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Soda sulphur pulping of mandar for manufacturing writing and printing paper

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Abstract: Chips of mandar were subjected to pulping in the laboratory using soda–sulphur process and for that optimum conditions were established on the basis of yield and permanganate number and freeness of the pulp and breaking length, tear factor, burst factor and brightness of the unbleached pulp-sheets. The pulps were then bleached and the above properties for both bleached pulp and pulp-sheets were also determined and reported. It has been found that good quality writing and printing paper can be obtained from the wood of mandar tree through soda sulphur pulping process followed by subsequent bleaching of the pulps using conventional 3 and 5 stage systems.
Key words: Soda sulphur, mandar, paper pulp

Introduction

Mandar (*Erythrina indica* Lamk.) is an angiosperm belonging to leguminosae family. It is a medium size, rapid growing tree reaching a height 25 feet from the ground. The tree is abundantly found in the tropical countries like Bangladesh, Burma, India, Andaman and Nicobar islands. The tree is mainly used by the villagers as fuel. The chemical composition of mandar was determined (TAPPI, 1-4, 1969) and it contains alpha cellulose 42.35%, lignin 28.65%, pentosan 10.24% and ash 0.26%. As there is no report of making pulp and paper from mandar by soda sulphur process in literature, so the present studies were made in details.

Materials and Methods

For each experiment 500 g. o.d. chips of mandar were used in rotating closed digestor of 20 L capacity. The temperature rose with the rise of pressure and vice versa. At the end of cooking of each experiment the pulp was washed thoroughly with water. Optimum pulping conditions were established by varying the percentage of caustic soda and elemental sulphur as well as time, temperature and material-liquor ratio and for that careful determinations for unbleached pulp-yield and permanganate number of the pulp were made (TAPPI-5, 1969). The paper properties of the unbleached pulp-sheets were also determined. Pulps thus obtained with the optimum pulping conditions were then bleached with 3 stage CEH and 5 stage CEHEH bleaching systems where C is meant for chlorination, E for caustic extraction and H for sodium hypochlorite treatment. Chlorination was applied for an hour at 3.5% consistency at room temperature at pH 1–2. Caustic extraction (2%) was made for an hour at 13.5% consistency at pH 12–13. The extraction was continued at a temperature of 70-80^{o}C. The duration of hypochlorite was also for 60 minutes at pH 9–11. All other conditions of hypochlorite treatment remained same as those of chlorination. In case of 3 stage CEH bleaching, 60% chlorine was used and the rest 40% chlorine was used at the end of 3rd stage from hypochlorite solution. The distribution of chlorine for 5 stages CEHEH bleaching system was 60%, 20% and 20% respectively for chlorination, 1st and 2nd hypochlorite treatments. Pulps, before and after bleaching, were disintegrated and beaten in a Hollander beater by TAPPI procedures (TAPPI-6, 1969) for a period of 0 to 60 minutes and samples of pulp-slurry were collected at 0, 10, 20, 30, 40, 50 and 60 minutes and pulp-sheets were made (TAPPI-7, 1969) and tested for paper properties like breaking length, tear factor, burst factor and brightness (TAPPI, 8-11, 1969). The freeness of both unbleached and 3 stage and 5 stage bleached pulps were also determined (TAPPI-12, 1969).

Results and Discussion

The soda-sulphur pulps were obtained with the use of the optimum pulping conditions (Table 2). Comparing to other (Karim, 1980) the highest pulp-yield 50.02% (Table 3) obtained from the pulps of the unbleached origin (Table 1). The chemical composition of mandar showed that it contained 42.35% alpha cellulose. The percentage of the pulp yields and the amount of alpha cellulose the plant contained showed that there was no abnormal loss of cellulose during pulping and the loss were minimum during soda–sulphur cooking (Karim, 1980).

Like other cellulosic raw materials, the highest pulp-yield of 50.02% rather than soda and kraft pulps (Karim, 1980) was obtained with the addition of 1.0% elemental sulphur to the cooking liquor. Attempts were made for higher yields with more addition of elemental sulphur to the liquor. But it brought little success. So the amount of 50.02% considered as the highest pulp-yield for the present studies of mandar. In addition, the cooking time was dropped from 4.0 hours required for soda and sulphate pulping (Karim, 1980) to 2.0 hours for soda-sulphur pulping and thus 50% cooking time was saved.

