Journal of Advances and Scholarly Researches in Allied Education
Vol. 19, Issue No. 4, July-2022, ISSN 2230-7540

Eco-Friendly Natural Dye for Cotton Fabrics derived from Bark of Terminalia Arjuna

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Abstract - Researchers, however, have shown that they are detrimental to both human and environmental health. Through the use of a dip-dry-iron-cure procedure, Sodium citrate was used as an esterification catalyst and potassium peroxodisulfate as a free radical polymerization catalyst; Terminalia arjuna, Allium cepa, and maleic anhydride were all applied simultaneously to the cotton fabric. A dip-dry-iron-cure process was used to esterify and free radical polymerize itaconic acid using Allium cepa and Terminalia arjuna, respectively, as well as potassium peroxodisulfate and potassium sodium tartrate catalysts, respectively, on silk fabric.

Keywords: Eco-Friendly, Natural Dye, Cotton Fabrics, Bark and Terminalia Arjuna

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INTRODUCTION

The process of dying textiles has been around since the Bronze Age. Dyeing is a crucial step in the textile processing industry; it gives textiles their vibrant colors and patterns. The synthetic dyes that were so popular at the time were made from inexpensive petroleum and gave clothes a vibrant hue thanks to their easy-to-follow dying procedure and excellent colorfastness. The production of toxic, allergenic, carcinogenic, and environmentally and human-detrimental chemicals by synthetic dyes was eventually discovered, however. In India, the surrounding ecosystem was devastated by the dye effluent from the textile dying businesses, which included both chemical and organic contaminants. Humans, animals, and plants all suffered because of this pollution. Scientists sought for environmentally acceptable alternatives after discovering that dyeing units' effluent altered the water's hue.

Consequently, it is crucial to meet the demands of customers and the country's economy by introducing eco-friendly materials for use in textile processing if we want to raise the standard of life. Since natural dyes are both biodegradable and harmless to humans, they may be used instead of synthetic colors for this purpose. An assortment of natural colors may be derived from plants, animals, insects, or minerals. Fabrics dyed with natural dyes in antiquity quickly fell out of favor due to the widespread availability and low cost of synthetic dyes. However, natural dyes have recently gained global importance and relevance as a result of heightened environmental concern. It is possible to save the valuable petrochemical and the future of our planet by switching to natural organic dyes made from plants and forests. In addition to providing a wealth of dyestuffs, these natural dyes may provide a tidy profit via the environmentally responsible cultivation and sale of dye plants.

Use of natural dyes has its limits in terms of colorfastness and brightness. The colors that result from using them with metallic mordants, however, are vibrant and fast-acting. Using natural dyes in a commercial setting requires the development of suitable and standardized dyeing procedures that do not sacrifice the necessary quality of the colors applied to textile materials. By just changing his marketing approach, a manufacturer may easily shift customer focus to naturally colored items. In order to employ natural dyes in the business, it is crucial to conduct the necessary experiments and research. It would be great for the environment and our economy if local manufacturers could boost demand for natural coloring goods in international markets.

The Terminalia arjuna tree, which may reach a height of 30 meters and a diameter of 2–2.5 meters, is native to the South Asian area. New leaves emerge from this evergreen tree between the months of February and April. It is seen as exotic in India. Bark has antibacterial, astringent, cardiotonic, lithotriptic, anticoagulant, hypolipidemic, and antiuremic properties, making it a medicinal plant. Triterpenoids, tannins, and flavonoids are phytoconstituents derived from T. arjuna that have cardiovascular, anticancer, and antibacterial effects.

In cases of cirrhosis of the liver, the powdered bark of this plant acts as a diuretic, alleviating hypertension symptoms.

LITERATURE REVIEW

Gupta, Virendra. (2019) There has been a recent uptick in the use of plant-based colorants for clothing dying, thanks to the stringent environmental regulations in clothing and textiles enacted by environmentally conscious nations. Natural colours are attracting people's focus on the problem of synthetic dyes and their harmful implications, which may cause allergies and toxicity. One sustainable option for colorants is to use natural dyes. Its uses extend beyond textiles to include food colouring, pharmaceuticals, and craft materials. While natural dyes are great for the environment, skin, and eyes, they don't bind well with textile fibres. To fix them, textiles must be mordanted with metallic mordants, which may be harmful to the environment. This means that natural dyes are not completely dominant. This calls for more recent studies into the use of natural dyes on various natural fibres to create textiles that are entirely harmless to the environment. As a result, this review article covers the groundwork of natural dyes chemistry as well as some of the key studies in the field.

