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Manufacturing packing paper from acetic acid blended pulp of bamboo and bagasse

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Abstract: Packing paper was manufactured from acetic acid blended pulp of bamboo and bagasse. For this purpose chips of bamboo (Bambusa balcooa) were cooked in a 3 litre distillation flask with glacial acetic acid along with an inorganic HCl catalyst. Optimums pulping (cooking) conditions were established on the basis of unbleached pulp yield, permanganate (kappa) number, freeness of the pulp and paper (physical) properties of the unbleached (brown) pulp-sheets including breaking length, tear factor, burst factor, folding endurance as well as brightness of the same. Unbleached pulps were then made in bulk quantities and were blended (mixed) with acetic acid sugarcane bagasse pulp of unbleached origin in the ratio of 2:1 and then beaten in a laboratory beater upto 2000 revolutions. Paper-sheets were then made in Rapid Köthen sheet former, conditioned and tested for breaking length, tearing strength, brightness, folding endurance and bursting strength. The freeness of the blended pulp-slurries were measured accurately and recorded in the related table. Following the above methodology, packing and wrapping paper of high strength can be obtained from the blended pulp of borak bamboo and sugarcane bagasse.
Keywords: Bamboo (Bambusa balcooa), Sugarcane bagasse, Acetic acid, pulp, packing paper.

Introduction

Wood is the principal raw material for production of pulp in the world. Ninety percent pulp is produced from wood whereas only 10% pulp is produced from bamboo and reeds including jute, jute-stick, jute-cuttings, whole jute, green jute, bagasse, straw, nal, khagra, ekra, dhaincha, lemon grass, etc. Pulp and paper mills at home and abroad are always associated with some constant problems. Due to deforestation, scarcity of woods and bamboos as cellulosic raw materials now begins for pulp and paper industries in Bangladesh. So attentions have been given to alternate raw materials like sugarcane bagasse, straw, reeds, waste papers, jute, caddy, etc. and these are all now used to some extent by pulp and paper mills of the country. At present acetic acid has been used in research laboratories as solvent for extraction of lignin from woods and nonwoods. It is known as acetic acid pulping process (AAPP) which is one type of organosolv pulping as because the acid is organic. The strength of the acid should be as high as possible i.e. it must be glacial, the strength of which should be more than 90% at least. With the aid of a simple distillation flask of small capacity the pulping of cellulosic raw material is done open at atmospheric pressure. So it is also known as open pulping process. In the present studies broak bamboo (Bambusa balcooa) and sugarcane bagasse (Saccharum officinarum) have been selected for pulping by glacial acetic acid along with an inorganic catalyst of acid hydrochloric having the objective to obtain wrapping and packing paper of good strength.

Materials and Methods

Cellulosic raw materials: For wrapping and packing paper the use of acetic acid pulping process was made for making pulp from the sun dried borak bamboo and sugarcane bagasse.

Preparation of raw materials: With a view to determining moisture, the sun dried borak bamboo and bagasse were cut into pieces of about 1.0 cm in length, portions of the pieces of each kind were then put into an electric oven at 100 ± 2^0C for a minimum period of 18 hours.

Preparation of solutions: The cooking liquor consisting of acetic acid and catalytic solution of concentrated hydrochloric acid were all analar grade samples used for pulping. The strength of acetic acid solution used was more than 95%. All solutions for permanganate or kappa number determinations were prepared accurately and standardised.

Distillation: Pulping was done in a distillation flask of 3 litre capacity using a wax bath heated by Bunsen burner. There were glacial acetic acid solution as solvent in the flask and concentrated hydrochloric acid solution as catalytic one in the same. 100 g oven dried chips were used in each experiment.

Establishment of optimum conditions for pulping: Digestions were made under variation of the volume of solutions of acetic acid and hydrochloric acid, time and temperature against the raw material of borak bamboo. Optimum conditions were established after careful studies of the unbleached pulp yield, breaking length, tear factor, burst factor of the unbleached pulp-sheets as well as freeness of the pulp. For other cellulosic raw material of bagasse, optimum conditions established by Alam (2006) were adopted.

Pulp from optimum pulping (cooking) conditions: With the use of optimum cooking conditions, pulps were made from bamboo and bagasse separately and relatively in greater amounts for laboratory evaluation.

Determination of unbleached pulp yields: Samples of wet pulp were put in electric oven at 100 ± 2^0C for a minimum period of 18 hours for determination of unbleached pulp yield. Repeatation of heating of samples in electric oven was made until constant weight was given by the sample in each case.

Determination of permanganate number: The permanganate number was determined according to TAPPI procedures of T-214.

Laboratory evaluation of unbleached blended pulps: Required amount of the unbleached borak bamboo and bagasse pulp in the ratio of 2:1 was blended, disintegrated and beaten as per TAPPI standard procedures of(T-200) in a suitable laboratory beater (PFI mills) for different number of revolutions namely 0 to 2000 with an intermediate gap of 500 revolutions. Standard pulp-sheets each weighing 60 g/M^2 were made from the different collected samples in Rapid Köthen sheet forming machine and the sheets were conditioned and then tested for tensile (T-404), tear (T-470), bursting strength (T-403) and folding number, all according to TAPPI standard procedures.

