Laboratory Studies on Urea as an Additive in Pulping for Pollution Abatement

SHARMA G.D. AND SINGH MAN MOHAN

ABSTRACT

The literature survey revealed that urea as an additive in pulping yields pulp with better properties and lower screened yield than the kraft pulp and it helps in pollution abatement. To confirm these finding on our raw material studies were carried out in this Laboratory using urea as an additive from 0.0 to 2.0 in both kraft and Soda pulping. The results obtained indicates that by the addition of urea the yield reduced in the case of kraft pulping while in the case of Soda pulping it increases with the increase in reject percentage. BOD_5 and COD of black liquor show a considerable reduction in both cases. The kappa number of the pulp increases with the addition of urea in both cases resulting in higher bleach consumption. The bleach yield is also effected slightly The result also show that colour, BOD_5 and COD of the effluent from the alkali wash stage in bleaching is also considerably reduced. Further studies are required on the plant scale to confirm these findings.

INTRODUCTION :

In the modern society, paper has become a basic need of life. As such it will not be wrong if educational and living standard of any country are judged from the paper consumption of that country. The per capita paper consumption in India is meagre 2.2 kgs as against 100 kgs in U.K., 135 kgs in Canada and above 200 kgs in U.S.A. Even the countries like U.S.S.R., China and South eastern Asian countries are having paper consumption in the range of 15-20 kgs. It therefore can be seen that the paper consumption in our country shall have to increase and the paper industry in India will have to cope up with the demand.

On the other hand, the pulp and paper industry has an adverse impact on environment particularly as it consumes the principal resources of forests and pollutes surface water with trade effluent. The water consumption in our country is varying between 250-400 M^3 per ton of paper. So it is essential that in the discharges from the mill the quantity of the pollutant effecting the BOD and COD should be reduced.

Ecological consideration are having a substantial influence on the develpment of technology for existing plant and new installation in the pulp and paper industry. These problems have promoted much interest in search for novel sulfur free pulping process which could offer the desired higher pulp yields and qualities and which are less polluting than the conventional kraft process[1]. The processes being developed are anthraquinon–alkali cooking, oxygen-alkali cooking, alcohol-alkali cooking and and phenol alkali cooking. Experiments carried out in this Laboratory on anthraquinon as an additive are published earlier[2]. Extensive work has been carried out on alkali Oxygen delignification and bleaching of Soda bamboo pulp from bamboo, bamboo and mixed hardwoods and mixed hardwoods[3,4].

It has been reported by Roo and Chun[5] that urea reacts with wood in the urea alkali cooking and forms stable cello-Urathane, ammonium cellulose, ligno-Urathane and ammonium lignin as shown in equation 1 to 5.

$2NH_2.CO.NH_2–NH_2.CO.NH.CO.NH_2+NH_3$ Eq.1

Wood-OH + $NH_2.CO.NH\ CO.NH_2$–Cell-O-C°-NH_2 + Cell-O-C°–NH–NH_2+H_2O Eq.2

Wood–OH + NH_3—Cell–O–NH_4 Eq 3

Wood-OH + $NH_2\ CO.NH.CO.NH_2$–Lignin-O-C°-NH_2 + Lignin–O–C°–NH–NH_2+H_2O Eq.4

Wood–OH + NH_3–Lignin–O–NH_4 Eq.5

Draganova. R.etal[6] showed that urea can be used as a delignifying agent, Lyubavskaya[7,8] also carried out

Orient Paper Mills, Amlai.

further experiments with urea in presence of reducing agents like Sodium borohydride, hydrazine, or Sodium dithionate etc, with encouraging results. Roo and Cnun[5] have carried out work on pulping of oak using urea alkali with encouraging results Urea decompose nitrous acid, one of the aforementioned reduction products[6].

