

# EFFECT OF ANTHRAQUINONE IN ALKALINE PULPING OF *ACACIA AURICULIFORMIS*

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## ABSTRACT

Conventional soda pulping results in lower pulp yield and strength properties. It also needs a much longer cooking time. To overcome these difficulties a study on the effect of anthraquinone (AQ) in the alkaline pulping of *Acacia auriculiformis* was conducted. The result showed that 3.1 percent point yield gain was achieved in the soda pulping with 0.05% AQ addition. The yield was comparable to that of the kraft control. Further increase of AQ did not substantially increase the yield. In kraft-AQ pulping the gain in yield was less remarkable, although 1.4 percent point gain was obtained. Addition of AQ can substantially reduce the alkali requirement and/or duration of cooking. The quality of the AQ catalysed pulp was in no way inferior to the kraft control.

The feasibility of using AQ in a soda pulp mill in Bangladesh has been shown. It indicates a remarkable economical gain.

## সারসংক্ষেপ

প্রচলিত সোডা মণ্ডীকরণ প্রক্রিয়ায় প্রস্তুত মণ্ডের উৎপাদন এবং গুণগত মান অন্যান্য প্রক্রিয়ায় প্রস্তুত মণ্ডের চাইতে কম। এ ছাড়া, এ প্রক্রিয়ায় মণ্ডীকরণে অনেক বেশী সময়েরও প্রয়োজন। এসব সমস্যা দূরীকরণের উদ্দেশ্যে একাশিয়া অরিকুলিফরমিস গাছের ক্ষারীয় মণ্ডীকরণ প্রক্রিয়ার উপর এনথ্রাকুইনোনের প্রভাব পরীক্ষার জন্য সমীক্ষাটি চালান হয়। গবেষণায় দেখা যায় যে ০.০৫% এনথ্রাকুইনোন ব্যবহারে সোডা প্রক্রিয়ায় মণ্ডের উৎপাদন ৩.১ শতক একক বৃদ্ধি পায়। বৃদ্ধিকৃত মণ্ডোৎপাদন ক্যাফ্ট প্রক্রিয়ায় উৎপাদনের সমতুল্য। আরো দেখা যায় যে, মণ্ড উৎপাদন হারের উপর বেশী মাত্রায় এনথ্রাকুইনোন ব্যবহারের বিশেষ কোন প্রভাব নেই। ক্যাফ্ট-এনথ্রাকুইনোন প্রক্রিয়ায় মণ্ডের উৎপাদন ১.৪ শতকরা একক ভাগ বৃদ্ধি পায় কিন্তু এক্ষেত্রে সোডা-এনথ্রাকুইনোনের তুলনায় অনেক কম। এনথ্রাকুইনোন প্রয়োগে কণ্টিক সোডার মোট চাইনিদা এবং মণ্ডীকরণের সময় যথেষ্ট পরিমাণে হ্রাস পায়। এনথ্রাকুইনোন সংযোগে প্রস্তুত মণ্ডের গুণগত মান ক্যাফ্ট প্রক্রিয়ায় তৈরী মণ্ডের চাইতে কোন অংশে কম নয়।

পরিশেষে বাংলাদেশের একটি সোডা পাল্প মিলে এনথ্রাকুইনোন ব্যবহারের আর্থিক মথার্থতা দেখানো হয়েছে।

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## INTRODUCTION

It is well known that sulphide markedly promotes the alkaline digestion in making pulp. More severe conditions, e. g., longer cooking time and higher alkali charge are required during soda cooking to obtain a pulp of a desired kappa number. This results in a lower yield and inferior quality of pulp than that obtained in the kraft process. The problem can be overcome by 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 OD wood basis is sufficient to provide the benefits (Fossum *et al.* 1980 ; Holton 1977 ; Holton and Chapman 1977). The catalytic effect of AQ is more effective in soda pulping than in kraft pulping (Fossum *et al.* 1980 ; Kubes *et al.* 1988. More economic benefits are obtained with hardwood than with softwood (Fossum *et al.* 1980 ; Hanson and Michaels 1978).

