Repulping of wet strength paper towel with potassium monopersulfate

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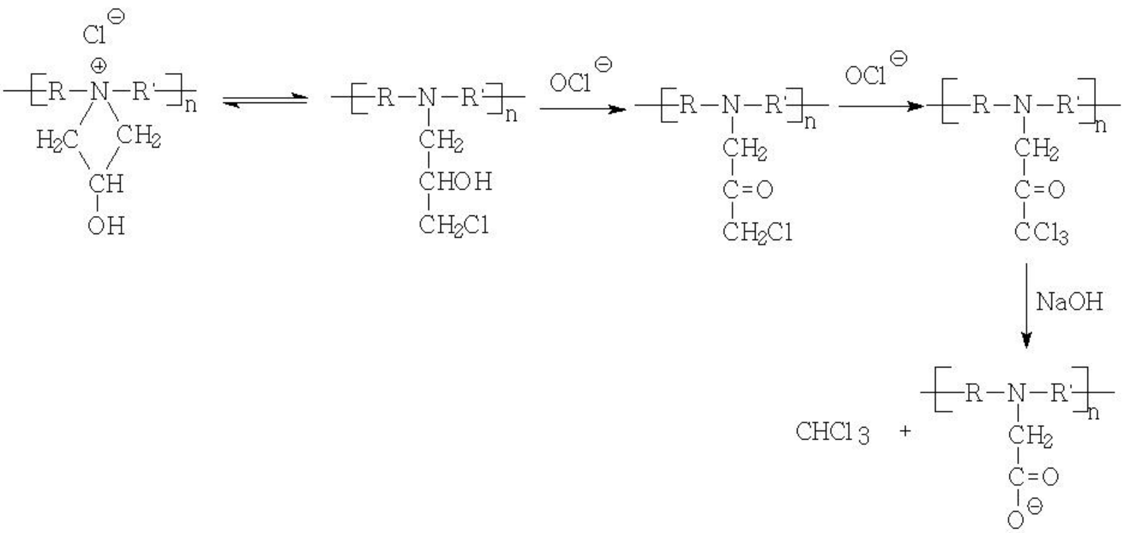
ABSTRACT: Potassium monopersulfate (KMPS) was used in repulping of polyamide-epichlorohydrin (PAE)-containing paper towel. The effectiveness of the repulping aid was compared with that of sodium hypochlorite. Addition of a 2.4% KMPS repulping aid achieved complete repulping of the paper towel, resulting in 88% screen yield and about 5% rejects. To reach a similar pulping result, two times the oxidative equivalent amount of sodium hypochlorite had to be used. Compared to the pulp fibers obtained from sodium hypochlorite repulping, those obtained from KMPS repulping had higher physical strength, longer fiber length, and lower fines content. This study demonstrated that KMPS was superior to sodium hypochlorite in repulping of PAE-containing paper towel in terms of effectiveness and pulp quality.

Application: This article is about the repulping of wet strength-containing paper towel with the help of potassium monopersulfate. Because the reagent is a non-chlorine compound, it is considered to be an environmentally friendly additive. Furthermore, the reagent has relatively low redox potential, thus causing less damage to the recycled fibers.

Wet strength resins are used in paper industries to obtain desired properties [1]. In the early stage, the resins were aminoplast types, including urea-formaldehyde and melamine-formaldehyde [2]. As neutral and alkaline papermaking developed, new resins that can be cured under neutral-to-alkaline pH levels emerged. Among those, polyamide-epichlorohydrin (PAE) has become widely accepted, especially in paper towel and tissue products [3].