Measurement of brightness: The brightness of the standard unbleached pulp-sheets was determined in accordance with TAPPI procedure (T-452) using $BaSO_4$ as standard.

Determination of tensile strength: For tensile strength the TAPPI procedures (T-404) were accurately followed.

Determination of tearing strength: The tearing strength of the unbleached blended pulp-sheets was determined as well according to TAPPI procedures of T-470.

Determination of bursting strength: The bursting strength of the same was determined by TAPPI standard procedures of T-403.

Freeness: The freeness of the unbleached pulp was also measured in Schopper Reigler apparatus by using 3 g o.d. pulp with the help of TAPPI standard procedures as recorded in T-227.

Results and Discussion

Results on acetic acid pulping process, effect of different pulping conditions on pulp production and pulp qualities were presented in tables 1-5. The unbleached acetic acid pulps from borak bamboo and sugarcane bagasse obtained by using optimum pulping conditions were recorded in table-3.

Right selection of optimum pulping conditions: The screened pulp-yield for borak bamboo by acetic acid pulping process was 54% which is much more higher than 46% obtained by Karim (1980) for his soda-sulphur pulping process for muli bamboo. 56% pulp-yield is the highest one for any sort of bamboo so far obtained as well as available in chemical literature. There is nearly 47% alpha cellulose in bamboo. The increased unbleached pulp-yield of 54% might be due to presence of hemicellulose along with alpha cellulose after removal of lignin from borak bamboo by acetic acid pulping process with the use rightly selected optimum cooking conditions (Table-3) for acetic acid, catalyst hydrochloric acid, time and temperature.

Table 1. Summary sheet of the results for borak bamboo obtained by acetic acid pulping

Experiment	Acetic acid solution (ml)	HCl solution (ml)	Temperature (^{0}C)	Time (minute) excluding 10 minute time at reflux	Material-liquor ratio	Screened pulp-yield (%)	Permanganate number	Breaking length (metre)	Tear factor	Burst factor	Brightnees (%)	Freeness (^{0}SR)
1	275	10	118±2	60	1:2.8	60	31	1650	54	16	20	35
2	300	10	118±2	60	1:3.1	54	27	1700	70	17	24	37
3	325	10	118±2	60	1:3.3	48	22	1765	66	18	29	40
4	300	08	118±2	60	1:3.1	62	33	1309	44	13	13	36
5	300	10	118±2	60	1:3.1	54	27	1700	70	17	24	37
6	300	12	118±2	60	1:3.1	48	22	1594	59	15	28	37
7	300	10	108±2	60	1:3.1	partially digested						
8	300	10	118±2	60	1:3.1	54	27	1700	70	17	24	37
9	300	10	128±2	60	1:3.1	over digested						
10	300	10	118±2	30	1:3.1	remained undigested						
11	300	10	118±2	60	1:3.1	54	27	1700	70	17	24	37
12	300	10	118±2	90	1:3.1	over digested						

For each experiment amount of borak bamboo used was 100 g o.d. basis.

Permanganate number: The permanganate or kappa number obtained with the unbleached pulp by optimum pulping conditions was found 27 which showed that the highest pulp-yield (54%) was not at the cost of pulp purity and the conditions were also adequate for good delignification.

Reduction in cooking time: Cooking time 5 hours for Karim (1980) for soda bamboo pulp, the same for Islam and Khan (1984) for sulphate bamboo pulp and 3 hours for Karim's (1980) soda-sulphur bamboo pulp reduced to 1 hour for borak bamboo for the present studies. The surprising reduction in cooking time was due to the use of a suitable inorganic acid catalyst HCl which helped in quick delignification. Thus reducing the time from 3-5 hours to 1hour only.

Bleaching: Bleaching in any form of the unbleached pulp in any form was not done as because it was unnecessary for wrapping and packing paper.

Blending and beating: For laboratory evaluation both unbleached pulps originated from borak bmboo and bagsse were blended respectively in the ratio of 2:1 and then disintegrated and beaten in laboratory beater (PFI mills) for 0 to 2000 revolution. Samples of pulpslurries were collected each after 500 revolutions. The required number of pulp-sheets were made from the pulp-slurries and then tested after conditioning of the sheets as per TAPPI procedures.

