

Effect of Accelerated Aging on Ambient Temperature Bleached & Dyed Paper from Cold Soda Pulp of Jute

Roy A K and Chattopadhyay S N

The increasing demand of handmade paper has left a big gap between the projected demand of 28000 tons in 2010 and the present production of 15000 tons. This gap can be reduced by introducing alternative ligno-cellulosic raw materials like jute and its byproducts. The small scale handmade paper units use cheap and user friendly technology and generally avoid heating system. With this in view NIRJAFT has developed a simple method of ambient temperature bleaching by hydrogen peroxide and dyeing by cold brand reactive dye of cold soda jute pulp for making white and coloured paper. These papers were subjected to accelerated ageing, which showed that ambient temperature bleached paper is more resistant to ageing than paper made from conventional method of bleaching. The fold number of ambient temperature bleached jute paper is much higher than the conventional bleached jute paper. The same trend was observed in case of the pulp bleached by ambient temperature process and dyed with cold brand reactive dye Procion Yellow M4G.

Key words: Accelerated ageing, Ambient temperature, Cold brand reactive dye, Cold soda process, Fold number, Hydrogen peroxide bleaching, jute fibre.

INTRODUCTION

We have a moral and intellectual responsibility not only to preserve our past heritage but also to ensure the survival of contemporary records of achievement for our posterity. As custodian of human heritage, we have the historic obligation to record our knowledge and history on durable and permanent paper. Quality of paper used in books and archives should not become yellow, fragile and brittle during lengthy storage in archives and libraries destroying written documents and printed publications. To achieve this we have to assess the age or shelf life of paper.

India has about 2795 handmade paper units (1) which are mainly based on cotton rags, hosiery cuttings and small quantities of waste paper. The increasing demand of handmade paper has left a big gap between the projected demand of 28000 tons in 2010 and the present production of 15000 tons (2). This gap can be reduced by introducing alternative ligno-cellulosic raw materials like jute and its byproducts.

Jute is an annual plant which grown mainly to the tune of about 1.5 million tons and this leaves a jute stick yield of about 3 million tons (3). Jute can be used as alternative raw material if we can produce permanent paper for archival paper from jute. To achieve this we have to assess the age or shelf life of jute based paper. The present

study was carried out to study the effect of accelerated ageing by the method developed by Preservation Research & Testing Division, Library of Congress, Washington DC, USA(4).

Jute based paper being ligno-cellulosic in nature is susceptible to ageing which is manifested by change in color or the strength properties of the white or colored paper. Study on the effect of accelerated ageing on cold soda jute pulp bleached by hydrogen peroxide at ambient temperature and dyed by cold brand reactive dye over different period of interval has yet not been reported.

Chemi-mechanical pulp of jute waste was made by the cold soda process. The NaOH causes swelling of the hemicellulose and the amorphous region of the fibre. No reaction with lignin is likely to take place during the NaOH pretreatment, but alkali reacts with the secondary wall, thus assisting in fibrillation of the S₁ and S₂ layers. Cold soda pulp was bleached by both conventional method and by the ambient temperature method and dyed with cold brand reactive dye procion Yellow G4M. All the bleached paper samples and the dyed paper samples were subjected to accelerated ageing for different period of interval i.e. 1, 2,3,4,5 and 7 days. Optical properties aged, physical properties and pH of the after samples along with the before aged samples were evaluated and analysed.

MATERIAL AND METHODS

Raw material / Cold soda pulp

Jute fibre was cut into 2-4 cm pieces and soaked in a 10 % NaOH solution at 1: 10 material to liquor ratio for 24 hours. The material was washed free of alkali and partially beaten in a valley beater. The yield of the pulp was 83% and the kappa number was 30.2%.

Conventional Bleaching of Cold Soda Pulp

A portion of the unbleached soda pulp was bleached in a covered vessel using H₂O₂ (20 ml/l) at 1: 20 material to liquor ratio, tri-sodium phosphate (5 g/l), NaOH (1g/l), sodium silicate (1g/l) and nonionic detergent (2g/l) for 1.5 h at 85-90° C. The pH was maintained at around 10. The bleached pulp was washed in normal water and neutralized with dilute acetic acid (2 g/l) and was given a final wash for further processing.

Ambient Temperature Bleaching of Cold Soda Pulp

A portion of unbleached cold soda pulp was bleached in a solution of H₂O₂ (100 ml/l) at 1:3 material to liquor ratio, trisodium phosphate (5g/l), NaOH (20g/l), sodium silicate (20g/l), sodium persulphate (10g/l), magnesium sulphate hepta hydrate (0.5g/l) and nonionic detergent (10g/l), the sample was squeezed to have a 100 % wet pick up and kept overnight at room temperature under cover. The bleached pulp was washed in normal water and neutralized with dilute acetic acid (2g/l) and was given a final wash with water for further processing.

