ALKALINE PULPING OF *PARASERIANTHES FALCATARIA* WITH ANTHRAQUINONE AS AN ADDITIVE

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ABSTRACT

Paraserianthes falcataria is a hardwood species suitable for making good quality kraft pulp with a high yield. The species is used as a raw material in one of the pulp mills in Bangladesh using soda process. Consequently, the pulp yield and quality are poor. To overcome these drawbacks this study has been conducted.

The study shows that anthraquinone (AQ) has a positive effect both in soda and kraft pulping of *P. falcataria*. AQ addition by 0.05% can reduce the alkali charge by 5 per cent points and increase the pulp yield by about 4 per cent points in soda pulping. The yield becomes equivalent to the kraft counterpart. The use of 0.15% AQ further increases the pulp yield to surpass the kraft. But the gain in yield with 0.15% AQ addition is not as remarkable as with the lower dose (0.05%). An addition of AQ in kraft pulping also increases the yield, but not to the extent as in soda pulping. It is also observed that the pulp quality improves by the addition of AQ both in soda and kraft pulping. The soda-AQ pulp is almost equivalent to the kraft counterpart, with only 6% lower value in tearing strength at a particular tensile strength.

সারসংক্ষেপ

প্যারাসেরিয়ানথিস ফ্যালকাটারিয়া কাঠ মণ্ডোৎপাদনের জন্য উত্তম। বাংলাদেশের একটি শিল্পে এই কাঠ থেকে সোডা পদ্ধতিতে মণ্ড তৈরী করা হয়। কিন্তু মণ্ডের উৎপাদন হার ও গুণগত মান খারাপ। মণ্ডিকরণে এনথ্রাকুনন ব্যবহার করে এ অসুবিধা দূরীকরণের উদ্দেশ্যে এ নিরীক্ষা চালানো হয়।

গবেষণায় প্রতীয়মান হয় যে, এনথ্রাকুইনন প্রয়োগে সোডা ও ক্র্যাফট পদ্ধতিতে প্যারাসেরিয়ানথিস ফ্যালকাটারিয়া কাঠের মণ্ডিকরণে সক্রিয় ভূমিকা রয়েছে। মাত্র ০·০৫% এনথ্রাকুইনন ব্যবহার করে সোডা প্রক্রিয়ায় ক্ষারের চাহিদা কাঁচামালের হিসাবে ৫% হ্রাস এবং মণ্ডোৎপাদন প্রায় ৪% বৃদ্ধি পেয়ে ক্র্যাফট পদ্ধতির সমতুল হয়। এনথ্রাকুইননের প্রয়োগে ০·১৫% এ বৃদ্ধি করলে মণ্ডোৎপাদন হার আরও বৃদ্ধি পায় এবং উৎপাদন হার ক্র্যাফটের তুলনায় কিছুটা বেশী হয়। তবে অল্প পরিমাণে (০·০৫%) এনথ্রাকুইনন প্রয়োগই বেশী লাভজনক। ক্র্যাফট পদ্ধতিতে মণ্ডিকরণেও এ রাসায়নিক প্রভাবক উল্লেখযোগ্য ভূমিকা রাখে। কিন্তু সোডা পদ্ধতির তুলনায় তা তত ফলপ্রসূ নয়। এনথ্রাকুইনন ব্যবহার করে সোডা ও ক্র্যাফট পদ্ধতিতে এ প্রজাতির কাঠ মণ্ডিকরণে প্রাপ্ত মণ্ডের গুণগত মানও উন্নত হয়। সোডা পদ্ধতিতে এ প্রভাবক প্রয়োগ করে ক্র্যাফট মণ্ডের সমপর্যায়ের মণ্ড তৈরী করা যেতে পারে।

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INTRODUCTION

It is well known that sulphide markedly promotes the alkaline digestion in making pulp. More drastic cooking conditions, e.g., a longer cooking time and a higher alkali charge are required during soda cooking to produce a pulp of a desired kappa number. As a result, the yield is lower and pulp quality poorer compared to that obtained in the kraft process.

