World Journal of Advanced Engineering Technology and Sciences

eISSN: 2582-8266

Cross Ref DOI: 10.30574/wjaets

Journal homepage: https://wjaets.com/

(Research Article)

Investigating the properties of rubbing fastness in jute-cotton blended pigment-printed fabric

Mahmuda Khatun [1], Shuranjan Sarkar [1,*], Mohammad Abdus Salam Khan [1], Ariful Islam [2] and Asib Iqbal [2]

[1] *Product Development Division, Jute Textile, Bangladesh Jute Research Institute, Dhaka, Bangladesh.*
[2] *Pilot Plant and Processing Division, Technology Wing, Bangladesh Jute Research Institute, Dhaka, Bangladesh.*

World Journal of Advanced Engineering Technology and Sciences, 2024, 11(01), 119–125

Publication history: Received on 24 December 2023; revised on 02 February 2024; accepted on 05 February 2024

Article DOI: https://doi.org/10.30574/wjaets.2024.11.1.0043

Abstract

Jute and cotton, both being natural cellulosic fibers, can be blended together to create a sustainable fabric that offers a new addition to the market. In this particular study, the focus was on investigating the fastness properties of jute-cotton blended pigment printed fabric. Fastness properties are crucial for any colored fabric, including jute-cotton blended ones, as they determine the fabric's ability to retain its color and resist any changes caused by external factors. The study examined the rubbing fastness of five different jute-cotton blended pigment printed fabrics. Rubbing fastness refers to the fabric's resistance to color staining and color change when subjected to rubbing or friction. The results of the rubbing fastness tests were evaluated on a grey scale, and they ranged between 3 and 5, indicating varying degrees of staining and color change. Additionally, other important parameters such as Ends per Inch, Picks per Inch, Gram per Square Meter (GSM), and air permeability were measured for the jute-cotton blended pigment printed fabric samples. Ends per Inch and Picks per Inch refer to the number of warp and weft threads per inch, respectively, and they contribute to the fabric's overall density and strength. The GSM, which measures the weight of the fabric per square meter, ranged between 191 and 285 for the samples. Furthermore, the air permeability, which indicates the fabric's breathability, ranged from 614 $m^3/m^2/h$ to 1628 $m^3/m^2/h$.

Keywords: Jute; Cotton Blended-Fabric; Printing; Fastness

1. Introduction

Jute, a type of bast fiber, is obtained from plants belonging to the *Tiliaceae* family, specifically the *Corchorus* species. Its scientific name is *Corchorus capsularis* [1-3]. Renowned for its affordability, jute is the most extensively cultivated bast fiber at present. This plant fiber primarily consists of lignocellulose and is commonly referred to as "Golden Fibres." It is predominantly grown in India, Bangladesh, and the surrounding subcontinent [4-6]. The chemical composition of jute fiber includes cellulose, hemicelluloses, lignin, and small quantities of other components like protein, mineral matter, pectin, and aqueous extract. Cellulose makes up the majority of jute fiber, accounting for approximately 58-63% of its composition. Hemicelluloses, another important component, make up around 20-24% of the fiber. Lignin, a complex polymer, constitutes approximately 12-15% of jute fiber. In addition to these major components, jute fiber also contains small amounts of protein (around 2%) and mineral matter (approximately 1%). Pectin, a type of polysaccharide, is also present in jute fiber [7-9]. Aqueous extract, which includes various soluble compounds, is another minor component of jute fiber. The unique chemical composition of jute fiber contributes to its desirable properties. The high cellulose content gives jute its strength and durability, making it suitable for a wide range of applications. The presence of hemicelluloses and lignin adds to its flexibility and resistance to microbial degradation. The protein content provides some natural resistance to pests and insects. Jute fiber is widely used in the production of various products, including sacks, bags, ropes, carpets, and textiles. Its affordability, biodegradability, and eco-friendliness make it a popular choice in industries such as agriculture, packaging, and home furnishings. The versatility of jute fiber, combined with its