EXPERIMENTAL :

In orient Paper Mill. Amlai urea using a mixture of bamboo (70%) and mixture of hardwoods (30%). The hardwoods mixture comprises of Sal, Salai and Saza (Shorea Robusta, Boswellia Serrata, Terminalia Tomentosa). Bamboo was chipped in Sumner Chipper and screened (−22+10 m.m. size), Mixture of hardwoods were chipped in KMW Chipper and screened.(22+10 m.m. size). The mixture of these screened chips was prepared in the ratio of bamboo and mixed hardwoods 70 and 30 percentage. Urea-kraft and urea-alkali pulping studies on the mixture of the screen chips were carried out in a 30 litre capacity electrically heated digestor having indirect force circulation using 18 percentage as active alkali in all the casses, keeping the bath ratio as 1:4 and at 165 C° for 4 hours (2 hours to raise to maximum temperature and 2 hours at maximum tamperature).

The Sulphidity in the case of kraft cook was 15.8 percentage. The pulps were washed and yields and kappa Number were determined according to TAPPI Standards and the results are recorded in Table–1. The black liquor was analysed for pH,° °Tw, R.A.A., total solid. inorganic organic percentage, organic N_2, BOD and COD. The results are recorded in the same Tabe–1. These pulps were beaten in P.F.I. mill to a freeness 45°SR and standard sheets was prepared and evaluated after conditioning. The results are recorded in Table–1.

These pulps were bleached by CEH Sequence under the conditions reported in Table–3. Colour, BOD_5 and COD of the effluents from the alkali extraction stage were determined and are recorded in Table–3. Beach yield, shrinkage and brightness of the final pulp obtained is also recorded in the same table–3.

These pulps were beaten in the P.F.I. mill to a freeness of 45°SR and standard sheets was prepared and evaluated after conditioning. The results are recorded in table–4.

EABLE–1

COOKING STUDIES OF BAMBOO (70%) AND HARDWOOD MIXTURE (30%) WITH UREA–KRAFT AND UREA–ALKALI

	Urea-kraft cook Number				Urea-alkali cook Number					
Particulars	1	2	3	4	5	6	7	8	9	10
Urca	—	0.5	1.0	1,5	2 0	—	0.5	1.0	1.5	2.0
Total yield,%	41.62	41.64	41.36	41.12	41,7	43.08	42.83	46.55	46.58	52 41
Screened yield,%	40.52	40.02	40.81	39.57	39.58	40.7	40.43	43.01	44.18	47.72
Reject,%	1.12	0.72	1.55	1.55	2.12	2.37	2.4	3.54	2.40	4 69
Kappa Number	26.78	29.88	29.45	28.88	31.16	42.10	54.16	52.73	54.4	50.04
BLACK LIQUOR ANALYSIS										
(i) pH	9.8	10.0	9.7	9.7	9.9	9.6	10.6	10.9	10.5	11.8
(ii) TW at 60° C	20.0	22 0	19.5	18 0	18.0	15.5	16 0	16.0	14 0	14.0
(iii) R.A.A.as Na_2O,gpl	23.25	20.15	19.37	20.15	20.15	13.18	15.50	13 73	12 40	13.95
(iv) T.solid%	23.76	23.62	22.37	21.48	17.50	16.40	16.28	15.80	14 50	15.70
(v) Inorganic%	31.64	23.07	36.70	36 75	21.95	26.23	23.36	32.10	29.40	28.80
(vi) Organic,%	68 36	76.93	63.30	63 25	78.05	73.77	76 64	67.90	70.60	71.20
vii) Organic, N_2%	0.061	0 072	0.076	0.117	0.120	0.084	0.14	0.182	0.241	0.224
(viii) BOD_5 mg/l	51000	48000	46500	46000	36000	50000	45000	40000	34000	30000
(xi) COD, mg/l	234400	196000	184400	177600	176000	285600	248000	196000	188000	185600

