The Effects of Sodium Percarbonate and Perborate Usage on Pulping and Flotation Deinking Instead of Hydrogen Peroxide

Emrah Pesman,[a] Sami Imamoglu,[a,]* Evren Ersoy Kalyoncu,[b] and Hüseyin Kırcı [b]

The main objective of this study was to evaluate the potential of sodium percarbonate and sodium perborate utilization during repulping of old news and magazine paper mixture. A series of experiments were performed to determine the effects of bleaching agents on ISO brightness and ink removal efficiency of pulp after flotation deinking. Conventionally, with other parameters are constant, the ISO brightness of pulp was increased from 45.24% to 54.10% and ink elimination ratio at 950 nm of pulp was increased to 69.12% with 1% sodium hydroxide and 1% (as active oxygen content) hydrogen peroxide usage. However, when sodium percarbonate was utilized instead of hydrogen peroxide (as 1% active oxygen content) without alkaline addition, the ISO brightness of the pulp was increased to 55.00%. Also, unlike the other bleaching agents, a favorable effect of sodium percarbonate on ink detachment was observed. The ink elimination ratio of floated pulp was increased to 74.31% with 1% (active oxygen) sodium percarbonate addition without alkaline usage. There were no additive effects of sodium perborate usage on brightness, and ERIC value of pulp could be determined. In this respect, sodium percarbonate utilization without sodium hydroxide addition was proposed for effective repulping, deinking, and prebleaching of waste papers, in a similar manner to the use of hydrogen peroxide.

Keywords: Flotation; Deinking; Sodium percarbonate; Hydrogen peroxide; Bleaching

*Contact information: a: Department of Forest Product Engineering, Artvin Coruh University, 08000 Artvin, Turkey; b: Department of Forest Product Engineering, Karadeniz Technical University, 61080 Trabzon, Turkey; * Corresponding author: imamoglusami@gmail.com*

INTRODUCTION

Alkaline additives, especially sodium hydroxide, are indispensable for traditional pulping and deinking processes during recycling of waste papers. It is commonly believed that ink detachment is improved by sodium hydroxide addition because of fiber swelling effect and chemical hydrolysis of some bonds between the substrate and some ink species. It is also suggested that sodium hydroxide addition during repulping of TMP increases the level of fiber swelling and improves the strength properties of handsheets (Gurnagul 1995). On the other hand, alkaline treatments, especially with sodium hydroxide, can cause pulp darkening (He *et al*. 2004). For this reason hydrogen peroxide usage has become a traditional application for waste paper repulping.

Hydrogen peroxide is used to decolorize the chromophores generated by the alkaline pH in a wood-containing pulp (Ferguson 1992). The bleaching activity of hydrogen peroxide can be attributed to the perhydroxyl anion (HOO-) which is formed in alkaline conditions, according to the following formula,

$$H_2O_2 + OH^- \longrightarrow OOH^- + H_2O$$

In addition to this, it has also been suggested that peroxide breaks bonds in print networks, which can help detach print from fibers and also create smaller print particles (Turvey 1995). Alkaline conditions are required for hydrogen peroxide bleaching and deinking operation, but conditions that are too alkaline are detrimental. One solution is to replace NaOH with other alkaline agents such as $Mg(OH)_2$ (Zeinaly *et al.* 2009; He and Li 2008). Another solution is to replace hydrogen peroxide with other alkaline peroxide compounds.

Some other peroxide compounds such as sodium percarbonate and sodium perborates have been utilized in detergency for the cleaning industry (Milne 1998). These oxygen-based compounds can be utilized like hydrogen peroxide for bleaching of wood-containing pulps too. Sodium percarbonate and sodium perborate are alkaline reactants unlike hydrogen peroxide and do not need extra caustic soda (NaOH) for bleaching activity. Meshcherova and coworkers (1982) conducted laboratory studies on the use of sodium and potassium perborates for bleaching softwood kraft pulps and they concluded that it is more advantageous to bleach kraft pulp with potassium perborate than hydrogen peroxide. Also sodium perborate monohydrate was utilized for reinforcement of oxygen delignification; it was found that the delignification ratio can be increased from 45.56% to 57.59% without selectivity loss (Pesman *et al.* 2010). Varennes and coworkers (1996) used sodium perborate tetrahydrate for bleaching of thermomechanical pulp. Brightness as high as 75% ISO was reached with the addition of 6.5% sodium perborate tetrahydrate. Moreover, by using sodium perborate monohydrate for the bleaching of SGW (Stone Ground Wood) pulp, the brightness of pulp increased from 49.64% to 64.74% ISO with a 1% active oxygen dosage without caustic soda usage (Pesman *et al.* 2006). When sodium perborate tetrahydrate is dissolved in water, sodium metaborate and hydrogen peroxide are generated, as can be seen in Eq. 2

$$[NaBO_2(OH)_2.3H_2O]_2 \overset{H_2O}{\rightleftharpoons} 2NaBO_2 + 2H_2O_2 + 6H_2O \qquad (2)$$

Leduc and coworkers (2002) studied the use of sodium percarbonate for bleaching of mechanical pulp. They concluded that the brightness gain obtained with sodium percarbonate bleaching is comparable to that obtained with an equivalent amount of hydrogen peroxide under conventional bleaching conditions (Eq. 3).

$$2Na_2CO_3 \cdot 3H_2O_2 \overset{H_2O}{\rightarrow} 2Na_2CO_3 + 3H_2O_2 \qquad (3)$$

Hydrogen peroxide is known to be a strong oxidizer. Contact with oxidable organic materials may cause spontaneous combustion. Hydrogen peroxide is catalytically decomposed by many common materials, resulting in the evolution of heat and oxygen, which can support the burning of combustible materials. Also hydrogen peroxide can cause health hazards too during handling. Due to these hazards and oxidative properties, storage and handling of hydrogen peroxide should be monitored carefully. Mills can receive hydrogen peroxide at 70% or 50% concentration. Highly concentrated hydrogen peroxide solution can be stored safely, with special engineered safety precautions and tight concentration solutions, such as special tank trucks, railcars, expensive storage tanks (aluminum and 304 and 306 stainless steels, special location away from potential contaminants), and special piping systems (TAPPI TIP 0606-24). Hydrogen peroxide is a cheap reactant, but handling and storage are big problems that increase the establishment costs of a mill.

