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ANTHRAQUINONE AND SURFACTANT EFFECT ON SODA PULPING

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ABSTRACT

The kraft pulping process purpose is to individualize cellulosic fibers and remove lignin by white liquor, which main components are sodium hydroxide and sodium sulfide. This process is known to produce high strength papers, but causes odorous pollution and increases costs of the black liquor recovery system. The soda process is an alternative of pulp production without sulfur compounds. This study carried out a comparison between Soda-control pulp, Soda-pulp with additives (AQ, Surfac. and AQ+Surfac.) and Kraft-control pulp. Anthraquinone made available a higher pulping yield for the Soda-process than that of the Kraft-control pulping, but also increased rejects content for the same kappa number. The surfactant did not produce good yield results as AQ did, but it kept shives content at low level. AQ decreases the alkali charge and residual in soda pulping, especially for AQS mixtures. No additive tested has got better viscosity results than those of Kraft-control pulp.

Keywords: Anthraquinone, kraft, pulping, soda, surfactant

INTRODUCTION

Kraft pulp has good strength characteristics, but is cause of odor pollution because of its sulfur compounds. The Brazilians pulp mills - especially those close to urban centers - have researched solutions on the subject in cooperation with environmental organizations.

The Soda process was widely used in the past, but it was, however, replaced by kraft process. The Soda pulping is an alternative for producing sulfur free pulp, but loss of viscosity is inbuilt, as is paper strength, because the high alkali charge and temperature.

The pulp additives market has undergone continuous innovation and improvement by way of heavy investments in research and production of new products. These new products can improve the soda pulping quality, getting it closer to the kraft pulp characteristics.

OBJECTIVES

In this study, a better understanding on the subject of soda pulping with additives was performed in the attempt to produce soda pulp comparable to kraft pulp within mechanical properties. This quality improvement was obtained by way of use of additives (AQ and surfactants) and modern pulping methods (Lo-Solids).

MATERIALS AND METHODS

Lo-Solids pulping

Chips of *Eucalyptus sp.* wood from the Brazilian pulp mill Cenibra were used, after its screening according to SCAN-CM 40:94 method.

Lo-Solids technology was performed for the cooking of all samples. This method consists in keeping a low dissolved solids concentration in black liquor through constant liquor replacements. Lo-Solid pulping is the most commonly and modern method used by Brazilians pulp mills. Kappa number 18 was used as delignification degree, a typical number for eucalyptus pulp.

The cooking was carried out in an M&K digester (7 L capacity), equipped with pump and heater for liquor circulation. The reactor connected to a set of heated and pressurized accumulator vessels, enabling replacement of white liquor. Time and temperature were controlled by computer, what allowed plotting H-factor against temperature.

Steam treatment was applied for 20 minutes on wood chips before white liquor addition, with 50% of the total effective alkali. The impregnation phase was performed at 115°C for 30 minutes. After that, 30% of the effective alkali was added on the first cooking phase and 20% on the second cooking phase. Both phases lasted 50 minutes, but final temperature varied between kraft and soda pulping.

The pulp was washed with tap water until neutral pH and screened on a Voith Sulzer screen with drill size 0,2 mm.

Additives and liquors

For production of the Kraft-control pulp, white liquor was prepared at laboratory mixing sodium hydroxide and sodium sulfide, 100 g/L of effective alkali and 30% sulfidity, without additives. To produce Soda-control pulp, sodium hydroxide was diluted up to 120 g/L concentration.

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Ashland provided 3 additives to get better soda pulp properties: anthraquinone (AQ), a mix of surfactants (Surfac.) and a mix of anthraquinone and surfactant (AQS).

AQ dosages were 0,015%, 0,03%, 0,06%, 0,12%, 0,24%, 0,36% and 0,48%. Surfac. dosages were 0,003%, 0,006%, 0,012%, 0,024%, 0,06% and 0,12%. AQS dosages were 0,06%, 0,12%, 0,24%, 0,36% and 0,48%. Pulping was performed in duplicate with 500 g oven dry wood chips.

Pulp analysis

Kappa number, screened yield (%), reject content (%) and viscosity (cm³/g) tests were performed on pulp, and effective residual alkali (g/L) was performed on black liquor.

For screened yield and rejects content, gravimetric method was used. Kappa number was determined by TAPPI T236 cm-85 method and viscosity by TAPPI T230 om-94 method. Using ISO 5351 method, the viscosity was converted to intrinsic viscosity. The black residual liquor was characterized by SCAN N-33:94 method.