*Corresponding author: Shuranjan Sarkar

sustainable nature, has led to increased demand and cultivation of jute plants in recent years. Overall, jute fiber, with its unique chemical composition and desirable properties, continues to be a valuable and sustainable resource in various industries. Its affordability, strength, and eco-friendly nature make it an ideal choice for a wide range of applications, contributing to its status as the most extensively cultivated bast fiber today [10]. A wide range of dyes, such as direct, acid, vat, azoic (naphthol), reactive, sulfur, and natural dyes, can be utilized for printing jute fabrics [11]. In the textile industry, cotton fiber is the most commonly employed natural fiber worldwide. Cotton, belonging to the *Gossypium* genus of the Gossypiae tribe and the Malvaceae family [12], is a type of cellulosic fiber. Various methods are employed to print cotton fabric using different dyes and pigments. Among these methods, roller screen printing is extensively utilized in industries. Printing involves the localized application of color, which can be achieved using diverse dyes and pigments depending on the fabric type. Pigment printing, which encompasses both organic and inorganic pigments, finds wide application. Most of these pigments are water-insoluble and exhibit indifference towards textiles. The use of a polymeric binder film in textiles serves the purpose of attaching the pigment color to the surface of the fiber. This film can be affixed to the fabric surface through either internal or external cross-linking between the fiber and the binder. Unlike dyeing techniques, which involve the penetration of color into the fabric, textiles colored with pigments require a curing process [13,14]. The reason for this is that pigments do not naturally have an affinity for textiles, so binders are necessary to secure the pigments onto the material. These binders require a curing procedure to ensure proper adhesion and durability. Organic pigments are commonly utilized in the printing, dyeing, and textile industries due to their high light fastness, excellent chemical stability, and crucial weather fastness. These properties make them ideal for applications where colorfastness and durability are important [15]. Pigment printing is a widely used method in the textile industry, accounting for approximately 50% of printed textiles worldwide. Its popularity stems from its efficient process, ease of operation, and versatility. This printing technique allows for precise and vibrant color application, resulting in visually appealing and long-lasting designs on textiles [16]. Overall, the use of a polymeric binder film and organic pigments in textile coloring provides a reliable and durable solution for achieving vibrant and colorfast designs on fabrics. The curing process ensures the proper adhesion of pigments to the material, resulting in high-quality and long-lasting printed textiles [17, 18]. Jute cotton blended fabrics undergo various printing methods using a range of natural and synthetic dyestuffs, including basic, reactive, pigment, and synthetic vat dyes. Natural dyestuffs used in this process include annatto (*Bixa Orellana*), ratan jot (Onosmaechoides), turmeric powder, and catechu. Synthetic dyestuffs encompass basic, reactive, pigment, and vat (Senegalia catechu) dyes [19]. The production of jute-cotton blended fabric is based on the utilization of both natural fibers. However, jute has certain drawbacks such as brittleness, insensitivity, significant variability in fiber length and fineness, limited capacity to withstand washing, and susceptibility to yellowing when exposed to sunlight. Moreover, pigment printing on these fabrics presents challenges, including the need for high curing temperatures, resulting in a rigid texture and inadequate resistance to rubbing for the printed products [20]. Nevertheless, further research is required to explore the potential of pigment printing on jute-cotton blended fabrics. The production of jute-cotton blended fabric using jute-cotton blended yarn in a cotton spinning system contributes to the diverse application of jute-based products. To ensure the sustainable use of these fabrics, it is essential to investigate the specific fastness properties of jute cotton blended pigment printed fabric, with particular emphasis on rubbing fastness and wash fastness, which are crucial among all the fastness properties. Therefore, these findings provide valuable insights into the performance and characteristics of jute-cotton blended pigment printed fabric. By understanding the fastness properties and other key parameters, manufacturers and consumers can make informed decisions regarding the suitability of this fabric for various end uses.

2. Material and Method

Samples of pigment printed jute-cotton blended fabric were obtained from the Jute Textile Wing of the Bangladesh Jute Research Institute (BJRI). The grey fabric was produced at the Jute-Textile Wing of the Bangladesh Jute Research Institute. Subsequently, the grey fabric underwent pigment printing at a local factory.

2.1. EPI and PPI

The determination of ends per inch (EPI) and picks per inch (PPI) involved the utilization of a magnifying glass to count the threads per inch in both the warp and weft directions. Figure 1 demonstrates the EPI and PPI measurement of colour fabrics.

