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Eco-Friendly Dyeing of Natural-Mordanted Viscose Fabrics with Natural Turmeric Dye

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Abstract

Synthetic dyes are not eco-friendly and have negative effects on the skin of the wearer when used to color apparel and textiles. Therefore, it is thought that natural dye is a good substitute for environmentally friendly textile coloration and manufacturing. In the present investigation, we used turmeric (Curcuma longa L.) extract to dye viscose garments. To increase the total uptake of dyes into the innermost regions of the fabric, pre-treatments with natural mordants (derived from Citrus lemon and vinegar) and chemical mordants (Potassium hydroxide and Sodium carbonate) were also conducted. The resultant color strength (K/S) of the bio-mordanted pre-treatment sample was greater than the chemical-mordanted sample by about 228.17%. Colorfastness of rubbing (dry and wet), washing, water, and perspiration (acidic and alkaline) tests were carried out to explore the fastness characteristics of colored fabric varieties. The results showed that natural mordants outperformed the chemical mordants. By doing so, this dyeing method suggested the possibility of using natural dyes with natural aids for viscose fabric coloring. Consequently, using extracted turmeric as a reliable dye source and a lemon as a bio-mordant could provide beneficial insight for more environmentally friendly textile dyeing and manufacturing.

Keywords: Natural mordants; Turmeric dyes; Eco-friendly; Viscose fabric; Citrus Lemon juice; Vinegar.

Introduction

The perspective of our customary attire has been drastically changing as a result of advancements in cloth production and coloration techniques. Prior to the creation and widespread use of synthetic dyes like azo, reactive, disperse, direct, and reactive dyes [1], the utilization of natural coloration originated from the ancient period by utilizing a variety of coloring sources [2]. The majority of textile manufacturers have switched to using synthetic dyes due to their affordability and availability [3, 4].

All synthetic colors are made from petrochemical sources, even though doing so involves risky chemical procedures that endanger the environment [5, 6]. Synthetic fibers and colors produce waste and have a carbon impact from manufacturing to disposal.[7] There won't be a requirement for effluent treatment if natural coloring agents are applied [8]. Customers are increasingly interested in using textile products that have been colored with natural and environmentally friendly dyes because of the growing awareness of eco-friendly organic products [9].

Natural dyes, as opposed to synthetic dyes, generated extremely rare, healthy, and gentle colors. [10] Because natural dyes require a mordant to fix them, the mordanting agent is crucial to textile coloring. [11] To fix natural dyes in the fiber or cloth, synthetic mordants are also utilized when dyeing with them. [12] Although synthetic mordants are readily available and come in a variety of colors, they can occasionally have adverse effects on the human body, including skin aversion. [13-28] Additionally, it releases harmful substances throughout its manufacturing and creates chemical dangers overall. [29] Therefore, natural mordants are necessary for sustainable ecology. Additionally, when using natural

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dyes for dying, natural mordants might be a substitute source of mordanting chemicals. [30] Historically, one of the most well-known and vivid naturally yellow colors was turmeric or curcumin. It is derived from turmeric's fresh or dried rhizomes. [31-38]

Cellulose fibers have the most diverse range of structures and characteristics of all textile fibers. Another significant cellulosic fiber that is mostly utilized in textiles is viscose. Viscose is experiencing a resurgence right now. Viscose is a substance that can be found in all land-based plant life as cellulose. A variety of dissolving grade wood pulps are used as the cellulose source to make viscose rayon. Viscose is intended to provide a solution to the issues that have been steadily getting worse: higher cotton costs on the global market; rising fibre demand, including a need to find new sources of fibre, as well as a need for a larger market for the wood and pulp business. [39]

Materials

Fabrics

Viscose fabric was kindly supplied by Misr El-Mehala Company, Cairo, Egypt.

Dyestuff

- El-Doha business provided the pure turmeric powder utilised in this study as a source of colours.
- Potassium Hydroxide and Sodium bicarbonate are used as chemical mordanting agents. The non-ionic detergent is used for colorfastness washing testing. All these chemicals were purchased from El-Gomhorya Company.
- The raw Lemon was processed to produce the citrus lemon juice that was employed in this study as a source of natural mordants. I bought a raw lemon at the store.
- In this study, natural mordants were also obtained from 5% vinegar. We bought vinegar from Wadi Food Company..

