

White and Coloured Handmade Paper from Jute Waste by Ambient Temperature Process

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Single step pulping-bleaching and sequential two-step pulping-bleaching was carried out following conventional high temperature high-pressure digestion process and developed ambient temperature process. Hydrogen peroxide, an eco-friendly chemical, was used as a bleaching agent. The bleached pulps were dyed by ambient temperature reactive dyeing process. The bleached and dyed pulps were used for making white and coloured papers by handmade process. All these papers were evaluated for its different physical and optical properties. Single step ambient temperature bleached pulps produce papers with sufficiently high tensile index and bursting index. Whiteness index and brightness index of the papers produced is also high to be used as writing grade paper. Colouration of bleached pulp with reactive dye produce handmade paper with bright and pure colour to be used for different attractive packaging purpose. The process is simple, economic and eco-friendly as the different liquor containing different chemicals are reused and the process does not produce any toxic effluents. The process is ideal for small scale and cottage industries.

INTRODUCTION

The golden fibre jute, is a cellulose rich lignocellulosic fibre have a tremendous prospect for its use in the production of handmade paper to be used for packaging, speciality printing and creative arts¹. With the growth of population, education, culture and business, the need for both the mill made as well as handmade paper is increasing day by day. So, there is always a search for new raw material to cater the increasing demand and jute fibre waste has proved to be a good alternative in this regard^{2,3}. Handmade paper of brown colour is generally produced from jute wastes by different small and cottage industries located mainly in urban and village area, suffers from a variety of resource problems like finance, water, energy, skilled man power and technical know how. To

cater the need of the customer, it is necessary to produce bleached as well as coloured handmade paper at a reasonable cost. Moreover, the process must be eco-friendly, so that the produce is globally acceptable. Considering all these factors a process has been developed to produce handmade paper from jute at ambient temperature using eco-friendly chemicals. To economise the process, the chemicals have been reused. Due to recycling of chemicals, the effluent disposal is minimum making the process eco-friendly as well.

Materials and Methods

Materials

Jute fibre waste has been used as raw material for making paper. Hydrogen peroxide was used as a bleaching agent. Sodium silicate, sodium persulphate, sodium hydroxide, magnesium sulphate heptahydrate, EDTA, acetic acid, sodium carbonate etc. were used as bleaching assistants.

Colouration of the bleached pulp

were carried out at ambient temperature using as reactive dye namely, Procion Red M8B using sodium sulphate and sodium carbonate as dyeing assistants.

All the chemicals used were of AR grade.

Methods

Conventional pulping and paper making

Soda Pulping of jute fibre has been done in the digester at 150°C for 2 hours using 15% (on the weight of the material) sodium hydroxide. This was followed by beating of the pulp in the beater and finally paper making using handmade process.

Single-step bleaching-pulping by conventional process and paper making.

Bleaching agent and assistants were added in the white liquor and digestion of the fibre were done as the previous method. The pulps produced were used for making handmade paper after beating.

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Ambient temperature Pulping and paper making

Grey jute fibre and jute fibre pretreated with EDTA were soaked in the water and then pressed to retain 100% moisture. It was kept for 24 hours. The fibres were then washed followed by beating in the beater for 1 hour. The pulps thus produced were used for making paper by handmade process.

Single step ambient temperature pulping-bleaching and paper making⁴.

Jute fibres of EDTA pretreated jute fibres were soaked in a liquor containing bleaching agent and bleaching assistants for 10 minutes. The fibres were then pressed to impart 100% liquor add on and kept for 24 hours. The fibers were then washed followed by beating in the beater for 1 hour. The pulp thus produced were used for making bleached paper by handmade process.

Two-step sequential process of pulping-bleaching and paper making.

Pulps were prepared by digestion process and ambient temperature process with EDTA pretreatment. These pulps were then bleached by ambient temperature hydrogen peroxide bleaching process developed by NIRJAFT. These bleached pulps were then beaten in

the better followed by paper formation by handmade process.

Colouration of pulp^{5,6}.

Ambient temperature processed-bleached pulp were placed in the beater and beaten for 10 minutes using 1:5 liquor ratios. Then required amount of reactive dye (8% owf) and glaubers' salt were added and beating continued for another 45 minutes. Then sodium carbonate is added for fixation of dye into the fibre and further beaten for another 45 minutes. After colouration, the pulps were washed thoroughly and then paper sheets were made using hand-made process.

Evaluation of paper

All the papers produced i.e. brown, bleached and dyed papers were conditioned and then following physical and optical properties were evaluated using standard testing procedures.

