

Studies on the Fastness Properties of Cotton Fabrics Dyed with Cutch (Sha)

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Abstract

Today the protection of environment has become a challenge for the chemical industry worldwide and the water pollution caused by synthetic dyes in particular, the control of effluent continues to be a problem. The use of natural dye prevents the environmental pollution. Natural dye can be extracted from various parts of plants such as flowers, leaves, fruits and barks. In this research, the bark of Cutch (Sha) was used for the preparation of natural dyes. Dyes were extracted from plant barks using water and then the color produced on cotton fabrics dyed with various dyeing methods and mordants, and also the fastness properties of the dyed cotton fabrics were studied. An attempt was also made on the dyeing of cotton fabrics with natural dyes using different mordants such as alum, slaked lime and copper (II) sulphate. Among these mordants, copper (II) sulphate demonstrated relatively more attractive colors and acceptable fastness on cotton fabric in all dyeing methods as indicated. Moreover, fastness tests especially for light, rubbing and washing on dyed cotton fabrics were carried out. Staining and changing in color were assessed by using standard grey scale and the results were recorded.

Key words: natural dye, mordant, cotton fabric, dyeing, fastness properties

Introduction

Natural dyes are obtained from vegetable, animal and mineral sources . Nature is full of fascinating colors and people had been exploiting them for dyeing garments, using them in food and many other items of the daily use. A dye can be generally described as a colored substance that has an affinity to the substrate to which it is being applied. It is usually used as an aqueous solution, and may require a mordant to improve the fastness of the dye on the fiber. The use of dyes to color textiles is generally considered to be about 2000 years old. Primitive men made the dyes from flowers, nuts, berries and other forms of vegetable and plant life, as well as from mineral and animal sources. These sources have provided such "natural dyes" throughout civilization.

All natural substances contain some amount of pigment, but effective dyes can only be made from a limited range of materials because natural dye pigments must be a stable chemical structure so that they can withstand such conditions as exposure to sunlight, laundering, wear, and tear. Natural dyes are pleasing to the eye and soothing to the mind because natural dyes use pigments derived from nature. Moreover, these environment-friendly dyes can help to reduce pollution and promote good health. Consequently, enterprises all over the world are now developing environment-sensitive products that incorporate natural dyes. Nowadays, with growing recognition of the seriousness of water pollution worldwide, natural dyes made from organic ingredients are enjoying a dramatic revival (Clark,1997).

This research concerned with the extraction of natural dye from the bark of jackfruit tree and application on cotton fabrics. The effect of dyeing on cotton material promotes to small and medium enterprises in textile.

The aim of the present research is to study the color produced on cotton fabrics with various dyeing methods, to study the fastness properties of dyed cotton fabrics, to solve the ecological and environmental problems related to the use of synthetic dyes and to substitute the imported product of the high quality and reasonable cost.

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Materials and Methods

Materials

In this study, the bark of Cutch (*Acacia catechu* Willd.) (Sinphyukyun Township, Magwe Region), was used as raw materials for the extraction of natural dye. Cotton fabrics were purchased from Win Thuzar Shop, Ministry of Industry and mordants such as alum (commercial grade), slaked lime and copper (II) sulphate (commercial grade) were purchased from local market (Academy Chemical Market).

Extraction of Natural Dye from Cutch Bark

The dye was extracted from the stem bark powders of cutch about (+65 mesh) by using water as aqueous medium. Powder of dried bark (3g, 5g, 7g) were weighed and placed in the stainless steel pot. Then (90ml, 150ml, 210ml) of water was added using the solid to liquid ratio of 1:30. The stainless steel pot was heated slowly to boiling point at which it was simmered for 45 minutes. Then the extracted solution was allowed to cool and filter. After that, the bark powders on the filter were squeezed out and removed.

Mordanting the Cotton Fabrics

In this research, alum (5 %), slaked lime (5 %) and copper (II)sulphate(5 %) were used as mordant. Before dyeing the cotton fabrics with natural dye, the bleached cotton fabrics were soaked in water for one hour.

Dyeing the Cotton Fabrics

Dried bark powder (3g, 5g, 7g) was placed in a beaker and dissolved in a little amount of warm water. Warm water (38°C) was added to a material using the ratio of 30:1. The solution was heated to a temperature of 80°C. Then, cotton fabric to be dyed was added into this solution and frequently stirred to obtain good penetration of dye molecules into the fabric. Dyeing process was done at 80°C for about 30 minutes.