RESULTS

Control pulp

The pulping conditions to produce the controls are given in **Table 1.**

Control pulping results are given in **Table 2**. As expected, kraft control showed the highest screened yield, with a 53.4% average. Intrinsic viscosity was 1231 cm³/g. The higher effective alkali charge on Soda-control 1 decreased the screened yield to 47.5%. Soda-control 2 showed 2% higher yield than Soda-control 1, but its viscosity was 205 cm³/g lower. Probably, the higher alkaline charge damaged hemicelluloses harder, decreasing yield and increasing viscosity.

Table 1. Pulping conditions

Pulping parameters	Kraft-control	Soda-control 1	Soda-control 2
Sulfidity	30%	-	-
Effective alkali	100 g/L	120 g/L	120 g/L
Liquor/wood ratio	4	4	4
Steam	20 min	20 min	20 min
Impregnation temperature	115°C	115°C	115°C
Impregnation time	30 min	30 min	30 min
Time to temperature	15 min	15 min	15 min
Pulping temperature	155°C/160°C	155°C/160°C	172°C/172°C
Pulping time	50 + 50 min	50 + 50 min	50 + 50 min
Alkali charge rate	50%/30%/20%	50%/30%/20%	50%/30%/20%
H-Factor	635	649	2070

Table 2. Control pulping results

Sample	Rep. #	H-Factor	EA,%	Kappa n.°	Brightness %ISO	Yield, %			Visc. cm³/g	EAR g/L
						Screened	Reject	Total		
Kraft-control	1	635	20.0	18.1	-	53.5	0.1	53.6	1230	9.4
	2	634	20.0	17.7	-	53.2	0.1	53.3	1233	8.6
	Avg	635	20.0	17.9	35.5	53.4	0.1	53.5	1231	9.0
Soda-control 1	1	665	56.0	17.9	-	47.7	0.0	47.7	1062	42.4
	2	633	56.0	18.1	-	47.2	0.0	47.2	1072	42.4
	Avg	649	56.0	18.0	35.5	47.5	0.0	47.5	1067	42.4
Soda-control 2	1	2072	25.0	18.3	-	49.7	0.1	49.8	871	11.8
	2	2068	25.0	17.9	-	49.2	0.1	49.3	853	13.3
	Avg	2070	25.0	18.1	33.4	49.5	0.1	49.6	862	12.6

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Soda pulping with additives

For comparison purposes, on soda pulping with additives only Soda-control 2 was used, which will be defined as Soda-control only. Results were compared with Kraft-control as well.

Soda pulping with Anthraquinone (Soda-AQ)

Anthaquinone was tested up to the limit of the yield growing. Results are given in **Table 3**.

The yield for soda with 0.12% AQ dosage was higher than that for Kraft-control, 0.3% higher. The highest yield was obtained for the 0.36% AQ dosage.

Soda-AQ 0.36% could give until 5.2% higher screened yield in comparison to the Soda-control, and 1.3% higher compared to Kraft-control. As shown in Table 3, yield increases with the AQ dosage until 0.36%, and decreases for the 0.48% dosage.

The reject content also increases with AQ dosage due to the alkaline charge reduction. Soda-AQ 0.48% has used 2.5% less alkali than Kraft-control. The effective residual alkali decreases with the alkaline charge, but holds acceptable levels for Lo-Solids pulping.

The AQ addition improves viscosity, but not enough to exceed the Kraft-control viscosity.

Soda pulping with surfactant (Surfac.)

The average results for surfactant pulping are given in **Table 4**.

The surfactant addition gave a minor screened yield gain compared with Soda-control, 2.1% more. But it was not enough for performing better than the Kraft-control. The alkaline charge for Soda-Surfac. 0.12% was 1% lower compared to Soda-control. A decrease from 25% to 24%.

The viscosity increased when compared to Soda-control, but not showing any relation with the surfactant dosage. The reject content kept constant.

