ENVIRONMENTAL SCIENCE ARCHIVES
ISSN: 2583-5092
Volume II Issue 2, 2023
www.envsciarch.com

RESEARCH PAPER OPEN ACCESS

Study on Strength Behaviour of Handmade Paper Treated by Sizing Material 'Rosin'

HM Zakir Hossain[1], SMB Rahman[2], MM Rashid[1], Jahid Sarker[1] and Mahmuda Khatun[1]

[1]Bangladesh Jute Research Institute (BJRI), Manik Mia Avenue, Dhaka, Bangladesh
[2]Jahangirnagar University, Savar, Dhaka, Bangladesh
Correspondence and requests for materials should be addressed to HMZH (email: zakir1@bjri.gov.bd)

Received: 2022/06/12
Accepted: 2023/05/15
Published: 2023/07/03

Abstract

With a view to fabricating prominently strong handmade paper, MCC suspension (exterior additive), wax emulsion (interior additive) and reinforcement were applied with rosin. Optimal outcome was achieved on application of rosin incorporated with alum (internal additive) and MCC suspension. The strength was enhanced by 24.23% on rosin-alum treatment and use of MCC suspension. It was also noticed that use of rosin along with wax always lowered the strength.

Keywords: Handmade; Jute; Paper; Sizing material; Rosin

Introduction

The environment and economy of Bangladesh is under danger for usage of Polypropylene (PP) and Polyethylene (PE) wrapping materials. Plastic is the main culprit (Singh, 2022). Apparently vast amount of our soil is engaged daily by non-degradable polybags which degrades the fertility of land and resulting flood in Bangladesh due to obstruction the flow of rain water. In these circumstances, innovation of a disgraced natural wrapping material is very essential and paper prepared with low-priced jute fibre to get elevated strength and lofty water hating quality can be a way out. Besides this, due to inroads of synthetics, the utilization of jute as packaging purpose has been decreased (Mohammad, 2010). On the other hand, requirement of non-wood plant fibres as raw material has been being amplified day by day (Atchison, 1990; Chandra, 1997). Hence, by using jute as the raw material of paper, the application of jute could be diversified.

It has been shown that when MCC in the shape of regenerated cellulose gel is mixed with bleached kraft pulp to produce hand sheet (Hand towel), the mechanical properties (Young Modulus, Tensile Index, Tear indices & Folding Endurance) of hand sheet are improved (Isogai,1997). The tensile strength and folding endurance of hand sheet are enhanced when blown up starch pulp are applied with wood pulp owing to reinforcing impact of starch pulp on inter fibre cohesion among timber pulps. There had a synergistic effect on the boost in folding endurance when poly-amidiamine epicholohydrin resin (PAE is applied with blown up starch pulp (Suzuki et al., 1997). The impact of MCC, CMC and combination of MCC and CMC on hydrophobic character of paper produced from jute was studied. It has been found that the water repulsive property of handmade paper was improved for treating with MCC deferment. Blend of CMC solution and MCC suspension (50:50), enhances the hydrophobic nature usually for enhancing MCC concentration in the mixture but the hydrophobic nature is declined with the raise of CMC density in the mixture (Hossain et al., 2006a, 2006b).

It has been stated that application of glutaraldehyde and poly vinyl alcohol not only improved wet strength of paper but also significantly increased the strength, tensile energy, absorption and folding endurance of treated paper (Abdullah et al., 1978). An Egyptian filler substance 'Talc' customized with phthalic anhydride was applied as interior sizing resulted enhanced mechanical

and optical properties of sized hand-sheets (Ibrahim et al, 2009).

In the present study, interior sizing material 'rosin' (generally used water repulsive compound in stock sizing) along with MCC suspension (exterior additive), wax emulsion (interior additive) and reinforcement were applied for producing handmade paper of elevated power.

Materials and methods

Bangladesh Jute Research Institute and Mennonite Central Committee provided with jute fibre (Bangladesh white B) and chemicals with laboratory facilities respectively. Seven experiments were performed, such as:

Experiment-01: Preparing control paper avoiding sizing/ reinforcement.
Experiment-02: Formulating paper with rosin incorporated with alum as interior sizing.
Experiment-03: Formulating paper by means of inner sizing (rosin-alum) and introducing jute fibre as reinforcement.
Experiment-04: Producing paper with rosin-alum and wax emulsion as inner sizing.
Experiment-05: Formulating paper with rosin-alum' wax emulsion as interior sizing and introducing jute fibre as reinforcement.
Experiment-06: Producing paper with rosin-alum as inner sizing and MCC as exterior sizing.
Experiment-07: Making paper with rosin-alum as inner sizing and introducing jute fibre as reinforcement along with MCC as outer sizing.