After dyeing, the dyed fabrics were lifted out and squeezed by hand. They were rinsed with warm water and then rinsed in cold water to remove the unfixed dyes. Finally, the fabrics were dried at room temperature and ironed.

In this research, pre-mordanting method, post-mordanting method and simultaneous mordanting and dyeing method were used. In pre-mordanting method, mordanting process was done before dyeing operation. In post-mordanting method, mordanting process was done after dyeing operation. In simultaneous mordanting and dyeing method, mordant, dye and fabric were added in a pot and treated together.

Testing the Color Fastness of Dyed Fabrics

After dyeing, color fastness on dyed fabrics were tested to determine the fastness properties. In the dyeing of textile substrates, the following fastness tests were used. There were fastness to sea water, fastness to perspiration, fastness to gas fume, storage, rubbing, light and washing. In this study, light fastness, washing and rubbing fastness tests were carried out to determine the color fastness on dyed fabric.

To evaluate the color fastness of the dyed fabric, the changes of color due to the conditions of test were compared with the color of original fabric. And then the color transfer and staining on cotton and polyester/ cotton blend fabrics were determined by using Grey Scales. (Harwood and Bramhall, 1987).

Measurement of Color Development and Dye Absorption on cotton Fabrics

The color developed on the dyed cotton fabrics were determined by CIELAB system coordinates L^* , a^* , b^* , with C^* and h^* value refers to the lightness of colors ranging from zero for black, 50 for grey and 100 for white. The positive and negative values of a^* refer to red and green color components while the positive and negative values of b^* refer to yellow and blue color components respectively. For neutral point, the values of a^* and b^* were zero.

The values of chroma C^* and the angle of hue h^* were used to show the color saturation and the range of color, the angle of hue, h^* , being measured starting from red to yellow, i.e, hue angle 90° refers to yellow shade, hue angle 180° refers to green shade, hue angle 270° refers to blue shade, etc. When the value of chroma was increased, the color will be more saturated to a shade.

Results and Discussion

Cutch dye shows the good dry rubbing fastness and light fastness in all cotton fabrics dyed by all of the mordants used. However, good wet rubbing fastness was found in cotton fabric dyed by copper (II) sulphate mordant. In washing fastness, the change of shade ratings showed poor fastness whereas staining on cotton and polyester/ cotton fabric had good fastness grade. For change shade in washing fastness test, the copper (II) sulphate mordant gave comparatively better fastness than the other mordants used. Color fastness results of dyed cotton fabrics for each group of mordant were shown in Table 1 to Table 3 and color development of cotton dyed with Cutch bark were shown in Figure. 4, 5 and 6.

Comparing the results in Table 1, pre-mordanting method with copper (II) sulphate was found due to the better results of color fastness than that of alum and slaked lime mordant. And the results in Table 2, post-mordanting method with alum and slaked lime mordant gave nearly the same results for color fastness. Table 3 demonstrated that simultaneous-mordanting and dyeing method with copper (II) sulphate mordant gave the better color fastness results than the other two mordants. Therefore, simultaneous-mordanting and dyeing method with copper (II) sulphate mordant was the most suitable for natural dye extracted from the bark of cutch.

Table 4 and Figure 1 show that a^* and b^* values lie in the region between red and yellow color. The colors of the samples were closer to yellow shade than red because their hue angles were between 80.83 to 89.61. The colors developed on cotton fabrics were light reddish yellow because the color values were 0.05 to 2.90 red, 7.21 to 17.99 yellow and 71.54 to 77.05 lightness. According to chroma values, the maximum color saturation occurred by using simultaneous mordanting method.

From Table 5 and Figure 2, it can be seen that the colors developed on cotton fabrics were light brownish yellow with a little trace of green and red shade because the color values were 70.45 to 78.50 lightness, -0.82 to -1.6 green and 0.10 to 2.95 red and 5.43 to 23.26 yellow. According to chroma values, maximum color saturation and maximum dye absorption occurred by using post-mordanting method with 7g dye solution.

