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คุณสมบัติการย้อมสีและความคงทนของสีของผ้าไหม และผ้าฝ้ายที่ย้อมด้วยน้ำสกัดจากเปลือกของต้นยูคาลิปตัส

Dyeing and Colour Fastness Properties of Silk and Cotton Fabrics Dyed with Eucalyptus Bark Extract

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บทคัดย่อ

งานวิจัยนี้เกี่ยวข้องกับการสกัดสีย้อมจากเปลือกของต้นยูคาลิปตัส และนำมาย้อมบนผ้าไหมใช้อุณหภูมิการย้อมที่ 90 องศาเซลเซียส นาน 40 นาที ค่าพีเอชน้ำย้อมเป็น 4 และใช้อัตราส่วนวัสดุสิ่งทอต่อน้ำย้อมเป็น 1:30 สำหรับย้อมผ้าฝ้ายใช้อุณหภูมิการย้อมที่ 60 องศาเซลเซียส และไม่ต้องปรับค่าพีเอชน้ำย้อม ส่วนสภาวะอื่นๆ เหมือนกับการย้อมผ้าไหม ผ้าไหมที่ผ่านการย้อมสีจะได้สีเหลืองถึงน้ำตาล ยกเว้นเมื่อใช้เหล็กเป็นสารมอร์แดนท์จะได้สีเทาถึงน้ำตาลเข้ม สำหรับผ้าฝ้ายที่ผ่านการย้อมสีจะได้สีเหลืองถึงส้ม ยกเว้นเมื่อใช้เหล็กเป็นสารมอร์แดนท์ จะได้สีเทาอ่อนถึงเทา คุณสมบัติของผ้าไหมและผ้าฝ้ายที่ผ่านการทำมอร์แดนท์และย้อมสีจะมีความคงทนของสีต่อการซักล้าง ต่อเหงื่อ และต่อน้ำอยู่ในระดับดีถึงดีมาก แต่จะมีความคงทนของสีต่อแสงและต่อการขัดถูในระดับปานกลางถึงดี

Abstract

This research was concerned with dye extraction from the bark of eucalyptus and application for silk and cotton fabric dyeing. Silk and cotton fabrics were treated with pre-mordanting process before dyeing experiments, in order to facilitate dye absorbency of fabrics such as silk dyeing at 90°C for 40 minutes and pH 4, cotton dyeing at 60°C for 40 minutes and pH no adjustment. The best result was achieved when liquor ratio between fabric and dyed solution as 1:30 was employed. Silk dyed in the solution extracting from the bark of eucalyptus with mordant compound displayed yellow to brown colour except fabric using fesrrous (Fe) mordant exhibiting the shade of dark brown to grey. For cotton fabric, the shade of yellow to orange was obtained, except fabric using ferrous (Fe) mordant displaying the shade of pale grey to gray. Silk and cotton fabrics treated with pre-mordanted and dyeing process has presented the properties of colour fastness to washing, water and perspiration from good to very good level whereas colour fastness to light and rubbing was from fair to good level.

คำสำคัญ : สีย้อมธรรมชาติ ยูคาลิปตัส มอร์แดนท์ ไหม ฝ้าย

Key words : Natural dye, Eucalyptus, Mordant, silk, Cotton

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1. Introduction

The natural dyes may have, a wide range of shades, which can be obtained from various parts of plants including roots, barks, leaves, flowers and fruits (Allen, R.M.L, 1971). They normally require mordants, which are metallic salts of aluminum, iron, chromium, copper and others, for ensuring the reasonable fastness of the colour to sunlight and washing (Robertson, S.M., 1973). The metal ions can act as electron acceptors to electron donor to form co-ordinate bonds with dye molecules, which are insoluble in water. Lately, there has been increasing interest in the natural dyes, as public becomes aware of ecological and environmental problems related to the use of synthetic dyes. As the use of natural dyes cuts down significantly on amount of toxic effluent resulting from the synthetic dye process. Thai natives still use natural dyes in home industries as well as in hansdicraft works. In Thailand, a number of different types of plants are employed for dyeing (Moeyes Marjo, 1993). One of the plant uses for dyeing is eucalyptus, although eucalyptus has been used in paper industry, oil eucalyptus and textile dyeing. In this study, the effect of temperature, time, pH, the kind of mordant and colour fastness of silk and cotton fabrics dyed with eucalyptus bark were investigated.

