Dissolving Pulp From Jute Stem (Corchorus Capsularis) By Water Prehydrolysis Kraft Process

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ABSTRACT

Laboratory experiments on the production of dissolving pulp from medium grade jute stem by the water prehydrolysis Kraft process are described. Pulps are bleached with (CEHEHD) sequence. Yield of Pulps thus obtained from jute stem are comparatively lower than that of control muli bamboo. The bleaching loss of pulp is high compared to muli bamboo pulp. The characteristics of jute stem pulps are almost similar in quality to rayon grade pulp of muli bamboo except ash content. The high ash i.e. adhering silica from pulp may be reduced if good centricleaner facilities are used in the process. The brightness of jute stem pulp is about 88% (Elrepho).

INTRODUCTION

Muli bamboo (Melocanna baccifera) is the main fibrous raw material for production of rayon grade pulp in Bangladesh. Now-a-day it is very scare due to serious biotic factor, management and extraction problems. It is, therefore, imperative to search for alternative source of fibrous raw material for manufacturing rayon grade pulp. The jute stem may be considered as an alternative source.

Previously, studies were conducted in the laboratory for making dissolving pulps from jute cutting, a bottom portion of the bast fiber (Rahman 1977, Kalam et al 1981), caddies (Islam and Khan 1968, Rahman 1977, Kalam et al 1981, Anon 1992), jute bast fiber (Islam 1967) and jute stick (Saha et al 1973). A study on green jute plant (Ishaque and Barua 1994) and process trial for production of dissolving pulp was done (Shahidullah et al 1994). Jute stem contains 60.78% celloulose (Islam and Khan 1981) against 57.6% in muli bamboo (Bhowmick 1993). Consequently, it was found favourable for use in producing dissolving pulp: The separation of jute fiber from the stick on retting is tidious, time consuming and expensive. Moreover, during the retting operation, the stream and air of surrounding areas become severely poluted. Success in the use of jute stem for making dissolving pulp may, therefore, overcome many of the problems. This study, therefore, aims at producing dissolving pulp from medium grade jute stem without retting.

EXPERIMENTAL

RAW MATERIAL PREPARATION

Jute (Corchorus capsularis) stem was collected from the jute yard of Karnaphuli Paper Mills. It was free from leaves, roots, fungus and bacteria. It was air-dried and cut into small chips of about 2-4 cm. in length and chips thickness was 0.3 to 15 mm. During cutting, the core was practically free from

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fiber. Moisture content of chips was about 13%. After moisture determination, the jute stem chips are kept in an air-tight polythene bags for subsequent experiments. Industrial chips of muli bamboo was used for comparison, after air-drying.

PULPING

The pulping process used was prehydrolysis kraft. The prehydrolysis step was carried out in a electrically heated stainless steel rotating digester of 10 litre capacity. The digester could accomodate only 1 kg. of jute stem ships on oven dry (OD) basis against 2 Kg of bamboo chips. This means that pulp production from jute stem would be more costly due to its low packing density. The jute stem and bamboo was prehydrolysed with water. The prehydrolysis conditons are:

- Chips to water ratio, 1:6 for jute stem and 1:4 for muli bamboo.

- Prehydrolysis temperature, 170°C.

- Time to raise prehydrolysis temperature 150 minutes.

- Prehydrolysis time at temperature 120 minutes for jute steam and 90 minutes for muli bamboo.

After the completion of prehydrolysis the PH of prehydrolysate liquors were found 4.2 for jute stem and 3.9 for muli bamboo. The prehydrolysed mass of jute stem was then cooked by the kraft process. The sulphidity of cooking liquor was 20%. The active alkali charge was varied from 20%, 21%, to 22% as NaOH for jute stem and 20% for muli bamboo. The other cooking conditions are:

- Material to liquor ratio, 1:5 for jute stem and 1:4 for muli bamboo.

- Maximum cooking Temperature, 170°C.

- Time to raise cooking temperature, 90 minutes.

- Time at temperature, 120 minutes for jute stem and 90 minutes for muli bamboo.

After completion of the cook, pulp was washed thoroughly with water, disintegrated and screened on a flat vibratory screen with 0.508 mm slots. The screened pulp was pressed to remove the excess water, shredded, weighed and sampled to determine the moisture content. The screened pulp was then stored in polythene bags in a refrigerator for subsequent analysis, for Kappa number as per SCAN-C 1:77 test method, Pulp Viscosity as per JIS P 8101 method (1976), Pentosans as per T 203-61 method, ash content

Table-1

Kraft pulping of jute stem (liquor to material ratio 5:1 for jute stem, 4:1 for muli bamboo, rishing of cooking temperature to 170°C in 90 minutes, cooking time at temperature 170°C for 120 minutes for jute stem and 90 minutes for bamboo and sulphidity 20%.