Figure 1 EPI and PPI measurement with counting glass

2.2. GSM

The fabric samples were subjected to measurement of their weight in grams per square meter using a GSM cutter and an electric balance. GSM cutting and measurement of printed fabric are depicted in Figure 2 and 3.

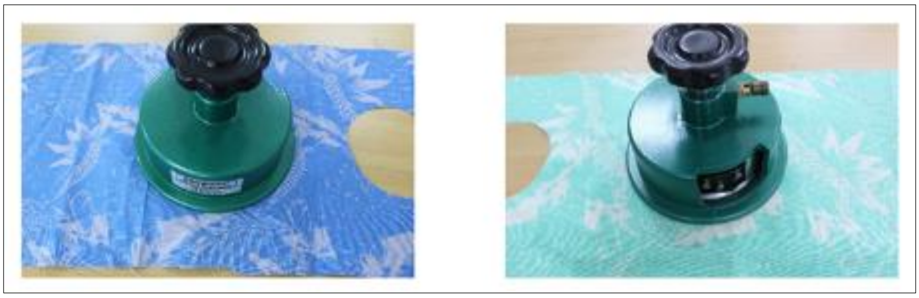

Figure 2 Printed fabric sample cutting with GSM cutter

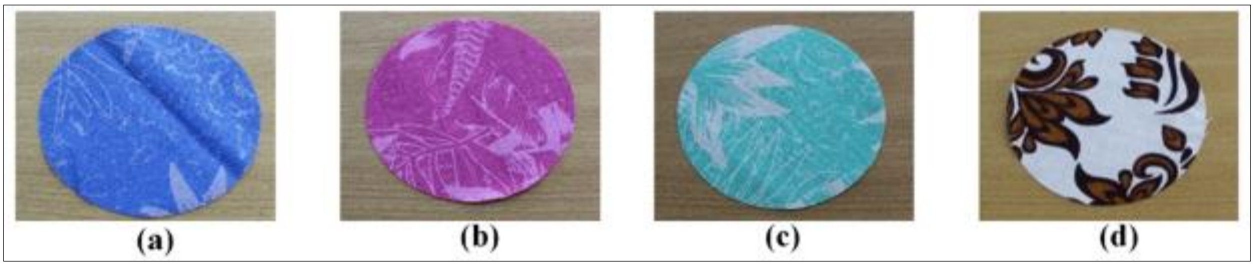

Figure 3 Printed fabric sample for GSM measurement

2.3. Pigment Printing

There are different types of printing processes available. This printing was done using pigment and roller-screen printing methods. The fabric is prepared for printing. Then, the printing paste with pigment and thickener is prepared. The printing is done using the roller-screen printing method. Then, the sample is dried, followed by curing.

2.4. Color fastness

Colour fastness refers to the ability of a dyed or printed textile material to withstand the effects of various factors it is exposed to during textile manufacturing and daily use, such as water, light, rubbing, washing, perspiration, and other common influences. The International Organization for Standardization (ISO) has established a colour subcommittee to evaluate the fastness of colours. Light fastness is graded on a scale of 1 to 8, while other types of fastness are graded on a scale of 1 to 5. This assessment takes into account two separate factors: colour fading, which refers to changes in the colour of the sample, and staining of colour, which measures the colour stain in the undyed material used in the test procedure.The Grade for Rubbing and Wash fastness is presented in Table 1.

Table 1 The Grade for Rubbing and Wash fastness

Grade	Fastness Type
1	Poor
2	Moderate
3	Good
4	Very Good
5	Excellent

2.5. Rubbing fastness procedure

A prowhite rubbing fastness tester was utilized in the testing laboratory of Jute-Textile Wing, BJRI to conduct crocking fastness or rubbing fastness tests. The printed fabric samples were subjected to dry and wet rubbing by the rubbing head using a crocking cloth. The rubbing fastness test was carried out following AATCC TM 08. The rubbing fastness tests of printed fabrics are shown in the Figures 4, 5, and 6, respectively.