The quality of the soda-AQ pulp appears to be species dependent and that of the kraft-AQ is equivalent to the kraft counterpart (Akhtaruzzaman 1984). Thus, it is essential to study the effect of AQ in the pulping of a particular species.

*Acacia auriculiformis* is a light hardwood species having fibre dimensions almost similar to civit (*Swintonia floribunda*) (Siddique and Chowdhury, unpub). It is, amongst others, used as a pulping raw material (Davidson 1985). In Bangladesh it has achieved good growth (Davidson 1985). Thus, because of its potentiality

as a fibrous raw material, a study on the response of AQ in alkaline pulping was undertaken.

## MATERIAL AND METHODS

Logs of *Acacia auriculiformis* were collected from roadside plantations along Chittagong-Kaptai road. The debarked logs were chipped in a laboratory chipper machine. The chips were then air dried and sampled for pulping.

The chips were pulped by kraft and soda process, with and without AQ, in a 23 l rotating digester using indirect heating system. The digester was initially heated to a temperature of 80°C and then airdried chips equivalent to 2000 g oven-dried chips were charged with the chemicals in all the cooks. The effect of AQ on kraft and soda pulping was studied by adding two doses of AQ, viz., 0.05% and 0.15% on oven-dried wood. As 14% alkali (as Na<sub>2</sub>O) was not sufficient to reach the target kappa value of 20, normal soda control was done at 17% alkali (as Na<sub>2</sub>O) charge. In all the cases, cooks were made at three different cooking times to obtain three values of kappa number. Other cooking conditions were maintained at 14% active alkali (as Na<sub>2</sub>O), 25% sulphidity (for kraft), 4 : 1 liquor to wood ratio and 90 min to raise the temperature to 170°C.

At the end of the digestion, the cooked chips were discharged, washed, disintegrated and then screened. The screened pulps were pressed to remove excess water, shredded, weighed and then sampled to determine the moisture content. The screening

Table 1. Effect of anthraquinone in kraft and soda pulping of *Acacia auriculiformis* (liquor-to-wood ratio 4 : 1, raise to cooking temp of 170°C in 90 min)

Active Alkali (as $N_2O$ ) %	Sulphidity %	AQ dose %	Total cooking time min	Screened yield %	Screenings %	Total yield %	Kappa number	Physical strength properties of pulp at 450 CSF				
								Tear index $mNm^2/g$	Burst index $kPa$	Tensile index $Nm/g$	Density $kg/m^3$	Beatin time min
14	25	0	214	46.9	0.7	47.6	20.0	7.87	4.96	60.5	695	20.0
14	25	0	182	47.2	0.4	47.6	21.2	9.05	5.86	74.5	575	24.0
14	25	0	150	46.9	2.1	49.0	25.6	7.92	6.07	78.5	648	26.0
14	25	0.05	150	47.0	1.3	48.3	19.4	7.90	5.35	74.0	604	24.0
14	25	0.05	182	45.0	0.5	45.5	12.3	6.70	5.21	72.5	700	12.0
14	25	0.05	130	47.6	1.7	49.3	21.0	7.10	6.23	80.5	701	25.0
14	25	0.15	182	48.1	1.1	49.2	15.6	7.42	7.08	86.2	756	23.0
14	25	0.15	150	48.4	0.9	49.3	20.7	8.48	6.08	82.4	702	21.0
14	25	0.15	130	47.2	3.7	50.9	26.7	8.33	5.55	76.1	702	20.0
14	0	0	240	45.0	4.0	49.0	39.2	7.52	4.91	67.4	631	20.0
14	0	0	360	45.6	1.3	46.9	30.5	6.85	5.20	72.5	710	22.0
14	0	0	420	45.3	0.9	46.2	30.4	6.60	4.90	67.0	710	26.0
14	0	0.05	241	47.1	0.9	48.0	21.8	7.93	6.10	80.7	630	17.0
14	0	0.05	273	46.9	0.5	47.4	20.1	7.36	5.80	72.6	630	20.0
14	0	0.05	209	47.3	0.8	48.1	24.7	7.64	6.00	83.2	689	20.0
14	0	0.15	209	46.9	1.0	47.9	20.6	7.40	5.54	77.6	453	20.0
14	0	0.15	245	47.7	0.5	48.2	19.9	7.92	5.42	68.7	694	18.0
14	0	0.15	176	48.0	1.6	49.6	23.6	7.75	5.67	74.2	720	17.0
17	0	0	360	43.0	0.4	43.4	18.0	5.60	4.60	48.2	602	18.0
17	0	0	300	44.2	0.2	44.4	19.1	6.32	4.60	62.6	650	17.0
17	0	0	240	44.7	0.5	45.2	21.7	7.32	5.05	65.0	715	17.5