PAE is produced through the condensation of dibasic acid and diethylene triamine and further alkylation with epichlorohydrin [2]. The product formed as such carries an azetidinium chloride cationic functionality, with an average number molecular mass in the range of 10,000 to 500,000 [4,5]. Due to the cationic nature, the resin adsorbs onto the negatively charged fiber surfaces in a mono-molecular layer model [4]. It is hypothesized that the resin establishes wet strength mainly through homo-crosslinking and fiber-crosslinking [6]. In the former, the crosslinking among the resulting PAE resins in the network can restrict cellulose swelling and rehydration. This is supported by the observation that a variety of pulp fibers gave a similar percentage of wet/dry [6] strength, indicating that pulp fiber is not involved in the reactions leading to the wet strength. However, the functionalities (epoxide and azetidine) in the polymer can crosslink among the resin during curing. This results in the formation of a protective layer on the fiber-fiber bonding area [7,8]. As to the fiber-crosslinking, the bonding between fiber and resin can enhance the dry strength and wet strength. Espy and Rave [9] found that the initial retained resin primarily reacted with carboxylic groups in fibers, which corresponds to the rapid increase in wet/dry strength. Obokata and Isogai [5] further demonstrated that azetidinium groups of PAE and carboxyl groups of cellulose fibers could form ester linkages. Siqueira agreed that fiber-resin ester bonds could form, but such bonding was not important for the wet strength obtained [10]. It should be noted that pulp fibers with high carboxylic content, such as higher-yield pulp fibers, are expected to develop higher levels of esterification. As a result, the homo-crosslinking and fiber-crosslinking decrease the wettability of the treated paper, and thus maintain paper strength even in the wet state. Unlike the fragile linkages formed from other wet strength resins, such as glyoxalated polyacrylamide [3,8], the cross linkages from PAE are quite permanent [5,7,8,10,11]. Consequently, the water resistance created by PAE constitutes a great challenge for the repulping of the used products and the broke [8,12].

Repulping of PAE-containing paper requires the destruction of the epoxidized polyamine-amide. This is usually accomplished by the use of strong oxidizing agents. Sodium hypochlorite is one such reagent that is widely used in the repulping of PAE-containing papers due to its low cost and perceived high efficiency. Hypochlorite oxidizes PAE and generates carboxylic acid groups in the polymer as shown in **Fig. 1**. Hypochlorite may also attack the methylene group alpha to the nitrogen atom in the resin, and thus forms a less stable amido-chloride moiety [8]. The introduction of the hydrophilic carboxylic acid groups and destabilizing of the resin will enhance the water wettability of the resin and thus help fiber liberation during repulping. However, the residual hypochlorite could have a negative impact on the performance of newly added resin when the recycled pulp fibers are reused in the papermaking

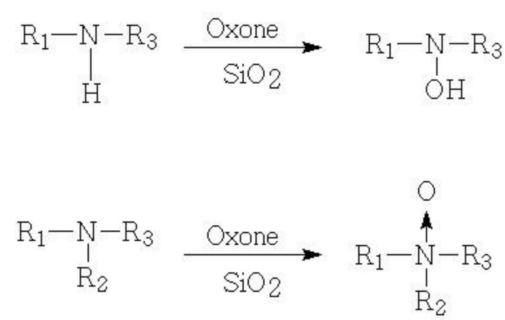


1. Oxidation of azetidinium in polyamide-epichlorohydrin (PAE) by hypochlorite in alkaline medium [10].

process [3]. Also, the formation of chloroform and other undesirable chlorinated substances in hypochlorite repulping could have a detrimental effect on the environment [10,13].

Non-chlorine persulfate oxidizing agents can be used as repulping aids for PAE-containing paper and broke [10,13-16]. These reagents include the peroxydisulfates ($Na_2S_2O_8$, $(NH_4)_2S_2O_8$, $K_2S_2O_8$) and potassium monopersulfate (KMPS), which is stabilized as the triple salt, $2KHSO_5*KHSO_4*K_2SO_4$. Although thermodynamically strong oxidizers, the peroxydisulfates are kinetically slow to react and proceed primarily through free radical pathways [10,14,17]. However, free radical intermediates are non-selective and can lead to cellulose fiber damage in addition to PAE resin degradation. In contrast, in the absence of transition metal catalysts [18,19], KMPS does not oxidize substrates via free radical intermediates and is believed to be more selective for PAE oxidation and preservation of fiber quality. Through oxygen atom transfer chemistry, KMPS is capable of oxidizing a wide range of substrates, including primary, secondary, and tertiary amines [20, 21]. Via surface mediation on silica gel or alumina, Fields and Kropp [22] reported that potassium monopersulfate oxidizes the primary and secondary amines to the corresponding hydroxylamines, and can convert tertiary amines to amine oxides, as shown in **Fig. 2**.