- a) Tensile Index
- b) Bursting Index
- c) Whiteness Index
- d) Yellowness Index
- e) Brightness Index
- f) K/S value
- g) λ_{max}
- h) Reflectance(%)

RESULTS AND DISCUSSION

Jute, being a lignocellulosic fibre contains about 60% cellulose, 22% hemicellulose, 12% lignin, etc. is an

ideal raw material for making pulp and paper. The fibre being cellulose rich, paper from jute can be prepared either by digestion method or without digestion. Handmade paper is mainly produced by artisans without digestion and they prefer different fibre waste including jute. Single-step process of pulping and bleaching was therefore studied for jute at ambient temperature and for comparison, conventional digestion method was also carried out. In every case control pulp i.e. without bleaching was also prepared. The test results of papers produced from each pulp have been tabulated in table 1-4.

It is clear from the table-1 that the tensile index and bursting index is high in case of hot digestion process. This may be due to the preferential removal of lignin and small chain hemicellulose/cellulose fraction which results in cellulose rich pulp producing paper of higher strength. Ambient temperature process also removes impurities along with short length fraction of its different chemical constituents and produces pulp, which can be effectively used for making handmade paper of sufficient strength to be used for different purposes earmarked for it. EDTA pretreatment is found to have some positive effect on the tensile and busting properties of the paper produced from it as its tensile and bursting index is higher than the

Table-1: Comparison of physical and optical properties of the papers produced from pulp by conventional digestion process and ambient temperature process.

Treatment	Strength properties of the paper		Optical properties of the paper		
	Tensile Index (N.m/g)	Bursting Index (Kpa.m ²)	Whiteness Index (HUNTER)	Yellowness Index (ASTM D-1925)	Brightness Index (TAPPI 45)
Hot digestion process	34.51	3.67	62.35	33.66	24.28
Ambient temp. process	17.87	2.53	62.95	32.65	34.64
Ambient temp. process with EDTA pretreatment	20.41	2.76	66.51	25.05	40.43

Table 2: Comparison of physical and optical properties of the papers produced from pulp by two-step sequential process of pulping-bleaching either by hot digestion or ambient temperature process.

Two-step sequential bleaching-pulping process	Strength properties of the paper		Optical properties of the paper		
	Tensile Index (N.m/g)	Bursting Index (Kpa.m ²)	Whiteness Index (HUNTER)	Yellowness Index (ASTM D-1925)	Brightness Index (TAPPI 45)
Hot digestion process	32.17	3.56	70.94	20.97	48.29
Ambient temp. process	18.78	2.82	82.16	18.52	62.81
Ambient temp. process with EDTA pretreatment	23.17	2.99	83.42	8.08	70.21

paper produced without pretreatment. So, this ambient temperature process can be utilised for making handmade paper where higher bursting strength is required particularly for packaging. All the papers show low whiteness and brightness indices while yellowness index is high. These papers are generally termed as brown papers.

Detail analysis of the table-2 indicate that there is a tendency of decrease in tensile and bursting index values of the paper produced by hot digestion method while the tensile index and bursting index values of the paper produced by ambient temperature pulping process improves. The preferential removal and modification of lignin in the later case may be responsible for increase in the tensile and bursting index values. For the other case only

lignin modification and further depletion of hemicellulose takes place leading to decrease in tensile and bursting index values. There is a substantial improvement of whiteness/brightness indices and fall of yellowness index of the papers produced after bleaching. It is seen that the whiteness and brightness index of the paper produced by ambient temperature process with EDTA pretreatment is maximum while the whiteness brightness indices are low in case of paper produced by hot digestion method followed by ambient temperature bleaching. Hot alkaline treatment during digestion process may be the reason for low whiteness and brightness index in this case.

It is clear from table-3 that the single step bleaching process using digestion method produces paper

with high tensile and bursting index but its optical properties are very poor i. e. low whiteness/brightness index and high yellowness index. So, inspite of using bleaching agent the paper produced is brown in colour. The black liquor produces from pulping completely consumes the bleaching agent and no bleaching agent is available for the fibre to make it white. In other two cases pulp produced is white and bright as the bleaching agent is preferentially reacted with the pulp. In case of EDTA pretreatment, the whiteness and brightness index of the paper produced in maximum as the metal present in the liquor is chelated which otherwise destroys a part of hydrogen peroxide. In the single step ambient temperature bleaching process, whiteness / brightness index of the paper

Table 3: Comparison of physical and optical properties of the papers produced from pulp by single step bleaching-pulping process either by hot digestion or ambient temperature process.