Teklemariam (2014) Natural dyes are examined in this research along with their characterisation and chemical/biochemical analyses. Colourants are extracted from a variety of natural sources, various pests are analyzed, and a binary combination of natural dyes is applied. Colours extracted from plants come from a variety of sources, including plants, animals, minerals, and more. They may be characterised by their chemical and biological properties, which can be examined using chromatographic and UV-visible spectroscopy studies.

Křížová, Hana. (2015). The confectionery, food, cosmetics, medicine, leather, paper, paint, ink, and dyestuff sectors are just a few that benefit from natural colourants and dyestuffs, a category of non-wood forest products. There are a lot of concerns and issues with using natural colours, thus this page compares and contrasts them with synthetic dyes. Is it true that natural colours are less harmful to the environment than synthetic dyes? Is it feasible, advantageous, and sustainable to utilise natural dyes in textiles on a large scale? With the use of current scientific understanding, let's attempt to figure this out.

Guha, Arun. (2019) the textile industry generates massive amounts of wastewater that include harmful elements; nonetheless, despite its many benefits to humankind, it is damaging the ecosystem. Toxic effects are mostly caused by synthetic colors. Natural dye is the only option available to us if we want to protect our environment. The universe is rife with natural color supplies. This article discusses potential 2008–2018 sources of natural dyes. We have been piecing together a list of prominent natural dye suppliers, including onions, carrots, marigolds, orange peel, roses, etc. This article has covered topics such as isolation procedures, dyeing processes, and fastness qualities.

Jordeva, et al (2020) Because of their biodegradability and excellent environmental compatibility, natural dyes have recently garnered a lot of attention for use in textile dyeing. The experts say that natural dyes have a lot of promise and might eventually replace synthetic ones in certain applications. This document compiles research on natural dyes, including studies on their properties, analysis, and categorization; methods for extracting colors from onion skins; and the impact of various mordents and mordanting techniques on color saturation. From a green perspective, switching to natural dyes instead of synthetic ones may open up new markets and provide more employment opportunities while simultaneously lowering pollution and danger.

RESEARCH METHODOLOGY

We utilized untreated, itaconic acid of a commercial grade that was bought from M/s Macromols India Ltd. We sourced our natural dyes from M/S Eco-N-Viron in Serampore, West Bengal, India. Their plants used include Allium cepa and Terminalia arjuna. Half of the extracts were solid, while the other half was water-based. For all other tests, we only used substances classified as laboratory reagents. Bleached plain weave cotton fabric with 380 ends dm-1 and 300 picks dm-1, 14 tex warp and 15 tex weft, with an average area density of 106 g m-2 was used in this investigation. We used maleic anhydride that had not been processed and was acquired from M/s Macromols India Ltd. M/S Eco-N-Viron of Serampore, West Bengal, India, supplied the natural dyes made from Terminalia arjuna and Allium cepa.

We tested the colorfastness of cotton fabrics dyed with Allium cepa and Terminalia arjuna by washing them in a Launder-O-Meter in accordance with the protocol outlined in IS: 3361-1984 (ISO-II). For the evaluation of shade alterations, the grey scales with the designation ISO105-AO2:1993 were used, and for staining, the scale with the identification ISO105-AO3:1993 was employed.

DATA ANALYSIS

Optimization aqueous extract of Terminalia arjuna

Color was seen to be readily released into hot water by an aqueous extract of Terminalia arjuna barks. If you boil 100 ml of water with 5 to 20 grams of bark for an hour, you'll see a dramatic improvement in the intensity and saturation of the color. the dye extract had a deep red hue.