Fig. 1. Pure natural Turmeric dyes.

Methods

Extraction of Lemon Juice

A lemon metal juicer was used to extract the lemon juice mordant. The raw, fresh lemon is first purchased at the supermarket. One kilogram of lemons was used, which were well washed in clean water before being sliced in half. Then use a hand-held metal squeezer to squeeze the lemon pieces. After filtering it via a nylon filter, about 155 ml of pure juice was extracted from 1 kg.

Fabric Pre-treatment with natural mordants

The application technique for natural lemon juice and vinegar mordants is shown in Fig. 2. First, two separate pots each contained 150 ml of fresh lemon juice and 100 ml of 5% vinegar. The lemon pot was then filled with 100 ml of water. samples were placed in the pot and the timer for the process was begun. One sample from each pot was removed after 1 hour, 3 hours, and 5 hours. The samples were squeezed and then left to dry.

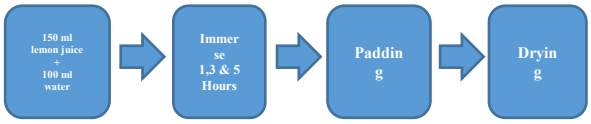

Fig. 2. Lemon juice mordant application process curve

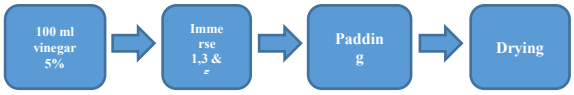

Fig. 3. Vinegar 5% mordant application process curve

Fabric Pre-treatment with synthetic mordants

Mordants are chemicals that help dyes adhere on fibers after application. Additionally, they enhance the fabric's ability to take up dye and aid in enhancing color and lightfastness. Here, various mordanting agents were used to treat viscose. The potassium hydroxide and sodium bicarbonate were prepared for usage by making a solution with a 5 gm/L concentration.

Initially, a 5 g weighted sample of viscose fabric and 1 g of room temperature mordanting chemical was added to 200 ml of water in a saucepan. Immerse the sample in the solution right away, then increase the temperature of the solution to 80 °C and hold it there for 50 minutes. The sample should then be rinsed with cold water and air dried. Fig. 4 illustrates the application process curve for chemical mordants.

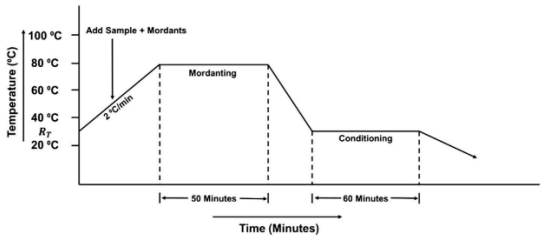

Fig. 4. Synthetic mordants process curve

Dyeing using natural turmeric dye

Natural turmeric colours were used to dye viscose fabric. According to the following recipe, the dyeing was done:

Natural Turmeric Dyes: 1%
Time: 60 Minutes.
Temperature: 90°C.
L.R: 1:20
Sample Weight: 5 gm

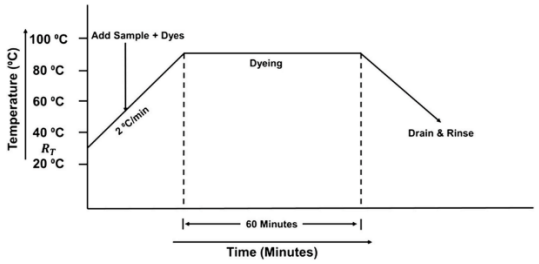

Fig. 5. Dyeing process curve with natural turmeric dyes.

The liquor ratio used to color the mordanted samples was 1:20. First, a pot was filled with a 1% stock solution of natural turmeric powder. Placed the pot in the water bath after adding the mordanted sample to it. After running the water bath for 60 minutes at 90°C, it was cooled to 40°C. [40] Finally, give the samples a five-minute cold rinse before letting them dry. The application process curve is shown in Fig. 5 after the fabric has been dyed.

