Using Oxygen and Peroxide to Bleach Kraft Pulps

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An oxygen-chelation-peroxide (OQP, EopQP or QEopP) sequence brightened a kraft pulp to an ISO brightness of 70%, provided that the kappa number of the pulp entering the peroxide stage was below 17. When the kappa number before P was as low as 10, the brightness after QP increased linearly to about 79%. High temperatures (90°C) and long retention times (4 h) in the P stage increased the brightness of the pulp provided that the pulp was first chelated and that residual peroxide remained in the bleach liquor. The correct combination of H_2O_2, NaOH, $MgSO_4$ and DTPA in the bleach liquor was necessary to achieve the best brightening response. The QP stages did not affect the tear-breaking length relationship of the handsheets. An enzyme (xylanase) treatment included as a stage in the OQP or the EopQP sequence improved the brightness by about 1 point.

INTRODUCTION

In order to meet market demands for totally chlorine compound-free (TCF) bleached kraft pulps, bleach plants in some mills are being configured to use oxygen (O) and peroxide (P) stages to brighten pulp [1-5]. These stages can at best produce brightnesses of around 80 on softwood kraft pulps and about 85 on hardwood kraft pulps without sacrificing pulp properties.

Successful peroxide brightening in a TCF process depends on availability of a pulp with a kappa number preferably below 15, and removal of transition metal ions from the pulp before the peroxide stage. A low kappa pulp is achieved without difficulty in mills equipped with an oxygen delignification stage. The next chlorination tower and washer can be adapted for a chelation (Q) stage [1] or for pulp acidification (A) [6] to remove metal ions. The peroxide treatment can be done in the extraction stage or even in the chlorine dioxide towers, provided that the metallurgy is compatible. This combination of stages is designated OQP, and one version of the process has been named the "Lignox" process by Eka-Nobel [1].

Those mills lacking an oxygen delignification stage can combine extended cooking and a peroxide-reinforced low-pressure oxidative delignification (Eop) [7] to lower the kappa number before bleaching in single or multiple P stages. The chelation stage can be done in the chlorination tower before the Eop delignification stage. The P stages can be apportioned between the remaining DED towers, with consideration for compatibility of materials of construction. This sequence is designated QEopPP.

The objective of our work was to demonstrate how pulps from various sources respond to chelation and peroxide treatment, and to determine the requirements in each stage to obtain the maximum brightness gain from OQP and QEopP sequences.

EXPERIMENTAL

Various commercially prepared softwood and hardwood kraft pulps were either oxygen-delignified in the mill, or in a specially designed laboratory mixer described elsewhere [8]. The treatments listed in Table I reduced the kappa numbers by approximately 30% (Eop) and 45% (O).

A chelation treatment with DTPA or EDTA was done at 30 min, 50°C, and 3.5 or 2.0% consistency (Table I). The pulp was acidified to pH 5 with H_2SO_4 before adding the chelant to ensure that the pH during the chelation was less than 7. The pulp was washed thoroughly with deionized water after the Q stage.

The peroxide stage was maintained at 10% consistency, 90°C and 240 min when applied to the chelated pulp. These conditions correspond to those recommended by Basta et al. [1,4]. Without the chelation stage in the sequence, the conditions were 70°C and 120 min. The ranges of charges of H_2O_2, NaOH, DTPA, and $MgSO_4$ in the peroxide bleach liquor used in the experiments are listed in Table I. After the P stage, the perox-

TABLE I
CONDITIONS USED IN OQP AND EopQP BLEACHING

Stage	O	Eop	Q	P
Process variables				
Consistency, %	10	10	3.5 or 2.0	10
Time, min	60	60	30	120 or 240
Temp, °C	90	90	50	70 or 90
Pressure, MPa	0.68	0.27	—	—
Time at pressure, min	60	10	—	—
Chemicals, % on pulp, o.d. basis	NaOH: 2.5–3.5 $MgSO_4$: 0.5	NaOH: 2.5 $MgSO_4$: 0.25–0.5 H_2O_2: 0.5	EDTA: 0.2–1.2 H_2SO_4 to acidify pulp	H_2O_2: 2.5 NaOH: 1.5–3.0 $MgSO_4$: 0.05-0.5 DTPA: 0.2
120 min, 70°C in P of OP sequence; 240 min, 90°C in P of OQP sequence				

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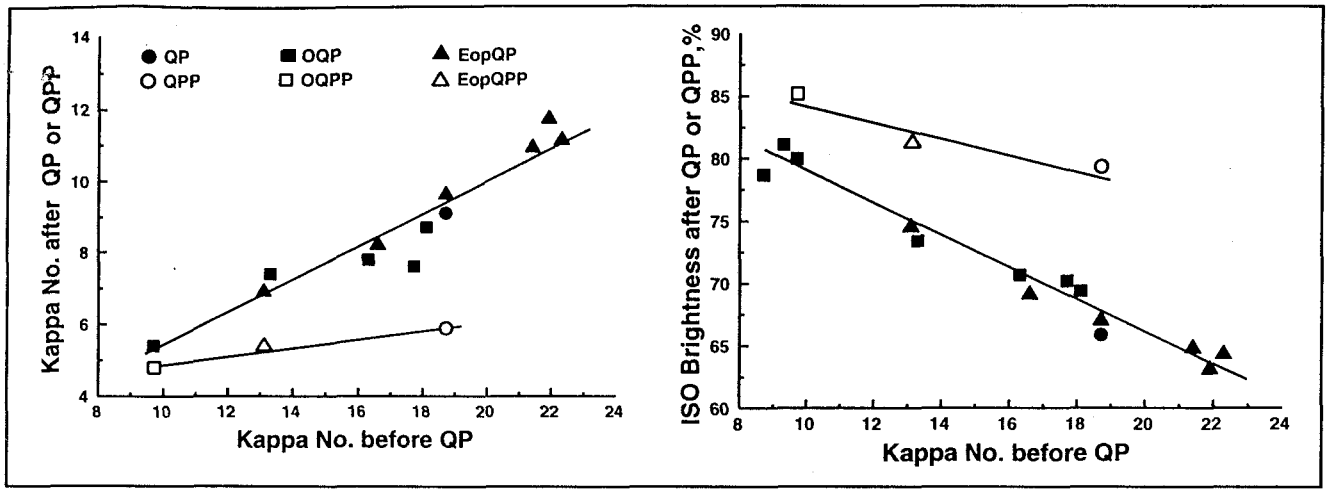

