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Effect of Pulping and Bleaching on Handmade Paper from Jute

*S. N. Chattopadhyay**
Principal Scientist

*N. C. Pan**
Principal Scientist and head of division Chemical and Biochemical processing

*S. Bhowmick**
Technical Officer

** ICAR-National Institute of Natural Fibre Engineering & Technology*

Abstract: *Handmade paper industry occupies a very important position in India and employs a large number of rural artisans. The beauty of the handmade paper industry is that they can utilise a variety of raw materials depending on the availability and can produce a wide range of products. The cooking of lignocellulosic fibres like jute is an important step in paper making which requires a lot of chemical and energy and produce effluents. Moreover multistage bleaching or bleaching using high alkaline conditions also pose threat to this sector. In order to reduce the severity of the bleaching treatment innovative peracetic bleaching of the pulps has been done and paper has been produced. There is a little deterioration of physical properties of the papers compared to that produced by grey papers but the physical properties retention is much better in comparison to that produced by peroxide bleached papers. This may be due to the milder condition of bleaching i.e., low temperature and alkalinity used in this bleaching caused minimum degradation to cellulose component of the pulp resulting in better retention of physical properties. The pulps produced by Alkaline Sulphite Anthraquinone Methanol (ASAM) and Alkaline Sulphite (AS) pulping process have produced better yield as well as physical properties. So, bleached handmade paper with good retention of tensile properties can be produced with sufficient whiteness if peracetic acid bleaching is followed after ASAM or AS pulping. The yield is also good in this case.*

Keywords: *Bleaching, Jute fibre, handmade paper, hydrogen peroxide, Peracetic acid, whiteness index, tensile properties*

Introduction

The pulp and paper industry are one of India's oldest and core industrial sector. The demand and use of pulp and paper have marked the levels of civilisation and development of many societies. The pulp in society used in education, information storage, advertising, communication, in protection, transportation and securities of goods in transit, protection of human health and sanitation in form of tissues and sanitary paper products. Both wood and non-wood resources are currently exploited for manufacturing of pulp, paper, and soft boards, which consists of similar chemical constituents although in dissimilar magnitudes. India has about

2795 handmade paper units which are mainly based on cotton rags, hosiery cuttings, tailor cuttings and small quantities of waste papers[1-3].Demand of paper is expected to rise in future with increasing literacy and growth of the manufacturing sector in India. This has created a big gap between the projected demand and the present production of handmade paper which can be reduced by introducing alternative ligno-cellulosic raw material like jute[4-5].

Jute is lignocellulosic fibre widely cultivated in India, Bangladesh, Nepal, Myanmar, etc are mainly utilised for making technical textiles but the processing wastes as well as low grade fibres can be prudently utilised for making pulp. As the quantity of pulp which can be made available from jute fibre being low in volume may be used for preparation of handmade paper and can act as alternative raw material source for pulp and paper industry. Majority of the raw material used in handmade paper sector is wastepaper, paper board, hosiery cuttings, cotton rags etc which does not require pulping step but jute being lignocellulosic material needs pulping for further processing into handmade paper. Different pulping method may be adopted in jute pulping which produce pulp with different yields and properties.

Multistage bleaching is generally followed in pulp and paper industry to produce white paper which is lengthy and needs lots of resources and machineries. In handmade paper sector particularly for jute single step bleaching using hydrogen peroxide is mainly advised. The bleaching is mainly carried out at high temperature and alkaline condition results in white paper with substantial loss in physical characteristics. Recently some novel bleaching agents like per acetic acid has been identified which can be processed at low temperature and mild alkaline condition in single step to produce white paper with high retention of physical properties as that of unbleached pulp.

So, in this work jute fibre has been subjected to pulping by different processes and then single step bleaching has been carried out either by hot hydrogen peroxide process or by innovative peracetic acid process. The optical and physical properties of the handmade paper have been studied in detail and compared.

Materials and Methods

Materials

Jute fibre: Jute fibre of low quality was cut into 2-4 cm pieces and used for pulping.

Chemicals: The following chemicals were used in the experiments : Sodium Hydroxide, Sodium sulfite, Anthraquinone, Methanol, Hydrogen peroxide, Trisodium phosphate, sodium silicate, Per Acetic Acid, Tetra sodium phosphate and Sodium carbonate.

Methods

Alkaline Sulphite Anthraquinone Methanol (ASAM) Pulping: Jute fibres were subjected to ASAM pulping using sodium hydroxide (5%), sodium sulphite (20%),anthraquinone (0.1%) at 1:10 material to liquor ratio having 10% methanol at 160^{0}C for 3 hours.