Sodium percarbonate (15.3% active oxygen) or sodium perborate tetrahydrate (10.4% active oxygen) usage is safer to use than hydrogen peroxide and easily stored when compared with peroxide. Also these reactants contribute to alkalinity and reduce or eliminate the amount of extra alkali required for the deinking process.

In the present study, the possibility of repulping and flotation deinking of ONP/ MAG papers with sodium perborate and sodium percarbonate was investigated. More specifically, this work deals with the investigation of sodium percarbonate and sodium perborate as prebleaching and dispersion agents without sodium hydroxide usage for repulping of old news and magazine papers. In the study, the effects of sodium hydroxide, hydrogen peroxide, sodium perborate, and sodium percarbonate concentration on the ISO brightness, ink removal efficiency, and yield of flotation deinked waste pulps were investigated.

EXPERIMENTAL

Material

News (Vatan) and magazines (Borsa), printed on 31.03.2007 and 27.01.2007, respectively, with oil-based offset printing ink and used in this study for waste paper furnish, were obtained from Doğan Printing Center. These waste papers were stored in a dark-closed warehouse at room temperature. For comparability of each experiment, the same pages of news and magazines were selected, and a mixture of waste papers (80% news and 20% magazines) was prepared. Some properties of the waste papers are shown in Table 1. The composition of mechanic and chemical pulp contents of papers were determined by using the phloroglucinol-HCl test (Levlin and Soderchjelm 1999). Fibers in the paper samples were classified using the Lorentzen fiber classification system.

Table 1. Some Properties of Recycled Waste Papers

	Composition of Paper			Fiber Classification	
	Mech. Pulp (%)	Chem. Pulp (%)	Ash Content (%)	Long Fiber (%)	Fines (%)
Newspaper from News	77.32	22.68	1.40	59.01	24.89
LWC paper from Magazine	60.00	40.00	26.23	63.79	19.37

Pulping

Pulping was carried out at 45 to 50 °C for 10 min in a Micro-Maelström laboratory pulper as described by Imamoglu and co-workers (2013). The system was heated and speed controlled by digital processing. The loading of the pulper was done manually, and 100 g oven-dry old news/magazine papers (80 g news, 20 g magazine) were used in each experiment. To eliminate variability, the consistency of pulp suspensions was diluted to 7% with deionized water. For each experiment, 1% fatty acids (Olinor RS-4200 obtained from Meteksan pulp and paper mill), 1% sodium silicates, and 0.2% EDTA were added into the pulper.

The variable parameters, sodium hydroxide, and oxygen-based bleaching agent charges, were varied from 0% to 1%, as shown in Table 2. For coherent comparison of bleaching agents, the charges of the agents were selected according to the active oxygen content. The active oxygen content of hydrogen peroxide (H_2O_2) is 47%, sodium perborate tetrahydrate (S_PB) is 10.41%, and sodium percarbonate (S_PC) is 15.3% approximately. Namely 7.06 g of hydrogen peroxide (30%), 9.60 g of sodium perborate tetrahydrate, and 7.68 g of sodium percarbonate is necessary to reach 1 g active oxygen content.

The order of chemicals added in pulper was the alkaline agent, sodium silicate, EDTA, bleaching agent (H_2O_2 or S_PB or S_PC), and towards the end of pulping fatty acid soap as surfactant.

Flotation

After the pulping, dispersed ink and pulp were transferred to the flotation cell and diluted to 1% with deionized water. The flotation deinking was carried out at 45 to 50 °C for 10 min in the Degussa type flotation cell. Before flotation, 0.003 mol/L of calcium chloride was added into the flotation cell, and uniform distribution was provided with pulp suspension. Aeration was applied at 2.5 L/min, and the speed of stirring was kept constant at 1450 rpm. At the end of the flotation, deinked pulp was separated from floated wastes and filtrates for analysis.

Table 2. Charge of Variable Parameters during Pulping

NaOH %	H_2O_2* %	S_PB* %	S_PC* %
-	0.25	0.25	0.25
	0.50	0.50	0.50
	0.75	0.75	0.75
	1.00	1.00	1.00
0.25	0.25	0.25	0.25
	0.50	0.50	0.50
	0.75	0.75	0.75
	1.00	1.00	1.00
0.50	0.25	0.25	0.25
	0.50	0.50	0.50
	0.75	0.75	0.75
	1.00	1.00	1.00
0.75	0.25	0.25	0.25
	0.50	0.50	0.50
	0.75	0.75	0.75
	1.00	1.00	1.00
1.00	0.25	0.25	0.25
	0.50	0.50	0.50
	0.75	0.75	0.75
	1.00	1.00	1.00

*Bleaching agents as active oxygen content

Preparing Pads and Optical Test

Deinked pulp was taken from the flotation cell and put in a Degussa thickening cell to remove water that remained from the flotation process. The mixture was drained through a 200-mesh wire screen in the thickening cell. Finally, dry matter of thick pulp, which was around 30% consistency, was determined and stored in the refrigerator at <4 °C until used. The ash contents of deinked pulps and rejects were determined according to TAPPI Method 211-om93. Total yield was calculated for each of the trials based on dry paper fed into the pulper (Table 3).

Filter pads for optical tests of treated pulps were prepared in accordance with the modified INGEDE-1 method. A specified amount of thickened pulp was initially mixed with deionized water in a beaker with mild mixing for 2 min. The consistency of the fiber suspension was then set at 0.3% by adding more water, and the pH of the suspension was adjusted to 7. Prepared pulp suspension was filtrated over black filter paper to evaluate pad with the basis weight 225 g/m², followed by drying at 95 ºC for 10 min with the drying unit of a Rapid Köthen handsheet machine.