The drawbacks in soda pulping can be overcome by an addition of anthraquinone (AQ) along with the white liquor (Fossum *et al.* 1980 ; Hanson and Michaels 1978 ; Holton 1977). A small addition of AQ in kraft and soda cooking enhances the rate of delignification with improved yield. AQ addition in the order of 0.05 - 0.15% on oven-dry (OD) wood basis is sufficient to provide the benefits (Akhtaruzzaman *et al.* 1987 ; Fossum *et al.* 1980 ; *Kubes et al.* 1980). More economic benefits are obtained in soda-AQ pulping with hardwoods than with softwoods (Fossum *et al. 1980 ;* Hanson and Michaels 1978).

Paraserianthes falcataria (Syn. *Albizia falcataria),* a hardwood species, has been found to be an exceptionally good raw material for pulping by the kraft process (Akhtaruzzamn *et al. 1971).* In Bangladesh, the species is recently utilized in the Sylhet Pulp and Paper Mills by the soda process. Thus, there is a good scope of improving the pulp yield in the mill. But the question remains on the quality of the pulp. This has arisen because no generalization can be made as to the quality of soda-AQ pulp (Akhtaruzzaman 1984). It appears to be dependent on the wood species. Soda AQ pulps from black spruce have about 20% lower tearing strength than kraft pulps (Kubes *et al. 1980).* Douglas fir showed a tear reducing of about 10% (Kubes *et al. 1980).* Contrary to this, the tearing strength did not impair in a mixture of spruce, balsam and pine (MacLeod *et al. 1980), Pinus radiata* (Farrington *et al.* 1979) *and Acacia auriculiformis* (Akhtaruzzaman *et al.* 1987). Other strength properties compare favourably with the kraft (Akhtaruzzaman *et al.* 1987; MacLeod *et al. 1980).* In the case of bagasse and a mixture of hardwoods, soda-AQ and kraft pulps are quite similar in all strength properties. The quality of kraft-AQ pulps is equivalent to the kraft counterpart (MacLeod *et al.* 1980). These observations warrant an investigation on the effect of AQ on a particular species, especially to note the effect on the strength properties. With this aim in view, this study has been undertaken.

MATERIALS AND METHODS

Paraserianthes falcataria wood, about 10 years old, was collected from the experimental plantation in the Bangladesh Forest Research Institute campus. The logs were debarked and chipped in a laboratory chipper machine. The chips were air-dried and hand-sorted to remove the undersized and oversized chips. The accepted chips were about 25 mm x 12 mm x 3 mm in dimensions.

Pulping was done by kraft and soda processes with and without AQ in a 23 litre rotating digester using indirect steam. The digester was initially heated to a temperature of 80°C, and then air-dried chips equivalent to 2 kg OD chips were charged with the chemicals. The effect of AQ was studied by using two doses of AQ, viz., 0.05 and 0.15% on OD wood. The different points of delignification were obtained by varying the cooking time (the points were obtained in normal soda cooking by varying the alkali charge). Other cooking conditions

were maintained at 14% active alkali as Na_2O (except normal soda), 25% sulphidity (for kraft), 4 : 1 liquor to wood ratio, 90 minutes to raise the temperature from 80°C to 170°C and cooking at 170°C.

At the end of the digestion, the cooked chips were discharged, washed overnight under running water, disintegrated and then screened on a flat vibratory screen with 0.38 mm slots. The screened pulp was pressed to remove the excess water, shredded, weighed and sampled to determine the moisture content. The screening rejects were oven-dried. The pulp yield and screened pulp kappa number were then determined. The pulp was beaten in a Valley beater machine to different freeness values and handsheets were made for determining the strength properties on conditioning the sheets at 23 ±1°C and 50 ±1% relative humidity. The pulp strength properties were determined according to SCAN Test Methods.