2. Experimental

2.1 Materials

Multifiber D.W. type, silk and cotton fabrics (Standard Adjacent Fabrics for Staining of Fastness: ISO 105-F: 1985) were used without further purification. Potassium aluminium sulphate hydrate ($AlKO_8S_2.12H_2O$), Copper sulphate hydrate ($CuSO_4.5\ H_2O$), Stannous chlorine hydrate ($SnCl_2.\ 2\ H_2O$), Iron (II) sulphate hydrate ($FeSO_4.7\ H_2O$), Sodium carbonate (Na_2CO_3) (Italma (Thailand) Co, Ltd). Acetic acid (CH_3COOH) (Lab Scan Asia Co, Ltd) and Non ionic soap (Matapon X - 80) (Ilin Enterprise Co, Ltd).

2.2 Extracting

The eucalyptus bark was cut into small pieces by blender. Then eucalyptus bark was the raw material for dye extraction was at 100 °C for 1 hour and liquor ratio of material: water was 1:40. The eucalyptus bark extract solution (natural dye solution) obtained in this study was reddish brown colour.

2.3 Dyeing Method

Silk and cotton fabrics were dyed with the natural colouring matter extracted from eucalyptus bark at liquor ratio 1:30, was heated at different durations (10-60 minutes), and different temperatures (30-100 °C). The dyed samples were rinsed with cold water, washed in a bath of liquor ratio 1:30 using 1 g/l of non-ionic soaping agent (Matappon X-80) at 50 °C for 10 minutes, then rinsed and finally dried at ambient temperature. They were measured for K/S value by spectrophotometer. The pH values were recorded with pH meter and adjusted with dilute solution of sodium carbonate and acetic acid, then varying the pH

values as 4, 5, 6 and 7 respectively though process at 90 °C and 60 °C for silk and cotton fabrics respectively for 40 minutes, the liquor ratio was 1:30, when finished, measured the K/S value by spectrophotometer.

2.4 Mordanting Method

The optimal condition for mordant application on silk and cotton were investigated which in pre-mordant process at 30 °C for 10 minutes and then quantity of mordant substance was 0.1 % owf., then passed thought dyeing process at 90 °C and 60 °C for silk and cotton fabrics respectively for 40 minutes, the liquor ratio was 1:30. They were measured for K/S value by spectrophotometer.

2.5 Colour Fastness Test

With regard to the dyestuff properties of the dyeing agent, the ability of mordanting agent to fix on a fiber is the important requirement. Obviously, this relates to the colour fastness properties, which normally test according to ISO standard test. These tests including colour fastness to light colour fastness to washing, colour fastness to water, colour fastness to perspiration, and colour fastness to rubbing. The test results were expressed in grey scale terms instead of the K/S value. According to the standard grey scale for color change and grey scale for colour staining.

2.6 Characterization

The reflectance value and the corresponding K/S values for the dyed samples was measured using a spectrophotometer (Spectraflash SF 600 Datacolor) interfaced to a digital PC under illuminant D_{65} with a 10° standard observer. Colour strength, K/S, was calculated from the reflectance values using Kubellka-Munk equation as follows: $K/S = (1-R)^2/2R$. Where R is the decimal fraction of the reflection of the dye fabric, K is the absorption coefficient and S is scattering coefficient (K. McLaren, 1976). Colour change and colour staining were assessed using grey scale.