Table 3. Soda-anthraquinone pulping results

Sample	H-Factor	EA,%	Kappa	Brightness, %ISO	Yield, %			Visc. cm³/g	EAR g/L
					Screened	Reject	Total		
Kraft-control	635	20.0	17.9	35.5	53.4	0.1	53.5	1231	9.0
Soda-control	2070	25.0	18.1	33.4	49.5	0.1	49.6	862	12.6
Soda-AQ 0.015%	2064	22.5	18.2	32.5	50.2	0.1	50.2	967	9.2
Soda-AQ 0.03%	2011	21.5	18.2	30.2	52.1	0.2	52.2	953	7.7
Soda-AQ 0.06%	2028	20.5	18.0	31.2	52.7	0.2	52.9	1026	6.9
Soda-AQ 0.12%	2088	19.0	17.9	29.8	53.7	0.3	54.0	1023	4.9
Soda-AQ 0.24%	2053	18.3	18.5	28.9	54.5	0.5	55.0	1039	3.5
Soda-AQ 0.36%	2037	18.3	17.9	29.1	54.7	0.3	55.0	1034	3.8
Soda-AQ 0.48%	2032	17.5	17.9	29.7	53.7	0.4	54.0	1005	4.7

Table 4. Soda-Surfac. pulping results

Sample	H-Factor	EA,%	Kappa	Brightness, %ISO	Yield, %			Visc. cm³/g	EAR g/L
					Screened	Reject	Total		
Kraft-control	635	20.0	17.9	35.5	53.4	0.1	53.5	1231	9.0
Soda-control	2070	25.0	18.1	33.4	49.5	0.1	49.6	862	12.6
Soda-Surfac. 0.003%	2011	25.0	18.5	35.0	49.0	0.1	49.1	935	12.5
Soda-Surfac. 0.006%	2041	25.0	18.0	33.8	49.8	0.1	49.8	913	13.2
Soda-Surfac. 0.012%	2003	25.0	17.8	35.0	50.3	0.1	50.3	902	11.2
Soda-Surfac. 0.024%	2094	24.0	17.9	33.4	50.8	0.1	50.9	902	10.7
Soda-Surfac. 0.060%	2031	24.0	18.1	34.9	51.6	0.0	51.6	897	10.5
Soda-Surfac. 0.120%	1988	24.0	18.3	34.1	49.9	0.0	49.9	919	11.4

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Table 5. Soda-AQS pulping results

Sample	H-Factor	EA,%	Kappa	Brightness %ISO	Yield, %			Visc. cm^3/g	EAR g/L
					Screened	Reject	Total		
Kraft-control	635	20.0	17.9	35.5	53.4	0.1	53.5	1231	9.0
Soda-control	2070	25.0	18.1	33.4	49.5	0.1	49.6	862	12.6
Soda-AQS 0.06%	2022	21.5	18.1	31.5	52.4	0.2	52.6	1005	7.1
Soda-AQS 0.12%	2040	20.5	18.2	32.1	52.4	0.4	52.8	996	6.4
Soda-AQS 0.24%	2013	19.5	17.5	28.9	53.9	0.2	54.1	1031	3.4
Soda-AQS 0.36%	2050	19.0	18.5	28.1	54.0	0.4	54.4	1077	3.8
Soda-AQS 0.48%	-	18.5	18.5	28.4	54.2	0.4	54.6	1050	3.8

Soda pulping with anthraquinone and surfactant (AQS)

The surfactant promotes a dispersant action and also increases wood chips impregnation, thereby complementing the anthraquinone chemistry action in protecting carbohydrates and in lignin reduction. Results for Soda-AQS pulping are given in **Table 5**.

The highest yield was obtained with the 0.48% AQS dosage, 0.8% more than Kraft-control. The surfactant content on AQS mix was not enough to avoid rejects. As shown in Table 5, the higher dosage produced 0.4% rejects content.

The alkaline charge and effective alkali residual decreased with the increasing of the AQS dosage. The Soda-AQS 0.48% alkali pulp was 1.5% lower than the Kraft-control pulp. The higher viscosity was 1077 cm^3/g for Soda-AQS 0.36%, but lower than that of the Kraft-control.

CONCLUSIONS

The anthraquinone addition increases the soda pulping screened yield level and, for some dosages, this yield turns out higher than that of the Kraft-control yield. However, reject content increases for same kappa number. The same came about with the AQS mix pulp.

Surfactant addition did not show good results for screened yield, but kept a low reject content. The surfactant dosage for the AQS mix pulp can be increased if aimed at converting rejects in screened yield.

Some anthraquinone dosages decrease a lot the alkali charge and effective alkali residual, mainly for AQS pulping. So, it is possible to reduce the H-factor when the AQ dosage is increased, thereafter making the viscosity higher.

Any additive could produce Soda-pulp with a higher viscosity than that of the Kraft-control pulp.

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