TABLF—2

STRENGTH PROPERTIES OF UREA KRAFT AND UREA–ALKALI UNBLEACHED PULP

Particulars	Urea–Kraft					Urea–Alkali				
	1	2	3	4	5	6	7	8	9	10
Basis wt. gsm	57.8	57.5	59.7	56.6	58.4	61.2	59.6	57.8	59.2	59.8
Breaking length Meters	5590	5700	6200	6650	6850	6540	6930	7670	7540	7400
Burst factor	45.0	47.3	46.9	47 7	42.8	44 1	48.7	50.2	50 7	51.8
Tear factor	103.8	109.0	134.0	116.6	109.6	101.3	100.7	93.4	94.6	92.0
Double fold	1095	1560	1260	1310	1320	885	906	830	890	750
Tensile Index NM/g	54 83	55 86	60.76	65.25	67.15	64.08	67.99	75 20	73.97	72 57
Burst Index Kpa m^2/g	4 41	4.64	4 60	4.68	4.20	4.32	4.77	4.92	4.97	5.08
Tear Index mNm^2/g	10.18	10 69	13.14	11.43	10.75	9.93	9 87	9.16	9.27	9.02

TABLE–3

CEH BLEACHING SEQUENCE OF UREA KRAFT AND UREA ALKALI UNBI EACHED PULP.

S.No.	Particulars	Urea–kraft			Urea–alkali						
		1	2	3	4	5	6	7	8	9	10
1.	CHLORINATION:										
	Cl_2 added,%	6 0	6.5	6.5	6.5	6.5	6 5	6.5	6.5	6.5	6.5
	Cl_2 consumed,%	4.6	4 9	5.2	5.9	6.0	5 5	5.8	5.8	6.0	6.0
	Final pH	1.8	1.9	1.8	1.9	1.8	2.0	2.2	1.9	2.0	2.0
2.	ALKALI EXTRACTION :										
	Alkali added,%	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2 5	2.5	2.5
	Final, pH	11.3	11.4	11.4	11.3	11.2	11.1	11.1	11.2	11.1	11.2
	EFFLUENT :										
	Colour,Pt-Co Unit	4800	4250	4250	4000	4000	5000	4670	4520	4520	4670
	BOD_5Mg/L	680	440	380	350	320	650	500	440	360	350
	COD,Mg/L	2400	1640	1440	1360	1248	2240	1736	1584	1448	1368
3.	HYPOCHLORITE ADDITION :										
	Hypochlorite added,%	4.0	4.0	4.0	4:0	5.0	5.0	5.0	4.5	4.5	4 5
	Hypochlorite Cons:%	2 9	.31	3.2	3.2	4.9	4.2	3.4	4.0	4.2	3.4
	Final pH	7.8	8.1	8.2	8.0	8.3	8.4	8.2	8.1	8,2	8.4
4.	Total Cl_2 added,%	10.0	10.5	10.5	10.5	11.5	11.5	11.5	11.0	11.0	11.0
5.	Total Cl_2 Cons.%	7.5	8.0	8,4	9.1	10.9	9.7	9.2	9 8	10.2	9.4
6.	Bleach yield % (On OD ehips)	35.1	35.4	34 4	33.9	32.5	35.4	34 4	35.7	33.8	33.5
7.	Shrinkage,%	13.4	11.6	15 7	14.3	18.1	13.1	15.2	17.4	16.5	16.6
8.	Brightness PV,%	78	80	80	82	85	75	76	75	78	75