Raw Materials	Jute stem		Bamboo	
Active alkali, % as NaOH on OD. material	20.0	21.0	22.0	20.0
Consumed active alkali, % as NaOH on OD. material	15.5	16.3	16.8	15.7
Total solid in black liquor (before dilution), % w/w	11.0	11.6	11.8	19.8
Kappa Number,	23.3	17.1	16.0	15.8
Unbleached screened pulp yield, %	33.8	32.3	32.0	35.6
Screening rejects, %	0.2	0.2	0.1	0.1
Total yield %	34.0	32.5	32.1	35.7
Relative viscosity (Cuoxam)	11.5	9.9	9.7	12.3
Degree of polymerisation	1346	1238	1224	1396
alpha-cellulose content, % on OD. Pulp	93.4	93.9	94.8	95.5
Pentosans content, % on OD. pulp	2.7	2.6	2.3	2.4
Ash content, % on od. pulp	1.8	1.7	1.8	1.1
Schopper Reigler value (°SR)	-	19	20	14

as per T 211m-58 method and °SR as per SCAN-C 19:58 method. The residual alkali of black liquor was analysed according to Sweddish method (Anon 1974). The results are given in Table-1.

BLEACHING

The unbleached pulp was bleached with CEHEHD. After final bleaching, the pulp was treated with 2% HCL at 4% consistency for 30 minutes. The pulp after each bleaching stage was washed throughly with water and the yield of bleached pulp was determined. The bleached pulp analysed for alpha-cellulose, pentosan, ash, solubility and viscosity as per standard testing procedure. The degree of polymerisation (DP) was determined from viscosity. All results are shown in Table 2.

RESULTS AND DISCUSSION

The pH of hydrolysate liquor from jute stem was 4.2 and that of muli bamboo 3.9. This indirectly indicates that the removal of pentosans from fibrous raw material has been complete sufficiently during prehydrolysis.

It is seen in Table-1 that the yield of brown pulp from jute stem was 32.0% on oven dry FRM at a kappa number of 16.0 and 35.6% from muli bamboo at kappa number of 15.8. Thus the yield of unbleached pulp from jute stem was about 3.6 percent unit lower than muli bamboo at the same point of delignification. The yield decrease with jute stem is due to either higher proportion of extractives in the jute bark (Nahar 1987) or higher amount of hemicellulose content in the jute core (Guha et al 1965, Sanyal et al 1981, Shafi, 1994).

Alkali consumption of jute stem was higher than that of muli bamboo at the same point of delignifications (Table-1). The jute stem without retting contains higher amount of extractives. The ethanol extractive content of unretted bark was reported to be 6% (Nahar 1987). Thus during pulping of jute stem, a large portion of alkali is consumed for utilization of the extractives. An active alkali charge of 22% was needed to reach a kappa of 16.0 with jute stem against 20% with bamboo to delignify to a kappa number of 15.8.

It is also observed in Table-1 that the pentosans content of jute stem and bamboo pulps was almost the same. The alphacellulose of unbleached pulp from jute stem was 94.8%. It compares favourably with rayon grade pulp from muli bamboo. The relative viscosity or the degree of polymerisation (DP) of cellulose from jute stem was slightly less. Cellulose of lower viscosity or DP will result a poor strength yarn. Jute stem pulp has higher Schopper-Riegler value (°SR) compared to bamboo pulp. Consequently, the washing efficiency of pulp will be poor leading to lower the solid content in the spent liquor. The ash in unbleached jute stem pulp was higher compared to bamboo pulp (Table-1). This is detrimental to the qualities of dissolving pulp.