Fig. 1. The kappa number and brightness obtained after QP and QPP applied to kraft-O or kraft-Eop pulp delignified to various kappa numbers correlate directly with the kappa number of the pulp entering the QP sequence. Chemical charges and conditions: see Table I.

ide-treated pulp was rinsed with SO_2 water at pH 5 during the washing step.

RESULTS AND DISCUSSION

Effect of Kappa Number on P Stage Brightening

Five softwood kraft pulps with kappa numbers ranging from 18.7 to 32.5 were subjected to OQP, QEopP and/or QP sequences. A second peroxide stage was applied to the softwood pulp whose starting kappa number was 18.7. This pulp was produced in a pilot plant under extended cooking conditions. The remaining pulp samples were obtained from pulp mills in Canada. The points in Fig. 1 represent the maximum brightness obtained as a result of optimizing the conditions in each peroxide stage. The H_2O_2 charge was 2.5% on pulp (o.d. basis).

The brightness and kappa number (Fig. 1) obtained after P_1 correlated directly with the kappa number of the pulp prior to the QP treatment. The QP stages bleached a pulp at a kappa number of 22 to a brightness of approximately 63%. By lowering the kappa number to 10 using a combination of extended cooking and oxygen delignification, the brightness after QP was as high as 80%. A kappa number of 16 was required to obtain a brightness of about 70% after peroxide bleaching. The method used to lower the kappa number before the QP stage did not affect the brightening capability of the P stage. The pulp, however, must be chelated before the peroxide bleaching stage, and the proper combination of chemicals and conditions must be applied in conjunction with the H_2O_2 addition in P to obtain maximum brightness gain. The effects of excursions beyond optimum conditions are shown in the subsequent sections.

A second P stage applied to a QP-, EopQP- or OQP-treated sample increased the brightness by 5–13 points (open symbols, Fig. 1), depending on the brightness of the pulp entering the P_2 stage. For example, a P_2 stage applied to a QP-treated pulp increased the brightness from 68 to 79%, a gain of 11 units. Only 5 brightness units were gained when a P_2 stage was applied to an OQP_1-treated pulp which had a brightness of 80%.

Chelation

A chelation step (Q stage) to remove metal ions [9] is commonplace when brightening mechanical pulps with hydrogen peroxide. Transition metal ions such as iron, manganese and copper greatly accelerate the catalytic decomposition of the active perhydroxyl ion, presumably through a free-radical mechanism [10]. The perhydroxyl ion is considered to be the active component responsible for the brightening reaction, and any unwanted side reactions which favour its decomposition waste peroxide and detract from the brightening process. Metals occurring naturally in wood are the primary source of the metal ions in pulp, with secondary contamination arising from the process water and equipment [9].

In chemical pulp bleaching, a chelation step has been reported to improve the effectiveness of oxygen delignification [11]. The acidic pH of a chlorination stage favours dissolution of metal ions, so a chelation stage before a peroxide stage is not necessary in a sequence beginning with a chlorination stage. Consequently, when chlorine compounds are eliminated from pulp bleaching, the metal ion content in the pulp becomes an important consideration [12].

The link between manganese content in an oxygen-delignified pulp and peroxide bleaching efficiency is shown in Table II. Without a chelation stage, the pulp contained 35.8 ppm manganese after a failed peroxide bleaching stage whereas, after successful

TABLE II
METAL ION CONTENT IN PULP AND EFFLUENT PROPERTIES AFTER OP AND OQP BLEACHING
Central Canadian Softwood Kraft-Oxygen

Pulp treatment	Mill kraft-O	OP	OQ	OQP
P stage				
H_2O_2 consumed, %	—	2.5	—	1.7
end pH	—	11.8	—	10.9
Kappa no.	14.2	8.9	—	6.2
ISO Brightness, %	—	45.4	—	70.6
Viscosity, mPa·s	23.2	17.4	—	17.5
Metal ion content in pulp, ppm				
Mn	52.4	35.8	2.8	2.2
Fe	38.4	17.6	9.2	6.5
Cu	1.7	1	nd	nd
Al	<50	nd	<50	nd
Effluent properties, kg/metric ton pulp of		P stage	Q stage	P stage
BOD	—	5.6	0.4	nd[1)]
COD	—	25.7	6.3	28.6
colour	—	11.3	2.7	3.1

All charges are expressed as per cent on pulp, o.d. basis
Q stage: 1.2% EDTA
P stage: 2.5% H_2O_2; 2.5% NaOH; 0.05% $MgSO_4$; 0.2% DTPA; 240 min; 90°C
nd: Not determined
1. Excess oxygen interfered with test