There are various reaction mechanisms suggested from time to time for addition of elemental sulphur to the cooking liquor and the most widely accepted mechanisms is represented as follows:

$$6\,NaOH + 4\,S \rightarrow 2Na_2S + Na_2S_2O_3 + 3H_2O$$

The sodium sulphide in the cooking liquor hydrolysis as follows and produces sodium hydrosulfide (NaSH) and sodium hydroxide.

$$Na_2S + H_2O \rightarrow NaHS + NaOH$$

Table 1 Variations in chemicals (NaOH and S), time, temperature and material liquor ratio along with permanganate number and freeness of the pulp and brightness and physical or paper properties of the pulp sheets of mandar

Experiment	NaOH (%)	Sulphur (%)	Temperature ^{0}C	Time including 55 minutes to reach temperature	Material-liquor ratio	Unbleached yield (%)	Permanganate number	Breaking length (m)	Tear factor	Burst factor	Brightness (%)
1	20	1.0	160	2.0	1 : 5	Not well digested					
2	22	1.0	160	2.0	1 : 5	50.02	17.98	3220	62.18	64.40	28.6
3	24	1.0	160	2.0	1 : 5	47.50	16.01	3400	60.08	67.76	31.0
4	22	0.0	160	2.0	1 : 5	Remain undigested					
5	22	0.5	160	2.0	1 : 5	47.06	21.98	2934	61.36	58.68	27.2
6	22	1.0	160	2.0	1 : 5	50.02	17.98	3220	62.18	64.40	28.6
7	22	1.5	160	2.0	1 : 5	50.17	18.05	3211	62.22	64.21	29.0
8	22	2.0	160	2.0	1 : 5	50.30	18.10	3201	62.34	64.10	29.3
9	22	1.0	150	2.0	1 : 5	Not well digested					
10	22	1.0	160	2.0	1 : 5	50.02	17.98	3220	62.18	64.40	28.6
11	22	1.0	170	2.0	1 : 5	47.00	16.48	3617	55.95	68.05	32.4
12	22	1.0	160	1.0	1 : 5	Not digested					
13	22	1.0	160	2.0	1 : 5	50.02	17.98	3220	62.18	64.40	28.6
14	22	1.0	160	3.0	1 : 5	44.65	14.29	3910	59.95	73.45	37.0
15	22	1.0	160	2.0	1 : 4	Not well digested					
16	22	1.0	160	2.0	1 : 5	50.02	17.98	3220	62.18	64.40	28.6
17	22	1.0	160	2.0	1 : 6	49.94	17.92	3242	61.47	64.61	29.0

Table 2 Optimum pulping conditions for soda-sulphur pulp of mandar

NaOH (%)	Sulphur (%)	Temperature ^oC (%)	Time in hours	Material-liquor ratio	Pressure kg/cm^2
22	1	160	2	1 : 5	6

Table 3 Yield and brightness of the bleached soda–sulphur pulp of mandar

Pulp	Bleached yield (%)	Brightness (%)
CEH	46.15	80.6
CEHEH	45.04	82.5

Table 4 Fibre-dimension of soda-sulphur pulp of mandar

Pulp	Length in mm			Diameter in mm		
	Maximum	Minimum	Average	Maximum	Minimum	Average
CEH	2.00	0.92	1.34	0.042	0.026	0.030
CEHEH	1.95	0.90	1.31	0.042	0.026	0.030

200 fibres were used for above purpose

Table 5 Fibre-fractions of soda-sulphur pulp of mandar

Pulp	Fibre-faction in percent (%)				
	0.50 – 0.99 mm	1.00-1.49 mm	1.50-1.99 mm	2.00-2.49 mm	2.50-2.99 mm
CEH	6.07	81.54	12.39	0	0
CEHEH	10.89	72.00	17.11	0	0