Soaping process of Dyed fabric

After the dying procedure, soaping was carried out. The samples are then washed using the following recipe:

Soaping was done at the end of the dyeing process. So, at the end of the dyeing process, the samples are washed by the following recipe:

Soaping Agent: 0.5 gm/L
L.R: 1:20
Temperature: 40 ◦C
Time: 10 Minutes

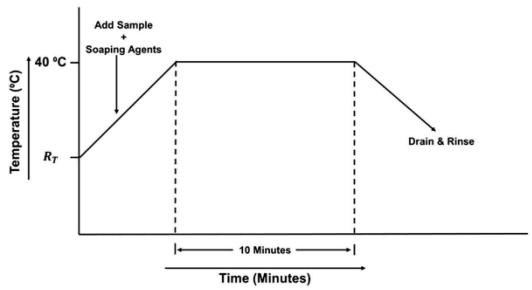

Fig.6. Dyed fabric soaping process curve

The dyed sample was first put into a pot together with the required quantity of soaping chemicals. Increase the temperature to 40°C gradually, as shown in Fig. 6, and soap the sample for 10 minutes. Following a hand-cold wash, the samples were allowed to air dry.

Measurements

Color measurements

Based on the Kubelkae-Munk equation, the colour strength (K/S) in the visible region of the spectrum (400–700 nm) was calculated:

$$\frac{K}{S} = \frac{(1-R)2}{2R} \dots\dots\dots (1)$$

In this formula, (K) stands for the adsorption coefficient, (R) for the dyed sample's reflectance, and (S) for the scattering coefficient.[41]

Fastness properties

According to a conventional procedure, the fastness qualities to washing, rubbing (dry & wet), sweat, as well as light fastness, were tested. [42-45]

Results and discussions

The impact of natural and artificial mordants on the colour strength of viscose fabric dyed with turmeric

To investigate the effects of bio-mordanting, viscose textiles were mordanted with lemon juice and vinegar, coloured with dry turmeric powder, and compared to those dyed with an identical dye but mordanted with a variety of synthetic mordents under equivalent dyeing conditions. To determine the K/S values for the colored washed samples, the color strength was assessed using a spectrophotometer; the findings are shown in Fig. 8.

According to the results, viscose fabrics mordanted with lemon juice for 5 hours as a bio-mordant and then dyed with turmeric had the highest K/S value after washing compared to the dyed sample mordanted with vinegar for the same period or with synthetic mordants like potassium hydroxide or sodium carbonate, where fabrics mordanted with sodium carbonate recorded the lowest K/S values.

This is made clear by the fact that citric acid, potassium, calcium, and magnesium all worked together to enhance the effect of colour absorption on the fabric since lemon extracts include tannins.As expected, the unmordanted sample had less color before and after washing due to the mild fixed dye's moderate degree of color loss because turmeric also includes tannins that function as mordants.

According to the findings, 3 hours of 5% vinegar mordanting on fabric produces more color strength than 1 or 5 hours. Therefore, the color intensity rises as the time duration rises until it reaches the highest K/S value. According to the findings, fabric that has been mordanted with citrus lemon for 3 hours instead of 1 displays a higher K/S value. Additionally, the cloth that has been lemon-mordanted for 5 hours demonstrates greater color strength than lemon-

mordanted fabric for 3 hours. Therefore, it is clear that as the period increases the color intensity does as well.

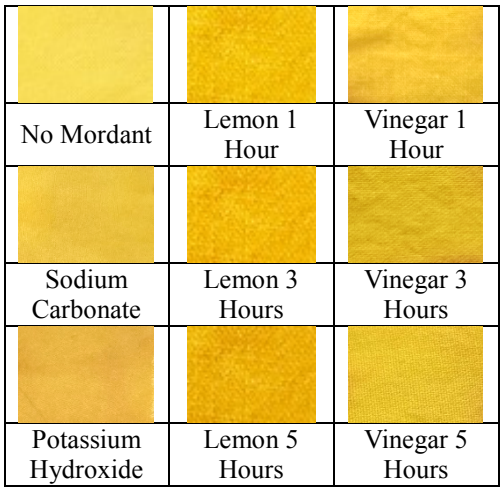

Fig. 7. Turmeric-dyed fabrics

Conclusions

Natural colored fabrics must be processed without the use of synthetic mordants to be considered eco-friendly goods. In this research, the researchers successfully investigated the use of lemon extract as a mordant to dye natural dye. We have demonstrated that lemon-mordanted samples when dyed under the same conditions as chemical-mordanted samples (potassium hydroxide and sodium carbonate in this instance), can even produce superior results. This was implied by the dyed sample that had been bio-mordanted having a deeper color shade than usual and having superior colorfastness characteristics than the synthetic mordanted samples or the un-mordanted. After dyeing and washing, wastewater contained less dye color.