Alkaline Sulphite Anthraquinone (ASA) Pulping: Jute fibres were subjected to ASA pulping using sodium hydroxide (5%), sodium sulphite (20%),anthraquinone (0.1%) at 1:10 material to liquor ratio at 160^{0}C for 3 hours.

Alkaline Sulphite (AS) Pulping: Jute pulp was prepared by alkaline sulphite pulping process in a rotary digester in which jute fibres were subjected to AS pulping using sodium hydroxide (5%), sodium sulphite (20%) at 1:10 material to liquor ratio at 160^{0}C for 3 hours.

Kraft Pulping (KP): Jute fibres were subjected to KP pulping using sodium hydroxide (10%), sodium sulphide (15%) at 1:10 material to liquor ratio at 160^{0}C for 3 hours.

Alkali Pulping (AP): Jute fibres were subjected to AP pulping using sodium hydroxide (25%) at 1:10 material to liquor ratio at 160^{0}C for 3 hours.

Bleaching of jute pulp:

A portion of the unbleached pulp was bleached in a covered vessel using two different bleaching agents like $H_2O_2$and peracetic acid as mentioned below:

Hydrogen peroxide bleaching (HP)

Bleaching were done in a closed vessel for 90 min at 80-85^{0}C, keeping the material to liquor ratio at 1:15 with hydrogen peroxide (2 Vol.), trisodium phosphate (5 g/L), sodium hydroxide (1 g/L) and sodium silicate (10 g/L). The pH of the bath was maintained at 10. After bleaching, the pulps were washed thoroughly in cold water, neutralised with acetic acid (2 ml/L), washed again in cold water and finally dried.

Peracetic acid bleaching (PAA)

Bleaching of pulp were done in a closed vessel for 120 min at 60-70^{0}C, keeping the material to liquor ratio at 1:15 with Per Acetic Acid (20 ml/L.), tetra sodium pyro phosphate (1-3 g/L) and sodium carbonate (1-2 g/L). The pH of the bath was maintained at 7.5-8. After bleaching, the pulps are washed thoroughly in cold water and finally dried.

Beating: Enzyme treated fibres, hot soda pulps and cold soda pulps were subjected to beating in laboratory

scale valley type beater for different durations to produce pulp of 40^{0}SR freeness.

Paper sheet formation: Paper sheets of 60 GSM were produces by using semi-automatic paper sheet making machine.

Standard hand sheets of 60 GSM were made from all three types of pulp i.e., bleached, unbleached after beating them in a Valley Beater to about 40^{0}SR freeness, using UEC hand sheet former.

Evaluation: All the paper sheets were kept in the standard testing atmosphere and following tests were carried out.

Optical properties: The Whiteness Index in HUNTER scale, Yellowness Index in the ASTM D1925 scale and Brightness Index in TAPPI 452 scale of handmade paper produced by different pulping processes were determined by Spectrascan-5100 computerised colour matching system using relevant software.

Physical properties10: Tensile properties were evaluated by Tappi Test Method – T404 om-85, Bursting Index was determined by Tappi Test Method – T403 om-85, Tearing strength by Tappi Test Method – T414 om-88 and Folding endurance (Schopper type) was determined by Tappi Test Method – T423 om-89. The instruments used were Tensile Strength Tester Veb Thuringer Industriewerk, Raunstein (Germany), Double Fold Tester, UEC, Saharampur, Bursting Strength Tester by UEC, Saharanpur and Tearing Strength Tester by UEC, Saharanpur.

Results and Discussions

Jute is an annual plant which grows to the tune of about 1.5 million tons and this leaves a jute stick yield of about 3 million tons. Jute can be used as an alternative raw material if we can produce speciality paper from jute. The pulp and paper industry are under constant pressure to reduce and modify environmental emission to air and water. In order to keep up with the increasing demand for pulp and paper and to meet increasing stringent environment regulations, the industry is looking towards technological improvements in the conventional pulping methods[6].

Handmade paper industry occupies a very important position in India and employs a large number of rural artisans. The beauty of the handmade paper industry is that they can utilise a variety of raw materials depending on the availability and can produce a wide range of products. The cooking of lignocellulosic fibres like jute is an important step in paper making which requires a lot of chemical and energy and produce effluents. Moreover multistage bleaching or bleaching using high alkaline conditions also pose threat to this sector. So, pulping and bleaching using low chemical concentration or alternative mild chemicals at a lower temperature can make the process user as well as environment friendly[7-9].

Pulping of jute was carried out by different pulping methods as mentioned in table-1 which clearly indicated that the yield of the pulp decreases with increase in alkalinity in pulp liquor and the severity of the treatment as the yield is less in kraft and alkali process of pulping. The yield is found to be better in case of peracetic acid bleaching.

