J. Agrofor. Environ. 2(2): 197-200, 2008 ISSN 1995-6983

Wrapping and packing paper from acetic acid blended pulp of nal

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Abstract: Nal (*Arundo donax*) a reed like celluslosic raw materials was selected for acetic acid pulping with a view to obtaining wrapping and packing paper. The optimum pulping (cooking) conditions regarding time, temperature, and chemicals like acetic acid and hydrochloric acids were established depending mainly on the basis of unbleached pulp-yield and permanganate or kappa number of the same. Series of pulping experiments were done in a distillation flask of 3 litre capacity kept in a wax-bath heated by Bunsen burner. By using optimum conditions, pulps in bulk quantities were also made. Those were disintegrated in a disintegrator and then beaten for different number of revolutions. Samples of pulp-slurries at 0, 500, 1000, 1500, 2000 revolutions were collected pulp or paper-sheet were made from each of the samples. The sheets were conditioned and that tested for paper or physical properties like breaking length, tear factor, burst factor, folding number and brightness. The freeness of the unbleached pulp was also determined and recorded. From the results, it has been found that good quality wrapping and packing paper can be made from nal by acetic acid pulping process in less cooking time.

Keywords: Acetic acid, pulp, nal (*Arundo donax*), cellulosic raw material and packing paper

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Introduction

Bangladesh is a country based on agriculture. It has been gradually developing day by day in many fields including business, commerce and industry as well. It is needless to say that pulp, paper, rayon, newsprint, celluphane, cellulose chemicals and other paper products are important to all countries of the world. The activity of a nation in respect of education, culture and industry is usually measured by per capita consumption of paper. The major portion of pulp manufactured throughout the world is utilized for writing and printing paper, wrapping and packing paper, news paper and other paper products. But the minor portion of pulp produced is spent for manufacture of rayon, celluphane and cellulose chemicals. Woods and bamboos, the basic raw materials for paper making in our country are not sufficiently available. This is due to deforestation and lack in plantation programme. So attention has been drawn to number of different varieties of reeds and reed-like substances. Out of them, jute, jute-stick, whole jute (jute and stick together), *dhaincha*, *nal*, *khagra* and *ekra* are remarkable. Some studies and researches have been made by Karim and Seal (2005) at Bangladesh Agricultural University, Mymensingh on pulp and paper by a comparatively new pulping process known as open pulping or acetic acid pulping technique. Acetic acid is an organic substance. It is used in glacial form in pulping of different cellulosic substances. It is known as acetic acid pulping process. The rate of delignification may be accelarated in presence of an inorganic mineral acid. The pulping is continued in simple distillation flask of different capacities. As the pulping is done in atmospheric process, so the process is also known as open pulping process. Acetic acid pulping is done in laboratories in a simple glass apparatus of distillation flask. Nal is a rapid growing plant and attains maturity in 3-4 months. It becomes 6-8 feet in height and 1-1.5 inches in width. It grows in different parts of Bangladesh. As there is report on its pulping by acetic acid, so the present studies were carried out with a view to obtaining pulp for wrapping and packing paper at low cost and in less cooking time.

Materials and Methods

Cellulosic raw materials: Acetic acid pulping process was applied to nal in order to obtain wrapping and packing paper.

Preparation of raw materials: With a view to determining moisture, the sun dried nal was cut into pieces of about 1.0 cm in length. Then a few samples of not more than 5 gram were put in an electric oven at 100±2°C for a minimum period of 18 hours for determination of moisture contents.

Preparation of solutions: The cooking liquor consisted of glacial acetic acid solution and concentrated solution of hydrochloric acid and the liquor was used for pulping nal in a distillation flask of 3 liter capacity. The strength of acetic acid solution was more than 95%.

Distillation: Pulping or cooking was done in a distillation flask which was put in a wax bath heated by Bunsen burner. Glacial acetic acid solution as solvent and concentrated hydrochloric acid solution as catalytic one were placed in the distillation flask. The amount of o. d. chips was 100g in each experiment of the series. The cooking started with the distillation of acetic acid solution at a temperature of 118±2°C.