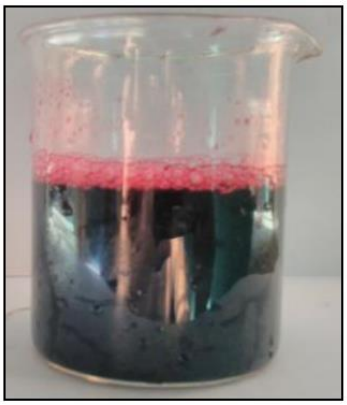

Figure 1: Aqueous extract from the barks of Terminalia arjuna

Dyeing Behavior of the Extract

Using a single mordanting process, this research achieved the color values of the strength of cotton fabrics colored with Terminalia arjuna bark. Findings indicated that Terminalia arjuna had more robust color strength ratings. The outcomes were the best with the post mordantning process among the three dying techniques. Ferrous sulphate and aluminum sulphate, two of the mordants used in the three dyeing processes, have very high color strength values. The results were better when using a 3% mordant concentration for coloring cotton.

Table 1: The standard process of dying cotton using bark extract of Terminalia arjuna produces a variety of colors using chemical and natural mordants in PM, POM, and SM.

Name of the mordants	Pre mordanting (PM)	Post mordanting (POM)	Simulataneous mordanting (SM)
Alum			
$SnCl_2$			
$FeSO_4$			
$K_2Cr_2O_7$			
$NiSO_4$			
$CuSO_4$			
Myrobolan			
Turmeric			
Cow dung			
Banana sap juice			

Optimization Mordant with Variations in Color Hues and K/S Values

Using pre-, simultaneous-, and post-mordanted dyeing techniques, a wide range of color colors were achieved. The values of L*, a*, b*, and K/S L* values range from 0 (very dark) to 100 (very light), indicating the perceived brightness or darkness. Red (+a) and green (-a) are denoted by a* and b* values, respectively, whereas yellow (+a) and blue (-b) are denoted by b* values. The pre-mordenting process yielded deeper color hues, with FeSO4 having a K/S ratio of 28.91 and copper sulphate a value of 23.2. The color tones produced, however, will be darker when the values of L* are reduced. It turns out that the color tones are deeper. with lower L* values indicating lighter hues, and the K/S values for FeSO4 are 30.5 and CuSo4 are 28.78 in the post-mordanting procedure. The deeper color tones are caused by the fact that FeSO4 is 18.63 and CuSo4 is 18.2 in the simultaneous mordanting process. Color tones will be deeper with lower L* values. the color worth of cotton infused with Terminalia arjuna bark are affected by mordants.

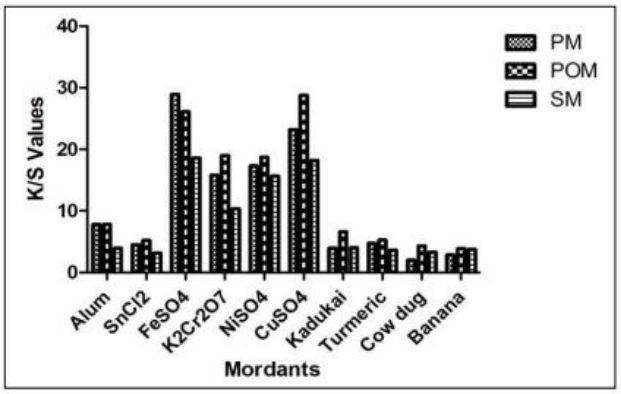

Figure 2: Terminalia arjuna dyes cotton garments with a surface color strength of 3% using a mordant concentration. Measurement of K/S with or without a mordant

Color Fastness Characteristics

The color fastness ratings of cotton fabrics dyed using Terminalia arjuna bark. These values were computed in this investigation using a single mordanting procedure. Terminalia arjuna exhibited superior light fastness characteristics, according to the findings. The post mordant procedure outperformed the other two dying techniques. Iron sulfate and aluminum sulfate, two mordants, work well in all three dyeing techniques.

Table 2: Fabric dyed using extract from Terminalia arjuna bark (mordant or not) and its impact on color strength