Brightness of filter pads was measured according to the TAPPI T 452 om-98 standard at a 457 nm modal wavelength. Measurements were done using a UV filter to avoid the disturbance of residual materials having some fluorescence effects. Colour measurements of filter pads were achieved according to TAPPI T 527-om 94 method, giving *L**, *a**, *b** values

Ink removal is one of the most important steps in recycling of mixed recovered office paper, old magazines, and old newspapers. Ink removal efficiency of a recycling operation is characterized by the brightness increment of the final paper over that of feed stock. Final paper brightness has been used as a product specification of recycled papers. However, the brightness measure has deficiencies in quantifying ink-removal efficiency and the amount of residual ink in deinked pulp because paper brightness depends on additional factors, such as pulp refining, pressing, calendering, and formation (Vahey *et al*. 2006). Jordan and Popson (1994) developed a near-infrared reflectance technique to measure residual ink concentration in paper made of deinked pulp using Kubelka-Munk theory (1931). The technique has been adopted by TAPPI as provisional test method T 567 pm-97 to measure the effective residual ink concentration (ERIC) of deinked pulp.

In this study ERIC values were calculated according to TAPPI test method T 567 pm-97, and also the ink elimination ratio at 950 nm (IE_{950} %) was calculated according to INGEDE test method 2

RESULTS AND DISCUSSION

Effects of Sodium Hydroxide on Deinked Pulp Qualities

Alkaline agents, especially sodium hydroxide are indispensable for traditional repulping and deinking of waste papers. Sodium hydroxide improves the swelling of fiber, as well as saponifying and dissolving the carrier parts of ink. Thus ink pigments easily release from fiber.

In the present study, the effects of sodium hydroxide on yield, color, brightness, and effective residual ink concentration of deinked pulps were determined. Table 3 shows the yield parameters of deinked pulps. pH-1 was measured before pulping, after chemical addition, pH-2 was measured at the end of the pulping, and pH-3 was measured after the flotation process from filtrate. TSS and TDS values were determined by gravimetric measurements and evaporation from flotation filtrate according to TAPPI-656

Table 3. Yield Parameters of Deinked Pulps and Rejects

NaOH (%)	Pulping pH-1	Pulping pH-2	Flotation pH-3	Pulp Yield (g)	FLS (g)	TSS (g)	TDS (g)
0.00	8.8	7.6	7.5	75.84	22.74	3.524	4.108
0.25	9.6	7.9	7.8	77.14	19.71	2.688	5.984
0.50	10.7	9.9	8.6	77.84	18.24	2.167	6.280
0.75	11.2	10.5	9.2	77.96	18.17	2.091	6.810
1.00	11.5	10.6	9.4	79.87	17.13	1.960	6.950

The pH at the exit of the pulper is often between 8.5 and 10.5 when deinking a newspaper/magazine furnish. In our study the pH (pH-2) at the exit of pulper was determined as 10.63 with 1% sodium hydroxide addition. Increased sodium hydroxide charges gave rise to a yield gain during flotation. Also sodium hydroxide addition decreased the total suspended solids (TSS) content of filtrate after flotation. The optimum charges of sodium hydroxide leads to effective ink detachment and optimum ion balance during flotation. Depending on increased alkali charge, the total dissolved solids (TDS) contents in filtrate were increased (Table 3). Hemicellulose dissolution and ink-carrier dissolution by alkaline treatment affected the TDS augmentation.

As shown in Fig. 1, the increased sodium hydroxide charges led to an increase in the ink elimination value (IE_{950}) of pulp, while it did not affect the ISO brightness. Alkaline addition at the deinking process had a positive effect on ink removal but also a negative effect on pulp yellowness (Fig. 2).

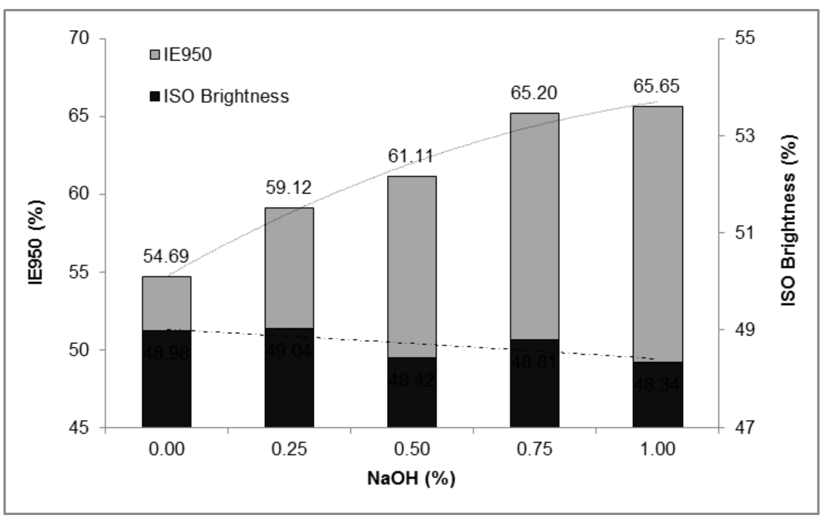

Fig. 1. Effects of NaOH charges on ISO brightness and IE950 value of pulp

Effects of Oxygen-Based Bleaching Agents on Deinked Pulps Qualities

The addition of hydrogen peroxide to the pulper has become a conventional practice aimed at inhibiting or balancing the alkaline yellowing of pulps. In this study, the alternative peroxide compounds sodium perborate and percarbonate were investigated and compared with hydrogen peroxide. The optical properties of pulps, bleaching agents and sodium hydroxide charges are shown in Tables 4, 5, and 6.

