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Original Research Article

Dye for the Future: Natural Dye from *Morinda Lucida* Plant for Cotton and Silk Fabrics

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ABSTRACT

Various methods of application of selected eco-friendly mordants were studied. Alum and ferrous sulphate were the mordants selected. Each mordanting method was evaluated against the color strength and fastness. On cotton fabrics, post mordanting exhibited very good (4) to excellent fastness (5) wash fastness, and very good light fastness (6) with both mordants. Silk fabrics registered very good (4) to excellent (5), and very (6) good light fastness with simultaneous mordanting for both mordants used. The optimum contact time recorded for cotton with both mordants on the basis of color strength and fastness is 50 minutes.

Keywords: *mordants, mordanting, fastness, color strength.*

INTRODUCTION

Dyeing with natural colorants was one of the oldest techniques practiced during the ancient civilization. This is evident from the Ajanta, Ellora, Sithannavasal, Mithila wall paintings (mural art) and paintings in Egyptian Pyramids which were exclusively done with natural colorants. The first synthetic dyes were invented by William Henry Perkin in 1856 and they received faster acceptability due to a wide range of applications in various fields like food, cosmetics, photodynamic therapy, non-linear optical activity and more importantly in textile industries due to ease in dyeing, and overall cost factor. [1,2] But, during the last few decades, the use of synthetic dyes is gradually decreasing due to an increased environmental awareness and harmful effects because of either toxicity or their non-biodegradable nature. The synthetic dye stuffs are suspected to cause allergies, and are carcinogenic and detrimental to human health. [3]

In the early 21st century, the market for natural dyes in the fashion industry is experiencing resurgence. Western consumers have become more concerned about the health and environmental impact of synthetic dyes in manufacturing and there is a growing demand for products that use natural dyes. Due to the current eco-consciousness, researchers' attention has been shifted to the use of natural dyes for dyeing textile materials. [4] However, the natural dyes have their own limitations like availability, color yield, stability, and lack of reproducibility of shades. In Uganda, forty plant species with potential to produce natural dyes for textile applications were identified [5] these plants include: *Albizia coriaria, Morinda lucida* and *Vitellaria*

paradoxa among others. Colors and shades from natural dyes are influenced by; the source, extraction and application procedures as well. Thus for these dyes to be used in the textile industry, the extraction methods, mordanting methods, and dyeing variables for each source have to be standardized. This is to allow the development of regular shades and colors with good fastness. In this respect therefore, the study established suitable methods for application of selected mordants on cotton and silk fabrics.

MATERIALS AND METHODS

Materials: The stem bark of *Morinda lucida* plant species was freshly extracted from a village in Mukono district in central Uganda brought to the lab and dried in open air at room temperature. Plain knitted cotton fabric 100% was bought from Southern Range Nyanza Textile Mill in Jinja, Uganda. Knitted silk fabrics were bought from Kawanda Agricultural research station, Uganda. Alum, Ferrous sulphates were used as mordants. Crockmeter and CIELab Color data machine were used for analysis.

Extraction of the dye: Aqueous method of extraction as in the method described by Deo and Roshan (2006) was used to extract dye from dried and pulverized plant sample. [6] The colored crude dye solution (150 ml) was diluted with distilled water (50 ml) and immediately used for dyeing.

Dyeing cotton and silk fabrics: Scoured and bleached plain woven cotton (1.5 g) and scoured bleached knitted silk fabrics (1.5 g each) were used. Three mordanting methods were used as described below for each of the mordant.

Pre-mordanting method: this was done according to the method of AATCC; [7] the textile fabric was first soaked in aqueous solution of mordant (10% o.w.f) for 30 minutes at a temperature of 85°C in 250ml beaker and then transferred into a dye bath and soaked for 30 minutes. After dyeing, the fabrics were thoroughly washed with 2g/L of ®*nomi* powder detergent solution at 50^0C for 10 minutes and rinsed with tap water.

Simultaneous mordanting: The textile fabrics were dyed by a simultaneous mordanting method as described. [8] After dyeing, the textile material was washed properly and soaping carried out by 2g/L industrial soap solution at 50^0C for 10 minutes. The fabric was then rinsed with water and dried at room temperature.

Post-mordanting method: this was done according to the method described by John *et al*. (1994) [9] keeping the material to liquor ratio (LR) of 1:20. After dyeing, the textile material was washed properly and soaping carried out by 2g/L industrial soap solution at 50^0C for 10 minutes and rinsed with tap water.