Table-1: Yield of jute pulp after different pulping as well as bleaching

Pulping process	Yield after digestion	Yield after HP bleaching	Yield after PAA bleaching
ASAM	63	91	98
Sulphite-Anthro	65	93	95
Sulphite	68	92	95
Kraft	57	92	95
Alkali	52	93	96

These pulps were used to make paper using semi-automatic sheet former. All the papers were evaluated for optical & physical properties and tabulated in table-2 and table-3 respectively.

Table-2: Optical properties of the paper produced from different grey jute pulps

Pulping Process	K/S	Whiteness Index (HUNTER)	Yellowness Index (ASTM D1925)	Brightness Index (TAPPI 452)	L	a	b
ASAM	0.60	67.6	31.5	39.9	76.6	2.7	13.9
Sulphite-Anthro	0.64	69.0	32.3	41.4	78.0	2.7	14.6
Sulphite	0.74	66.7	35.3	38.2	76.2	3.2	15.6
Kraft	0.72	64.8	31.8	36.6	73.9	3.3	13.1
Alkali	0.21	69.6	28.0	43.3	77.6	2.2	11.8

Table-3: Physical properties of the paper produced from different grey jute pulps

Pulping Process	Folding (Number)	Tear index (mNm²/g)	Tensile Load (N)	Tensile Strength (KN/M)	Elong (%)	B.L (KM)	Burst Index (KPam²/g)
ASAM	300	11.33	48.9	3.84	3.36	5.55	4.77
Sulphite-Anthro	132	11.33	46.5	2.94	2.91	5.27	4.87
Sulphite	228	10.2	47.66	3.32	3.15	5.40	4.46
Kraft	163	9.64	47.25	3.15	3.30	5.35	4.31
Alkali	2	3.85	16.17	1.09	1.16	1.83	1.10

It is clear comparing the tables 2 and 3 that the physical properties of the papers produced by ASAM and AS process is better and the optical properties are similar in all the cases. This may be due to the milder and effective pulping by separation of cellulose without damaging it.

In order to compare the bleaching of the pulp using two oxidising bleaching agents, all these pulps were bleached separately by conventional hydrogen peroxide and developed peracetic acid bleaching process. These bleached pulps were used for making paper and optical as well as physical properties were evaluated. Optical and physical properties of hydrogen peroxide bleached samples are tabulated in table-4 and table-5whereas peracetic acid bleached samples are tabulated in table-6 and table-7.

Evaluation of bleached paper from H_2O_2 bleaching

Table-4: Optical properties of the paper produced from different grey jute pulps followed by hydrogen peroxide bleaching

Pulping Process	K/S	Whiteness Index (HUNTER)	Yellowness Index (ASTM D1925)	Brightness Index (TAPPI 452)	L	a	b
ASAM	0.21	79.5	20.6	58.3	85.8	1.16	9.7
Sulphite-Anthro	0.32	76.2	23.7	52.5	83.5	0.89	11.6
Sulphite	0.18	82.6	19.2	63.0	88.5	-0.31	10.3
Kraft	0.05	88.9	10.7	75.9	92.5	-0.07	5.4
Alkali	0.08	85.8	10.8	70.5	90.6	-0.12	5.7

Table-5: Physical properties of the paper produced from different grey jute pulps followed by hydrogen peroxide bleaching

Pulping Process	Folding (Number)	Tear index (mNm²/g)	Tensile Load (N)	Tensile Strength (KN/M)	Elong (%)	B.L (KM)	Burst Index (KPam²/g)
ASAM	16	8.74	29.1	1.94	1.93	4.29	3.20
Sulphite-Anthro	-	6.79	12.6	0.94	1.03	2.23	1.32
Sulphite	3	6.77	20.5	1.36	1.10	2.25	1.51
Kraft	-	2.54	6.05	0.40	0.69	0.66	-
Alkali	-	2.03	7.74	0.50	0.49	0.81	-

It is evident that the papers produced after hydrogen peroxide bleaching of the different pulps is whiter but the physical properties of the papers have been deteriorated substantially after the bleaching. The consecutive treatment of the jute fibre i.e., pulping followed by high temperature as well as high alkaline bleaching may be degraded the cellulose resulting in very poor physical properties particularly in case of KP, ASA and AP. In other two cases the performance is comparatively better.

In order to reduce the severity of the bleaching treatment innovative peracetic bleaching of the pulps has been done and paper has been produced. Evaluation of bleached paper from PAA bleaching has been tabulated in tables 6 and 7.