From Table 6 and Figure 3 show that a^* and b^* values lie in the region between red and yellow and thus the colors developed on cotton fabrics were brownish yellow. According to the chroma values, maximum color saturation occurred by using pre-mordanting method with 5g dye solution and maximum dye absorption occurred in simultaneous-mordanting method.

It could be observed that cotton fabrics using simultaneous-mordanting and dyeing method with each types of mordants were the most suitable for good color fastness. From these results, copper (II) sulphate mordant demonstrated relatively more attractive colors and acceptable fastness on cotton fabric in all dyeing methods because it is a versatile chemical with an extensive range of used in industry.

Table 1. Effect of Mordant on Changes in Color Fastness of Cotton Fabrics Dyed with Cutch Bark Using Pre-mordanting Method

Sr. No	Types of Mordant	Sample Code	Rubbing Fastness		Washing Fastness			Light Fastness
			Dry	Wet	Change of Shade	Staining on cotton p/c		
1.	Alum	A ₁₁	4	3	1	4 -5	4 -5	4
		A ₁₂	4	3	2	4 -5	4 -5	4
		A ₁₃	4	3	1	4 -5	4 -5	4
2.	Slaked lime	B ₁₁	4	3 - 4	1	4 -5	4 -5	4
		B ₁₂	4	3	1	4 -5	4 -5	4
		B ₁₃	4	3	1	4 -5	4 -5	4
*3.	Copper (II) sulphate	C ₁₁	4	4	2	4 -5	4 -5	4
		C ₁₂	4	4	2	4 -5	4 -5	4
		C ₁₃	4	4	2	4 -5	4 -5	4

Table 2. Effect of Mordant on Changes in Color Fastness of Cotton Fabrics Dyed with Cutch Bark Using Post-mordanting Method

Sr. No	Types of Mordant	Sample Code	Rubbing Fastness		Washing Fastness			Light Fastness
			Dry	Wet	Change of Shade	Staining on cotton p/c		
1.	Alum	A ₂₁	4	3 - 4	1	4 -5	4 -5	4
		A ₂₂	4	3 - 4	2	4 -5	4 -5	4
		A ₂₃	4	3	1	4 -5	4 -5	4
2.	Slaked lime	B ₂₁	4	3 - 4	1	4 -5	4 -5	4
		B ₂₂	4	3 - 4	1	4 -5	4 -5	4
		B ₂₃	4	3	1	4 -5	4 -5	4
*3.	Copper (II) sulphate	C ₂₁	4	4	2	4 -5	4 -5	4
		C ₂₂	4	4	2	4 -5	4 -5	4
		C ₂₃	4	4	2	4 -5	4 -5	4

Table 3. Effect of Mordant on Changes in Color Fastness of Cotton Fabrics Dyed with Cutch Bark Using Simultaneous-mordanting Method

Sr. No	Types of Mordant	Sample Code	Rubbing Fastness		Washing Fastness			Light Fastness
			Dry	Wet	Change of Shade	Staining on cotton p/c		
1.	Alum	A ₃₁	4	3 - 4	2	4 - 5	4 - 5	4
		A ₃₂	4	3 - 4	2	4 - 5	4 - 5	4
		A ₃₃	4	3	2	4 - 5	4 - 5	4
2.	Slaked lime	B ₃₁	4	3 - 4	3	4 - 5	4 - 5	4
		B ₃₂	4	4	3	4 - 5	4 - 5	4
		B ₃₃	4	3	3	4 - 5	4 - 5	4
*3.	Copper (II) sulphate	C ₃₁	4	4	3	4 - 5	4 - 5	4
		C ₃₂	4	4	3	4 - 5	4 - 5	4
		C ₃₃	4	4	3	4 - 5	4 - 5	4

Note : p/c = polyester + cotton , 1= very poor, 2 = poor, 3 = fair, 4 = good and 5 = excellent,

* = the most suitable condition

These experiments were conducted at Development Centre for Textile Technology in Ministry of Industry, Yangon Region.