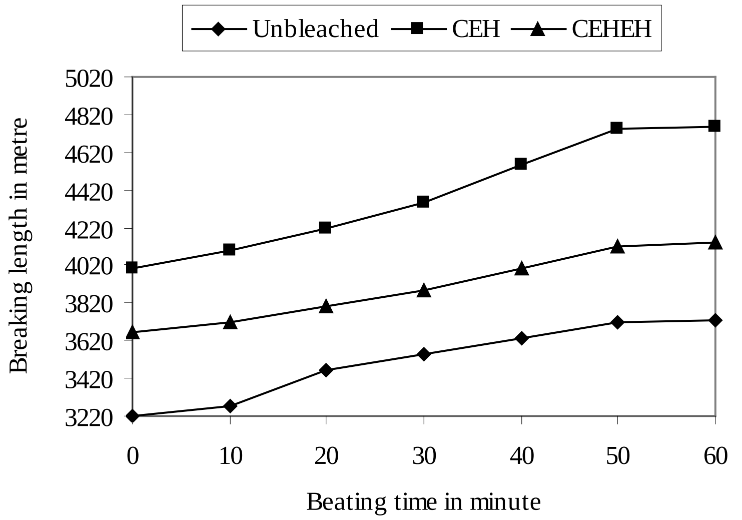

Fig. 1. The breaking length of the unbleached, CEH and CEHEH bleached soda sulphur madar pulp

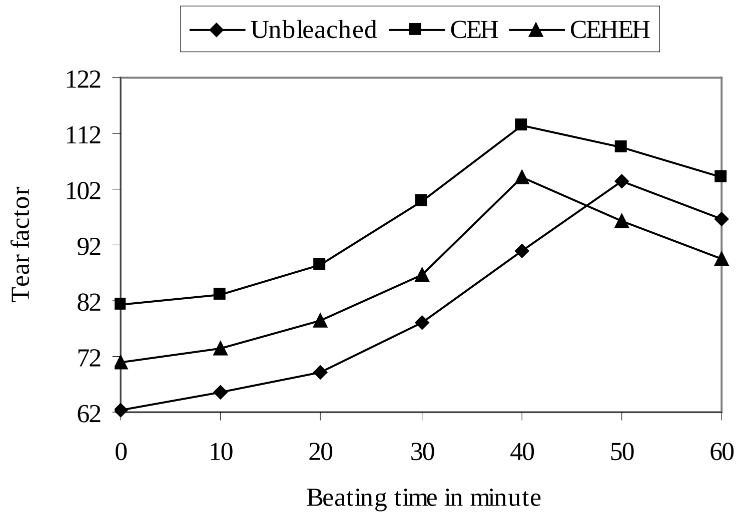

Fig. 2. The tear factor of the unbleached, CEH and CEHEH bleached soda sulphur mandar pulp

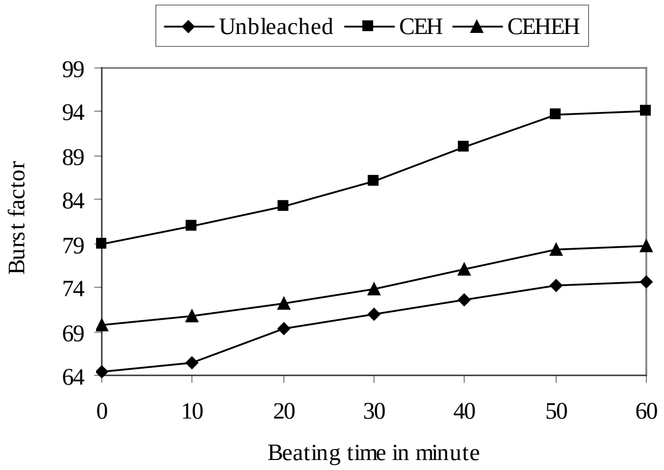

Fig. 3. The burst factor of the unbleached, CEH and CEHEH bleached soda sulphur mandar pulp

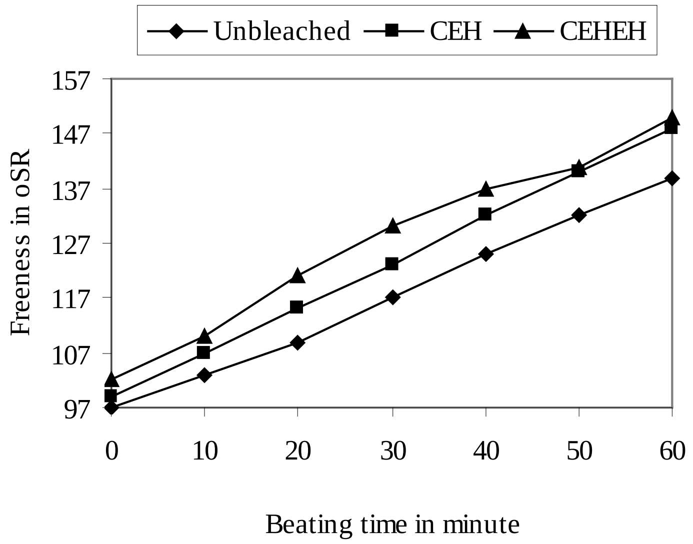

Fig. 4. The freeness of the unbleached, CEH and CEHEH bleached soda sulphur mandar pulp