Table-6: Optical properties of the paper produced from different grey jute pulps followed by peracetic acid bleaching

Pulping Process	K/S Value	Whiteness Index (HUNTER)	Yellowness Index (ASTM D1925)	Brightness Index (TAPPI 452)	L	a	b
ASAM	0.20	81.1	20.1	60.3	87.3	0.1	10.5
Sulphite-Anthro	0.24	80.2	22.6	58.4	86.9	0.1	11.8
Sulphite	0.31	78.8	25.4	55.7	86.1	0.1	13.4
Kraft	0.10	84.4	12.7	68.2	89.4	-0.1	6.7
Alkali	0.15	83.4	18.7	64.3	89.0	0.4	9.7

Table-7: Physical properties of the paper produced from different grey jute pulps followed by hydrogen peroxide bleaching

Pulping Process	Folding	Tear index	Tensile Load	Tensile Strength	Elong(%)	Breaking Length	Burst Index
ASAM	71	9.49	38.22	2.55	3.33	4.40	3.44
Sulphite-Anthro	12	6.89	29.68	1.98	2.73	3.42	2.03
Sulphite	28	8.0	36.92	2.46	2.78	4.18	2.66
Kraft	9	8.0	29.96	1.99	2.45	3.39	2.00
Alkali	1	2.6	14.56	0.97	1.43	1.65	0.81

Analysis of the results of table 6 and 7 shows that whiteness of the paper produced from bleached pulp is good and comparable to that produced by hydrogen peroxide bleaching. There is a little deterioration of physical properties of the papers compared to that produced by grey papers, but the physical properties retention is much better in comparison to that produced by peroxide bleached papers. This may be due to the milder condition of bleaching i.e., low temperature and alkalinity used in this bleaching caused minimum degradation to cellulose component of the pulp resulting in better retention of physical properties. The pulps produced by ASAM and AS pulping process have produced better yield as well as physical properties. So, bleached handmade paper with good retention of tensile properties can be produced with sufficient whiteness if peracetic acid bleaching is followed after ASAM or AS pulping. The yield is also good in this case.

Conclusions

- The yield of the pulp decreases with increase in alkalinity in pulp liquor and the severity of the treatment as the yield is less in kraft and alkali process of pulping. The yield is found to be better in case of peracetic acid bleaching.
- The handmade paper produced from grey pulps produces the best physical properties and both the processes of bleaching i.e. hydrogen peroxide and peracetic acid produces white paper.
- The physical properties of handmade papers produced from bleached pulps are always inferior than that produced by grey pulps. Among the different pulping processes ASAM and AS pulps produce paper with better physical properties after both the bleaching processes.
- The physical and optical properties of the paper produced by peracetic acid bleaching were found to be better than that produced by hydrogen peroxide bleaching.

References

1. Mathur, R.M., Thapliyal, B.P. and Singh, K., Challenges confronting Indian paper industry in changing scenario, IPPTA J., 21(3), 2009, 95-99.

2. Lwako, K.O., Joseph, B. And Baptist, K., A review on pulp manufacturing from non wood plant materials, International journal of Chemical Engineering and Applications, 4 (3), June 2013, 144-148.

3. Hath Kagaz, ii(7-9), July-September, 2004

4. Roy, A.K., Ghosh, I.N., Chattopadhyay, S.N., and Day, A., Jute - An alternative raw material for rural based handmade paper unit, Proceeding of Advances in agro processing and rural empowerment, Agricultural Engineering Division, The Institution of Engineers (India), Kolkata, 17-18 February, 2006.

5. Roy, A.K. and Chattopadhyay, S.N., Jute- An alternative Raw material for packaging Paper, IPPTAJ., 24(3), July – Sept, 2012, 121-124.

6. Chuphal, y., Kumar, V. And Thakur, I.S., Biodegradation and decolorisation of pulp & paper mill effluent by anaerobic and aerobic microorganisms in a sequential bioreactor, World Journal of Microbiology and Biotechnology, 21(8-9), 2005, 1439-1445.

7. Roy, A.K. and Chattopadhyay, S.N., Environment friendly pulping of jute, IPPTA J., 23(2), April – June, 2011, 197-199.

8. Environment Friendly Technologies for the Pulp and Paper Industry, Ed. Paymond A Yong and Masood Akhtar, John Wiley & Sons Inc. 1997.

9. Roy, A.K. and Chattopadhyay, S.N., Effect of accelerated ageing on paper made from cold soda pulping of jute, IPPIA J., 20(2), April – June, 2008, 123-126.

10. TAPPI Test Methods (Technical Association of Pulp & Paper Industry, New York) 1991, T-236 om-85, T404 om-87, T 403 om-85, T 423 om-89, t 414 om-88.

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