TABLE III
TREATMENT TIME AND WASHING EFFICIENCY IN THE Q STAGE OF AN OQP SEQUENCE

Pulp source	Western Canadian SWK-O			Central Canadian SWK-O	
Q stage					
Time, min	5	30	30	30	30
End pH	5.9	6.6	6.5	6.2	6.1
Washing efficiency, %	≈100[1)]	≈100	88[2)]	≈100	70[3)]
P stage					
H_2O_2 consumed, %	1.7	1.6	2.0	1.6	2.3
ISO Brightness, %	69.6	69.5	69.8	72.3	68.8

Q: 0.5% EDTA; 50°C
P: 2.5% H_2O_2, 2.5% NaOH; 0.05% $MgSO_4$; 0.2% DTPA; End pH, 11.3–11.5
Pulp washing after Q:
1) well washed
2) pressed from 2 to 15% consistency
3) pressed from 4 to 12% consistency

TABLE IV
EFFECT OF pH IN THE Q STAGE OF AN OQP SEQUENCE
Western Interior Softwood Kraft-Oxygen; Kappa No. 14.8

Chelant in Q, % on pulp, o.d. basis	EDTA, 0.6%				DTPA, 0.6%			
Q stage								
Start pH	2.0	3.0	5.0	7.0	3.0	5.0	7.0	9.0
End pH	2.1	3.2	6.6	8.5	4.0	7.2	9.3	10.1
P stage								
H_2O_2 consumed, %	2.1	2.1	1.6	2.4	1.4	1.4	2.1	2.3
ISO Brightness, %	71.0	71.3	71.4	64.1	71.0	68.8	66.1	65.7

Q stage: pH adjustment made with H_2SO_4
P stage: 2.5% H_2O_2; 0.05% $MgSO_4$; 0.2% DTPA; 2–2.5% NaOH; end pH 10.7–11.9

chelation and peroxide bleaching, the pulp contained only 2.8 ppm of manganese. As a result of removing the harmful metal ions, the brightness after the P stage rose from 45.4 to 70.6, a gain of 25 points. Earl and Nguyen [6] showed that an acid wash maintained at a pH as low as 1.8 with H_2SO_4 also releases metal ions from the pulp, thus offering an alternative to EDTA and DTPA chelation in the sequence.

Time and Washing Efficiency

Chelation at 2.0% consistency, 50°C, and a washing efficiency of 88 or ≈100% between the Q and P stages resulted in the same brightening response in the P stage after 5 or 30 min (compare last 2 columns in Table III). Basta et al. [1], however, found that a 10% consistency chelation gradually improved in efficiency as the retention time was increased from 15 to 120 min. Both Basta et al.'s [5] and our results (Table III) indicate that poor washing efficiency between Q and P adversely affected the P stage brightness response. The transfer of metal ions into the P stage promoted the decomposition of peroxide into intermediate species which are prone to attack cellulose [5].

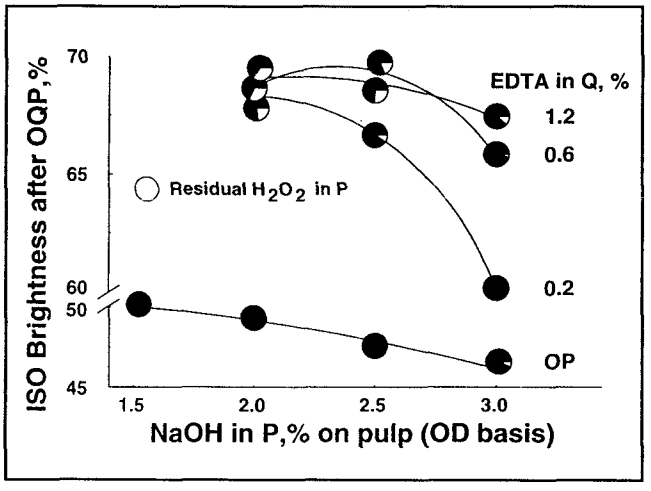

Fig. 2. Comparing the effect of EDTA charge in the Q stage on brightness and residual peroxide after OQP at various alkalinities in P. Eastern Canadian spruce-fir-pine kraft-oxygen pulp. kappa number 18.1; 2.5% H_2O_2, 0.05% $MgSO_4$; 0.2% DTPA in P.

Chelant Charge and pH

Application of 0.2% EDTA in Q resulted in a good brightness response after P but only at 2% NaOH charge in P (Fig. 2). An excursion beyond optimum alkalinity in P resulted in a severe brightness penalty and depletion of peroxide residual. The more heavily chelated pulps (0.6 and 1.2% EDTA on pulp) maintained high brightness levels with application of 2.5% and even 3.0% NaOH in P. The higher charge of EDTA improved the brightening capability of the P stage by about 1 point with less peroxide consumption, and made the pulp tolerant towards a wider range of alkalinity.

The effect of pH during the EDTA or the DTPA chelation on the efficiency of the peroxide bleaching was tested on a mill-oxygen-delignified softwood kraft pulp (kappa no. 14.8) (Table IV).

EDTA and DTPA chelated best when the pH of the pulp stock entering the Q stage was below 5 (Table IV). The brightness after P was progressively poorer when the stock pH increased beyond 5. The pH tended to rise slightly during the Q stage as a result of the alkalinity of the EDTA or the DTPA solution. Basta et al. [1,4] also showed that EDTA and DTPA were equally effective at a starting pH between 5 and 7. A chelation at this range of pH is thought to be best for the removal of the manganese ion, while retaining the magnesium ion, which benefits peroxide bleaching.

