness of the DIP deinked

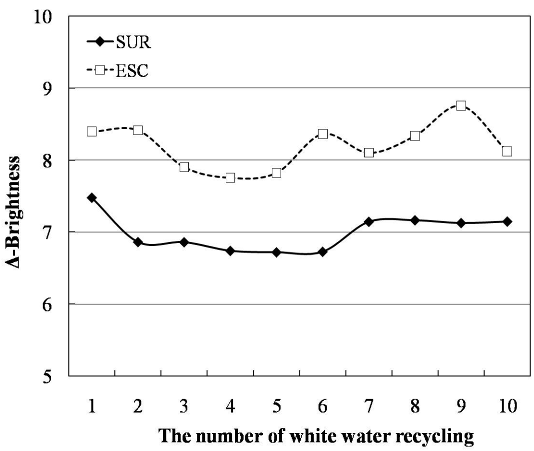

Fig. 2. △-Brightness of the handsheets. (SUR: surfactant, ESC: enzyme surfactant complex)

with ESC was 8.5 points while that of DIP deinked with SUR was 7.5. Thus, a small amount of enzyme can increase the brightness of the DIP. The △-brightness of the DIP was maintained while recycling and reusing the white water. Based on these results, it is apparent that the white water can be recycled without affecting the process in enzyme deinking of ONP with low alkalinity.

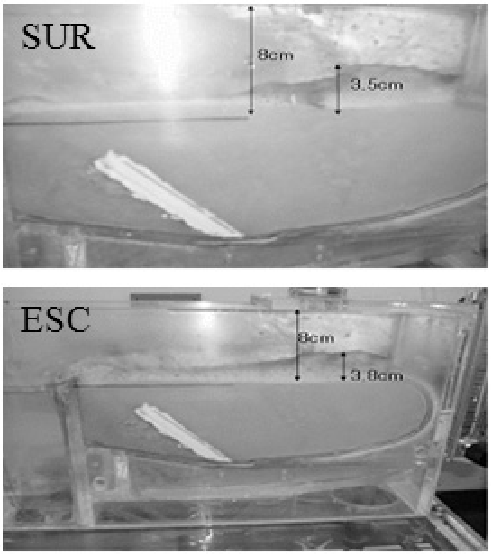

Fig. 4. Photography of the foam layer in the flotation cell.

3. 2. Yield of deinked pulp

The yield of acceptable pulp from the pulp slurry after deinking is shown in Fig. 3. The pulp yield from ESC deinking was slightly higher than that of SUR deinking. The pulp yield from the second deinking with recycled white water was about one percent lower, because fine fibers sticked on filler or pigment were removed more efficiently.

3. 3. Foam layer during froth flotation

Photographs of the foam layer in the flotation cell and the measured foam layer depth are shown in Figs. 4 and 5. The foam layer in ESC deinking was thicker than that in SUR deinking, due to the dispersive ability of the enzyme protein. The amount of foam in both methods increased gradually with recycling of the white water. After 5 times reuse of the white water, the foam layer thickened suddenly to 6.5 and 5.5 cm and stabilized at that level. Stabilization of the foam layer in the froth flotation cell indicates that foaming is not a concern in the ESC deinking process.

3. 2. pH of the white water

The pH of the white water increased gradually with recycling of the white water to near pH 10, since the concentration of NaOH and Na_2SiO_3 increased to

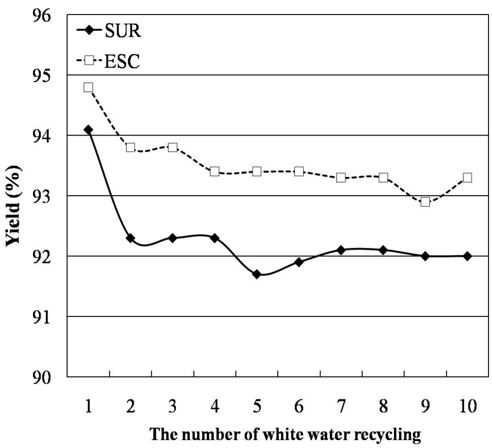

Fig. 3. Yield of the DIP.

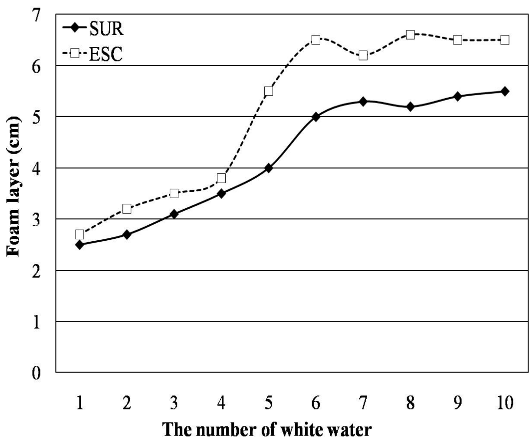

Fig. 5. The depth of the foam layer.