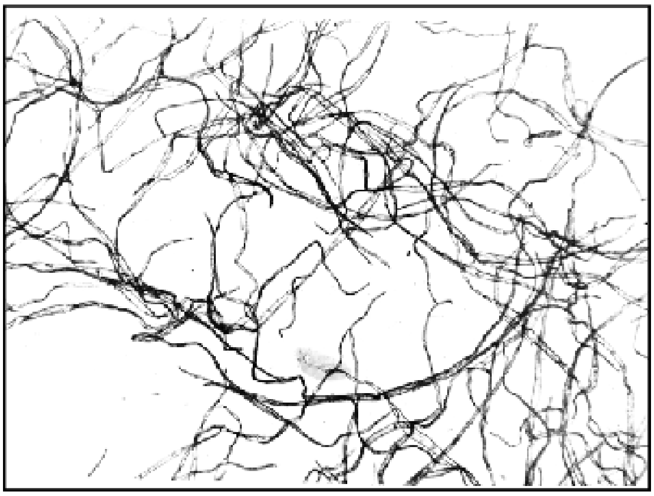

Fig. 5. The photomicrograph of the CEH soda-sulphur mandar pulp

Thus the sodium sulfide increases the sodium hydroxide content in the cooking liquor. More importantly it produces hydrosulfide which exerts a highly beneficial effect on the pulping reactions. For example, the presence of the hydrosulfide acts as a buffer and tends to reduce the degrading or injurious effects of more active sodium hydroxide on cellulose and hemicellulose giving rise to higher pulp-yields and stronger pulps. The hydrosulfide also reacts with lignin forming thiolignin which, in turn, makes lignin more readily soluble in alkali and thus reduces time for pulping or cooking.

The permanganate number of the soda-sulphur–mandar pulp was found to be 17.98 which also showed that the unbleached pulp-yield obtained was not at the cost of pulp purity but due to correct selection of optimum pulping conditions which were adequate for good delignification.

The brightness of CEH and CEHEH soda–sulphur pulps of mandar were respectively 80.6% and 82.5% which were higher than kraft and soda pulps as obtained by Karim (1980)

The fibre-length and diameter for 3 stage and 5 stage bleached pulps were recorded in table-4. The photomicrograph of the soda-sulphur pulps is also given (Figure 5). From the photomicrograph, it is seen that the fibres of the mandar pulps were thin-walled and contained parachchyma cells. The maximum fibre length was 2.00 mm and the minimum length was 0.92 mm. The average fibre-length was 1.34 mm as shown in the Table 4. From the fibre-length of soda-sulphur pulps it has been found that the degradation of the fibres was minimum with soda-sulphur pulps. From the related studies, it is also considered that mandar pulp is one of the medium fibres.

For laboratory evaluation, the unbleached, 3 stages CEH and 5 stage CEHEH bleached soda-sulphur pulps were disintegrated and beaten for 0-60 minutes in a Hollander beater. From figures it is seen that the breaking length and burst factor of the above pulps increased from 0 to 60 minutes due to gradual increase in the surface of the fibres in optical contact. The tear factor of the unbleached pulps increased from 0 to 50 minutes but in case of CEH and CEHEH bleached pulps; it increased from 0 to 40 minutes of beating time (Figure 2). But it is also a fact that the tear factor decreased in each case with the progress of the beating due to decrease in fibre length. The CEH soda – sulphur pulp had the maximum tear factor of 113.35 which is higher than soda and sulphate pulps of muli bamboo (Karim and Islam, 1993).

Like other cases (Karim and Islam, 1993, 1994; Karim and Kartik 1996, Karim and Seal, 2001), the freeness of all the mandar pulps of unbleached, 3 and 5 stages bleached decreased from 0 to 60 minutes of time i.e. during the entire period of beating.

From the present studies it can be concluded that good quality writing and printing paper can be obtained from mandar by soda–sulphur pulping and bleaching the obtained pulp by either 3 or 5 multistage system.

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