The oxidation of secondary and tertiary amines by KMPS makes the reagent a potentially attractive repulping aid for the recycling of PAE-containing paper towel. However, few publications can be found in this area. In this paper, KMPS was used for the repulping of PAE-containing paper towel. The performance of the KMPS repulping aid was compared with that of sodium hypochlorite and alkali-only repulping to evaluate its effectiveness in repulping of paper products containing wet strength resins.



2. Amine oxidation by potassium monopersulfate (KMPS).

EXPERIMENTAL

Repulping

A 200-g sample of ovendry (o.d.), commercially available multifold paper towel with PAE wet strength agent was torn into 1 in. x 1 in. pieces and weighed in a plastic beaker. Next, 1000 ml of tap water was added to soak the torn paper for 10 min. At the same time, the benchtop pulper was adjusted to a desired repulping temperature. When the soaking was completed, the contents of the beaker were transferred into the pulper. Additional water was added so that the final consistency in the pulper reached 5%. When the contents inside the pulper reached the experimental temperature, 5N sodium hydroxide was used to adjust pH to 10.5, if it was required. This was followed by the addition of a repulping aid, which initiated the start of repulping time. A power cell was used to monitor the energy input

Experiment	Repulping Aid	Aid Dosage	Oxidation Equivalent	Ph	Temperature, °C
KMPS	KMPS	2.4%	1	10.5	60
Hypo 60	NaOCl	1.0%	2	10.5	60
Hypo 30	NaOCl	1.0%	2	Unadjusted	30
Alkali-only	None	0.0%	0	10.5	60
KMPS = potassium monopersulfate; Hypo 60 = hypochlorite, repulping at 60°C; Hypo 30 = hypochlorite, repulping at 30°C; NaOCl = sodium hypocholrite.					

I. Repulping conditions: 5% consistency, 550-rpm repulper speed, 35-min repulping time.

for the calculation of energy consumption. Repulping time was 35 min. By the end of repulping, the pH of the slurry was recorded. About 1/4 of the resulting slurry was transferred into a British disintegrator for an additional 10 min disintegration at 2000 rpm. The input energy was also recorded. The total energy input, including repulping and post disintegrating, was recorded. The final slurry was screened in a Somerville screen for 40 min. The slot opening of the screen plate was 0.15 mm. During the screening, a water head over the screen was maintained at 3 in. and water flow was kept constant. Accepts that passed through the screen plate and rejects that were left on the screen were collected and weighed and were used to calculate the screen yield (accepts weight/starting paper weight*100) and rejects (rejects weight/starting paper weight*100).

To make a full comparison, four sets of experiments were conducted as outlined in **Table I**: an alkali-only control without using repulping aid; two repulping runs with sodium hypochlorite (“hypo”), conducted under different temperature and pH conditions; and a repulping run with KMPS. Each of the experiments was run in duplicate, resulting in a total of 8 repulping experiments. Because KMPS is intrinsically acidic [23], repulping is typically carried out at elevated pH; the pH adjustment, repulping aid dosage, and temperature for all experiments are shown in Table I.

KMPS was used as received from LANXESS Corporation (Pittsburgh, PA, USA), under the trademarked name Oxone. Sodium hypochlorite solution (15%) was purchased from VWR International (Radnor, PA, USA). The concentration of the hypochlorite was determined by standard iodometric titration prior to use. KMPS and sodium hypochlorite were dosed based on dry weight of pulp: KMPS as a 100% dry product, and hypochlorite as the commercial liquid (100% basis).

Canadian Standard Freeness (CSF)

The CSF was measured by following the TAPPI Standard Test Method T 227 “Freeness of pulp (Canadian standard method).”

Handsheet forming

For each pulp stock prepared in the previous Repulping section, 6 handsheets were formed following TAPPI Standard Test Method “Forming handsheets for physical tests of pulp.”

Handsheet testing

The formed handsheets were tested for physical properties of tensile strength, tearing resistance, and bursting strength in accordance with the corresponding TAPPI Standard Test Method T 220 “Physical testing of pulp handsheets.”