Position of Q in the Sequence

The QEopP sequence performed slightly better than did EopQP (Fig. 3), probably as a result of the kappa number being lower after QEop (19.6) than after Eop (21.5). The Q stage, therefore, improved the delignification efficiency of the peroxide component within the Eop stage. Chelating the pulp two stages before the P stage did not diminish the effectiveness of the peroxide bleaching reaction, but whether or not this is realistic in a mill depends on the metal ion contaminants in the wash water and process chemicals used during bleaching. A short touch-up chelation just before the P stage may be expedient if a chelation is done early in the sequence.

P Stage Conditions

Alkalinity

The peroxide brightening process requires a specific alkalinity for the perhydroxyl ion to brighten the pulp (Figs. 3, 4). Excessive alkalinity causes the pulp to darken and the residual peroxide to be depleted. This reaction is common in mechanical pulp brightening [13]. The history of the pulp treatment may shift the optimum pH conditions necessary to obtain maximum brightness gain (Fig. 2). As with mechanical pulp brightening, the optimum alkalinity in the P stage must be established on each pulp source to maximize brightness gain and peroxide residual. The unspent peroxide can be recycled to supplement the fresh peroxide in the bleach liquor entering the stage.

Time and Temperature

The unreacted peroxide in the P stage bleaching of a chelated pulp may be ex-

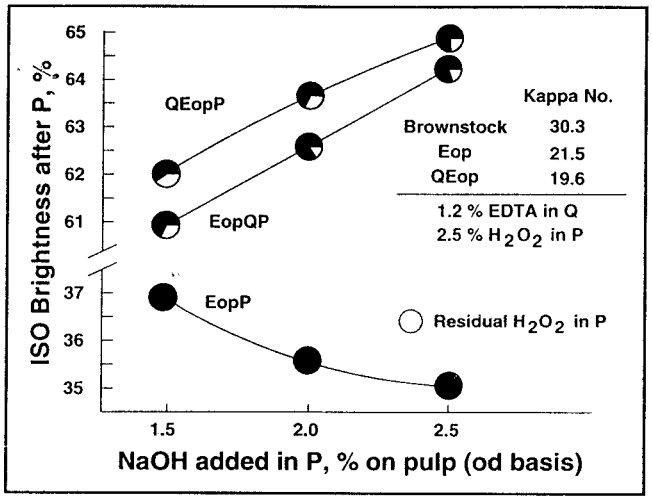

Fig. 3. Comparing QEopP and EopQP bleaching applied to a coastal western Canadian softwood kraft pulp at various alkalinities in the P stage.

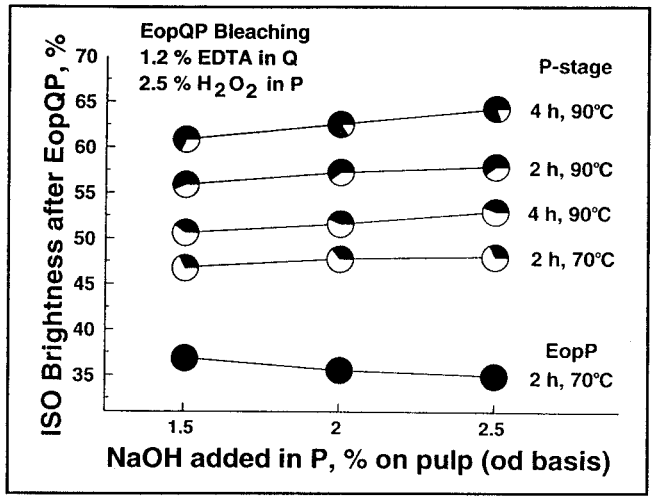

Fig. 4. EopQP bleaching of a western Canadian coastal kraft pulp using various temperature, time, and NaOH charges in the P stage. After Eop: ISO brightness, 27.4%; kappa no. 19.6. The white segments in the circles indicate the residual peroxide (as a % of the original charge).

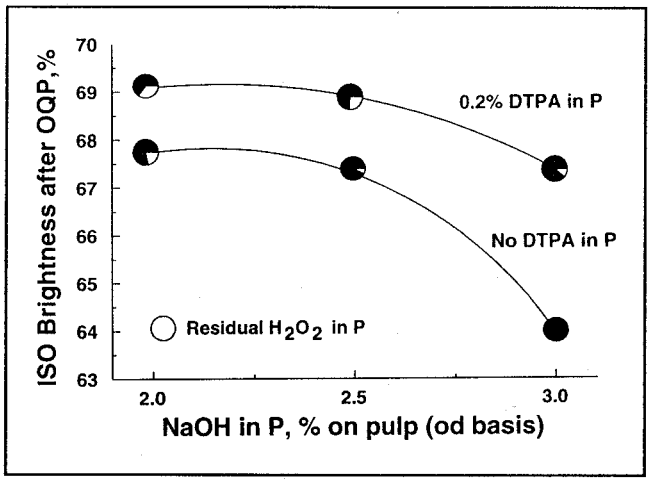

Fig. 5. The inclusion of DTPA in the P stage bleach liquor gives a brightness advantage of 1.5 units after OQP (with 2.5% NaOH) and improves the alkali tolerance over a wider range of NaOH charges in P. Eastern Canadian spruce-fir-pine kraft-O pulp; kappa no. 18.1. 1.2% EDTA in Q; 2.5% H_2O_2, 0.05% $MgSO_4$ in P.