Table 2. Summary sheet of the results for the acetic acid bagasse pulp of unbleached origin by Alam (2006)

Experiment	Acetic cid solution (ml)	HCl solution (ml)	Temperature (^{0}C)	Time (minute) excluding 15 minute time at reflux	Material-liquor ratio	Screened pulp-yield (%)	Permanganate number	Breaking length (metre)	Tear factor	Burst factor	Brightnees (%)	Freeness (^{0}SR)
1	175	10	116+2	60	1:1.8	remained undigested						
2	275	10	116+2	60	1:2.8	55	23	2309	47	22	27	44
3	375	10	116+2	60	1:3.8	52	21	2200	44	18	34	44
4	475	10	116+2	60	1:4.8	47	18	2080	40	15	39	43
5	275	5.0	116+2	60	1:2.8	remained undigested						
6	275	7.5	116+2	60	1:2.8	-						
7	275	10.0	116+2	60	1:2.8	55	23	2309	47	22	27	44
8	275	12.5	116+2	60	1:2.8	46	18	2119	43	20	35	45
9	275	10	106+2	60	1:2.8	remained undigested						
10	275	10	116+2	60	1:2.8	55	23	2309	47	22	27	44
11	275	10	126+2	60	1:2.8	49	17	2018	41	19	40	44
12	275	10	116+2	30	1:2.8	remained undigested						
13	275	10	116+2	45	1:2.8	partially undigested						
14	275	10	116+2	60	1:2.8	55	23	2309	47	22	27	44
15	275	10	116+2	75	1:2.8	50	18	2208	44	18	34	44
16	275	10	116+2	90	1:2.8	44	14	2110	39	15	41	44

For each experiment amount of sugarcane bagasse used was 100 g o.d. basis.

Table 3. Effect of different pulping conditions on acetic acid borak bamboo and sugarcane bagasse pulp production

Raw materials	Acetic acid solution (ml)	Volume of catalytic soln.(ml)	Temper-ture (^{0}C)	Time (minute) at reflux excluding 10 minutes to reflux	Time (minute) at reflux excluding 15 minutes to reflux	Material -liquor ratio	Pressure
Borak bamboo	300	10	118±2	60	-	1:3.1	Atmospheric
Sugarcane bagasse	275	10	118±2	-	60	1:2.8	Atmospheric

Table 4. Yield, permanganate number and brightness of the unbleached acetic acid borak bamboo and sugarcane bagasse pulp using optimum pulping conditions

Pulp Used	Screened yield (%)	Permanganate number	Brightness (%)
Borak bamboo	54	27	24
Sugarcane bagasse	55	23	27

Table 5. Effect of beating on paper properties of blended pulp of borak bamboo and sugarcane bagasse

No. of revolutions	Breaking length	Tear factor	Burst factor	Freeness (°SR)	Brightness (%)	Folding number
00	1700	70	17	38	22	0.5
500	2890	76	22	45	23	5.0
1000	3310	86	26	52	24	8.0
1500	3500	90	28	60	25	15.0
2000	3628	79	29	67	26	22.0

Breaking length and burst factor: It was observed from the table 5, that the breaking length and the bursting strength of the blended sheets increased with the increase in number of revolution from 0 to 2000. The highest breaking length was 3628 metre (Table 5) obtained at revolution of 2000. The highest burst factor was also found 29 (Table 5) with the same pulp with the same number of revolution. It was due to the fact that the area of the fibre in optical contact was gradually increasing with the progress of beating. The breaking length 3628 metre was higher than that of Karim and lslam (1988) obtained by them for their studies for dhaincha by soda and soda-sulphur process.

Tear factor: From the (Table 5) it is seen that the tear factor of the blended acetic acid borak bamboo and sugarcane pulp increased from 70 for 0 revolution to 90 for 1500 revolution due to increase in fibre length of the pulp and then decreased to 79 for 2000 revolution. But the highest tear factor 90 for the present studies is comparable to Karim (1980) and even higher than Islam and Khan (1984).

Freeness: The freeness values for the blended pulp were also determined (Table 5). The freeness (0SR) increased straight-line-wise from O number of revolution to 2000 number of revolution. It increased more or less uniformly from 38 to 67.

Brightness: The measurement of brightness of the blended pulp-sheets though not important for wrapping and packing paper, yet was measured out of academic interest. From the brightness (Table 5) it is evident that the brightness of the blended pulp-sheets increased from 22 to 26 due to increase in number of revolution upto 2000. It means beating has little effect on brightness.

Folding number: The folding numbers of the blended unbleached pulp sheets as recorded in table 5 increased linearly through the entire period of beating. It increased from 0.5 for 0 revolution to 22 for 2000 number of revolution. The increase of the folding number was also due to increase in fibre length of the pulp of optical contact of the beater with the same and such behaviour in respect of folding number is a natural phenomenon for long fibre pulp present originally in all sorts of bamboo plants including borak one whose amount in the blended pulp is twice than that of the bagasse.

References

Alam, M.M. 2006.Acetic acid bagasse pulp for wrapping and packing paper. A thesis of Master of Science. Department of Agroforestry. Bangladesh Agricultural University, Mymensingh. pp. 44-45.

Islam, M. A. and Karim, M. S. 1988. Studies on sulphate pulping of dhaincha. Bangladesh J. Sci. Ind. Res., XXIII Nos. (1-4): 24-33..

Islam, M. A. and Khan, M. A. 1984. Pilot plant production of writng paper from the kraft pulp of whole jute stalk (jute plant without retting). Bangladesh J. Sci. Ind. Res., Vol. XIX, Nos. (1-4), 119-128.

Karim, M.S. 1980. Pulping on jute-stick by soda-sulphur process. Pakistan J. Sci. Ind. Res. Vol. 32, June, No.: 6: 428-429.