Cupriethylenediamine solubility and viscosity

The tests followed a similar procedure to TAPPI Standard Test Method T 230 “Viscosity of pulp (capillary viscometer method).” In brief, 0.25 g fibers (o.d. mass) were weighed into a 50-ml dissolving bottle. After 25 ml water and several glass beads were added, the bottle was sealed and shaken for 1 h. A 25-ml 1 M cupriethylenediamine (CED) hydroxide solution was measured into the vial, followed by the purge of nitrogen for 2 min. The bottle was sealed and then shaken for another hour. The mixture was filtered through a crucible. The filtrate was tested for viscosity following the TAPPI T 230 procedure. The crucible was washed until no blue color persisted. The residue content was determined after the crucible was dried at 105°C overnight.

Fiber morphology

Fiber morphology was evaluated using a Fiber Quality Analyzer (Model FQA 360, OpTest Equipment Inc.; Hawkesbury, ON, Canada). In the analysis, a diluted fiber suspension was passed through an optical cell. The image of the passing fiber was caught in the charge-coupled device (CCD) camera. Each test assessed 5000 fiber objects (fines and fibers). After computer analysis, the size and shape of the detected fiber was determined. Fiber quality analysis (FQA) determined the content of fines, fiber length, curl, kink, and width. Each sample was tested twice with 5% or less testing error.

Experiment	Initial pH	End pH	Energy Input, kwh	Screen Yield, %	Rejects, %
KMPS-1	10.0	8.8	0.25	88.00	5.49
KMPS-2	10.0	8.8	0.25	88.16	4.86
Average	10.0	8.8	0.25	88.08	5.18
Hypo 60 -1	10.7	10.4	0.25	88.95	5.85
Hypo 60- 2	10.7	10.4	0.25	88.25	6.78
Average	10.7	10.4	0.25	88.60	6.32
Hypo 30- 1	9.8	8.4	0.26	76.54	21.12
Hypo 30- 2	9.8	8.4	0.26	77.34	20.62
Average	9.8	8.4	0.26	76.94	20.87
Alkali – 1	10.5	10.5	0.29	72.16	25.09
Alkali – 2	10.5	10.5	0.29	71.39	25.88
Average	10.5	10.5	0.29	71.78	25.49

KMPS = potassium monopersulfate; Hypo 60 = hypochlorite, repulping at 60°C; Hypo 30 = hypochlorite, repulping at 30°C.

II. Repulping of Kleenex paper towel.

RESULTS AND DISCUSSION

Repulping

Table II lists the repulping results from four sets of experiments. Before the addition of repulping aid, pH values of the slurries were adjusted to 10.5 using concentrated sodium hydroxide. The pH values shown in Table II were those measured immediately after the addition of repulping aid. As indicated previously, because of its acidity, addition of KMPS immediately reduced the pH value to 10.0. As the repulping proceeded, the pH value further decreased to 8.8. This is expected, because the monopersulfate concomitantly generates bisulfate acidic species while oxidizing substrates [24,25]:

$$HSO_5^- + \text{substrates} \rightarrow \text{Oxidized substrates} + HSO_4^-$$

The resulting bisulfate can further neutralize the hydroxide anion, leading to the decrease in medium pH.

In contrast, addition of hypochlorite increased the pH value from 10.5 to 10.7. As repulping proceeded, the pH value of the slurries decreased slightly. The initial increase in pH upon the addition of hypochlorite is due to the alkaline nature of hypochlorite solution. The subsequent decrease in pH as repulping proceeds is due to formation of acidic oxidation products. As indicated in Table II, the pH drop in hypochlorite repulping is actually very minimal due to the pH adjustment prior to the addition of the repulping aid. For the hypochlorite repulping that did not have initial pH adjustment, repulping pH decreased more significantly to 8.4 due to the lack of alkaline buffer. As expected, the alkali-only control experiments without repulping aid exhibited no change in pH.

As shown in Table II, the energy consumption during repulping is lowest with the addition of an oxidative repulping aid at elevated pH. This indicates that added oxidizer and alkali facilitated better fiber separation and thus reduced energy consumption. The energy consumption for repulping with either KMPS or hypochlorite is 14% lower than that of alkali-only repulping. This is a potentially significant energy cost savings in commercial scale production.