Table 4. Results of Color Developed and Dye Absorption of Cutch on Cotton Fabrics by Using Alum Mordant

Sr. No.	Dyeing Method	Sample Code	Dye (g)	Dye Absorption	CIEL* a* b* System				
					L*	a*	b*	C*	h*
1	Pre-mordanting	A ₁₁	3	0.800	77.05	0.31	8.19	8.2	87.81
		A ₁₂	5	0.600	72.95	1.38	13.47	13.54	84.14
		A ₁₃	7	0.320	74.03	1.63	12.95	13.05	82.82
2	Post-mordanting	A ₂₁	3	0.250	76.81	0.05	7.21	7.21	89.61
		A ₂₂	5	0.700	73.28	1.18	14.07	14.12	85.23
		A ₂₃	7	0.750	74.2	0.6	12.08	12.09	87.16
3	Simultaneous - mordanting	A ₃₁	3	0.821	74.53	0.69	11.28	11.31	86.52
		A ₃₂	5	0.880	72.73	2.39	16.65	16.83	81.82
		A ₃₃	7	0.920	71.54	2.9	17.99	18.22	80.83

Table 5. Results of Color Developed and Dye Absorption of Cutch on Cotton Fabrics by Using Slaked Lime Mordant

Sr. No.	Dyeing Method	Sample Code	Dye (g)	Dye Absorption	CIEL* a* b* System				
					L*	a*	b*	C*	h*
1	Pre-mordanting	B ₁₁	3	0.130	75.65	-1.23	12.50	12.56	95.63
		B ₁₂	5	0.150	73.34	-0.82	16.13	16.15	92.93
		B ₁₃	7	0.180	70.45	0.72	21.45	21.46	88.08
2	Post-mordanting	B ₂₁	3	0.050	72.0	0.10	13.81	13.81	89.60
		B ₂₂	5	0.072	67.65	2.72	23.26	23.41	83.32
		B ₂₃	7	0.092	65.20	2.95	23.24	23.43	82.77
3	Simultaneous - mordanting	B ₃₁	3	0.352	78.50	-1.48	5.43	5.63	105.23
		B ₃₂	5	1.750	77.33	-1.60	6.02	6.23	104.87
		B ₃₃	7	1.875	76.64	-1.60	7.25	7.42	102.47

Table 6. Results of Color Developed and Dye Absorption of Cutch on Cotton Fabrics by Using Copper (II) Sulphate Mordant

Sr. No.	Dyeing Method	Sample Code	Dye (g)	Dye Absorption	CIEL* a* b* System				
					L*	a*	b*	C*	h*
1	Pre-mordanting	C ₁₁	3	3.300	63.94	3.13	22.79	23.00	82.17
		C ₁₂	5	3.800	60.51	3.79	26.63	26.90	81.89
		C ₁₃	7	4.280	65.94	3.42	24.78	25.01	82.14
2	Post-mordanting	C ₂₁	3	0.800	67.30	0.69	14.23	14.25	87.21
		C ₂₂	5	2.522	60.88	2.33	16.82	16.98	82.10
		C ₂₃	7	2.952	57.13	3.23	17.64	17.94	79.63
3	Simultaneous - mordanting	C ₃₁	3	2.300	63.26	1.09	17.94	17.97	86.51
		C ₃₂	5	3.600	58.37	3.95	20.70	21.07	79.20
		C ₃₃	7	5.400	57.60	4.18	21.53	21.93	79.02

Note: L* = lightness of color, a* (+) = red color, a*(-) = green color, b*(+) = yellow color, b*(-) = blue color,

C* = chroma value, h* = hue angle

These experiments were carried out at Textile Engineering Department, Yangon Technological University.