Evaluation of color fastness and color strength on the fabrics

Fastness to washing: This was carried out following the procedure of AATCC test method 61, 2 (A) using a Launder-o-meter. The 1.5 g dyed sample was stitched around the edges of a white cotton sample. The specimen was then given a domestic washing at 40^0C for 30 minutes using industrial soap as the detergent with a ratio of 1:50. After the treatment, the composite specimen was removed and rinsed in cold water and then dried in an oven. The dried sample was then assessed for change in color of dyed specimen and staining of adjacent fabric with grey scale and grading was given.

Fastness to rubbing: Color fastness to dry rubbing and wet rubbing fastness were tested as per AATCC test method 8 using a manually operated Crockmeter and grey scale. In the dry-rubbing test, the finger covered with the dry bleached fabric was moved back and forth along a track of 10 cm long on the dyed fabric for 20 times making

ten complete turns of the crank at the rate of about one turn per second. In the wet-rubbing test, the same procedure was used, with a fresh dry dyed specimen and un-dyed cloth wetted with distilled water. Staining of bleached white cotton fabric by dyed fabrics was assessed with standard grey scale.

Fastness to light: Color fastness to light exposure was determined as per IS: 2454 method. The half of the samples was exposed to UV light in a Shirley MBTF Microsal fade-o-meter along with the eight blue wool standards for 24 hours. The fading of each sample was observed against the fading of blue wool standards (1-8).

Color measurement: Color development and dye absorption potential of cotton fabrics were evaluated in terms of CIELab color coordinates. [10]

RESULTS AND DISCUSSIONS

Color fastness without application of mordant: Variable color shades were formed on both fabrics dyed with extracts from the bark of *Morinda lucida*. The variation in color shades is owed to the use of different mordanting methods for the different mordants with respect to dyeing time. As can be noted in Table 1 below, Silk recorded a good wash and light fastness of 3 and 4 respectively. It also had a very good dry rub fastness of 4 and wet rub fastness of 3-4. On cotton fabrics a weak wash fastness of 2 was registered with a good light, dry and wet fastness of 4, 3 and 3 respectively. Without application of mordant, color fastness on cotton registered was generally weak compared to that for silk fabrics.

Table 1: Color fastness without application of mordants

Fabric	Wash fastness		Light fastness	Rubbing fastness	
	Color change	Staining		Dry	Wet
Silk	3	2/3	4	4	3 – 4
Cotton	2	½	4	3	3

Color fastness using various mordanting methods: In Table 2 below, it can be noted that mordanting with both alum and ferrous markedly improved fastness of color on cotton fabrics for the various mordanting methods used. Very good to excellent fastness wash fastness of (4) and (5) were recorded for the various mordants and mordanting methods. The light fastness registered ranged from good to very good in grades of range (4-5) to (6), and very good and good dry and wet rub fastness of ranges (4) to (4-5) and (3) to (4) respectively. Generally post mordanting exhibited the best fastness with the mordants with excellent wash fastness of (5) and very good light fastness of grades (5-6) to (6). However there was no significant difference in dry and wet rub fastness for the three mordanting methods. A remarkable improvement in fastness was recorded for all mordants and mordanting methods. The iron species produced greener and deeper shades and alum produced yellower shades that varied with the method of application of mordant on the fabrics.

Various color shades were recorded on silk fabrics on application of the selected mordants. From Table 3, it can noted that simultaneous mordanting gave excellent wash fastness of (5) with both alum and ferrous sulphate mordants. Simultaneous mordanting also registered a very good light and dry and wet rub fastness of (6), (4-5) and (4) respectively. Both pre mordanting and post mordanting registered very good wash fastness of (4) and good light fastness of grades (5) and (5-6) with both mordants. There was no significant difference in fastness recorded for both alum and ferrous sulphate.

Generally, in-terms of color fastness of the dye on silk, simultaneous mordanting gave the best output. Natural dye from *Morinda lucida* plant species, with light fastness rating of range (5) to (6) and wash and rub fastness range of (4) to (5) met the minimum performance requirements and

suitability for application on silk and cotton fabrics.