Chan and Lau believed that alkali could hydrolyze PAE, leading to repulping of the resin-treated paper if pH was above 10 at elevated temperature [8]. However, the data shown in Table II indicate that alkali alone could not completely disintegrate this PAE-treated paper towel under the conditions of these experiments. Repulping of the paper towel using sodium hydroxide at pH 10.5 and 60°C could only disintegrate 72% of the fibers. This result thus indicates that hydrolysis of PAE by alkali alone was far from complete and is consistent with Melchiorre, who found that alkali alone could only reach about 54% fiber disintegration within 30 min when sodium hydroxide was used for repulping of PAE-containing paperboard [3].

The addition of oxidative repulping aids substantially improved repulping. A 2.4% dosage of KMPS with initial pH adjustment essentially completely disintegrated the paper towel, resulting in 88% screen yeld and about 5% rejects. To increase screen yield further with even lower rejects, a longer repulping time could be employed. Melchiorre [3] reported that the fiber yield of PAE-containing

Experiment	CSF, ml	Tensile Strength, kN/m	Tensile Index, N. m/g	Burst Strength, KPa	Burst Index, Kpa.m²/g	Tear Strength, mN	Tear Index, mN.m²/g
KMPS-1	580	1.32±0.07	20.39±1.22	79.17±8.68	1.22±0.16	481.4±6.3	7.41±0.10
KMPS-2	580	1.36±0.08	20.86±1.48	80.48±5.85	1.24±0.06	570.4±62.7	8.76±0.94
Average	580	1.34±0.05	20.63±0.89	79.83±4.84	1.23±0.08	525.9±49.88	8.09±0.70
Hypo 60-1	580	1.19±0.09	18.07±1.26	74.07±5.81	1.13±0.09	497.4±8.49	7.57±0.09
Hypo 60-2	580	1.25±0.07	18.79±1.06	73.10±5.22	1.10±0.08	480.7±49.70	7.21±0.72
Average	580	1.22±0.06	18.43±0.81	73.59±3.61	1.12±0.06	489.2±22.35	7.39±0.33
Hypo 30-1	601	1.32±0.11	19.97±1.66	79.24±6.80	1.20±0.11	526.5±47.9	7.96±0.73
Hypo 30-2	601	1.31±0.10	19.84±1.46	74.41±1.58	1.12±0.02	511.6±60.8	7.73±0.94
Average	601	1.32±0.07	19.91±1.02	76.83±3.73	1.16±0.06	519.1±32.8	7.85±0.50
Alkali-1	601	1.28±0.05	19.66±0.34	85.71±5.37	1.32±0.08	445.9±10.2	6.87±0.16
Alkali-2	601	1.20±0.05	19.16±1.08	79.58±3.10	1.27±0.05	467.0±27.7	7.45±0.52
Average	601	1.24±0.04	19.41±0.57	81.88±3.46	1.30±0.05	459.2±15.40	7.16±0.32

KMPS = potassium monopersulfate; Hypo 60 = hypochlorite, repulping at 60°C; Hypo 30 = hypochlorite, repulping at 30°C.

III. Strength properties of the repulped fiber. (Note: Physical strength data based on testing of 5 handsheets.)

paperboard could be increased by 10% when the repulping time was increased from 30 min to 75 min. Of course, this yield increase would require higher energy input.

Using the same oxidative equivalent, hypochlorite is less effective in this study than KMPS in terms of the degree of repulping. Several trials (not shown) with hypochlorite at the same oxidative equivalent (i.e., 0.5%, 100% basis) as 2.4% KMPS resulted in much lower screen yield and much higher rejects. To reach an equivalent repulping result, two times the oxidative equivalent amount of sodium hypochlorite was required. Temperature and pH buffer significantly affect the repulping with hypochlorite. As indicated in Table II, when repulping with hypochlorite at 30°C without sodium hydroxide buffer, the screen yield was only 5% higher than that using sodium hydroxide alone. Chung [13] also found that both temperature and pH played important roles in hypochlorite repulping of PAE-treated pulp. It was concluded that high temperature enhanced the oxidative reaction with the PAE resin; high pH helps to maintain a high concentration of hypochlorite anion (OCl^-), which is the effective species for PAE degradation.