RESULTS AND DISCUSSION

The results on the effect of AQ in kraft and soda pulping of *Paraserinthes falcataria* are given in Table 1. It is observed from Table 1 and Fig. 1 that an addition of AQ markedly reduced the cooking time. A target kappa number of 20 could not be attained in normal soda cooking at an alkali charge of 14% (as Na_2O). The kappa number in such a case was 46.0 at a total cooking time of 176 minutes (Table 1). This is too high a kappa number for a bleachable grade of pulp. Thus, pulping to the desired degree of delignification in normal soda pulping was attained by varying the alkali charge. Table 1 shows that an alkali charge of about 19% at a total cooking time of 176 minutes was needed to pulp to a kappa number of 20. With an addition of 0.05% AQ in the soda white liquor, an alkali charge of 14% could cook to this kappa number at a total cooking time of 180

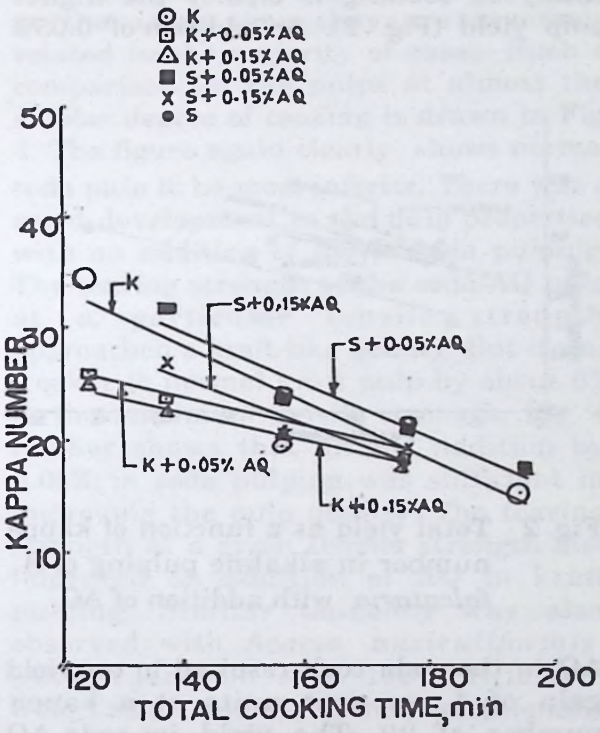

Fig. 1 Delignification during alkaline pulping of *P. falcataria* with addition of AQ (K stands for kraft, S for soda)

minutes. Thus, an addition of only 0.05% AQ can make a saving in alkali by 5 per cent points. Fig. 1 further shows that the total cooking time in soda + 0.05% AQ and kraft cooking were almost equivalent. Consequently, an addition of 0.05% AQ in soda pulping can reduce the alkali demand, and at the same time delignify at a similar cooking time as with the kraft. Soda + 0.15% AQ cook needed a shorter cooking time than the kraft. AQ addition also improved the delignification in kraft pulping. But the catalytic effect of AQ was less remarkable in kraft pulping compared to soda pulping.

Compared to normal soda and kraft pulping, the greatest advantage of AQ catalysed cooking is clearly the higher pulp yield (Fig. 2). An addition of 0.05%

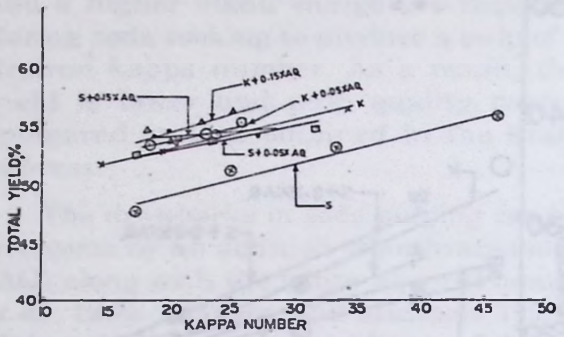

Fig. 2 Total yield as a function of kappa number in alkaline pulping of *A. falcataria* with addition of AQ

AQ in the soda cook resulted in an yield gain of 4 per cent units at a kappa number of 20. The yield in soda-AQ (0.05%) pulping was almost equivalent to that in kraft pulping. Further increase of the AQ dose to 0.15% increased the yield by another 1 per cent unit. Thus, yield protection in soda pulping of *Paraserianthes falcataria* can be achieved by a small addition of AQ such as 0.05% on OD wood.