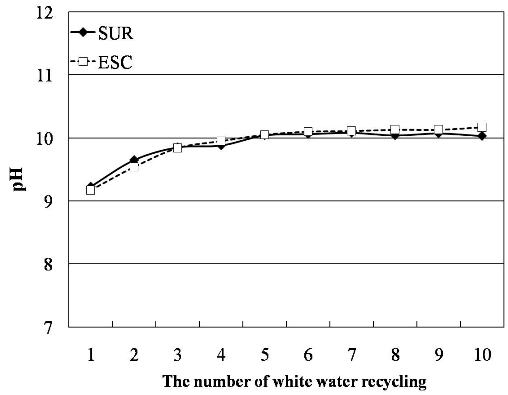

Fig. 6. pH of the white water.

some degrees. However, the pH of the white water also stabilized at pH 10. Because more than 85% of the enzyme (Denimax BT) activity remained at pH 10, the enzyme was able function effectively in the recycled white water (9).

3. 3. Suspended solid

Fig. 7 shows the suspended solids content in the recycle white water. The suspended solids content in the ESC deinking process was almost the same level as that of the SUR deinking process. The enzymes used in the ESC deinking process did not generate any micro-particles or compounds that would increase the suspended solids.

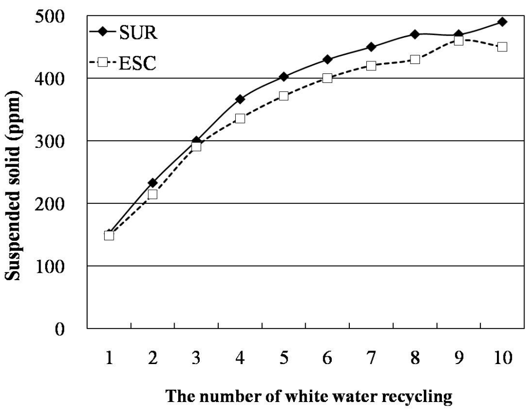

Fig. 7. Suspended solids content.

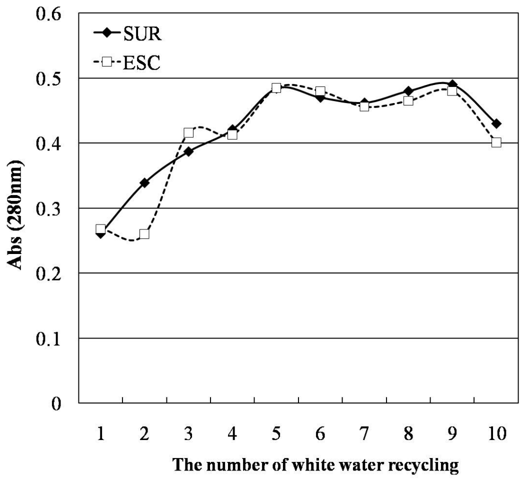

Fig. 8. Turbidity of the white water.

3. 4. Turbidity

The turbidity of the white water is shown in Fig. 8 as UV absorption at 280 nm. It could be expected that the turbidity of the white water in the ESC deinking would be much higher than that of the white water in the SUR process, because the enzyme proteins have absorbance at 280 nm. However, the turbidity of the white water was not substantially different between the two methods.

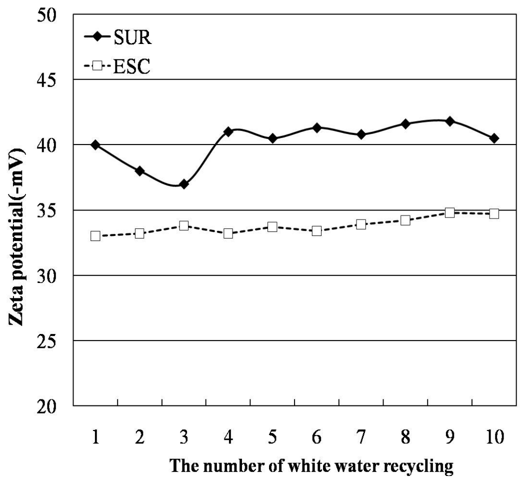

Fig. 9. Cationic demand of the white water.

3. 5. Cationic demand

The cationic demand of the white water is shown in Fig. 9. The zeta-potential of the white water in the ESC deinking process was somewhat higher and was much more stable than that of the white water in the SUR deinking process.

3. 6. COD

The COD of the white water increased after 3-4 reuse. After the fifth recycling, the COD of white water stabilized at ~1,200 ppm. The COD of the white water in the ESC deinking process was lower than that of the white water in the SUR deinking process. Thus, ESC deinking can improve the properties of the process effluent.

4. Conclusions

1. The brightness and yield of the DIP were improved with enzyme- added deinking.
2. The amount of foam in the deinking process with the enzyme surfactant complex was higher than with synthetic surfactant deinking. However, it was not enough to cause process problem.
3. The pH and turbidity of the white water in deinking with the enzyme surfactant complex were similar to those of the white water in surfactant deinking.
4. The suspended solids content, cationic demand, and COD of the white water from deinking with the enzyme surfactant complex were improved over those of the white water from surfactant deinking.

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