*National Institute of Research on Jute & Allied Fibre Technology (ICAR)
12 Regent Park, Kolkata-700040*

Dyeing of Ambient Temperature Bleached Cold Soda Pulp

The bleached pulp was dyed in an open bath with cold brand reactive dye Procion yellow M4G (4% on weight of material) containing Sodium sulphate (60g/l) using 1:20 material to liquor ratio at ambient temperature for 1 hour. Then sodium carbonate (20 g/l) was added to the bath and dyeing continued for another 1 hour. The pulp was then washed thoroughly and then soaped in non-ionic detergent (5 g/l) at 40° c for 30 minutes, followed by a final wash.

Handmade Paper and Standard Hand Sheet

Handmade paper sheets and standard hand sheets of 60 GSM were made from the conventional bleached pulp; ambient temperature bleached pulp and dyed pulp. The pulp were beaten in a Valley Beater to the standard freeness and paper sheet were made using an auto vat and a hand sheet former (Universal Engineering Corporation, Saharanpur).

Accelerated Ageing

All the paper samples i.e., unbleached, bleached and dyed paper samples were sealed in air tight containers and subjected to accelerated ageing in an oven at 100° C following the method adopted by at Preservation Research & Testing Division, Library of congress, Washington DC, USA (4). The moisture content of the conventional bleached jute paper, ambient temperature bleached paper and dyed paper were 6.18%, 5.71% and 10.79% respectively.

pH Measurement

Paper samples (1g sample) were cut in to 2-3 mm size and soaked in 70 ml of distilled water for 1 hour and the pH was measured in Eutech CyberScan PCD 6500 apparatus.

Evaluation of Optical Properties

Optical properties of the paper samples before and after subjecting them to accelerated ageing were evaluated for 457 nm Brightness, Whiteness Index E 313(D65/10), Yellowness Index E 313 (D65/10) and Post colour number $\{100 \times (K/S)_{\text{After Ageing}} / (K/S)_{\text{Before Ageing}}\}$, K= Co-efficient of absorption, S= Co-efficient of scattering } in HunterLab LabScan XE Brightness tester.

Evaluation of Physical Properties

Tensile Index, Bursting Index and

Double fold (Schopper type) were evaluated in Tensile Strength Tester Veb Thuringer Industrierwerk, Raunstein (Germany), Double Fold Tester, Veb Werkstoffpriiuma Schinen, Leiplig (Germany) and Bursting Strength Tester by Ubique Enterprises, Pune.

RESULTS AND DISCUSSION

Detailed analysis of table 1 and fig. 1 showed that in case of ambient temperature bleached paper of cold soda pulp of jute the loss of whiteness index and increase of post color number i.e., yellowing or colour reversion is drastic beyond 3 days of exposure. This is also corroborated by the sharp fall of the pH curve and the fold number of strength properties vide table 4 and fig.s 4 &5 of ambient temperature bleached paper of cold soda pulp of jute. Whereas, in case of conventional

bleached jute paper wide table 2 and fig. the loss of whiteness index and increase of post colour number is drastic beyond 2 days of exposure. This is also corroborated by the pH curve and the fold number or strength properties curves, as revealed by a sharp fall beyond 2 days of exposure in table 5 and fig. 6&7. Thus ambient temperature bleached paper is more resistant towards ageing compared to the conventional bleached paper of cold soda pulp of jute. The fold number of the ambient temperature bleached cold soda jute paper is much higher compared to the conventional bleached cold soda jute paper.

Better resistance to ageing and the higher fold number of the ambient temperature bleached jute paper may be because of the use of low temperature and higher alkalinity adopted in the bleaching process.

Table 1 : Effect of Accelerated Ageing on Ambient temperature Bleached Cold Soda Jute Paper

Samples	Time Days	457 nm Brightness	Whiteness Index WI E313 (D65/10)	Yellowness Index YI E313(D65/10)	k/s	Post color No. $100 \times (K/S)_{\text{AA}} - (K/S)_{\text{BA}}$
Ambient Temperature Bleached Paper	Day 0	51.28	-10.07	31.17	0.30	0
	Day 1	37.25	-46.13	41.52	0.66	36
	Day 2	34.71	-51.13	42.75	0.78	48
	Day 3	30.28	-63.34	45.91	1.01	71
	Day 5	17.56	-103.16	57.17	2.60	230
	Day 7	16.59	-115.51	60.98	2.90	260