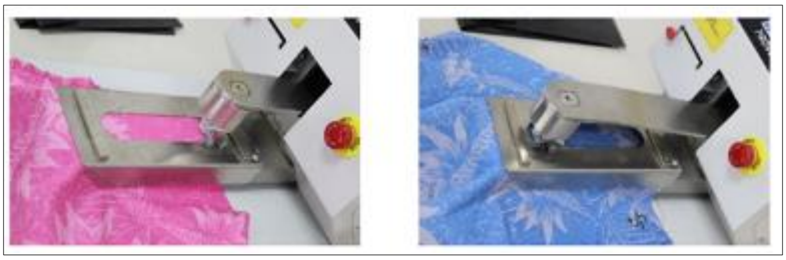

Figure 4 Rubbing fastness of printed fabric samples test in rubbing fastness tester

Figure 5 Color change evaluation of rubbing fastness test of printed fabric sample

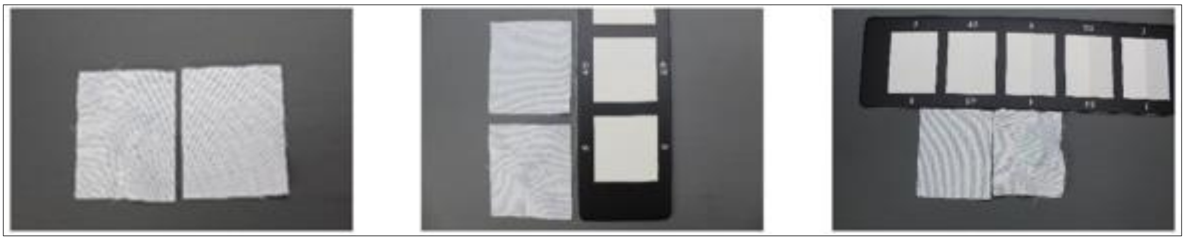

Figure 6 Staining evaluation of rubbing fastness test of printed fabric sample

2.6. Handle and visual assessment

For any coloured fabric, the very first assessment is the hand feel and visual appearance, which were done manually.

2.7. Air permeability

Air Permeability test of printed fabric is shown in the Figure 7. The air permeability is a measure of air passed through the fabric sample in certain conditions. A prowhite air permeability tester was used to test this property. The readings have been collected directly from the monitor while testing. The test conditions were 28°C, 58% RH, and 125 Pa, and the disc size used was 25 cm^2.

Figure 7 Air Permeability test of printed fabric samples

3. Results and Discussion

3.1. Handle and visual assessment

In order to determine the acceptability of a fabric, it is crucial to prioritize the fabric's hand feel. The term "fabric handle" pertains to the tactile experience of the material and is therefore contingent upon the sense of touch. This aspect primarily hinges on the quality of the fabric and any associated treatments it has undergone. The printed sample exhibits a delightful hand feel, devoid of any unpleasant sensations or stickiness. From a visual standpoint, the printed sample exudes vibrancy, an array of colours, and an appealing appearance. Notably, there is no bleeding of printed pastes, and the print edges maintain a sharp and precise delineation.

3.2. EPI, PPI, GSM and Air permeability of the printed fabric samples

In Table 2, the characteristics of experimental samples are recorded. The sample 1 has an average EPI of 68, indicating the number of warp yarns per inch in the fabric. The average PPI of sample 1 is 60, representing the number of weft yarns per inch in the fabric. The GSM of sample 1 is 191, indicating the weight of the fabric per square meter. Additionally, the air permeability of sample 1 is recorded as 1016 $m^3/m^2/h$, which measures the ease with which air can pass through the fabric. The properties of sample 2 are showcased. This sample has an average EPI of 53, indicating a lower density of warp yarns compared to sample 1. The average PPI of sample 2 is 20, indicating a significantly lower density of weft yarns compared to sample 1. The GSM of sample 2 is 196, slightly higher than that of sample 1. The air permeability of sample 2 is recorded as 1628 $m^3/m^2/h$, indicating a higher level of air permeability compared to sample 1.