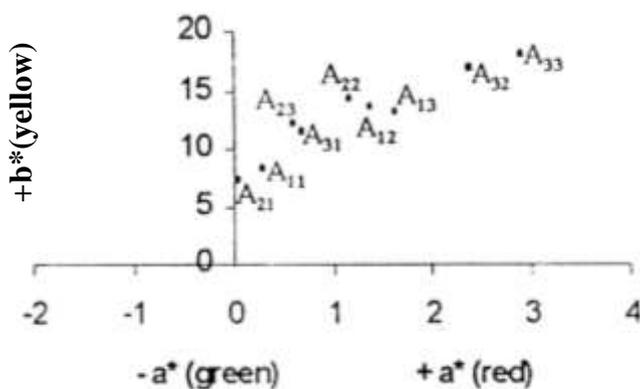


Figure 1. Color Developed of Cutch on Cotton Fabrics by Using Alum Mordant

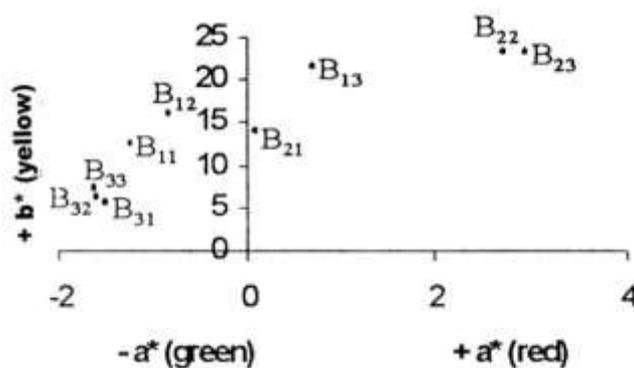


Figure 2. Color Developed of Cutch on Cotton Fabrics by Using Slaked Lime Mordant

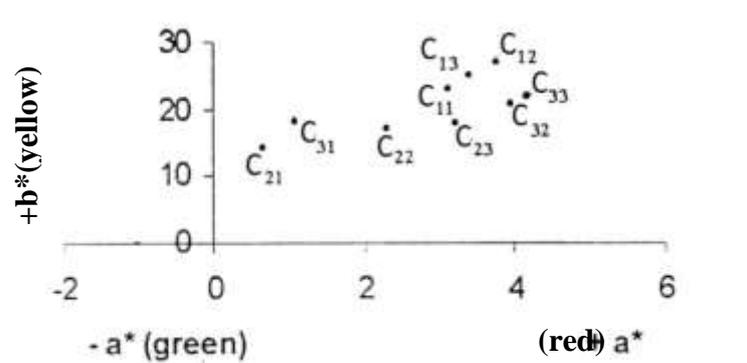


Figure 3. Color Developed of Cutch on Cotton Fabrics by Using Copper (II) Sulphate Mordant

Method of Dyeing	Sample Code	3% Dye Solution	Sample Code	5% Dye Solution	Sample Code	7% Dye Solution
Pre-mordanting Method	A ₁₁		A ₁₂		A ₁₃	
Post-mordanting Method	A ₂₁		A ₂₂		A ₂₃	
Simultaneous-mordanting Method	A ₃₁		A ₃₂		A ₃₃	

Figure 4. Color Development of Cotton Dyed with Cutch Using Alum Mordant

Method of Dyeing	Sample Code	3% Dye Solution	Sample Code	5% Dye Solution	Sample Code	7% Dye Solution
Pre-mordanting Method	B ₁₁		B ₁₂		B ₁₃	
Post-mordanting Method	B ₂₁		B ₂₂		B ₂₃	
Simultaneous-mordanting Method	B ₃₁		B ₃₂		B ₃₃	

Figure 5. Color Development of Cotton Dyed with Cutch Using Slaked Lime Mordant

Method of Dyeing	Sample Code	3% Dye Solution	Sample Code	5% Dye Solution	Sample Code	7% Dye Solution
Pre-mordanting Method	C ₁₁		C ₁₁		C ₁₁	
Post-mordanting Method	C ₂₁		C ₂₁		C ₂₁	
Simultaneous - mordanting Method	C ₃₁		C ₃₁		C ₃₁	

Figure 6. Color Development of Cotton Dyed with Cutch Using Copper (II) Sulphate Mordant

Conclusion

In the application of natural dye on cotton fabric, mordanting with copper (II) sulphate in all dyeing methods can produce attractive colors and acceptable fastness on cotton fabric.

The rubbing and light fastness of dyed fabric by cutch dye were good and washing fastness of fabrics using copper (II) sulphate mordant was also good.

It can also be concluded that cotton fabrics dyed by using simultaneous mordanting and dyeing method was the best for color fastness and cost effectiveness. This research work would be implemented for the development of Myanmar Traditional Textile Industry.

Acknowledgements

We are grateful to Professor Dr Maung Maung Naing, Rector, Dr Si Si Khin and Dr Tint Moe Thuzar, Pro-Rectors, Yadanabon University and Dr Khin Hnin Aye, Professor and Head of Department of Industrial Chemistry, Yadanabon University, for their permission to submit this article. I would like to express my gratitude to supervisor Dr Khin Thet Ni, Professor and Head (Rtd) , Department of Industrial Chemistry, University of Yangon, for giving permission to use research facilities and her suggestions during the research work.

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