TABLE V
COMPARING H_2O_2 CHARGE IN THE P STAGE OF AN OQP SEQUENCE
Western Canadian Softwood Kraft-Oxygen; Kappa No. 14.8

P stage				
Temp, °C	70	70	90	90
H_2O_2, % added	2.5	3.0	2.5	3.0
% consumed	0.8	0.9	1.4	2.0
End pH	11.0	11.3	10.7	10.9
After OQP:				
ISO Brightness, %	62.6	65.5	69.2	70.5
Brightness after 1 h reversion, %	61.2	63.9	67.8	69.1

Q stage: 0.9%; EDTA; pH 6.3–6.5
P stage: 2.5% NaOH, 0.05% $MgSO_4$; 0.2% DTPA; 240 min

ploited by using high temperatures and long retention times to drive the peroxide to delignify and bleach the pulp [1,4]. The results in Fig. 4 show that a 2 h P stage (2.5% H_2O_2 in EopP) raised the brightness of an Eop pulp from 27.4% by only 9.5 units to 36.9% with complete depletion of peroxide. EopQP bleaching, however, increased the brightness to 48.1% with only 0.8% H_2O_2 consumed (on pulp) after 2 h and 70°C in P. Forcing the residual peroxide to react with the pulp over a 4 h retention time at 90°C resulted in a brightness of 64.3% with 2.0% consumption of H_2O_2 (on pulp). Increasing the temperature from 70 to 90°C improved the peroxide brightening reaction more than did extending the retention time from 2 to 4 h. Increasing the H_2O_2 charge in P from 2.5 to 3.0% did not compensate for the brightening loss as a result of operating the P stage at 70 instead of 90°C (Table V). The advantage of brightening with a peroxide stage at temperatures as high as 95°C for long retention times has been observed on mechanical pulps [13].

DTPA and $MgSO_4$ in the P stage Bleach Liquor

Incorporating DTPA into the peroxide bleach liquor in the P stage in addition to a chelation stage (1.2% EDTA on pulp) offered a gain of 1.5 brightness units (with 2.5% NaOH), a higher peroxide residual in the bleach liquor, and a tolerance towards a wider alkalinity range (Fig. 5).

A small amount of $MgSO_4$ (usually about 0.05% on pulp, expressed on the basis of the total weight of $MgSO_4$) is added in the peroxide bleaching of mechanical pulps to prevent decomposition of the perhydroxyl ion [9].

The results in Fig. 6 show that a slight gain in brightness was obtained by the presence of $MgSO_4$ (0.05% as $MgSO_4$ on o.d. pulp basis) in the bleach liquor. Increasing the $MgSO_4$ charge to 1% on pulp, however, had an adverse effect on brightness gain.

The viscosity improved when the bleach liquor contained a $MgSO_4$ charge higher than 0.2% on pulp (o.d. pulp basis). The well-known effect of $MgSO_4$ as a cellulose protector during oxygen delignification [7] may also be applicable in the aggressive peroxide bleaching reaction. This is undergoing further investigation.

Strength Properties and Yield of OQP-Bleached Pulps

The tear-breaking length curve drawn in Fig. 7 indicates that QP bleaching with a charge on pulp of 1.2% EDTA in Q and the forcing conditions in the P stage did not affect these strength properties of the oxygen-delignified pulp even though the viscosity decreased from 23.2 to 17.5 mPa·s after the P stage (Table II).

We suspected that the highly alkaline conditions of the harsh P stage might cause excessive loss of the hemicellulose portion of a pulp, which would result in a substantial

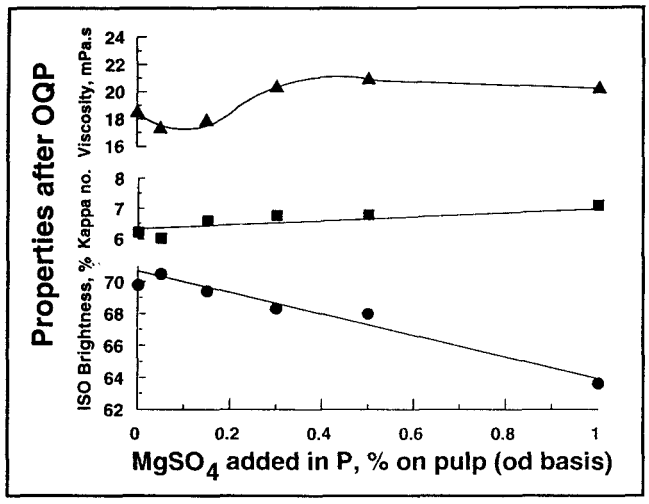

Fig. 6. Effect of $MgSO_4$ in the P stage on brightness, kappa number and viscosity after OQP. Central Canadian SWK, Kappa number after O, 13.6; 0.5% cuene viscosity, 23.2 mPa·s. 0.6% EDTA in Q; 90°C, 240 min, 2.5% NaOH, 0.2% DTPA in P.

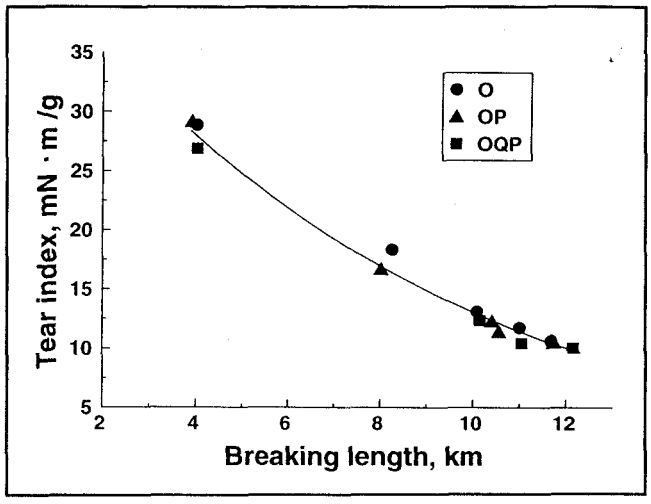

Fig. 7. OP and OQP bleaching did not affect the tear-breaking length performance compared to the results obtained on the O-delignified pulp. Pulp source, see Table II.