Establishment of optimum conditions for pulping: Series of experiments were made with the variation of volume of acetic acid solution, hydrochloric acid solution, time and temperature. Optimum conditions were established after careful studies of the unbleached pulp yield and permanganate number of pulp, breaking length, tear factor, bust factor of the unbleached pulp sheets. In addition, freeness of the pulp was also determined.

Determination of unbleached pulp yields: Two samples of wet pulp weighing not more than 5 g each were put in an electric oven at 100±2°C for a minimum

period of 18 hours for determination of unbleached yield.

Determination of permanganate number: The permanganate number was repeatedly determined according to TAPPI standard procedure of T-214. It is also known as kappa number.

Laboratory evaluation of unbleached pulps: Required amount of the unbleached pulp of nal was obtained by optimum cooking conditions, disintegrated and beaten as per TAPPI standard (T-200) in a suitable laboratory beater (PFI mills) up to 2000 revolutions. Samples of pulp-slury at 0 revolution and after each 500 revolutions were collected. Standard pulp-sheets each weighing 60 g/M^2 were made from the different collected samples in Rapid Köthen sheet former and the sheets were conditioned and then tested for tensile (T-404), tearing (T-470) and bursting strength (T-403), all according to TAPPI standard procedures.

Measurement of brightness: The brightness of the standard unbleached pulp-sheets though not necessary yet was determined according to TAPPI procedure of T-452 against that of $BaSO_4$.

Determination of tensile strength: The tensile strength of the pulp or paper sheet was also determined with TAPPI standard procedures.

Determination of tearing strength: The tearing strength of the unbleached pulp-sheets was determined with the use of 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: Schopper Reigler apparatus was used for determination of freeness in °SR unit. The amount of o.d. pulp was 3 g and the related TAPPI standard procedures were adopted for the purpose.

Results and Discussion

Results on acetic acid pulping process, effect of different pulping conditions on pulp production and pulp qualities were presented in Tables 1-4. The unbleached acetic acid pulps from obtained by using optimum pulping conditions were recorded in Table-2.

Table 1. Summary and results of experiments with nal obtained by acetic acid pulping

Experiment	Acetic acid solution (ml)	HCl solution (ml)	Temperature (^{0}C)	Time (minute) excluding 15 minute time at refux	Material-liquor ratio	Screened pulp-yield (%)	Permanganate number	Breaking lengt h (metre)	Tear factor	Burst factor	Brightness (%)	Freeness (^{0}SR)
1	250	10	118±2	75	1:2.60	58	29	2607	45	18	14	33
2	275	10	118±2	75	1:2.85	52	26	3110	54	24	18.5	35
3	300	10	118±2	75	1:3.10	46	22	2935	48	22	16	32
4	275	8	118±2	75	1:2.85	60	31	2800	49	22	17	36
5	275	10	118±2	75	1:2.85	52	26	3110	54	24	18.5	35
6	275	12	118±2	75	1:2.85	44	20	2912	51	20	20	34
7	275	10	108±2	75	1:2.85	partially digested						
8	275	10	118±2	75	1:2.85	52	26	3110	54	24	18.5	35
9	275	10	128±2	75	1:2.85	over digested						
10	275	10	118±2	60	1:2.85	60	33	2900	48	22	14	40
11	275	10	118±2	75	1:2.85	52	26	3110	54	24	18.5	35
12	275	10	118±2	90	1:2.85	49	20	2726	50	21	20	31

For each experiment amount of nal used was 100 g oven dry basis.

Right selection of optimum pulping conditions: The screened unbleached pulp yield for nal was 52% which was very high. It indicates that the optimum pulping conditions did not give rise to abnormal loss in alpha cellulose as well as hemicellulose during distillation i.e. time of cooking nal by acetic acid in presence of hydrochloric acid as catalyst. It was possible only due to right selection of optimum pulping conditions regarding correct volumes of glacial acetic acid solution as solvent and concentrated hydrochloric acid solution as catalyst, time and temperature.

The permanganate number: The permanganate number of the unbleached pulp obtained with optimum pulping conditions was only 26 which showed that the high pulp yield 52% was at cost of sufficient amount of removal of lignin from the inner as well as outer surface of the cellulosic raw material of nal again indicating that the chosen conditions of acetic acid, hydrochloric acid, time and temperature were right and adequate for good delignification.