Single step bleaching pulping process	Physical properties of the paper		Optical properties of the paper		
	Tensile Index (N.m/g)	Bursting Index (Kpa.m ²)	Whiteness Index (HUNTER)	Yellowness Index (ASTM D-1925)	Brightness Index (TAPPI 45)
Hot digestion process	35.43	3.88	64.47	34.14	36.32
Ambient temp. process	20.46	3.01	79.53	9.38	65.84
Ambient temp. process with EDTA pretreatment	25.85	3.27	81.78	10.43	72.11

Table-4: Colour yield of the bleached paper produced by single-step or two-step method using reactive dye.

Bleached Pulp	Single step process			Two-step process		
	λ_{max} (nm)	K/S Value	RFL	λ_{max} (nm)	K/S Value	RFL
Hot digestion process	570	10.09	4.51	570	8.73	5.15
Ambient temp. process	530	10.16	4.48	530	7.45	5.94
Ambient temp. process with EDTA pretreatment	530	11.58	3.98	530	8.41	5.33

produced is slightly lower than that produced by two step process due to presence of dust, dirt and impurities present in the fibre in the earlier case. But the physical properties of the paper produced by single step ambient temperature bleaching pulping method is slightly higher than that produced by two-step ambient temperature method.

It is evident from table - 4, that the K/S Value of the paper is always on higher side in case of paper produced by single-step pulping-bleaching. process compared to its corresponding paper produced by two-step process of pulping-bleaching. Intimate contact of alkali for a longer duration in case of single step process results in the pulp with more open structure and accessible reactive sites, which ultimately help dye molecules to enter easily inside the fibre of the pulp and react with the more available reactive sites producing better colour yield. Colour yield is maximum in case of pulp produced by ambient temperature process with EDTA pretreatment and minimum in case of hot digestion in every case. It is also seen that the colour is bright and pure in case of the papers produced by ambient temperature process either by two-step or one step method as the λ_{max} of the dye and the dyed paper is same in these cases while the colour produced is duller in case of the paper produced by hot digestion method particularly in case of single step pulping-bleaching process.

So, it is possible to produce white

and coloured handmade paper by ambient temperature process with sufficiently high tensile and bursting indices for their use in packaging, specialty printing and creative arts. The colour of the paper produced is very fast and does not bleed in presence of moisture and water.

CONCLUSIONS

1. Single step pulping-bleaching to produce bleached paper is only possible, if ambient temperature process is used.
2. Colouration of pulp at ambient temperature can be done using reactive dyes on ambient temperature bleached pulp to produce bright and pure colour, which can be effectively used to produce coloured paper by handmade process.
3. Single step ambient temperature pulping-bleaching process is simple and cost effective than ambient temperature two-step pulping-bleaching process. The liquor left out after single step pulping-bleaching can be reused after compensation of chemicals.
4. Hydrogen peroxide bleaching and reactive dyeing, both are environment friendly process. The liquor left out after each process can be reused so that the effluent produced is minimum causing minimum pollution.
5. Ambient temperature single step pulping-bleaching process is simple, cost effective and ecofriendly. So, this technology is ideal for small scale and cottage industries to produce

handmade paper from jute. Different types of paper like white, brown and coloured can be produced without using any thermal energy for different end use requirements like packaging, specialty printing and creative arts.

REFERENCES

1. Ghosh, I.N., Debsarkar, N.L., Day, A. and Mitra, B. C., Some studies on pulping characteristics of jute and other allied non wood plant fibres for paper manufacturer in the Handmade Paper Mills, IPPTA J., 11(1), 27-36, 1999.
2. Sanyal, A. K. and Day, A., Scope of using agricultural residues in pulp and paper industry, IPPTA J., 19(2), 1982.
3. Day, A. and Pandey, S. N. Production of pulp and paper from jute and other agrowaste as raw material, Jute News,, 2 (1), 1990.
4. Chattopadhyay, S. N., Pan N. C. and Day, A., A wet processing of jute at ambient temperature, AATCC (American Association for Textile Chemists and Colourists) Review, 4(9), 24-27, 2004.
5. Chattopadhyay, S.N., Pan, N. C. and Day, A., Reuse of reactive dyes for dyeing of jute fabric, Bioresource Technology, 97(2), 77-89, 2006.
6. Ghosh, I. N., Chattopadhyay, S.N. and Mondal, S.B., Studies on dyeing of jute pulp to make coloured paper, IPPTA J., 16(1), 41-44, 2004.