TABLE VI
USING ENZYMES DURING EopQP AND OQP BLEACHING

Pulp Source	Interior BC Softwood kraft Kappa No 28.7					Central Canadian hardwood Kappa No. 15.6			
Sequence	QEopQPP	XEopQPP		EopXQPP		EopXP	OQP	OXQP	O(XQ)P
Eop or O stage									
Kappa no.	21.9	21.4		22.3		21.4		8.7	
P_1 stage									
H_2O_2 consumed, %	1.6	1.6		1.8		2.5	1.4	0.9	1.2
ISO Brightness, %	63.1	64.8		64.3		36.8	78.7	79.6	77.9
Kappa no.	11.7	10.9		—		—	—	—	—
P_2 stage									
H_2O_2 consumed, %	1.5	1.7	1.5	1.5	1.4	—	—	—	—
ISO Brightness, %	74.0	75.1	76.3	75.8	75.7	—	—	—	—

Q stage: 0.6% EDTA; end pH 6.5
X stage: enzyme, 50 units/g pulp; 120 min; 60°C; 10% consistency; end pH 5.9
Eop stage: 60 min total, first 10 min at 0.27 MPa; 90°C; 10% consistency
P stage: 2.5% H_2O_2; 1.5–2.5% NaOH; 0.5% $MgSO_4$; 0.2% DTPA; 10.1–11.3 pH

loss of yield after the QP treatment. However, the yield across the QP stages of a mill-oxygen delignified pulp was 97.1% (Table II). In comparison, in other work in our laboratory, we found that, when conventional CdEo stages were applied to an oxygen-delignified pulp of kappa number 15, the yield was 98.0%. A subsequent D stage decreased the yield to 96.5% (using the oxygen-delignified pulp as 100% basis). But the brightness after the OCdEoD sequence was 90% ISO; a 70 brightness pulp after CdEoD would be expected to have a yield between 98.0 and 96.5%. The yield obtained after QP bleaching was within this range, so we conclude that the P stage did not in fact cause excessive loss of hemicellulose or other fibre components.

The COD in the effluent from the P stage of the OQP sequence was 28.6 kg/ADTP (Table II). Liebergott et al. [14] reported that the effluent from a D_{100}EoDED sequence applied to an oxygen-delignified softwood kraft pulp contains 24–28 kg COD/ADTP, which is about the same as we found in effluent from a single P stage even though the brightness after OQP is only 70%, while that after OD_{100}EoDED is 90%.

Enzyme Treatment before OQP Bleaching

In conventional bleaching, treatment of the brownstock with the enzyme xylanase can decrease the chlorine requirement by about 30% while hardly affecting the kappa number of the pulp [15]. Xylanase is believed to modify the hemicellulose such that the chlorine is capable of removing a greater fraction of the lignin [16]. To determine whether xylanase would have a similar effect, we included a xylanase stage (X) in the EopQP sequence.

The XEopQP and the EopXQP combinations bleached the pulp to respective brightnesses of 64.8 and 64.3%, which were 1.7 and 1.2 units higher than that after EopQP (63.1%) (Table VI). The slight brightness advantage offered by the sequence containing the X stage was maintained after the P_2 stage. An acid wash at pH 6 between P_1 and P_2 did not improve the bleachability of the P_2 stage.

Likewise, an enzyme treatment of an oxygen-delignified hardwood kraft pulp before application of peroxide improved the brightness by about 1 unit (Table VI). Combining the EDTA and the enzyme in one stage to take advantage of their optimum pH tolerance (pH 5–7) did not improve the brightening response of the pulp towards the next P stage. It should be noted that the final pH of this stage rose to 7.7, which is above the optimum for the enzyme and may have impeded its reactivity.

SUMMARY

Successful application of a peroxide bleaching stage to kraft pulps depended on a chelation step to remove metal ions which interfere with peroxide bleaching, and on carefully controlled conditions throughout the stage to prevent brightness loss.

A chelation and a peroxide stage bleached a kraft pulp to brightnesses above 70% provided that the pulp had a kappa number below 17. When the kappa number before the P stage was decreased to as low as 10, the brightness after the peroxide stage increased linearly to about 79%. A kappa

number of 10 could be achieved in practice by extended cooking and an Eop-type of delignification if a full-fledged oxygen delignification is not available.

The P stage raised the brightness of a chelated pulp by as much as 35 points when high temperatures (90°C) and long retention times were used under optimum alkaline conditions to maintain residual peroxide. If accompanied by the right chemical make-up in the bleach liquor, these forcing conditions did not affect pulp strength nor yield. A P_2 stage bleached the pulp to brightnesses of 75-85%, depending on the brightness of the pulp entering the P_2 stage. An enzyme treatment in the QP bleaching process offered only a 1-point brightness gain.

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ABSTRACT: An oxygen-chelation-peroxide (OQP, EopQP or QEopP) sequence brightened a kraft pulp to an ISO brightness of 70%, provided that the kappa number of the pulp entering the peroxide stage was below 17. When the kappa number before P was as low as 10, the brightness after QP increased linearly to about 79%. High temperatures (90°C) and long retention times (4 h) in the P stage increased the brightness of the pulp provided that the pulp was first chelated and that residual peroxide remained in the bleach liquor. The correct combination of H_2O_2, NaOH, $MgSO_4$ and DTPA in the bleach liquor was necessary to achieve the best brightening response. The QP stages did not affect the tear-breaking length relationship of the handsheets. An enzyme (xylanase) treatment included as a stage in the OQP or the EopQP sequence improved the brightness by about 1 point.