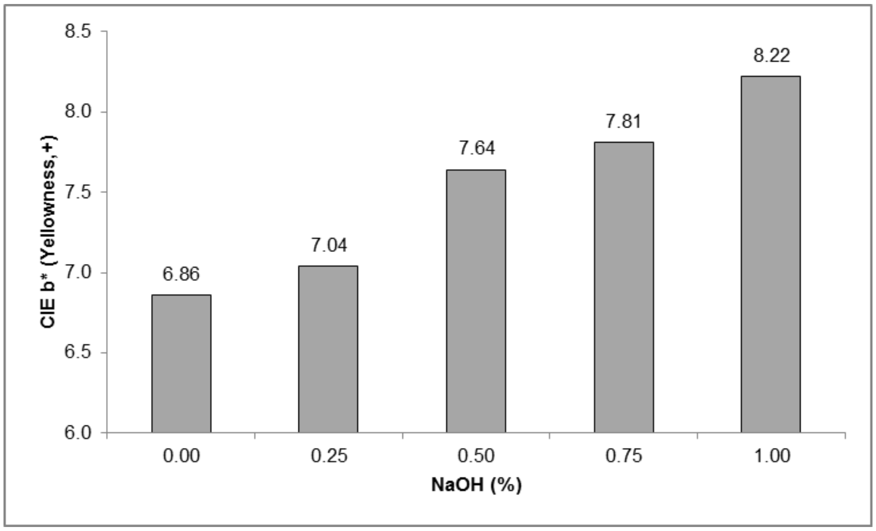

Fig. 2. Effects of NaOH charges on CIE b* value of pulp

Table 4. Effects of H_2O_2 and NaOH on Optical Properties of Deinked Pulps

NaOH %	H_2O_2[1] %	ISO Brightness %	IE950 %	ERIC ppm	L*	a*	b*
0.00	0.25	49.00	52.22	206.3	78.78	-0.36	6.50
	0.50	49.44	49.95	216.1	78.81	-0.37	6.30
	0.75	49.65	51.02	211.5	78.85	-0.45	6.18
	1.00	50.19	52.29	206.0	79.04	-0.41	6.14
0.25	0.25	50.42	55.94	190.2	79.48	-0.38	6.89
	0.50	51.00	57.30	184.3	79.81	-0.40	6.56
	0.75	51.54	59.18	176.2	80.41	-0.54	7.18
	1.00	52.12	59.72	173.9	80.98	-0.58	6.87
0.50	0.25	50.95	61.19	167.6	80.19	-0.46	7.63
	0.50	52.38	62.68	158.1	81.34	-0.61	7.71
	0.75	52.87	62.78	160.7	81.67	-0.63	7.63
	1.00	53.04	63.31	158.4	82.19	-0.65	7.65
0.75	0.25	51.01	64.87	151.7	80.21	-0.54	8.20
	0.50	52.77	64.58	152.9	82.01	-0.64	8.11
	0.75	53.15	64.92	151.5	82.40	-0.65	8.28
	1.00	53.75	65.22	150.1	82.71	-0.69	8.11
1.00	0.25	51.88	65.62	148.4	81.56	-0.62	8.35
	0.50	53.46	66.42	145.0	82.75	-0.73	8.65
	0.75	54.06	67.37	140.9	82.92	-0.79	8.77
	1.00	54.10	69.12	133.3	83.02	-0.81	8.60

[1]Active oxygen

The main role of bleaching agents is to increase the brightness of pulp; this is done to counteract alkaline yellowing. But hydrogen peroxide requires the use of an alkaline agent for generation of the perhydroxyl anion that is responsible for the bleaching of pulp. On the other hand, sodium perborate and percarbonate are alkaline peroxide compounds and do not need extra alkaline for bleaching activity.

Table 5. Effects of S_PB and NaOH on Optical Properties of Deinked Pulps

NaOH %	S_PB[1] %	ISO Brightness %	IE_{950} %	ERIC ppm	*L**	*a**	*b**
0.00	0.25	50.31	55.70	191.2	80.07	-0.45	6.90
	0.50	51.06	56.55	189.3	80.34	-0.64	7.16
	0.75	52.28	59.22	176.1	81.34	-0.71	7.63
	1.00	52.53	59.38	175.6	81.63	-0.73	8.00
0.25	0.25	50.50	58.43	181.6	79.87	-0.47	7.22
	0.50	51.04	59.39	178.6	80.57	-0.64	7.70
	0.75	52.24	60.17	168.7	81.35	-0.74	7.84
	1.00	52.34	60.87	170.0	81.32	-0.79	8.11
0.50	0.25	50.80	62.37	161.4	80.51	-0.55	7.95
	0.50	51.85	62.41	162.3	80.94	-0.63	7.95
	0.75	52.35	62.70	161.0	81.87	-0.73	8.50
	1.00	52.70	62.93	160.0	81.90	-0.75	8.51
0.75	0.25	50.67	64.81	151.9	80.48	-0.57	8.21
	0.50	52.12	64.72	152.3	81.66	-0.64	8.46
	0.75	52.16	64.66	152.6	81.68	-0.66	8.79
	1.00	52.81	65.00	151.1	82.03	-0.70	8.88
1.00	0.25	49.99	65.66	149.2	80.53	-0.50	8.69
	0.50	51.90	66.08	149.0	81.49	-0.60	8.95
	0.75	52.11	65.42	149.3	81.58	-0.65	9.08
	1.00	53.12	66.66	143.9	82.50	-0.71	9.15