Table 2 EPI, PPI, GSM and Air permeability of printed fabric samples

Sample	EPI	PPI	GSM	Air permeability, $m^3/m^2/h$
1	66.8	59.2	191.34	1016.744
2	53	20.2	196	1628.123
3	53.2	33.6	246.006	882.064
4	53	35.8	284.44	613.62
5	53.2	35.8	242.64	789.418

The properties of sample 3, sample 4, and sample 5 are documented also in Table 2, respectively. These samples all share the same EPI value of 53, indicating a consistent density of warp yarns. They also possess nearly identical PPI values of 34, 36, and 36 respectively, indicating a similar density of weft yarns. However, there are variations in the GSM and air permeability values among these samples. Sample 3 has a GSM value of 246, indicating a higher weight per square meter compared to sample 1 and sample 2. Its air permeability is recorded as 882 $m^3/m^2/h$, indicating a lower level of air permeability compared to sample 1 and sample 2. Sample 4 has a GSM value of 284, indicating the highest weight per square meter among all the samples. Its air permeability is recorded as 613 $m^3/m^2/h$, indicating a lower level of air permeability compared to sample 1, sample 2, and sample 3. Sample 5 has a GSM value of 242, slightly lower than that of sample 3. Its air permeability is recorded as 789 $m^3/m^2/h$ indicating a lower level of air permeability compared to sample, 1 sample 2, and sample 3, respectively.

3.3. Rubbing fastness of printed fabric samples

The rubbing fastness characteristics of samples 1 through 5 have been recorded in Table 3. According to Table 3, sample 1 exhibits outstanding dry rubbing fastness with a rating of 5, indicating excellent performance in colour staining and colour change on the grey scale. In terms of wet rubbing fastness, the sample demonstrates a level of fastness that falls between good and excellent and sample 2 also displays excellent results in dry rubbing.

Table 3 Rubbing fastness of printed fabric

Sample	Dry rubbing		Wet Rubbing	
	Staining on white cotton	Color change	Staining on white cotton	Color change
1	5	5	4-5	4-5
2	5	5	3-4	4-5
3	5	5	5	5
4	5	5	4-5	4-5
5	4-5	5	4-5	5

However, when it comes to wet rubbing, the staining results range between 3 and 4, while the colour change fastness falls between 4 and 5. Sample 3 showcases an exceptional rating of 5 across all fastness scales documented in Table 3. Sample 4 exhibits an overall fastness rating of 5 in dry rubbing and a rating of 4 to 5 in wet rubbing, as indicated in this table. Lastly, table 3 presents the rubbing fastness outcomes of sample 5, which fall within the range of 4 to 5 overall.

In a nutshell, all the printed fabric samples, except for sample 5, show exceptional performance in the rubbing fastness test when dry. They exhibit minimal staining and colour change on the grey scale. Sample 5, on the other hand, still performs very well in terms of staining and colour change. When it comes to wet rubbing, sample 3 falls between good and very good in terms of staining. The rest of the samples demonstrate very good to excellent staining properties, and their colour change during wet rubbing is also within the very good to excellent range. In terms of air permeability, sample 3 stands out with the highest measurement of 1628.12 $m^3/m^2/h$. On the contrary, sample 5 has the lowest air permeability, measuring at 613.62 $m^3/m^2/h$.

4. Conclusion

Five randomly selected fabric samples, made from a blend of jute and cotton and printed with pigments, were subjected to examination. Despite their varying physical characteristics, the primary observation from the examination is that the printed samples exhibit satisfactory rubbing fastness properties. It is worth noting that the dry rubbing fastness outperforms the wet rubbing fastness, which is a common occurrence. Consequently, the jute-cotton blended pigment printed fabric can be deemed suitable for applications that require excellent dry rubbing fastness. However, the acceptance of this fabric also relies on the specific end-use and customer demand. It is imperative to investigate other fastness properties thoroughly before making a definitive conclusion.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest is to be disclosed.

References

[1] Thiruchitrambalam A, Athijayamani M, Sathiyamurthy A, Thaheer, ASA. A review on the natural fiber-reinforced polymer composites for the development of roselle fiber-reinforced polyester composite. Journal of Natural Fibers, 2010, 7(4), 307-323.

[2] Ahmed Z, Sarkar S. Review on jute leaf: A powerful biological tool, International Journal of Scientific Research Updates, 2022, 04(01), 64-85.