Reduction in cooking time: The total time for cooking nal by acetic acid was 90 minutes which is not enough in comparison with a few hours required by other pulping processes for different cellulosic raw materials by Karim and Islam (1989, 1988, 1986) for jute, jute stick, rice straw, dhaincha, bamboo, ekra, etc. The surprising reduction in cooking time was due to the use of a suitable inorganic acid catalyst HCl which helped in quick delignification.

Table 2. Optimum pulping conditions for acetic acid pulp of nal

Acetic acid solution (ml)	Volume of HCl solution (ml)	Temperature (^{0}C)	Time (minute) for digestion excluding 15minutes to reflux	Material liquor ratio	Pressure
275	10	118±2	75	1: 2.85	Atmospheric

Table 3. Pulp yield, permanganate number and brightness of the unbleached acetic acid nal pulp using optimum pulping conditions.

Screened yield (%)	Permanganate number	Brightness (%)
52	26	18.5

Table 4: Effect of beating on paper properties of unbleached acetic acid nal pulp-sheet

Name of revolation	Breaking length(m)	Tear factor	Burst factor	Freeness (°SR)	Bright Ness (%)	Folding number
0	2709	53	22	29	18.0	3
500	3110	54	24	36	18.5	10
1000	3712	56	27	45	19.0	22
1500	3862	57	30	54	19.5	40
2000	3909	50	31	64	19.5	60

Bleaching was avoided: Leaching in any form of single or multi stage system was completely avoided as because it is a step not required at all for obtaining wrapping and packing paper. The unbleached or brown pulp is used for manufacture of packing and wrapping paper.

Beating: Beating in PFI mills was done by putting required amount of unbleached pulp in mills. Beating was adopted from 0 to 2000 number of revolutions with an intermediate gap of 500 revolutions where slurries of unbleached nal pulp were collected and stored for sheet formation. Pulp or paper sheets were made from different collected sample slurries by Rapid Köthen sheet former, conditioned and tested for tensile, tearing, bursting strengths, brightness, etc. The freeness was also measured.

The breaking length and the bursting strength: It is seen from table 4 hat both the breaking length and burst factor increased with increase in revolution number of beating. The increase was due to the increase in fibre length in optical contact of the fibre with the beater during the period of beating with very high force. In the present studies of the acetic acid pulping of nal, 3909 meter was the highest breaking length found with beaten nal pulp for 2000 revolutions and 31 was the highest burst factor for same pulp beaten for same number of revolutions.

The tearing strength: The tearing strength was recorded in the form of tear factor which increased from 53 for 0 revolution to 57 for pulp that revolved for 1500 number due to increase in area of fibres of unbleached pulps with the progress of beating but it dropped to 50 probably due to decrease in area of fibres in optical contact of the pulp at revolutions number 2000 (Table 4). The maximum tear factor 57 is high enough for pulp for wrapping and packing paper.

The brightness: The brightness measurement of the unbleached pulp was not essential as bleaching was not required for pulp for wrapping and packing paper. Yet the brightness was measured out of interest against that of barium sulphate. It increased from 18 for unbeaten pulps of 0 revolutions to 19.5 for pulp beaten to 2000 number of revolutions (Table 4) brightness increased only 1.5% for the whole period of the beating. It means beating has little effect on brightness.

The freeness: The freeness (°SR) increased uniformly from 29 to 64 with the progress of beating (table 4). It is a characteristic behaviour of a sort of long fibre like nal.

The folding endurance: The folding endurance was determined in the form of folding number as recorded for beaten pulp of nal (Table 4). The folding number was originally at 3 with the unbeaten unbleached pulp at 0 revolution. The folding number rose to 60 at the end beating upto revolutions number 2000. The folding number is one of the characteristic paper properties of both wrapping and packing paper as well as writing and printing paper. The increase in folding number means the increase in the strength of folding endurance of the paper. It proves that the beating of the pulp up to 2000 number of revolutions was made properly for increase in strength of the same.

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