[1]Active oxygen

Table 6. Effects of S_PC and NaOH on Optical Properties of Deinked Pulps

NaOH %	S_PC[1] %	ISO Brightness %	IE_{950} %	ERIC ppm	*L**	*a**	*b**
0.00	0.25	50.98	62.99	159.8	80.04	-0.19	7.04
	0.50	53.40	70.06	129.3	82.09	-0.51	7.39
	0.75	54.30	73.99	112.3	82.81	-0.55	7.96
	1.00	55.40	74.31	110.9	83.78	-0.57	8.09
0.25	0.25	52.30	68.91	137.9	81.48	-0.49	7.70
	0.50	54.30	71.71	122.2	82.57	-0.60	7.72
	0.75	55.20	74.25	111.2	83.35	-0.62	8.33
	1.00	55.70	73.00	116.6	83.71	-0.66	8.26
0.50	0.25	52.80	69.03	137.7	81.61	-0.60	7.75
	0.50	54.40	72.07	120.6	82.84	-0.62	8.23
	0.75	55.30	73.76	113.3	83.50	-0.67	8.47
	1.00	55.80	71.37	123.6	83.89	-0.69	8.55
0.75	0.25	52.60	69.87	130.1	81.92	-0.58	8.07
	0.50	54.80	71.80	121.8	83.27	-0.60	8.47
	0.75	55.20	70.19	128.7	83.36	-0.75	8.62
	1.00	55.40	69.71	130.8	83.93	-0.71	9.04
1.00	0.25	53.20	70.91	125.6	82.27	-0.63	8.47
	0.50	54.60	70.25	128.4	83.30	-0.65	8.83
	0.75	54.90	63.10	159.3	83.27	-0.82	8.91
	1.00	55.00	62.30	162.8	83.41	-0.87	9.12

[1] Active oxygen

In Fig. 3, the effects of hydrogen peroxide, sodium perborate tetrahydrate, and sodium percarbonate usage on ISO brightness of pulps, without sodium hydroxide addition, are shown. In the absence of any alkaline additives, increased hydrogen peroxide did not show any notable effect on brightness. But sodium perborate and sodium percarbonate addition each increased the brightness of pulp, as can be seen in Fig. 3. Sodium percarbonate was more effective than sodium perborate with respect to brightness gain because of the low temperature of repulping (45 to 50°C). Sodium percarbonate can be activated at low temperature (Takeda *et al.* 1984), but sodium perborate needs high temperature, such as 70 to 80 °C, for activating.

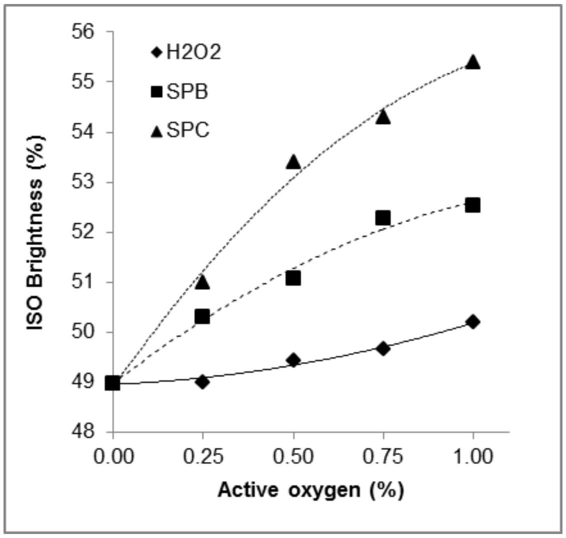

Fig. 3. Effects of bleaching agents on ISO brightness without alkaline usage

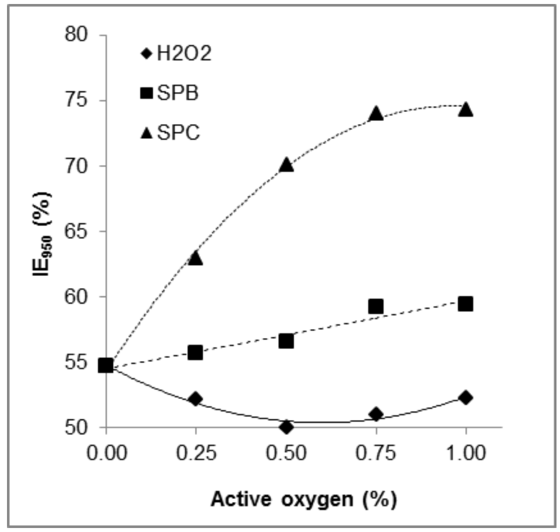

Fig. 4. Effects of bleaching agents on ink elimination ratio without alkaline usage

Figure 4 shows the ink elimination ratio of pulps and Table 7 shows the pH values of these experiments. It is evident that sodium percarbonate can provide the needed alkaline for deinking activity by itself. Unlike the other bleaching agents, the favorable effect of sodium percarbonate on ink detachment was determined. This result may help to account for the fact that the highest ISO brightness of pulp was achieved too.

Table 7. pH Values of Pulping Conditions after Repulping Process

Active oxygen (%)	H_2O_2	S_PB	S_PC
0.00	7.5	7.5	7.5
0.25	7.6	8.0	8.5
0.50	7.7	8.3	8.9
0.75	7.5	8.5	9.1
1.00	7.7	8.6	9.1

For an accurate comparison of these peroxide compounds, the same charges of bleaching agents and also the same pH conditions must be provided. In Fig. 5, the effects of bleaching agents on yield and in Fig. 6, the effects of bleaching agents on suspended solids content of filtrate at similar pH conditions are shown. Highest yields and lowest rejects (namely fiber losses) were obtained with sodium percarbonate usage. The highest suspended solid contents were also obtained. This means that sodium percarbonate usage with increased caustic soda decreased the floatability of fines and inks or increased the dispersion of ink particles. If inks and fines could be floated well, then the suspended solids in the filtrate would be decreased.