Table 1: Preparation parameters for various experiments

Experiment No.	Condition for Pulp Preparation		p^H following Washing	p^H with Additives	Remarks
	Temperature °C	Relative Humidity (%)			
1	27.0	47	7.5	5.5	No additive used
2	28.4-28.7	39-50	6.5	5.5	Rosin-alum
3	28.4-28.7	39-50	7.5	5.5	Rosin-alum and jute fibre
4	30.5-31.0	30-33	7	5.5	Rosin-alum and wax
5	31.1-31.5	27-33	7.5	6.5	Rosin-alum, wax and jute fibre
6	28.4-28.7	39-50	6.5	5.5	Rosin-alum and MCC
7	28.4-28.7	39-50	7.5	5.5	Rosin-alum,jute fibre and MCC

Fiber sample preparation

The fibers were cleaned cautiously to remove barks and roots. These cleaned fibers were cut to the dimension of 0.5 - 1.0 inch.

Making Pulp

***Boiling*:** 18 gm of caustic soda (6% of the material) was dissolved in 10 (ten) litre water by boiling. The quantity of water was maintained about 10 litre throughout the entire steaming process. As soon as water touched the boiling temperature, cut fibers (300g) were engaged in the hot water of a open tube and boiling was continued for 4 hours to remove some impurities as may be soluble in mild alkalis at moderately high temperature as well as to soften and condition the fiber. After the fibers had been sufficiently boiled, they were thoroughly rinsed in water until the effluent was nearly clear. The length of washing time was so adjusted that the fiber/ stock will be as clean as possible with a minimum of fiber loss.

***Beating*:** The cleaned jute fibers were placed in the open vessel of the beater along with 70 kg of fresh water. The fibers were converted into a pulp through cutting and beating in beater for 2.25 -2.5 hours. The pulp was keep standing for 17.25 hours. Then pulp was washed to maintain pH 7.

***Internal Sizing*:** The pulp after wash was treated with various sizing procedures to improve strength and hydrophobic character of the papers to be formed. Pulp was reserved in an open bucket containing 20 litre of water.

1.5% Rosin (on the weight of fibre material) soap solution was added and moved 5 minutes using a blender. After 30 minutes, 3% alum solution was added, and it was agitated for an additional 5 minutes. The mixture was blended for 5 minutes following addition of 1.5% Rosin soap. Then 0.75% was emulsion was added (after 30 minutes) and agitated for a further five minutes. 3% alum solution was then added and moved for 5 minutes. The pulp was reserved for 20 minutes following the application of internal sizing.

Rosin is the most generally used water repulsive compound in stock sizing, Rosin**,** also known as Greek pitch or colophony (Lattin: *pix græca*), is a solid resin form derived from conifers, primarily pines, and other plants. It is created by vaporizing the volatile liquid terpene components in fresh liquid resin by heating it. Its hues range from yellow to black and are semi-transparent in nature. Rosin is breakable at room temperature and dissolves when heated to a stovetop. It is mostly made up of several resin acids, especially abietic acid.

Rosin size soap Preparation: 500g of crushed rosin was consumed. 50g of NaOH (rosin powder containing 10%) was dissolved by heating in to 1 liter water. Initially Rosin powder was converted into paste by including a few hot caustic soda solutions. Rosin soap was made by mixing the remaining rosin paste and caustic soda solution and boiled 30 minutes.

***Rosin Size Solution Preparation*:** 4.5gm (1.5% on the weight of fibre material) rosin soap was selected and solution was formulated simply combining hot water and Rosin soap.

***Alum Solution Preparation*:** 9gm (3% on the weight fiber material) alum was selected and alum solution was made by adding hot water.

***Preparation of wax solution*:** 2.25g (0.75% on the weight of fiber) liquid paraffin wax was mixed in water by stirring in a blender. No emulsifier was used.

***Washing of pulp/stuff*:** The stuff after unloading from beater was kept on a net to allow the liquid to be drained out. The stuff was adequately washed in water so that the materials would be in neutral condition.

***Determination of pH*:** pH is the indirect measurement of the substance's chemical condition showing the degree of acidity or alkalinity was measured by pH paper.