AA = After Ageing, BA = Before Ageing

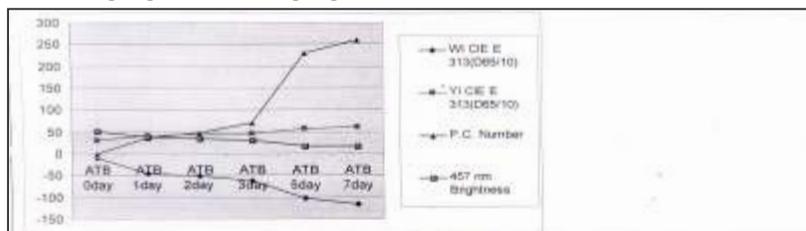


Fig. 1 Effect of Accelerated Ageing on Optical Properties of Ambient Temperature Bleached Jute Paper

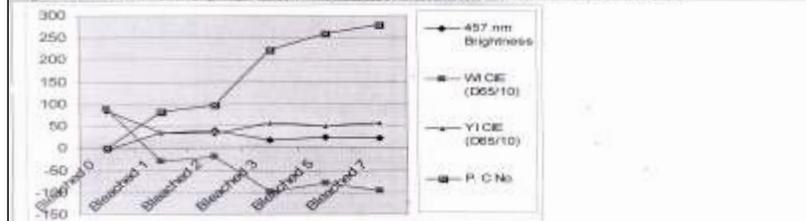


Fig. 2 Effect of Accelerated Ageing on Optical Properties of Conventional Bleached Jute Paper

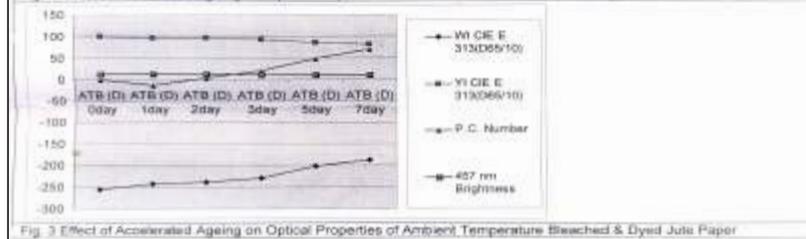


Fig. 3 Effect of Accelerated Ageing on Optical Properties of Ambient Temperature Bleached & Dyed Jute Paper

Table 2 : Effect of Accelerated Ageing on Conventional Bleached Cold Soda Jute Paper

Samples	Time Days	457 nm Brightness	Whiteness Index WIE 313 (D65/10)	Yellowness Index YI E313 (D65/10)	k/s	Post color No. $100 \times (K/S)_{\text{AA}} - (K/S)_{\text{BA}}$
Bleached Paper	Day 0	84.61	92.75	-3.03	0.74	0
	Day 1	45.10	0.66	25.82	1.57	82
	Day 2	40.46	-17.94	32.23	1.71	97
	Day 3	23.65	-78.60	49.80	2.97	223
	Day 5	21.98	-97.68	55.81	3.33	259
	Day 7	17.52	-99.07	56.69	3.52	278

AA = After Ageing, BA = Before Ageing

Table 3 : Effect of Accelerated Ageing on Ambient temperature Bleached & Dyed Cold Soda Jute Paper.

Samples	Time Days	457 nm Brightness	Whiteness Index WI E313 (D65/10)	Yellowness Index YI E313 (D65/10)	k/s	Post color No. 100x (K/S _{AA} - K/S _{BA})
Ambient Temperature Bleached Dyed Paper	Day 0	12.67	-254.66	99.22	4.00	0
	Day 1	12.5	-243.22	96.46	3.97	-13
	Day 2	12.47	-239.77	96	4.03	3
	Day 3	11.98	-229	92.42	4.21	21
	Day 5	11.26	-202.21	85.04	4.49	49
	Day 7	10.71	-186.29	81.06	4.71	71

AA = After Ageing, BA = Before Ageing

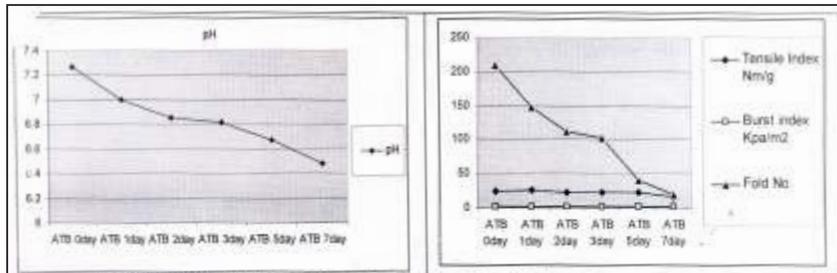


Fig. 4 & 5 Effect of Accelerated Ageing on pH and Strength Properties of Ambient Temperature Bleached Jute Paper