The unbleached pulp of jute stem with a kappa number of 16.0 gave a bleached yield of 85% on oven dry unbleachd pulp. On the otherhand, muli bamboo produced a bleached pulp yield of 93% with the pulp at a kappa number of 15.8. The bleaching loss for jute stem pulp was about 15%. Thus, there was a severe loss of cellulose on bleaching of jute stem pulp. This indicates that the pulp of jute stem deterioated severely on bleaching. The same phenomenon also occurred in bleaching of paper grade pulp from jute stem (Bhowmick 1988) and jute fiber (Akhtaruzzaman et al 1988). However, the viscosity or the DP of jute stem pulp is slightly lower compared to bamboo pulp. The desired viscosity may be made uniform with proper controlled in the bleaching stages. Cellulose of lower DP will affect the degree aging. As a result, the strength and structural stability of yarn will decrease. On the otherhand, if the DP is too high, the viscose would be too viscous to exhibits anomalous flow during manufacturing. Thus, specified viscosity always requires for dissolving pulp during regeneration. The brightness of bleached pulp was 86-88% Elrepho, which will porduce bright yarn. The characteristics of unbleached pulps are also shown in Table-2. It is seen that the alpha-cellulose and pentosans of jute stem pulp was also similar to muli bamboo pulp. These Characteristics can meet the requirement of dissolving pulps. But the ash content of jute stem pulp is slightly higher compared to bamboo pulp. A high percentage of ash is objectionable for rayon grade pulp, because it causes various troubles in viscose preparation and filtering. Better centricleaning facilities in the process may reduce the adhering silica content in ash of pulp to a lower units. But the question remains on raw material quality. Other properties of jute stem pulps are almost similar to muli bamboo pulp. The same grade of bamboo pulp are now used in marking staple fiber and cellophane.

COMPARISON OF JUTE STEM PULP WITH WOOD AND BAMBOO PULPS

The prehydrolysis-kraft pulp from jute stem has

Table-2

Bleaching of Kraft Pulp from jute stem and bamboo and the pulp characteristics

Particulars	Jute	stem	pulp	Bamboo pulp
UNBLEACHED PULP				
Kappa Number	23.3	17.1	16.0	15.8
Screened Pulp, % on OD. material	33.8	32.3	32.0	35.6
BLEACHING				
1. Chlorinations:				
Chlorine consumed as active Cl_2, % on OD. pulp	4.1	3.7	3.8	3.7
Final pH.	2.5	2.5	2.2	2.4
2. Extraction:				
Consumption of NaOH, % OD. pulp	1.6	1.5	1.5	1.4
Final pH.	11.0	11.0	11.2	11.1
3. Sodium Hypo Treatment:				
Hypochlorite consumed as active Cl_2, % on OD. pulp	1.5	1.4	1.4	1.5
Final pH.	9.4	9.5	9.5	9.5
4. Extraction:				
Consumption of NaOH, % on OD. pulp	0.6	0.5	0.5	0.5
Final pH	10.5	10.7	10.8	10.6
5. Sodium Hypo Treatment:				
Hypochlorite consumed as active cl_2, % on OD. pulp	0.3	0.3	0.3	0.3
Final pH.	9.1	9.1	9.3	9.3
6. Chlorine Dioxide consumed as active cl_2, % on OD. pulp	0.31	0.33	0.35	0.36
Final pH.	3.9	4.3	4.4	4.4
BLEACHED PULP				
Bleached yield, % on OD. unbleached pulp	86.1	85.1	85.0	93.0
Brightness of pulp, % (Elrepho)	86.0	87.5	88.0	87.0
Bleaching loss, % on Od. unbleached pulp	13.9	14.9	15.0	7.0
Alpha-cellulose content, % on OD. pulp	94.0	94.6	94:4	95.9
Pentosans content, % on OD. pulp	2.2	2.3	2.6	2.0
Ash content, % on OD pulp	0.17	0.18	0.16	0.1
Beta-cellulose content, % on OD. pulp	1.9	1.4	1.9	1.7
1% NaOH solubility % on OD. pulp	2.7	2.7	2.8	3.3
10% KOH solubility % on OD. pulp	9.0	9.4	9.1	9.0
Relative viscosity (Cuoxam)	4.4	4.3	4.2	4.6
Degree of polymerisation	714	704	690	743

Chlorination: Consistency 4%, time 1 hr. temp. 26°C, active chlorine applied 4.5% on OD. pulp.

Extraction: Consistency 10%, time 1 hr., temp. 60°C, NaOH used in Ist extraction 2% and 1% on OD. pulp in 2nd extraction.

Hypotreatment: Consistency 6%, time 1 hr., temp. 45°C, active chlorine applied in Ist hypo 2% on OD. Pulp and in 2nd hypo 0.5% with make up NaOH 0.2% on OD. pulp.

Chlorine Dioxide: Consistency 10%, time 3 hr., temp. 75°C, ClO_2 applied as active Cl_2 0.5% on OD. Pulp.

Table-3

Comparison jute stem pulp with dissolving pulp of wood (Anon 1959) and muli bamboo.