rejects were also oven-dried. The pulp yield and the screened pulp kappa number were determined. The pulp samples were then refined in a Valley beater to different freeness values and handsheets were made for determining the strength properties after conditioning at  $23 \pm 1^\circ\text{C}$  and  $50 \pm 1\%$  relative humidity. All the sheets were tested according to Scan Test Methods.

## RESULTS AND DISCUSSION

The results of the effect of AQ in kraft and soda pulping of *Acacia auriculiformis* are given in Table 1. It is observed from Table 1 and Fig. 1. that addition of AQ markedly reduced the cooking time to reach a particular point of delignification. An addition of 0.05% AQ gave a more pronounced effect than that of a higher dose (0.15%). Fig. 1 also shows

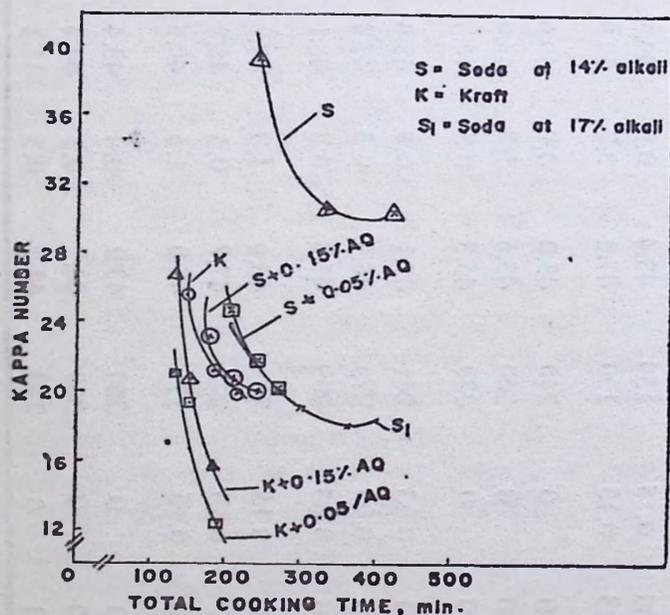


Fig. 1. Delignification during soda and kraft pulping of *Acacia auriculiformis* with addition of anthraquinone (Active alkali 14% as  $\text{Na}_2\text{O}$ , sulphidity for kraft 25%, rise of temperature 90 min. and cooking temp  $170^\circ\text{C}$ )

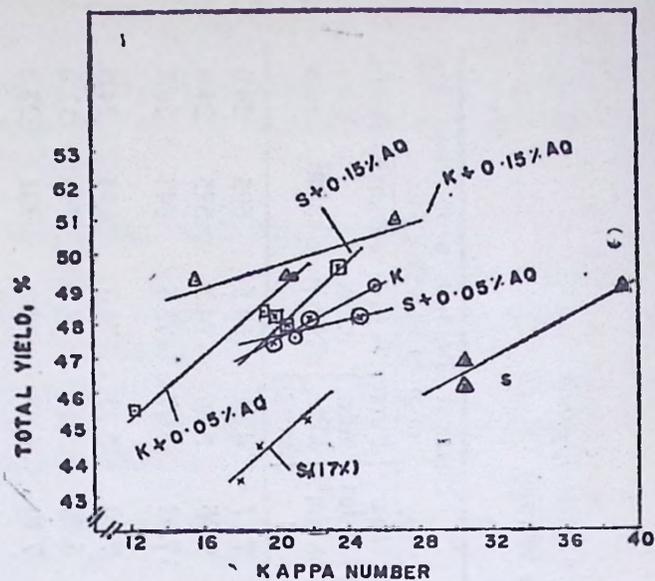


Fig. 2. Total yield as a function of kappa number in soda and kraft pulping of *Acacia auriculiformis* with and without anthraquinone.

that it is possible to reduce the alkali charge by 3% to reach the same kappa number. This small addition of AQ in a kraft cook lowered down the total cooking time by about 40% and cooking time at  $170^\circ\text{C}$  by about 65%.