TABLE—4

STRENGTH PROPERTIES OF UREA KRAFT AND UREA–ALKALI BLEACHED PULP

Particulars	Urea-kraft					Urea-alkali				
	1	2	3	4	5	1	2	3	4	5
Basis Wt. gsm	57 8	55.0	59.7	56 6	58.4	61.2	59.6	57.8	60.6	59.6
Breaking length Meters	4840	5020	5330	5470	5550	4860	5370	5420	2390	5370
Burst factor	29 8	28.9	29.3	28.3	27.4	30.6	36.3	36.8	37.1	38.6
Tear factor	61.9	60.9	60.3	63.0	58.5	78.4	80.7	83.8	86.2	84.0
Double fold	195	170	190	175	180	120	225	320	250	240
Tensile Index Nm/g	47.49	49.24	52.28	53.64	54.42	47.62	52.64	53.50	52.85	52.64
Burst Index KPa m^2/g	2.92	2.83	2.87	2.77	2.69	3.00	3.56	3.61	3.64	3.78
Tear Index mN m^2/g	6.07	5.97	5 91	6.17	5.73	7.69	7.91	8.21	8 45	8.24

DISCUSSION :

The yield of the pulp is higher in case of alkali cooks than in the case of kraft cooks and the Kappa Number is also higher in the alkali cooks than the kraft cooks as expected. With the increse in urea contents the percentage of rejects is increased. It is seen that with the increase in urea contents the percentage of organic nitrogen increased as expected and the increase was more pronounced in the case of alkali cooks. BOD_5 and COD decreases with the increasing urea contents and this decrease is more pronounced in the case of Soda pulp.

The strength properties do not show any trend though the breakiug length improves with the increase of urea percentage.

Table–3 showed that BOD_5 und COD falls considerably with the increase in urea proportions. The brightness of the pulp in the case of urea alkali cooks is not effected while it improves in the case of urea-kraft cooks with the increase in urea proportion. The strength properties are also not markly effected with the increase in urea proportion in both the cases though breaking length improves to some extent.

It can be concluded from this studies that addition of urea during pulping reduces the pollution load at a small cost of higher bleach consumption. It is suggested that these studies may further be extended to pulping of agricultural residue like wheat straw and rice straw for reducing the pollution load.

ACKNOWLEDGEMENT :

The authors are indebted to Sri I.M. Bhandari Executive Vice–President, Orient Paper Mills, Amlai for his kind permission to present this paper and to Sri N.R. Agarwal Works Manager, Orient Paper Mills, Amlai for his keen interest and valuable suggestions in this project.

REFERENCES :

1. Cox. L. A. and Worester, H. E., Tappi 54 (11) 1890 (1970).

2. Rawat Rajesh, Sharma G.D., Bhargava G. G., and Singh Man Mohan 'Kraft Anthraquinone pulping of Bamboo + Mixed hardwoods (70:30) Bamboo (100%) and Mixed Hardwoods (100%). IPPTA Vol. 2, No. 3, Sept 1985.

3. Dwivedi R P., Bhargava G. G., Kaul S. S,, and Singh Man Mohan "Alkali/Oxygen delignification

and bleaching of Soda bamboo pulp" (Part I,), IPPTA, Vol. 20, No. 4, Dec 1983.

4. Bhargava G. G., Dwivedi R.P., Kaul S.S., and Singh Man Mohan "Alkali/Oxygen delignification and bleaching of Soda bamboo pulp, bamboo + hardwoods pulp (70.30) and Mixed hardwood pulp" (Part-II) IPPTA Vol. 20, No. 4, Dec. 1983.

5. J.O. Roo and P.C. Chun "Studies on Urea-Alkali cooking" F.R.I., San 1, Cheougryangri Doug, Seoul, 131, Korea.

6. Draganova R, Z. I itovski and S Zhelev, "Reaction between poplar wood and urea in the productlon of high yield pulps behaviour of wood and its carbohydrate components" Tseluloza Khartiya 2 (5) 10-13 (1971) Bulg. ABIPC 43 : A 2962.

7. Lyubavskaya. R.A. and V.V. Voronova "Method of producing pulp" USSR Pat. 558, 082 (1977).

8. Lyubavskaya, R·A. and V.V. Noronova "Process for producing Semi-chemical pulp" USSR Pat. 560, 024 (1977).

9. Sarkanen and Ludwing "Lignins" P. 380.