Particulars	Jute stem pulps.	KPM Process Muli bamboo pulps	Low alpha cellulose wood pulps	High alpha cellulose wood pulps
Alpha-cellulose, %	94.4	95.0 - 96.0*	89.0 - 92.0	94.0 - 97.0
Beta-cellulose, %	1.9	3.0 - 4.0	3.0 - 4.0	2.0 - 2.0
Ash Content, %	0.16	0.1 - 0.11	0.03 - 0.2	0.04 - 0.11
10% KOH Solubility,	9.1	7.0 - 10.0	14.0 - 18.0	4.0 - 6.0
Degree of polymerison	690	-	400 - 800	400 - 1500
Pentosans,	2.6	2.7 - 3.0	-	-
Relative viscosity (Cuoxam)	4.2	4.4 - 4.6	-	-
Brightness% (Elrepho)	88	86	-	-

*Uncorrected.

an alpha-cellulose content compared with counterpart wood pulp. Thus, jute stem pulps are a good raw material for dissolving pulp. the ash content is slightly higher than wood pulps. The degree of polymerisation in final pulp of jute stem is similar to dissolving pulp obtained from wood and bamboo (Table-3).

GENERAL ASPECTS

The storage and transportation of the FRM must be seriously taken into account. Jute stem is susceptible to serious biodegradation and costly to transport.

Jute stem is very bulky with a specific gravity of 0.185 (Islam & Khan 1984). This makes the digester packing density very poor. Consequently, the pulp production with jute stem may be very expensive. The pulp drains at a slower rate making the washing more expensive, can be made less recovery efficiency.

CONCLUSION

The following concludes can be drawn in this study.

- Pulp yield is comparatively lower than that of bamboo.

- Active alkali requirement is higher compared to muli bamboo at the almost same point of delignificaiion.

- The bleaching loss is high in CEHEHD process for jute stem pulp.

- The ash content of jute stem pulp is slightly high.

- The charcteristics of the bleached pulp from jute stem are almost similar to commonly used bamboo and wood dissolving pulps.

- Dissolving pulp can be produced from jute stem by the water prehydrolysis-kraft process with an yield of bleached pulp of about 85% on oven dry pulp.

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REFERENCES

1) Akhtaruzzaman, A.F.M., Siddique, A.B. Bose, S.k., Das, P. Chowdhury, A.R. and Das, M.M. (1988) Tappi pulping conference proceedings 475-484.

2) Anon (1959) Man made textile encyclopedia, edi. press, J.J. Textile book publishers Ins. New York P-11.

3) Anon (1974) Lab, 25, Koknings-Laborationes. Lab-Anvisn Y-104, Sveriges Skogindustri Forbund, Mankaryd.

4) Anon (1992) A report on the Production of dissolving pulping from jute wastes, BCIC, Dhaka.

5) Bhowmick, K. (1988) Bano Biggyan Patrica, Vol. 17 (1 & 2): 8-14.

6) Bhowmick, K. (1993). Ph.D Thesis, University of Dhaka. Bangladesh.

7) Guha, S.R.D., Sharma, Y.K. and Mukherjee, N.Y. (1965) Indian Pulp and Paper 19 (12) 729-730.

8) Ishaque, A.K.M. & Barua, I.B. (1994) Research & Development Note No. 247. Chandraghona.

9) Islam, M.A. (1967) Pak. Jur. Sci. Ind. Res. 10 (5): 175.

10) Islam, M.A. and Khan. M.A. (1968) Pak. Jur. Sci. Ind. Res. 5 (1): 8-11.

11) Islam, M.A. and Khan, M.A. (1984) Bang. Jur. Sci. Res. Vol. 19 (1-4): PP 119-127.

12) Kalam, M.A., Biswas, S.C. and Barua, I.B. (1981) Research and Development note-229, Research Lab. KPML Chandraghona.

13) Nahar, N. (1987) Doctoral dissertation. Swedish University of Agriculture Science, Upsala, PP 42.

14) Rahman, S. (1977) Research & Development note-220 Res. Lab. KPML Chandraghona.

15) Saha, P.K., Dasgupta, P.C. and Mazumder, A.K. (1973) Cellulose Chemistry and Technology 7, 876.

16) Sanyal, A.K., Ray, A.K. and Ghosh, I.N. (1981) Indian Pulp and Paper 36 (3): 3-7.

17) Shafi, M. (1994) Ph.D. Thesis University of Dhaka, Bangladesh.

18) Shahidullah, M., Rahman, S.M., Barua, I.B. and Rahman, A.M. (1994) Process trial report on rayon grade pulp using green jute plant in the existing facilities on KPM.