RÉSUMÉ: Une séquence oxygène-chélation-peroxyde (OQP, EopQP ou QEopP) blanchira une pâte kraft à une blancheur ISO de 70% pourvu que l'indice Kappa avant le stade au peroxyde soit inférieur à 17. Lorsque l'indice Kappa avant le stade de peroxyde a été abaissé jusqu'à 10, la blancheur après QP augmentait de façon linéaire jusqu'à 79%. Une température élevée (90°C) et un temps de rétention de quatre heures dans le stade au peroxyde furent les meilleures conditions pour accroître la blancheur pourvu que la pâte soit d'abord traitée avec un agent chélateur et qu'un résiduel de peroxyde d'hydrogène soit présent dans la liqueur de blanchiment. La combinaison appropriée du H_2O_2, NaOH, $MgSO_4$ et du DTPA dans la liqueur de blanchiment est nécessaire pour obtenir la meilleure réponse à la blancheur. Les stades QP n'ont pas affecté la relation entre la déchirure et la longueur de rupture des formettes. Un traitement de la pâte avec un enzyme (xylanase) à divers endroits dans les séquences EopQP ou OQP améliora la blancheur d'environ un point.

KEYWORDS: KRAFT PULPS, OXYGEN BLEACHING, PEROXIDE BLEACHING, CHELATION, BRIGHTNESS, BLEACHING EFFLUENTS, MECHANICAL PROPERTIES, COLOR REVERSION.

REFERENCES

1. BASTA, J., HOLTINGER, L., LUNDGREN, P. and FASTÉN, H., "Reducing Levels of AOX – Part 3. Lowering of Kappa Number Prior to ClO_2 Bleaching", Proc. Intl. Pulp Bleaching Conf., Stockholm, Sweden pp. 23-34 (June 11-14, 1991) .
2. MALINEN, R., "Chlorine-Free Bleaching: State of the Art in Scandinavia", Proc. Non-Chlorine Bleaching Symp., Hilton Head, SC (March 2-5, 1992).
3. Howe Sound Pulp and Paper, Press Release, Globe and Mail (Nov. 1, 1991).
4. BASTA, J., HOLTINGER, L. and GUTKE, K., "Reducing Levels of AOX – Part 4. Lignox on Hardwood Pulps", Proc. TAPPI Pulping Conf., Orlando, FL, pp. 153-158 (Nov. 3-7, 1991).
5. BASTA, J., ANDERSSON, L. and HERMANSSON, W., "Lignox and Complementary Combinations", Proc. Non-Chlorine Bleaching Conf., Hilton Head, SC (Mar. 2-5, 1992).
6. EARL, P.F. and NGUYEN, X.T., "High-Brightness Chlorine-Free Bleaching Without Oxygen Delignification", Proc. Non-Chlorine Bleaching Conf., Hilton Head, SC. (Mar. 15-18, 1993).
7. LIEBERGOTT, N. and VAN LIEROP, B., "Alkaline-Peroxide-Oxygen-Treatment of Unbleached and Chlorinated Chemical Pulps", Canadian Patent 1,251,903 (April 4, 1989).
8. VAN LIEROP, B., LIEBERGOTT, N., TEODORESCU, G. and KUBES, G.J., "Using Oxygen in the First Extraction Stage of a Bleaching Sequence", *J. Pulp Paper Sci.* 12(5):J133-140 (1986).
9. DICK, R.H. and ANDREWS, D.H., "The Bleaching of Groundwood Pulp with Peroxide. The Influence of Certain Metals on Bleach Response", *Pulp Paper Mag. Can.* 66(3):T201-T208 (1965).
10. BAMBRICK, D.R., "The Effect of DTPA on Reducing Peroxide Decomposition", *Tappi J.* 68(6):96-100 (1985).
11. HIISVIRTA, L., "Oxygen Bleaching Process", *Paperi ja Puu* 53(7):439-443 (1970).
12. BASTA, J., HOLTINGER, L. and HOOK, J., "Controlling the Profile of Metals in the Pulp Before Hydrogen Peroxide Treatment", Proc. 6th Intl. Symp. Wood and Pulping Chem., Melbourne, Australia, pp. 237-244 (April 30-May 3, 1991).
13. LIEBERGOTT, N., VAN LIEROP, B. and HEITNER, C., "Rapid High-Temperature Brightening of High-Yield Pulps – Silicate-Free Hydrogen Peroxide Treatment". Proc. Intl. Mech. Pulping Conf., Vancouver, B.C. pp. 75-80 (June 2-5, 1987).
14. LIEBERGOTT, N., VAN LIEROP, B., NOLIN, A., FAUBERT, M.G. and LAFLAMME, J.K., "Modifying the Bleaching Sequence to Decrease AOX Formation", *Pulp Paper Can.* 92(3):84-90 (1991).
15. LIEBERGOTT, N., VAN LIEROP, B. and FLEMING, B.I., "Lowering AOX Levels in the Bleach Plant", Proc. TAPPI Pulping Conf., Orlando, FL, pp. 123-133 (Nov. 3-7, 1991).
16. PAICE, M.G., GURNAGUL, N., PAGE, D.H. and JURASEK, L., "Mechanism of Hemicellulose-Directed Prebleaching of Kraft Pulps", *Enzyme Microb Technol.* 14:272-276 (1992).