This research serves as a crucial foundation for the development of numerous more natural materials that may be utilized as mordants when dying textiles made of different fibers in addition to viscose. We just used lemon juice and vinegar here, Therefore, in the future, we might look into post-mordanting methods, dyeing and mordanting simultaneously, and mordant-containing dyes that don't require mordanting.

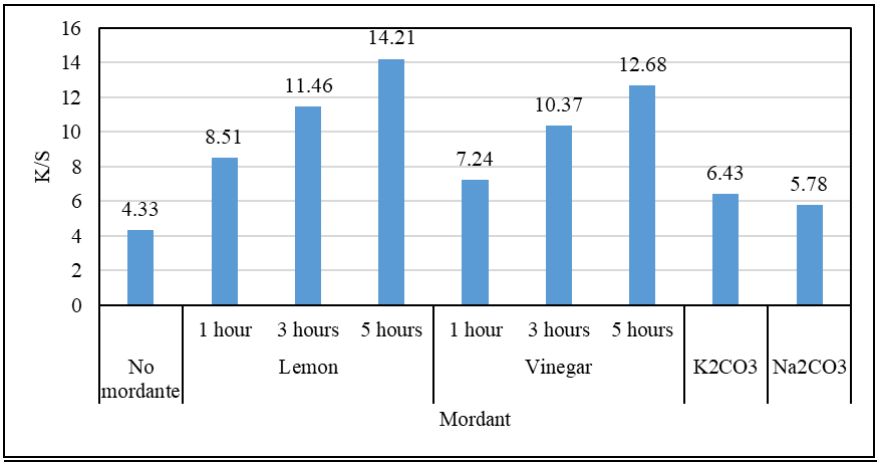

Fig. 8. Effect of natural mordants and synthetic mordants on the color strength of dyed viscose fabric with turmeric natural dye

Sample	K/S	Rubbing		Washing			Perspiration						Light
		Wet	Dry	Alt	St.1	St.2	Acidic			Alkaline			
							Alt	St.1	St.2	Alt	St.1	St.2	
No mordant	4.33	2-3	3	3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	5-6
Lemon 1 hour	8.51	4	4-5	4-5	4-5	4-5	4-5	4	4	4-5	4	4	6
Lemon 3 hour	11.46	4	4-5	4-5	4-5	4-5	4-5	4	4	4-5	4	4	6
Lemon 5 hour	14.21	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	6
Vinegar 1 hour	7.24	4	4-5	4-5	4-5	4-5	4-5	4	4	4-5	4	4	6
Vinegar 3 hour	10.37	4	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	5	6
Vinegar 5 hour	12.68	4-5	4-5	5	4-5	4-5	4-5	4-5	4-5	4-5	4	4-5	6
Potassium hydroxide	6.43	3-4	4	3-4	3-4	3-4	4	3-4	3-4	3-4	3-4	3-4	5-6
Sodium Carbonate	5.78	3-4	3-4	3-4	3-4	3-4	4	3-4	3-4	3-4	3-4	3-4	5-6

Fig. 9. Color fastness properties

St.1=Staining on cotton St.2=Staining on wool

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صباغة أقمشة الفسكوز بصبغة الكركم الطبيعية باستخدام مواد صديقة للبيئة

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من المعروف ان الصبغات الصناعية ليست صديقة للبيئة ولها آثار سلبية على جلد مرتديها عند استخدامها لتلوين الملابس والمنسوجات، لذلك يجب استبدالها بالصبغات الطبيعية التي تعتبر بديل جيد لتلوين المنسوجات باستخدام مواد صديقة للبيئة. وفي الدراسة الحالية ، استخدمنا خلاصة الكركم لصباغة أقمشة الفسكوز، حيث تم إجراء بعض المعالجات على أقمشة الفسكوز قبل عملية الصباغة باستخدام بعض المواد الحيوية مثل عصير الليمون والخل وبعض المواد الكيميائية مثل (هيدروكسيد البوتاسيوم وكربونات الصوديوم) لزيادة الامتصاص النسيج أثناء عملية الصباغة بصبغات الكركم الطبيعية.
الكلمات المفتاحية: صبغة الكركم، الفسكوز، ليمون، صديقة للبيئة.