Properties of the repulped fibers

The fibers produced in repulping were tested for CSF and formed into handsheets for physical strength tests. As indicated in **Table III**, pulp fibers from repulping with either KMPS or sodium hypochlorite at 60°C gave slightly lower CSF. This may be attributed to the fiber oxidation at high temperature, which caused "chemical refining." A slight refining is beneficial for physical strength and other paper towel properties, such as water absorption and softness.

Table III also listed the physical strength results, which were obtained from the test of five handsheets for each sample. At 60°C, repulping with KMPS resulted in increased physical strength of the fibers. Compared to the fibers from hypochlorite repulping, those from KMPS repulping had 12% higher tensile index, 10% higher burst index, and 9.5% higher tear index. The comparison is more varied with hypochlorite at 30°C and alkali-only repulping at 60°C. Hypochlorite at 30°C had comparable tensile and tear indices, but lower burst index, while alkali-only repulping at 60°C had lower tensile and tear indices, but higher burst index.

It is generally accepted that recycled fibers will lose physical strength due to the changes in fiber morphology and the bonding capability. Besides this, the oxidative repulping aid may also cause loss in dry strength of the recycled fibers because of cellulose degradation. The damage to the fibers is believed to be proportional to the thermodynamic redox potential of the repulping aid. Fisher [15] found that sodium peroxydisulfate ($Na_2S_2O_8$) repulping led to over 63.6% dry tensile loss, whereas hydrogen peroxide caused only 13.4% dry strength loss. Since the redox potential of KMPS is similar to that of hydrogen peroxide ($E^0_{HSO_5^-/HSO_4^-}$ = +1.82 V; $E^0_{H_2O_2/H_2O}$ = +1:76 V) [18] and is much lower than that of sodium peroxydisulfate (2.1 V), it is reasonable to believe that the oxidation to the fibers by KMPS should be less profound and should be comparable to that caused by hydrogen peroxide. In fact, Kennedy and Stock [21] pointed out that peroxydisulfate could cleave vicinal glycol bonds, which could result in the ring rupture in the cellulose glucose unit. However, this reaction would not occur when monopersulfate was used as oxidant. Although comparisons with peroxydisulfate and hydrogen peroxide are not included in this study, Table III does demonstrate that repulping with potassium monopersulfate preserves fiber strength.

To assess cellulose damage caused by the different repulping aids, viscosity measurement is a primary approach. However, Espy and Rave [9] demonstrated that the cured PAE resin on the fibers could prevent cellulose from being dissolved in a CED solution. It is logical to follow that high residual PAE can result in low cellulose dissolution, and thus lead to low cellulose content in the CED-cellulose solution. The measurement thus underestimates the true viscosity value. However, if different pulp samples give the same CED dissolution, the relative viscosity can be used to compare the cellulose damage. When 0.5 M CED hydroxide solution was used to dissolve the pulp fibers obtained through different experimental conditions, various amounts of residues were found, as indicated in **Table IV**. The pulp fibers from repulping with KMPS and with hypochlorite at 60°C (hypo-60) resulted in almost the same residue content. Those pulp fibers from hypochlorite at 30°C (hypo-30) and alkali only also gave similar contents, but around 1% higher than that of fibers from KMPS and hypo-60 repulping. The paper towel without repulping had the highest residue content at 6.5% higher than

Sample	Residue, %	Viscosity, mPa.s
KMPS	12.5	13.3
Duplicate	12.0	12.8
Average	12.3	13.1
Hypo-60	12.5	11.9
Duplicate	12.5	12.4
Average	12.5	12.2
Hypo-30	13.0	14.1
Duplicate	14.0	13.7
Average	13.5	13.9
Alkali-only	13.0	14.0
Duplicate	14.0	14.4
Average	13.5	14.2
Paper towel	19.5	11.4
Duplicate	18.5	11.2
Average	19.0	11.3