An addition of 0. 05% AQ in kraft cooking resulted in a gain in yield of 0.5 per cent unit compared to the normal kraft at a kappa number of 20 (Fig. 2). A higher AQ dose to 0.15% increased the yield by 1 per cent unit. Consequently, the effect of AQ was more remarkable in soda pulping. This is wholly in agreement with the literative (Akhtaruzzaman *et al.* 1987 ; Fossum *et al.* 1980).

The screening rejects at the same kappa number of the pulp were found to be independent on the AQ dose (Fig. 3).

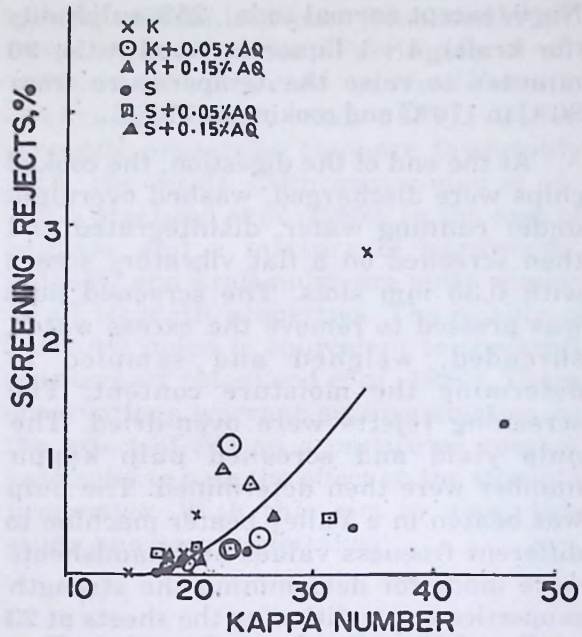

Fig. 3 Screening rejects as a function of kappa number in alkaline pulping of *P. falcataria* with addition of AQ

This is in agreement with the previous studies (Akhtaruzzaman *et al.* ; Nayak *et al. 1979).* Thus, the gain in screened yield remains in the same order as in total yield.

As regards the physical strength properties, the soda process produced the most inferior pulp as expected (Table 1). The quality of the pulp at the same freeness improved with an addition of AQ in soda cooking. The tensile strength of the pulp obtained in soda + 0.05% AQ cook was even better (14-24%) than that of the kraft counterpart. The bursting strength was almost similar. The tearing strength was, however, slightly inferior (3-6%). AQ

catalysed kraft pulping produced even better tensile, tear and bursting strengths than the kraft control.

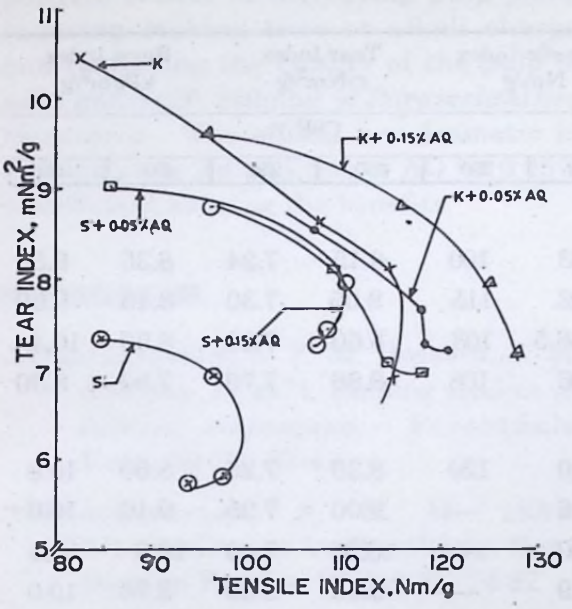

Fig. 4 Tear-tensile plots for pulps at a kappa number of 20 ± 2.5 in alkaline pulping of *P. falcataria* with addition of AQ