[3] Ahmed Z, Sarkar S. Advancement in biological chemistry and nanotechnological research on fiber plants. Generis Publishing. 2022. Available from: https://www.generis-publishing.com/book.php?title=advancement-in-biological-chemistry-and-nanotechnological-research-on-fiber-plants

[4] Sarkar S, Dilruba FA, Rahman M, Hossen M, Dayan AR, Khatton A, Sarker J, Uddin M. Isolation of microcrystalline alpha-cellulose from jute: A suitable and economically viable resource. GSC Biological and Pharmaceutical Sciences. 2022, 18(3), 219-225.

[5] Sayed BE, Othman GA, Hassabo H. An overview on the eco-friendly printing of jute fabrics using natural dyes. Journal of Textiles, Coloration and Polymer Science, 2021, 18(2), 239-245.

[6] Ghosh AP, Samanta AK, Das, D. Effect of Selective Pretreatments and Different Resin Post Treatments on Jute-Viscose Upholstery Fabric. Indian Journal of Fiber & Textile Research, 1994, 19(4),277-285.

[7] Pan NC, Day A, Mahalanabis KK. Chemical composition of jute and its estimation. Man Made Textiles in India, 1999. 2(11), 467-473.

[8] Sarkar S, Dilruba FA, Molla JB, Khan MRI, Escalating the Use of Jute (Robi-1)-Cotton Blended Yarn Rather than Entirely Made of Cotton Yarn, World Journal of Advanced Engineering Technology and Sciences, 2023, 10(02), 112-119.

[9] Molla JB, Sarkar S, Dilruba FA, Khan MAS, Rahman MM. Enhancing the Dependence of Blended Jute Yarn Rather Than Hundred Percent Cotton Yarn, World Journal of Advanced Research and Reviews. 2022, 15(02), 205-210.

[10] Molla JB, Dilruba FA, Sarkar S, Khan AS. Performance of Jute Cotton and Viscose Blended Woven Fabrics Compared to Hundred Percent Cotton Woven Fabrics: Regarding Mechanical and Comfort Properties. International Journal of Research Publication and Reviews, 2023, 4(11), 3085-3090.

[11] Sayed BE, Othman GA, Hassabo H. An overview on the eco-friendly printing of jute fabrics using natural dyes. Journal of Textiles, Coloration and Polymer Science, 2021, 18(2), 239-245.

[12] Gotmare V, Singh P, Tule B. Wild and cultivated species of cotton. Technical Bulletin; Central Institute for Cotton Research: Nagpur, India, 2000, 5.

[13] Haggag K, Ragheb AA, Thalouth AI, Rekaby M, Hennawi EHM, Shahin AA. Pigment printing of cotton fabrics using microwave irradiation. Research Journal of Chemical Sciences, 2015, 5(4) 20-25.

[14] Hebeish A, Rekaby M, Shahin AA, Ragheb AA. Novel nanopigment derived from vat dyes for printing cotton fabrics. Egyptian Journal of Chemistry, 2016, 59(1), 99-114.

[15] Li S, Boyter H, Stewart N. Ultraviolet (UV) Curing Processes for Textile Coloration. AATCC review, 2004, 4(8).

[16] Jiang, S., Wang, Y., Sheng, D., Xu, W., Cao, G. (2016). Examination of the dyeing properties of pigment printing fabrics in a water-ethanol mixed solvent. Carbohydrate polymers, 153, 364-370.

[17] Haroun, AA.,Diab, H. A., Hakeim, OA. (2016). Cellulosic fabrics printing with multifunctional encapsulated phthalocyanine pigment blue using phase separation method. Carbohydrate polymers, 146, 102-108.

[18] Islam, SU. (Ed.). 2023, Renewable Dyes and Pigments. Elsevier.

[19] Evrim, B. 2020, Fibrous Future of Architecture: Computer-Aided Fabrication of Hybrid Carbon Fiber and Jute Fiber Textile Chair Made with Weaving and 3D Printing Techniques.

[20] Haggag, K., El-Molla, MM., Shake, NO., Alian, NA., El-Shall, F N. Use of the novel synthesized aqueous binders for pigment printing cotton fabrics using three modes of fixation. International Journal of Textile Science, 2012, 1(6), 49-61.