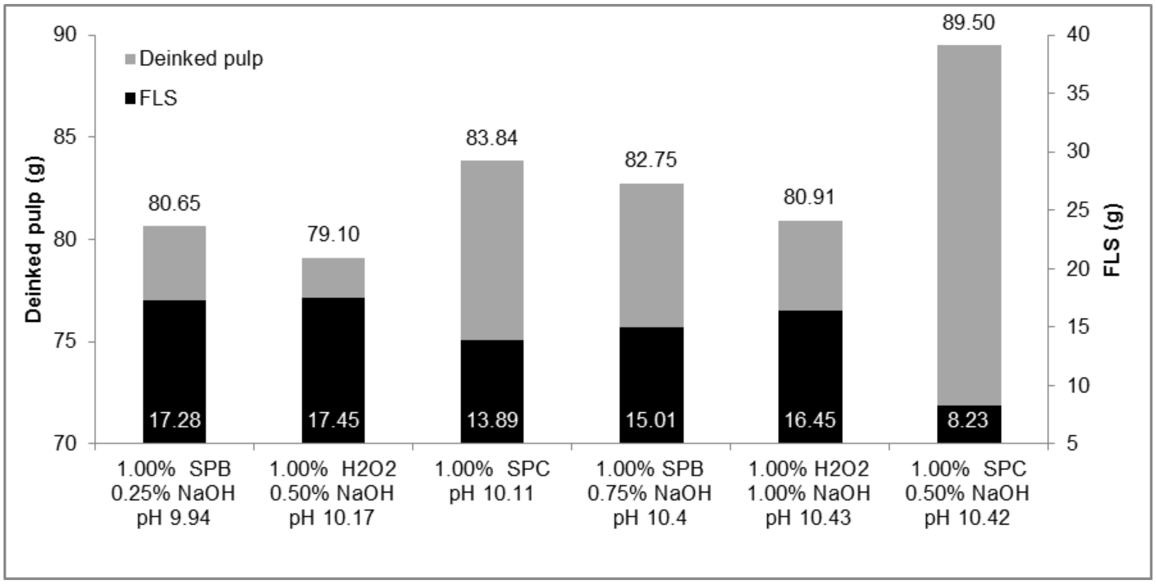

Fig. 5. Effects of oxygen-based bleaching agents on pulp yield at similar pulping pH

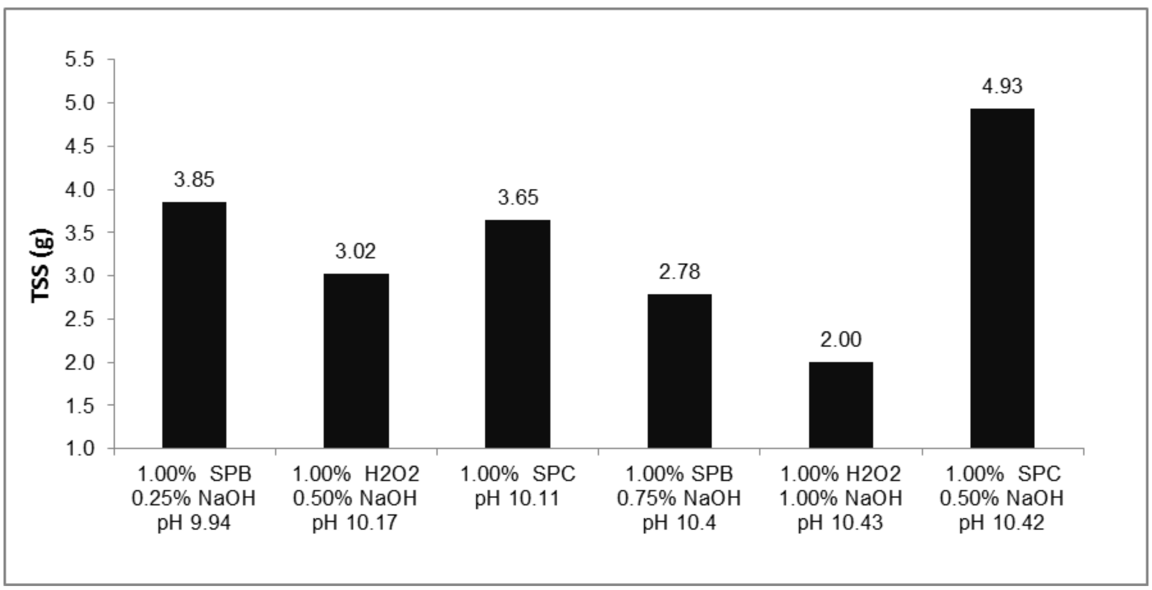

Fig. 6. Effects of oxygen-based bleaching agents on suspended solid contents of filtrate at similar pulping pH

But ink removal and brightness of pulp were not decreased with sodium percarbonate usage (Fig. 7). Because sodium percarbonate is a good dispersant, some parts of ink were removed by flotation and other parts were removed by thickening of the pulp. In other words, some contaminants were washed from the pulp more easily. The effects of bleaching agents on ISO brightness and Ink Elimination (IE_{950}) ratios are shown in Fig. 7.