***Lifting*:** A vat containing 20 litres of water was filled up with 1 liter of 0.05% polyamide solution. Pulp was floating evenly in water of lifting vat. Pulp was taken utilizing a lifting net, from the lifting vat in sheet form or lap form, and reserved on a bed table one after the other using pieces of cloth as separators.

***Reinforcement of fiber*:** Jute fiber filaments collected from carded BTB jute slivers were manually introduced between two pulp layers. The space between fibers (both vertically and horizontally) was kept 2.54cm.

***Pressing*:** The pulps in lap form were pressed for 15 minutes by hydraulic press having a capacity of 10 ton to from paper sheet.

***Paper drying*:** The created papers were sun-dried.

***Calendaring*:** After drying, the paper sheets became distorted. It was made flat by calendaring.

***External sizing*:** Firstly, MCC suspension at 0.5% (10g MCC in 2000 cc water) was made. Paper samples were waterlogged in the suspension of MCC for 1 minute. Then samples were cured in the sun.

Test of the Properties

The mechanical and physical characteristics of paper like thickness, GSM, tearing strength, Cobb water absorptivity, folding endurance were measured for each experimental group in the standard temperature and humidity for paper (Temp=23°C, RH=50%) according to TAPPI standard test methods[09-10] after conditioning for 3 days according to TAPPI T402 gm-93. Samples were cut from different sheet (one from each sheet) for every experiment.

***Thickness*:** 10 samples (10cmX10cm) were selected for each experiment. Thickness was determined by vernier calipers following TAPPI T4410m-97. At least five readings were taken from each sample and results were recorded in mm.

***GSM*:** 10 Samples (10cmX10cm) for every experiment were used. The sample weight taken by electronic weighing device, and these were multiplied by 100 to get the sample weight in Grams per Square Meter (GSM).

***Tearing strength*:** 10 samples (7.6 cmX6.3 cm) were taken. Tearing strength in gm-f was measured according to TAPPI. T414 om-98. Test specimens were cut accurately in each principal direction of the paper about 7.6 cm in length by exactly 6.3 cm in width, with slit to be cut 20mm in length, leaving exactly 43 mm between the end of the slit and the edge of the specimen. The machine was leveled and adjusted before each set of tests. The pendulum was positioned to test position. Test specimen was placed mid-way in the clamp with its upper edge parallel to the tops of the jaws and the handle was pushed downward to make the slit. The scale reading was found between 20 and 60 when single sheet was torn. Five reading were recorded for each principal direction of the paper (i.e. vertical and horizontal). The readings were rejected where tear line deviates more than 10 mm from the line of initial slit.

The tearing force and tearing index could be obtained by the following formula:
For the standard 1600-gf instrument with 0-100 scale

$$\text{Average tearing force, gf} = \left(\frac{16 \times \text{average scale reading}}{\text{Number of plies}}\right)$$

$$\text{Average tearing force, mN} = \left(\frac{16 \times 9.81 \times \text{averages calereading}}{\text{Number of plies}}\right)$$

Tearing Index =E/w

Where, E = The force in mN to tear a single ply
W = Grammage in g/m² (Oven dry wt.)

Results and Discussion

It was noticed that the average paper's GSM and thickness were 0.32 and 185.46mm respectively (Table 2). As the CV% of paper thickness (among tests) ranged from 7.37% to 22.38 percent, the mean paper thicknesses varied widely and the CV% (between experiments) was 13.16%. The mean GSM of paper also differed as the SD% was 4.81%-16.97% (inside experiment) and that amongst experiment was 8.85%. The variation in thickness and GSM was due to want of evenness in lifting.

It was found that the paper strengths were increased due to treatment by rosin in all but one (Experiment no.4) case where wax was applied on fibre as external sizing. The improvement in strength due to reinforcement was unexpectedly low (Experiment no. 3) due to want of cohesion among reinforcing fiber and pulp as well as long distance between the reinforcing fibers.

The application of rosin along with MCC suspension increased the tensile strength of paper in all cases and optimum result was found when the pulp was treated with rosin and suspension of MCC was added as exterior additive (Experiment no-6).