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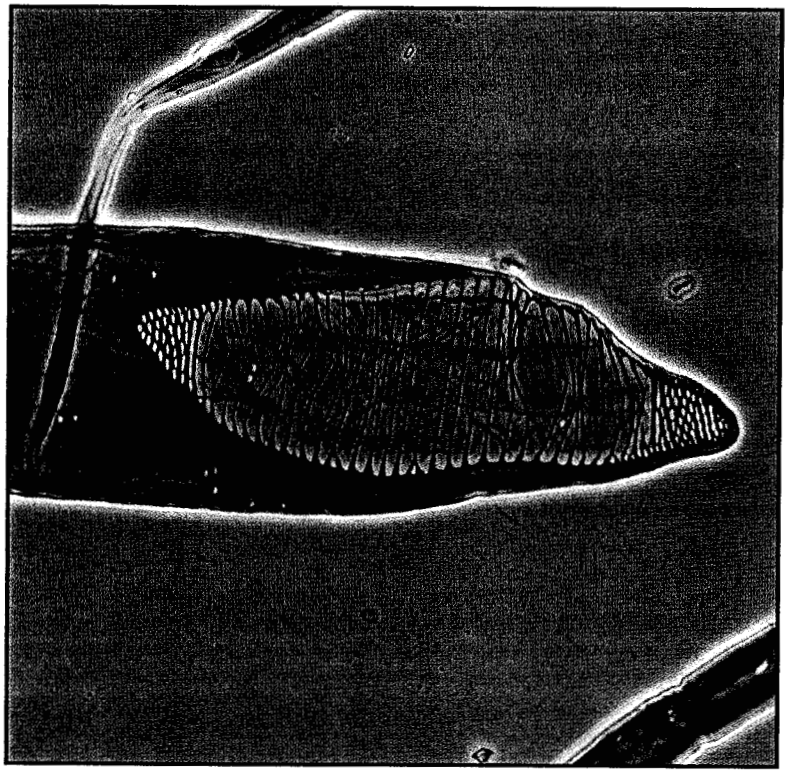

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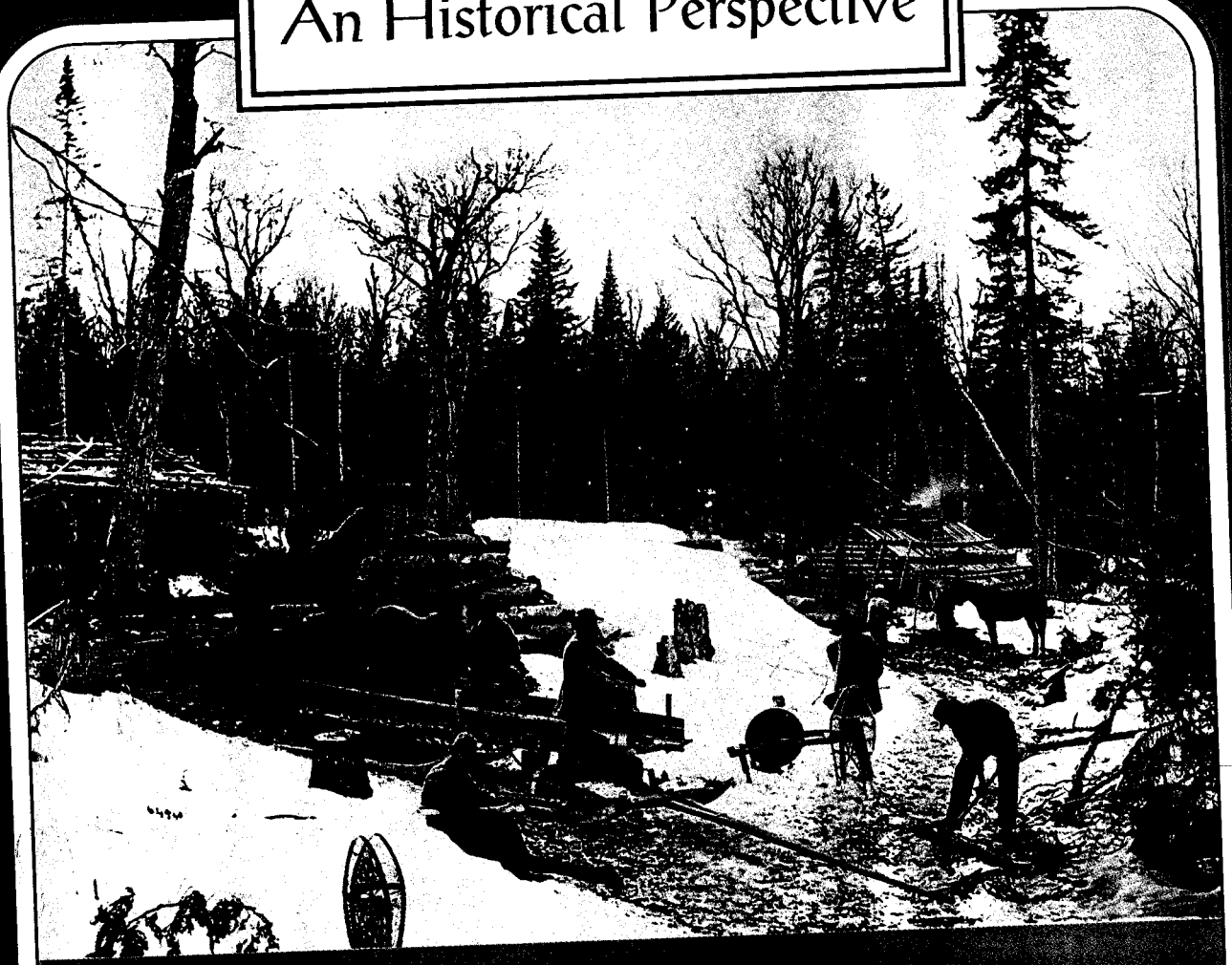

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