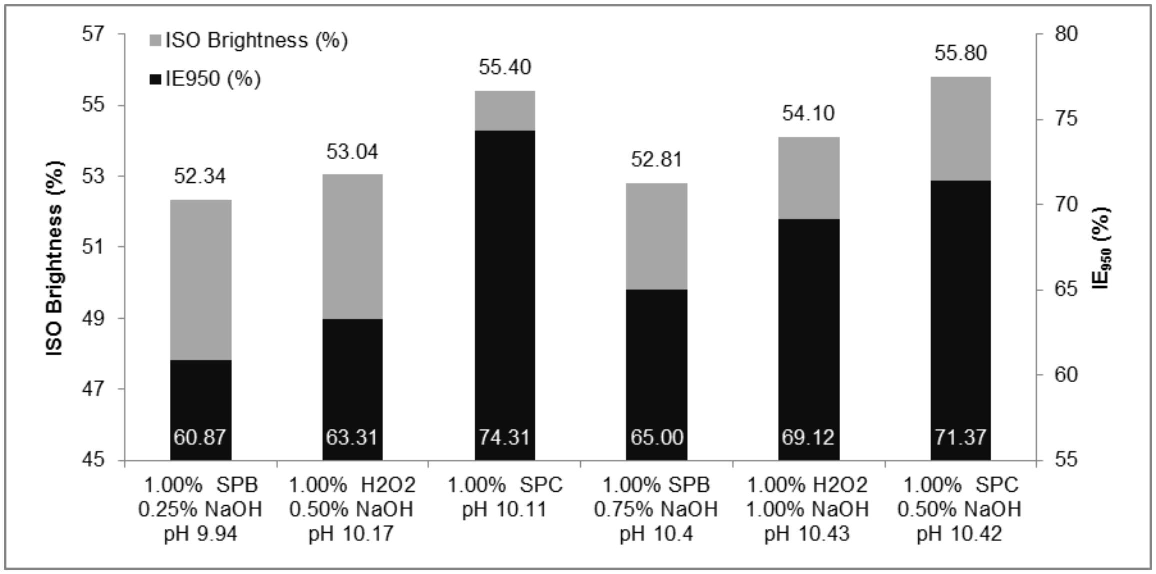

Fig. 7. Effects of oxygen based bleaching agents on ISO brightness and IE950 value of floated pulps at similar pulping pH

In Figure 8, the yellowness (CIE *b**) and greenness (CIE *a**) of pulps at similar pH conditions are shown. Yellowness of pulp is known to have a strong relationship with pH conditions of pulping. For this reason at similar pH conditions, similar CIE *b** and CIE *a** values were obtained with different oxygen-based bleaching agents.

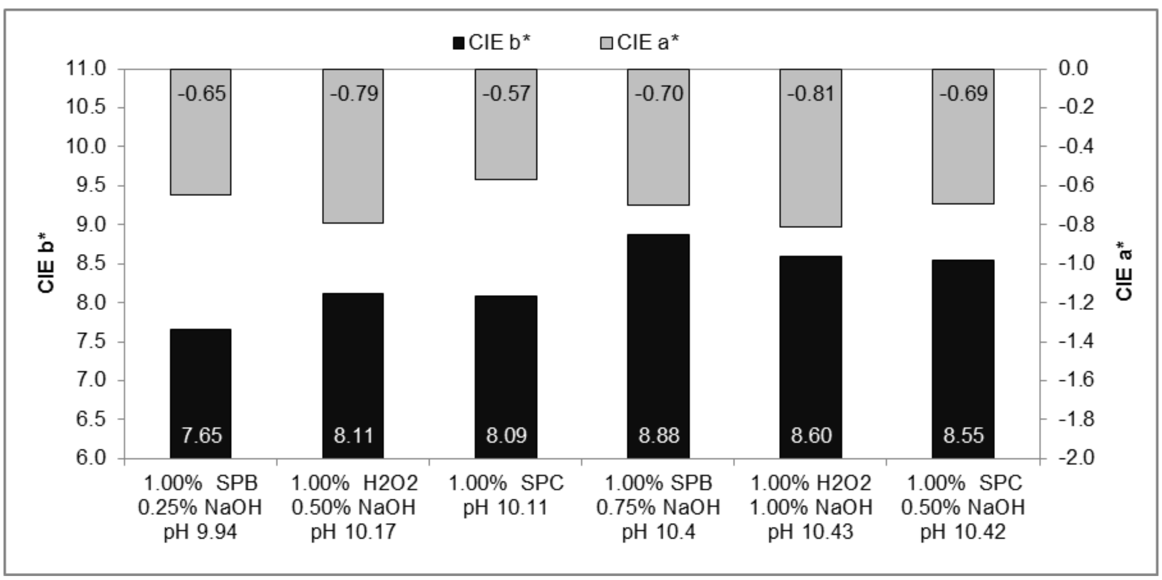

Fig. 8. Yellowness (CIE b*) and greenness (CIE a*) of pulps at similar pH conditions

As a result of this study, the optimum brightness, ink elimination ratio, and yields were obtained with sodium percarbonate (include 1% active oxygen) usage without sodium hydroxide addition. On the other hand, if the pH of pulping increased to extreme conditions by adding sodium hydroxide, floatability of inks and fines decreased. In Figs. 9 and 10, the effects of sodium percarbonate and sodium hydroxide charges on ink elimination ratio and yields of pulps are shown. Increased alkalinity and sodium percarbonate charges resulted in increased yield of the pulp, whereas the increased alkalinity decreased the ink removal by flotation because of the resulting highly negative ionic charges on the surfaces, which dispersed inks and fines. On the other hand dispersed ink particles were washed easily from the pulp during thickening.