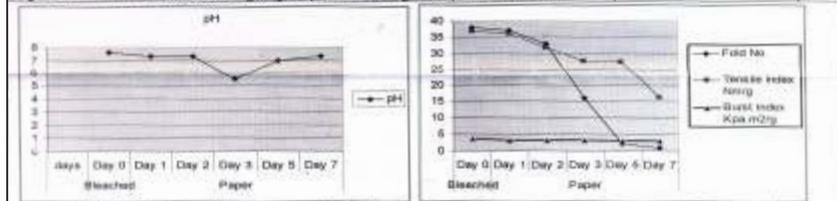


Fig. 6 & 7 Effect of Accelerated Ageing on pH and Strength Properties of Conventional Bleached Jute Paper

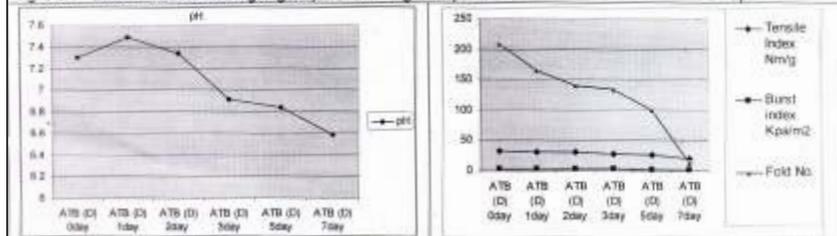


Fig. 8 & 9 Effect of Accelerated Ageing on pH and Strength Properties of Ambient Temperature Bleached & Dyed Jute Paper

Table 4 : Effect of Accelerated Ageing on pH and strength Properties of Ambient Temp. Bleached Cold Soda Jute Paper.

Samples	Time Days	pH	Tensile Index Nm/g		Burst Index Kpa.m ² /g		Fold No.	
				% Loss		% Loss		% Loss
Ambient Temperature Bleached Dyed Paper	Day 0	7.27	24.52	-	2.02	-	210	-
	Day 1	7	25.9	-	2.28	-	147	30
	Day 2	6.85	22.58	7.9	2.04	-	112	46.6
	Day 3	6.82	23.1	5.7	1.68	16.8	102	51.4
	Day 5	6.67	22.45	8.4	1.78	11.8	40	80.9
	Day 7	6.48	16.99	30.7	1.6	20.7	19	90.9

Table 5 : Effect of Accelerated Ageing of pH and strength Properties of Conventional Bleached Jute Paper

Samples	Time Days	pH	Tensile Index Nm/g		Burst Index Kpa.m ² /g		Fold No.	
				% Loss		% Loss		% Loss
Bleached Paper	Day 0	7.60	36.70	-	3.67	-	38	-
	Day 1	7.31	36.19	1.3	3.31	9.8	37	2.6
	Day 2	7.30	31.72	13.5	3.26	11.1	33	13.15
	Day 3	5.51	27.57	24.8	3.14	14.4	16	57.8
	Day 5	6.98	27.34	25.5	3.06	16.6	2	94.7
	Day 7	7.34	16.34	55.4	3.06	16.6	1	97.3

Table 6 : Effect of Accelerated Ageing on pH and strength Properties of Ambient Temp. Bleached & Dyed Paper

Samples	Time Days	pH	Tensile Index Nm/g		Burst Index Kpa.m ² /g		Fold No.	
				% Loss		% Loss		% Loss
Ambient Temperature Bleached & Dyed Paper	Day 0	7.3	33.34	-	2.92	-	209	-
	Day 1	7.49	31.65	5.0	2.81	3.7	165	21.0
	Day 2	7.34	31.01	6.9	2.74	6.1	141	32.5
	Day 3	6.91	28.51	14.4	2.62	10.2	134	35.8
	Day 5	6.84	26.00	22.0	2.11	27.7	100	52.1
	Day 7	6.58	18.94	33.56	1.46	50.0	13	93.7

Similar trend is observed in the case of the ambient temperature bleached and dyed with cold brand reactive dye Procion Yellow M4G. Table 3 and fig. 3 showed that the drastic change in the whiteness index and the fall in the post colour number is observed beyond 5 days of exposure. This is corroborated by the sharp fall in tensile index, burst index, fold number and the pH value beyond 5 days of exposure, vide table 6 and figs. 8 & 9. This may be due to the introduction of the cold brand reactive dye which give resistance to ageing of the dyed paper. The fold number of the ambient temperature bleached & dyed paper is much higher compared to the conventional bleached cold soda jute pulp and dyed with direct dye Chlorantine Fast Yellow TGLL(5).

CONCLUSION

- Ambient temperature bleached cold soda jute paper is more resistant towards ageing compared to the conventional bleached cold soda jute paper.
- Conventional bleached cold soda jute paper is highly susceptible to accelerated ageing.
- Paper from ambient temperature bleached cold soda jute and dyed with cold brand reactive dye showed minimum susceptibility towards ageing.
- The fold number of the ambient temperature bleached cold jute paper is much higher compared to the conventional cold soda bleached jute paper.

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