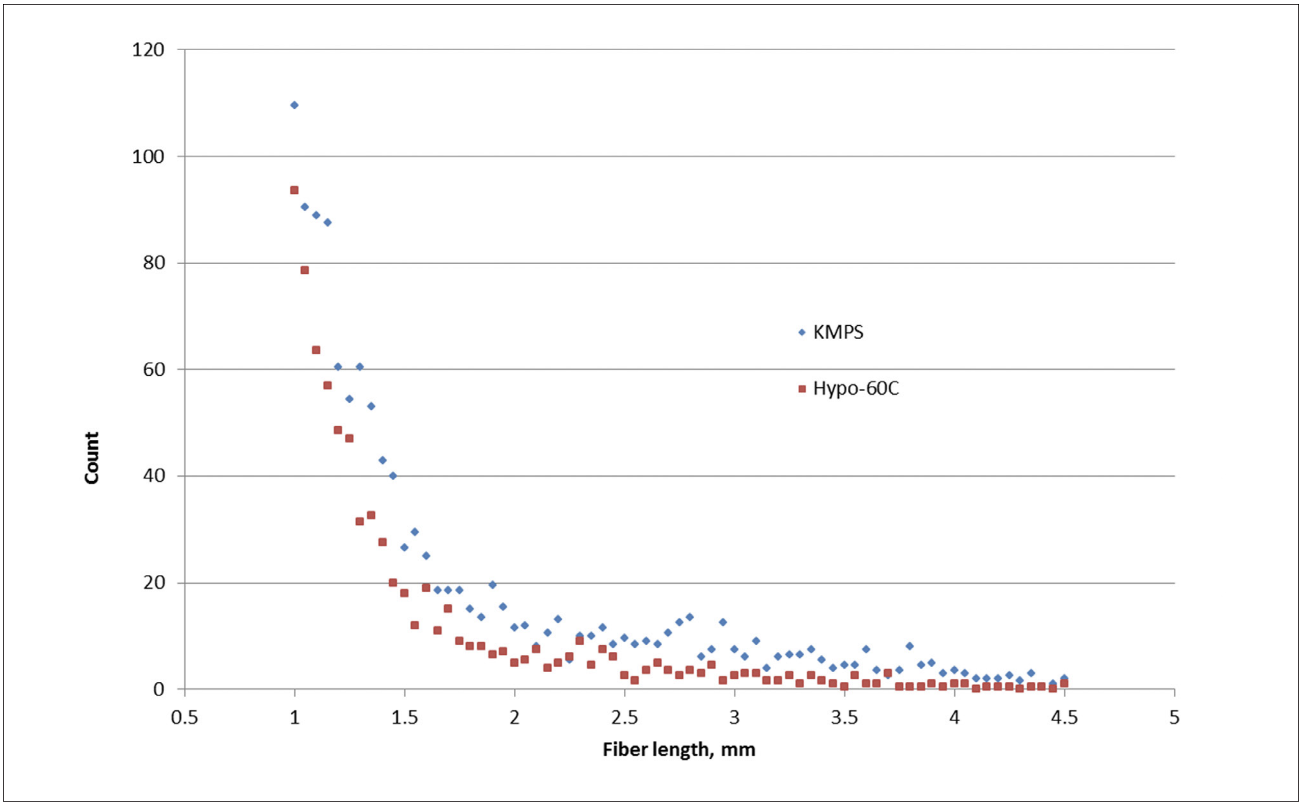
KMPS = potassium monopersulfate; Hypo 60 = hypochlorite, repulping at 60°C; Hypo 30 = hypochlorite, repulping at 30°C.