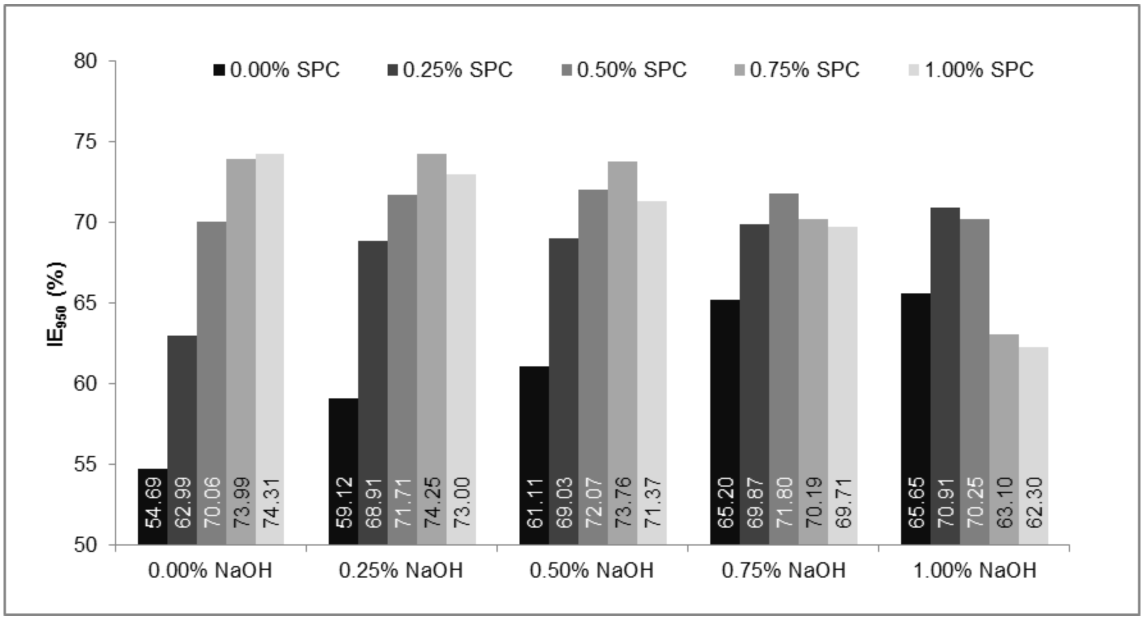

Fig. 9. Effects of S_PC charges on ink elimination ratio of deinked pulps

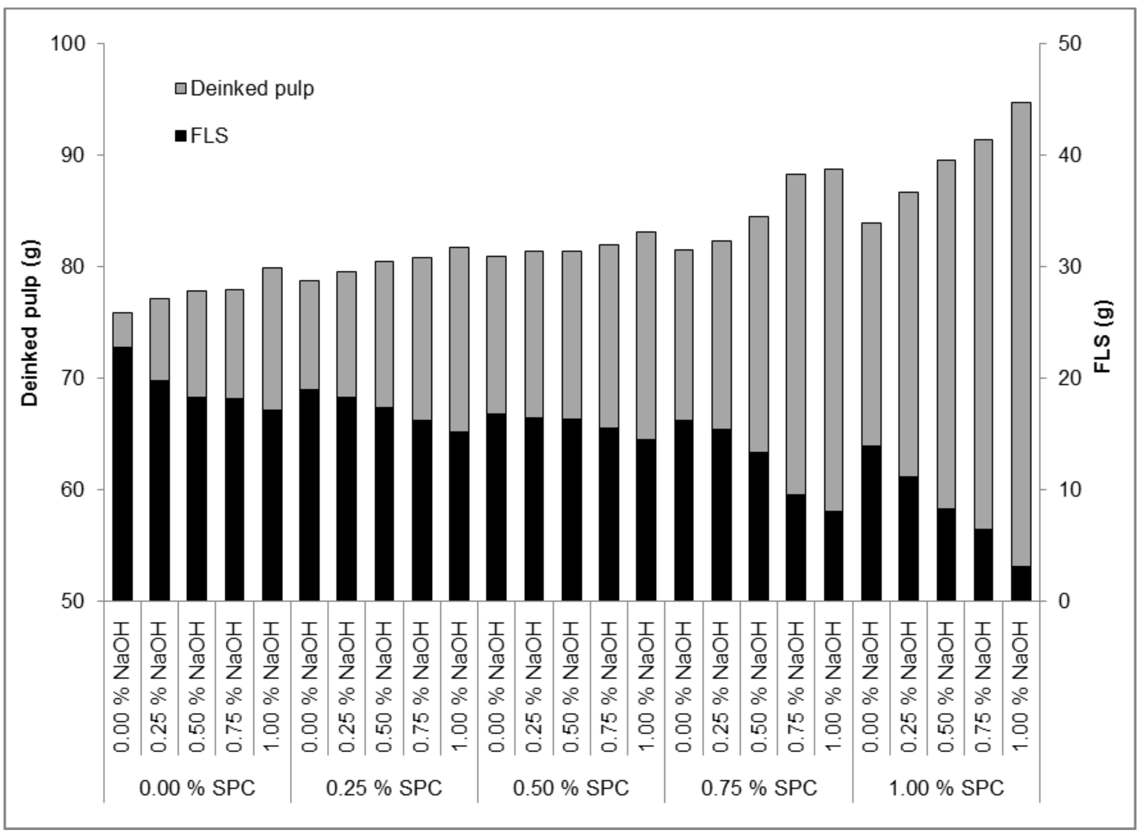

Fig. 10. Effects of S_PC charges on yield parameters of pulps

CONCLUSIONS

This paper has focused on the use of sodium percarbonate and sodium perborate for prebleaching of waste papers during repulping. These agents were examined with respect to ISO brightness, CIE *L*a*b** values, yield parameters, and ink elimination ratios. The advantage of using sodium percarbonate and sodium borate is that sodium hydroxide is not required for the bleaching reaction, since these chemicals contribute to alkalinity. Sodium percarbonate is a solid form of hydrogen peroxide and sodium carbonate. Likewise, sodium perborate is a solid form of hydrogen peroxide and sodium metaborate. A solid form of these peroxide derivatives is another advantage in the terms of handling and storage. Hydrogen peroxide requires special engineered safety precautions, but granulated percarbonate and perborate can be easily storage and used for bleaching processes.

Sodium percarbonate usage during pulping is more effective than sodium perborate on ISO brightness of pulp. Sodium percarbonate can be activated at low temperatures (30 to 50 °C), and a reaction temperature of 45 °C can be used during pulping. By contrast, perborate needs high temperatures (70 to 80 °C) for effective bleaching activity. In a deinking process, an alkaline additive is necessary not only for bleaching of pulp but also necessary for ink removal from pulp. Sodium percarbonate can provide the needed alkaline for deinking activity by itself. Sodium percarbonate usage (1% active oxygen) was increased the ink elimination to 74.31% without sodium hydroxide addition.

It is concluded that sodium percarbonate application during repulping may provide advantages relative to sodium perborate and hydrogen peroxide for improving brightness and ink removal efficiency.

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