AQ catalysed pulping resulted in a substantial gain in pulp yield (Fig. 2), particularly in the soda process. The beneficial effect can be achieved by an addition of 0.05% AQ. It is interesting to note that soda pulping with 0.05% AQ addition resulted in almost equivalent yield as in normal kraft pulping. The screening rejects at the same kappa number of the pulp was found to be independent of AQ dose (Fig. 3). This is in agreement with the literature (Nayak *et al.* 1979). Thus, gain in screened pulp yield remains in the same order as in total yield. The yield

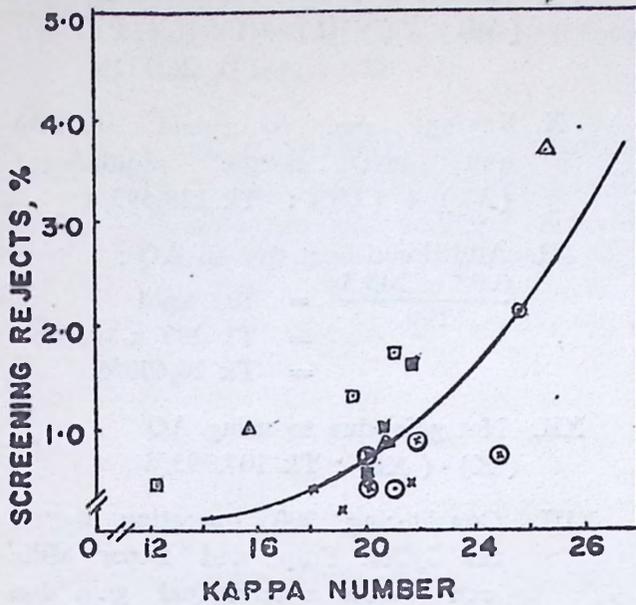


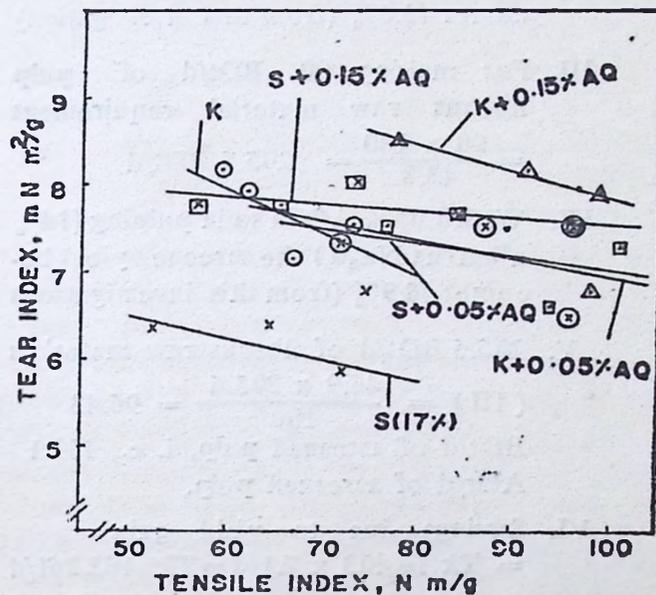
Fig. 3. Effect of anthraquinone on the screening rejects during soda and kraft pulping of *Acacia auriculiformis*.

- |                            |   |
|----------------------------|---|
| Kraft                      | ○ |
| Kraft+0.05% AQ             | □ |
| Kraft+0.15% AQ             | △ |
| Soda (17% alkali)          | × |
| Soda (14% alkali)+0.05% AQ | ⊗ |
| Soda (14% alkali)+0.15% AQ | ⊠ |

gain in soda and kraft pulping in presence of 0.05% AQ at a kappa number of 20 was 3.1 and 1.4 percent points respectively.