Table 2: Test results of handmade papers from Jute fibres

Exp. No.	Thickness(mm)				GSM(Gm/m²)				Tearing Strength Test	
	$Mean_w$	CVw (%)	$Mean_b$	CVb (%)	$Mean_w$	CVw (%)	$Mean_b$	CVb (%)	Tear Index mN.M²/Gm	Strength Increased (%)
1	0.28	11.16			175.8	09.84			33.93	-
2	0.30	09.31			181.4	06.03			40.75	20.10
3	0.35	14.29			202.9	16.97			35.43	04.42
4	0.28	10.47	0.31	13.16	163.5	09.71	182.31	8.85	33.22	-2.09
5	0.27	11.39			163.6	06.27			34.16	00.68
6	0.32	07.37			187.7	04.81			42.15	24.23
7	0.38	22.38			201.3	15.00			36.96	08.93

Tearing Index = Tearing Force (mN)/GSM (Gm/M²)
Experiment–01 : Control
Experiment –02 : Rosin+ Alum
Experiment –03 : Rosin + Alum+ Fiber Reinforcement
Experiment –04 : Rosin+ Alum +Wax as internal additive
Experiment –05 : Rosin+ Alum+Wax as internal additive+Fiber Reinforcement
Experiment-06 : Rosin+ Alum+ MCC (exterior stabilizer)
Experiment -07 : Rosin + Alum+ Fiber Reinforcement+ MCC as a supplement.

Conclusion

Introducing MCC suspension as an external additive and rosin-alum as an internal additive give the Handmade Paper 24.23% more strength compared to traditional method. Properties like GSM, thickness, are slightly increased but not significant after treatment by MCC suspension and rosin-alum. Thus, the finding of the study suggests a proper use of MCC suspension as an external additive and rosin-alum as an internal additive for manufacturing handmade paper having high strength property. Handmade jute paper is bio-degradable and environment friendly. It may be a possible replacement for polypropylene for packaging material.

References

Abdullah, Khan and Salam (1978) Preparation of Microcrystalline Cellulose from Jute. Bangladesh Journal of Jute and Fibre Research 12(3): 39-43.

Atchison JE (1990) Worldwide capacities of non-wood plant fibre pulping increasing faster than wood pulping capacities. TAPPI Nonwood plant fibre Pulping Progress Report 19:1-7.

Mudit C (1997) Use of non-wood plant fibres for Pulp and Paper industry: Focus on China. Masters' dissertation, Virgina Polytechnic Institute and State University, Virgina, USA.

Hossain HMZ, Mollah, Rahman ME, et al. (2006) Application of Micro-crystalline cellulose to Increase the Hydrophobic Property of Paper Produced from Jute Waste. Bangladesh Journal of Jute and Fibre Research 16(1-2): 12-17.

Hossain HMZ, Mollah, Rahman ME, et al. (2006) Modification of Handmade Paper from Jute by CMC in mixture with MCC suspension for Increasing Hydrophobic Property. Bangladesh Journal of Jute and Fibre Research 16(1-2):18-23.

Ibrahim MM, Mobarak F, El-Din EIS, et al. (2009) Modified Egyptian talc as internal sizing agent for paper making carbohydrate polymer 75(1): 130-134.

Isogai A (1997) Properties of hand sheets containing cellulose regenerated from cellulose/aquous NaOH solution. Journal of the Society of Fiber Science and Technology, Japan 53(3): 25-31.

Mohammad A (2010) Modification of jute fibre and fabrics-Bangladesh 11(9-10): 20.

Singh Z (2022) Microplastics are Everywhere. Environ Sci Arch 1(1):1-3.

Suzuki T, Isogai A and Onabe F1(997) Properties of hand sheets containing starch pulp prepared with variou wet-end additives. Journal of the Society of Fiber Science and Technology, Japan 53 (10): March 1997 (Abstracted in Textile Research Journal, USA. October-1997).

TAPPI Test method (1993) Standard Conditioning and testing atmospheres for paper, paper board, pulp handsheet and related products T402 om-93.

TAPPI Test method (1998) Water absorptivenes of sized (non-bibulous) paper, paper board and corrugated fiber board (Cobb test) T441 om-98.

Author Contributions
HMZH, SMBR, MMR, JS and MK conceived the concept, wrote and approved the manuscript.

Acknowledgements
Not applicable.

Funding
There is no funding source for the present study.

Availability of data and materials
Not applicable.

Competing interest
The authors declare no competing interests.

Ethics approval
Not applicable.

Citation: Hossain HMZ, Rahman SMB, Rashid MM, Sarker J and Khatun M (2023) Study on Strength Behaviour of Handmade Paper Treated by Sizing Material Rosin. Environ Sci Arch 2(2):91-96.