Dyeing Method	Conventional				
Colour strength	Process	L*	a*	b*	K/S Value K/S(λ=420 nm)
Without mordant	Pre	45.32	12.38	28.11	3.26
	Post	56.43	18.75	26.32	2.32
	SM	51.21	17.98	19.77	2.11
Alum	Pre	52.35	13.81	19.32	7.81
	Post	49.8	14.32	22.81	7.81
	SM	72.32	12.25	8.32	3.98
SnCl2	Pre	63.81	12.95	19.32	4.51
	Post	55.8	14.3	18.81	5.23
	SM	72.15	11.21	10.25	3.17
FeSO4	Pre	32.1	4.32	7.81	28.91
	Post	38.5	4.32	10.83	30.5
	SM	54.17	6.25	1.85	18.63
K2Cr2O7	Pre	63.81	11.93	10.32	15.8
	Post	49.98	12.19	16.32	19.01
	SM	71.89	7.63	4.38	10.34
NiSO4	Pre	54.81	15.38	29.32	17.31
	Post	49.62	19.73	24.68	18.73
	SM	54.32	13.51	15.73	15.66
	Pre	52.21	16.32	24.81	23.2
CuSO4	Post	44.32	16.3	24.42	28.78
	SM	61.32	11.81	17.35	18.2
Myrobolan	Pre	66.71	11.59	18.98	3.98
	Post	57.38	15.39	25.92	6.63
	SM	63.71	13.92	17.3	4.01
Turmeric	Pre	60.32	13.8	34.81	4.76
	Post	59.38	11.62	29.31	5.29
	SM	64.81	13.81	24.99	3.63
Cow dung	Pre	65.71	12.08	17.19	2.03
	Post	53.43	16.75	23.32	4.32
	SM	54.21	14.98	16.77	3.31
Banana sap	Pre	65.15	14.38	18.39	2.87
	Post	63.2	14.9	19.32	3.9
	SM	58.8	14.98	13.62	3.75

Table 3: Properties of Terminalia arjuna-dyed cotton fabric in regard to its fastness (Infused or not)

Dyeing Method	Conventional						
Fastness	Process	Washing fastness (IS-105-C03)	Light fastness (IS-2454-85)	Rubbing fastness (IS-766-88)		Perspiration (IS-105-E04)	
Mordant concentration: 3%				Dry	Wet	Acid	Alkali
Without mordant	Pre	3	3	3	3	3	3
	Post	3	3	3	3	3	3
	SM	3	3	3	3	3	3
Alum	Pre	4	3-4	4-5	4	4	4
	Post	4	3-4	4-5	4	4	4-5
	SM	4	4	4	4	4	4-5
SnCl2	Pre	4	3-4	4	4-5	4	4-5
	Post	4	3-4	4	4-5	3-4	4-5
	SM	4	3-4	4	4-5	4	4-5
FeSO4	Pre	5	4-5	4-5	4	4	4-5
	Post	5	4-5	4-5	4	4	4-5
	SM	4	4	4	4	4	4-5
K2Cr2O7	Pre	4	4	4	4	4	4-5
	Post	4-5	4	4	4	4	4-5
	SM	4	4	4	4	4	4-5
NiSO4	Pre	4	4	4	4	4	4-5
	Post	4	4-5	4	4	4	4-5
	SM	4	4	4	4	4	4-5
CuSO4	Pre	5	4-5	5	4	4	4-5
	Post	5	4-5	5	4	4	4-5
	SM	4	4	5	4	4	4
Myrobolan	Pre	3	3	3	2-3	2-3	3
	Post	3	3	3-4	3	3	3
	SM	3	3	3	3	3	3
Turmeric	Pre	3	3	3	2-3	4	3
	Post	3	3-4	3	3	4	3
	SM	3	3	3	3	4	3
Cow dung	Pre	2	2	2	2	2-3	3
	Post	2-3	2-3	3	3	3	3
	SM	2	2-3	2-3	3	3	3
Banana sap	Pre	3	2-3	3	2-3	3	3-4
	Post	3	3	3	3	3	4
	SM	3	3	3	3	3	4

CONCLUSION

In order to achieve a better balance in the qualities of the dyed substrates, making them higher performing and expanding their scope of use in diverse applications, the research presents studies that pertain to dyeing silk and cotton textiles using natural dyes Research on the properties of dyes made from Allium cepa and Terminalia arjuna, as well as their use on silk and cotton. Research on the use of itaconic acid and natural dyes for the finishing and dyeing of silk along with cotton. Research on the use of chemical and natural dyestuffs in the simultaneously dyeing and finishing silk and cotton. Terminalia arjuna has a pH of 4.3 in water while Allium cepa has a pH of 5.8 in water. Terminalia arjuna with Allium cepa in water had maximum absorption wavelengths of 397 and 381 nm, respectively. The wavelength of maximum absorption remained same when acid was added to the water-based Terminalia arjuna extract, but it changed from 381 to 405 when alkali was added.

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