It is well recognised that the properties of the pulp are interdependent. Hence, it is a more common practice to look into the tear-tensile relationship of the pulp. They are considered to be the most important strength properties, and at the same time they are inversely related in the majority of cases. Such a comparison for the pulps at almost the similar degree of cooking is drawn in Fig. 4. The figure again clearly shows normal soda pulp to be most inferior. There was a rapid development in the pulp properties with an addition of AQ in soda pulping. The tearing strength of the soda-AQ pulp at a particular tensile strength approached a kraft-like quality. But it was weaker to normal kraft pulp by about 6% at the maximum tensile strength. Fig. 4 further shows that an AQ addition by 0.05% in soda pulping was sufficient in improving the pulp quality. The tearing strength at a given tensile strength also improved on addition of AQ in kraft pulping. Similar tendency was also observed with *Acacia auriculiformis* (Akhtaruzzaman *et al.* 1987). It is seen from Table 1 and Fig. 4 that exceptionally good quality pulp can be produced from *Paraserianthes falcataria* by soda-AQ process. There are very few hardwood species which result in such a good quality pulp.

Table 1. Cooking conditions and pulp analyses for kraft (25% sulphidity), kraft (25% sulphidity) anthraquinone, soda and soda-anthraquinone pulping of *Paraserianthes falcataria*. Liquor to wood at 4:1, rise of temperature from 80°C-90 min, cooking temparature-170°C

Active alkali as Na_2O	Total cooking time	Screened Yield	Rejects	Total yield	Kappa number	Tensile index Nm/g		Tear index mNm^2/g		Burst index $kPam^2/g$	
						CSF					
%	min.	%	%	%		450	250	450	250	450	250
KRAFT											
14	195	51.7	0.0	51.7	14.9	103	100	8.15	7.24	8.35	9.55
14	176	52.9	0.5	53.4	20.7	102	115	9.05	7.30	8.15	9.50
14	156	52.8	0.2	53.0	19.5	86.5	103	8.60	7.20	8.90	10.4
14	124	53.7	2.8	56.5	34.3	106	108	8.86	7.70	7.90	8.30
KRAFT + 0.05% AQ											
14	176	53.3	0.1	53.4	18.5	110	120	8.30	7.25	8.60	10.0
14	156	53.0	1.1	54.1	23.7	116	—	9.00	7.95	9.10	10.0
14	137	53.9	0.2	54.1	23.4	140	—	8.95	7.40	10.3	10.3
14	124	54.7	0.3	55.0	25.8	119	—	9.10	8.00	8.70	10.0
KRAFT + 0.15% AQ											
14	176	54.3	0.2	54.5	18.4	116	128	8.80	7.15	8.65	9.80
14	156	53.6	0.1	53.7	20.1	124	—	8.90	7.05	9.05	10.3
14	137	54.1	0.9	55.0	22 .5	116	122	8.60	7.55	8.60	9.30
14	124	55.5	0.8	56.3	25.1	124	—	11.35	7.50	8.55	10.1
SODA											
14	176	54.2	1.3	55.5	46.0	94.0	111	8.66	7.40	6.29	7.45
16	176	52.8	0.4	53.2	33.5	101	105	8.30	7.05	6.90	8.23
18	176	50.8	0.2	51.0	25.0	91.5	104	8.80	7.05	6.75	8.35
20	176	47.6	0.0	47.6	17.6	88.0	95.0	7.20	5.75	6.80	7.55
SODA + 0.05% AQ											
14	195	52.3	0.2	52.5	17.6	108	114	7.20	6.20	8.10	8.80
14	176	53.3	0.2	53.5	20.6	109	118	8.10	6.96	8.42	9.30
14	156	53.5	0.2	53.7	23.6	106	114	7.98	6.98	8.10	8.80
14	137	54.2	0.5	54.7	31.8	103	111	7.01	7.22	7.43	8.70
SODA + 0.15% AQ											
14	176	53.9	0.1	54.0	18.9	106	110	8.25	7.50	7.73	8.60
14	156	54.5	0.1	54.6	20.2	106	109	8.20	7.42	7.18	8.48
14	137	53.9	0.5	54.4	27.0	102	108	7.48	6.90	6.40	8.25

CONCLUSIONS

It has been observed that AQ gives positive effects in increasing pulp yield, reducing cooking time or alkali charge and improving the quality of the pulp in soda and kraft pulping of *Paraserianthes falcataria*. The effects are dramatic in soda pulping. An addition of AQ by 0.05% is sufficient to bring the benefits.

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