Table 2. Color fastness on cotton fabrics with the application of mordants

Mordant	Mordanting method	Wash fastness		Light fastness	Rubbing fastness	
		Color change	Staining		Dry	Wet
Alum	PREM	4	2/3	5 – 6	4	3 – 4
	SM	4	2/3	4 – 5	4	3
	POM	5	2	5 – 6	4 – 5	4
Ferrous sulphate	PREM	4	2/3	5 – 6	4	3
	SM	3	2	6	4 – 5	3
	POM	5	2	6	4	3

PREM=Pre-mordanting, SM=Simultaneous mordanting, POM=post-mordanting

Table 3. Color fastness on silk fabrics with various mordanting methods

Mordant	Mordanting method	Wash fastness		Light fastness	Rubbing fastness	
		color change	Staining		Dry	Wet
Alum	PREM	4	2/3	5	4	3 -4
	SM	5	2	6	4 -5	4
	POM	4R	2/3	5 – 6	4 - 5	4
Ferrous sulphate	PREM	4	2/3	5 – 6	4	3
	SM	5	2	6	4 - 5	4
	POM	4	2/3	5	4	4

Remarks: R=Reddish. PREM=Pre-mordanting, SM=Simultaneous mordanting, POM=post-mordanting

The effect of dye contact time on color strength (K/S): Evaluation of color strength was done on cotton fabrics only due to a number of limitations. Post mordanting method was used in this case since it exhibited a superior color fastness over the other mordanting methods for cotton fabrics. The total color difference which is equivalent to color strength (K/S) in-terms of value was used as a basis. From Table 4 below, it can be noted that alum mordant gave lighter shade (L*>70) while ferrous sulpahte registered darker shades with values of L* at (70) and below. The increase in contact time darkened the shades produced as seen in decreasing values of L* with time. For alum the darkest shade was recorded at contact time of 50 minutes with no remarkable increase with time. The deepest shade was recorded with ferrous sulphate mordant at 60 minutes. The color strength recorded for alum increased from a value of (2.01) at 30 minutes to (3.65) at 60 minutes of contact. There was no remarkable change in color strength from 50 to 60 minutes, therefore 50 minutes is a suitable contact time with alum mordant. The a* values for alum mordant at all intervals were negative, this means that the shades produced were more green than red. With ferrous sulphate there was also a gradual increase in color strength with time and the greatest color strength of (15.00) was recorded at 60 minutes contact time. Not much time was given for the fabric to contact beyond 60 minutes perhaps there would be additional color strength recorded.

Table 4. Color data measurement on cotton for alum and ferrous mordants

Mordant	Dyeing time	Color coordinates					ΔE
		L*	a*	b*	C*	H^0	
Alum	30	81.14	-0.42	22.97	22.97	22.98	2.01
	40	77.74	-0.59	25.55	25.56	25.52	2.15
	50	76.47	-0.45	27.39	27.39	27.28	3.62
	60	76.36	-0.55	28.07	8.08	27.85	3.65
Ferrous sulphate	30	70.52	0.12	16.17	16.17	16.90	11.90
	40	71.71	-0.23	17.38	16.38	16.39	10.15
	50	65.92	0.31	19.27	19.27	22.16	13.71
	60	63.04	0.70	19.42	19.43	23.16	15.00

ΔE= Total color difference

The effect of contact time on wash fastness on cotton fabrics: The variation of wash fastness with time was established for both alum and ferrous sulphate mordants. For both mordants the preferred post mordanting method was used in the experiment. As recorded in Table 5, the

Table 5. Change in wash fastness with contact time

	Alum		Ferrous sulphate	
Time	color change	Staining	color change	Staining
30	3	3	3	2/3
40	4	3	3	2/3
50	4	2/3	4	2
60	5	2/3	4	2

With alum as the mordant, there was increase in color change with respect to time from good (3) at 30 minutes to excellent (5) at 60 minutes staining also improved from (3) to (2/3) a reduced staining from 50 minutes. Considering time as an important factor, a fastness grade of (4) at 50 minutes is very good and this could be an acceptable contact time for alum mordant. As well, for ferrous sulphate the color change improved from moderate (3) at 30 minutes to very good at 50 minutes with staining of (2/3) at 30 minutes and (2) at 50 minutes. No improvement was recorded in color change and staining beyond 50 minutes with ferrous sulphate.

CONCLUSION

Dye from *Morinda lucida* bark yielded various colors shades with alum and ferrous sulphate mordants and mordanting methods. The dye exhibited poor fastness on both cotton and silk fabrics. However, for cotton with application of mordants the dye exhibited excellent wash fastness (5), very good light fastness (6) and very good and good dry and wet rubbing (4-5) and (3) with various mordanting methods. The dye can therefore be classified as adjective dye. For silk fabrics the simultaneous method produced excellent wash fastness (5), very good light fastness (6) and very good dry and wet rubbing for both alum and ferrous sulphate mordants. The best color strength and fastness on cotton was recorded for contact time of 50 minutes with slight improvement at 60 minutes. The optimum time for contact in dye bath for cotton is therefore 50 minutes. Post mordanting gave the most suitable color fastness and strength. For silk fabrics, simultaneous mordanting registered the best color fastness.

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