IV. Residues and viscosity of the pulp dissolved in cupriethylenediamine (CED) solution.

Experiment		KMPS		Hypo 60		Hypo 30		Alkali-Only	
		1	2	1	2	1	2	1	2
Fines, %	Ari	2.60	3.30	5.10	4.60	4.80	4.15	5.75	5.40
	L.W	0.30	0.30	0.75	0.60	0.65	0.50	0.80	0.70
Fiber length, mm	Ari	0.834	0.911	0.649	0.684	0.679	0.720	0.688	0.720
	L.W	1.339	1.581	1.006	1.093	1.082	1.146	1.093	1.173
	W.W	2.060	2.436	1.561	1.695	1.707	1.808	1.726	1.882
Mean curl	Ari	0.151	0.149	0.138	0.156	0.147	0.145	0.147	0.145
	L.W	0.155	0.153	0.143	0.158	0.152	0.150	0.150	0.150
Kink	Index	2.30	2.25	2.24	2.46	2.37	2.31	2.36	2.35
	Angle	42.83	44.16	37.30	43.45	41.24	40.83	40.54	41.03
	k/mm	1.01	0.96	1.02	1.10	1.08	1.03	1.06	1.04
Width, µm		20.6	21.6	20.10	20.35	20.50	20.75	20.20	20.20

KMPS = potassium monopersulfate; Hypo 60 = hypochlorite, repulping at 60°C; Hypo 30 = hypochlorite, repulping at 30°C; Ari: arithmetic; L.W: length-weighted; W.W: weight-weighted.

V. Fiber quality analysis (FQA) of the resultant pulp fibers.



3. Fiber length distribution.

that from KMPS and hypo-60 repulping. Comparing the viscosity values for the pulp fibers from KMPS and hypo-60 repulping, the former was 1 unit higher in viscosity. Results thus indicated that there were still significant amounts of residual PAE on the reclaimed pulp fibers, even though the paper towel was disintegrated and fibers were screened to pass narrow slots. The residue content is closely related to the repulping conditions. Conditions of high temperature and high pH, with a highly efficient repulping aid, led to a low residual PAE. Compared to hypochlorite, KMPS caused less damage to cellulose, as shown by the relatively high viscosity value.

The FQA data in Table V presents similar results. The data show that using KMPS as a repulping aid produced better quality fibers compared to both hypochlorite and alkali-only repulping. Specifically, pulp from KMPS repulping yielded 34%–47% fewer fines and 24%–31% longer average fiber length. Although FQA fiber length could be affected by other factors, such as the incomplete disintegration of fiber bundles, the results are generally in line with the physical strength and viscosity data. Other fiber characteristics were comparable among the four sets of experiments. Because the curl and kink are usually created by mechanical force, such as the rotating propellers of the pulper, the similarity in curl and kink is expected because the pulp fiber should experience very similar mechanical action during the repulping.

Figure 3 displays the fiber length distributions of resultant pulps from KMPS repulping and hypo-60 repulping. More long fibers could be seen in the sample from KMPS repulping. This provides a visual comparison of fiber length among the two pulp samples. The results are in good agreement with the physical test results.

CONCLUSIONS

1. KMPS is an effective repulping aid for the repulping of PAE-containing paper towel, producing 88% fiber yield and about 5% rejects. Although sodium hypochlorite could be used to achieve a similar result, it requires a two-times higher oxidative equivalent amount of chemical. This reflects the greater selectivity of KMPS vs. hypochlorite in the oxidative degradation of PAE resin, while preserving repulped fiber quality.
2. Compared to the repulping with sodium hypochlorite and sodium hydroxide alone, repulping with KMPS produces pulp fibers with significantly higher physical strength, including tensile strength, burst strength, and tear resistance.
3. Repulping with KMPS produces repulped fiber with longer average fiber length and fewer fines as compared to both hypochlorite and alkali-only repulping under all conditions tested in this study. **TJ**

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ABOUT THE AUTHORS

Repulping of polyamide-epichlorohydrin (PAE) wet strength papers in an environmentally friendly way still remains a challenge. Finding an effective alternative to replace the conventional chlorine-containing reagents is in the best interest of the paper industry.

This research proves that potassium monopersulfate (KMPS) can aid in the repulping of PAE wet strength papers and maintaining fiber quality. It demonstrates that KMPS does not generate environmentally harmful byproducts and reduces the oxidative damage to reclaimed fibers.

The most difficult aspect of this research was proving the effectiveness of KMPS in degrading PAE while maintaining the fiber strength. To do this, we compared the physical strength, viscosity, and fiber morphology of the reclaimed fibers with those obtained by the chlorine-containing reagents.

This research shows that mills may have an alternative approach for repulping wet strength papers. The next step would be to explore its use in the industry.

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