As regards the physical strength properties, Table 1 also shows that burst index, tensile index and tear index of the pulp at a kappa of 20 ( $\pm 1$ ) improved with addition of AQ both in kraft and soda processes. Burst index and tensile index of soda-AQ and kraft-AQ pulps were superior to those of the kraft pulp. The tear index of soda-AQ pulp was almost equivalent to that of the normal kraft. The tear index of kraft-AQ pulp was even

better than that of its kraft counterpart. The change of tear index in the beating cycle for the pulps with similar residual lignin is shown in Fig. 4. The figure indicates that tear index of the pulp at a certain tensile index improved with AQ addition during pulping. Soda-AQ pulp resulted in better tear-tensile values than the reference kraft.



4. Tear-tensile plots for soda, soda-AQ, kraft and kraft AQ pulps at a kappa number of 20 ( $\pm 1$ )

Based on the findings in this investigation leading to increased yield, less alkali requirement, reduced cooking time, kraft-like or better pulp properties, there is a bright prospect for using AQ in two soda pulp mills in Bangladesh. However, its response to the specific raw materials now being used in these mills is warranted. Research in these directions are also in progress at the pulp and paper laboratories of the Bangladesh Forest Research Institute.

## ECONOMIC FEASIBILITY OF AQ ADDITION

An economic analysis of using AQ in a pulp mill in Bangladesh is shown below :

- I. Pulp mill : Sylhet Pulp and Paper Mills using soda process, capacity 100 AD t/d, i. e., 90 BD t/d of pulp
- II. If normal soda ( 17% alkali as  $\text{Na}_2\text{O}$  ) is used the screened pulp yield becomes 43.8% (from this investigation)
- III. For making 90 BDt/d of pulp fibrous raw material requirement  

$$= \frac{90 \times 100}{43.8} = 205.5 \text{ BDt/d}$$
- IV. With 0.05% AQ in soda pulping (14% alkali as  $\text{Na}_2\text{O}$  ) the screened yield becomes 46.9% (from this investigation)
- V. 205.5 BDt/d of fibrous raw materials  

$$\text{( III )} = \frac{46.9 \times 205.6}{100} = 96.43$$
 BDt/d of screened pulp, i. e., 107.1 ADt/d of screened pulp.
- VI. Savings due to yield gain  

$$= \text{Tk } 14,403 \times 7.1/\text{d} = \text{Tk } 102,261/\text{d}$$
- VII. Alkali requirement for normal soda pulping ( 17% NaOH as  $\text{Na}_2\text{O}$  ) =  

$$\frac{17 \times 1.29 \times 205.5}{100} = 45 \text{ t of NaOH/d.}$$
 With 80% efficiency in the recovery cycle,  $45 \times 0.8 = 36.0$  t/d of NaOH can be recovered. Thus, make-up NaOH requirement = 9 t/d
- VIII. Alkali requirement with 0.05% AQ in soda pulping (14% NaOH as  $\text{Na}_2\text{O}$ ) =  

$$\frac{14 \times 1.29 \times 205.5}{100} = 37.1 \text{ t of NaOH/d.}$$
 With 80% efficiency in the recovery cycle,  $37.1 \times 0.8 = 29.7$  t/d of NaOH can be recovered. Thus, make-up NaOH requirement = 7.4 t/d

- IX. Savings in caustic soda : 1.6 t/d  

$$\text{( VII )} - \text{( VIII )} = \text{Tk } 16,458 \times 1.6/\text{d}$$

$$= \text{Tk } 26,332/\text{d}$$
- X. Savings due to yield increase and less caustic requirement  

$$\text{( VI )} + \text{( IX )} : \text{Tk } 128,593/\text{d}$$
- XI. Additional cost due to AQ :  

$$\frac{0.05 \times 205.5}{100} = 103 \text{ kg/d}$$

$$= \text{Tk } 200 \times 103/\text{d}$$

$$= \text{Tk } 20,600/\text{d}$$
- XII. Net gain due to using AQ  

$$\text{( X )} - \text{( XI )} : \text{Tk } 107,993/\text{d}$$
- XIII. Considering 300 operating days : the Sylhet Pulp and Paper Mills can make a net annual gain due to AQ addition : Tk 32,398,000/-

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