3. Results and discussion

3.1 Factors affecting dyeing of silk and cotton fabric with eucalyptus bark extract

3.1.1 Effect of temperature for dyeing on silk and cotton fabrics

From the experiment to find the optimal temperature for dyeing silk and cotton fabric, the experimental result is shown in Table 1. From Table 1, dyeing silk and fabric in eucalyptus extracted from bark showed that the increasing temperature can increase the K/S value until reaching 90°C. The appearance colour of silk which dyed in eucalyptus bark extract was brown colour. The dyed cotton fabric showed that the increasing temperature can increase the K/S value until reaching 60°C the K/S value was constant. The appearance colour of the dyed in eucalyptus bark extract was yellowish orange. The result from Table 1 fabric can be plotted as Figure 1.

3.1.2 Effect of time for dyeing on silk and cotton fabrics

From experiment, the suitable time for dyeing silk and cotton were found the result is shown in Table 2. From Table 2, when the time in dyeing silk and cotton fabrics was increased, the K/S value increased. After 40 minutes, the K/S value was constant. The result can be illustrated as Figure 2.

3.1.3 Effect of pH value for dyeing on silk and cotton fabrics

The experiment is to find the suitable pH value for dyeing silk and cotton fabric. The result of experiment can be concluded as following Table 3. From the pH value experiment, the pH value of eucalyptus bark dyed was 6.2. From Table 3, pH value at 4.0 was the best result for dyeing silk fabric when compared with the other pH value. When increasing pH value, K/S value was declined. Without adjusting pH value when dyed cotton, gained darken hue value than the other pH value. The K/S value declined when pH value increased, as seen in Figure 3.

3.2 Effect of using difference type of mordant for silk and cotton dyeing

The experiment is to find the suitable condition for pre-mordant process and for dyeing process of cotton and silk fabric. The results are shown in Table 4. The K/S are shown in Table 4. It was found that the K/S values of pre-mordant silk and cotton fabrics were higher than those of un-mordanted fabrics except pre-mordanted on silk fabric with $SnCl_2$. The K/S values of silk fabric increased in the order of dyeing using Fe> Cu> Al> un-mordant> Sn, however, the K/S value of the cotton fabric increased in the order of dyeing using Sn> Fe> Cu> Al> un-mordant.

3.3 Colour fastness

The rating of fastness (light, rubbing, water, washing, and perspiration fastness) of pre-mordant and un-mordant cotton and silk fabrics dyed with eucalyptus bark are show in Table 5 to Table 10 respectively. It was found that the properties of colour fastness, washing water and perspiration in good to very good whereas colour fastness to light and rubbing was in fair to good.

4. Conclusions

The purpose of this study is to investigate the effect of temperature, time, pH and mordant type on dyeing properties and colour fastness of silk and cotton fabrics dyed with eucalyptus bark extract solution. It was found that silk and cotton fabric were treated with pre-mordanting process before dyeing experiments, in order to facilitate dye absorbency of fabric such as silk dyeing at 90 °C for 40 minutes and pH 4, cotton dyeing at 60 °C for 40 minutes and pH no adjustment. The best result was achieved when liquor ratio between fabric and dyed solution as 1:30 was employed. The K/S values of silk fabric increased in the order of dyeing using Fe> Cu> Al> un-mordant> Sn, however, the K/S value of the cotton fabric increased in the order of dyeing using Sn> Fe> Cu> Al> un-mordant. Silk dyed in the solution from bark of eucalyptus showed the shade of yellow-brown, excepting using ferrous (Fe)

showing the shade of dark brown-grey. For cotton fabric showed the shade of yellow-orange, accepting using ferrous (Fe) showed the shade of pale grey. The fastness properties of silk and cotton fabric after treated with pre-mordant and dyeing process. It presented the fastness, washing, water and perspiration on good to very good level but the fastness to light and rubbing on fair to good level.

Table 1 The ΔL^*, Δa^*, Δb^* and K/S value of dyed silk and cotton fabrics by varying temperature of dyeing

Dyeing Temperature (°C) for 1 Hour	Colour measurement (Silk fabric)			
	ΔL^*	Δa^*	Δb^*	K/S
30	-13.62	5.86	14.87	1.6038
40	-17.00	7.21	17.58	2.1647
50	-19.51	8.21	18.02	2.2658
60	-20.40	8.60	18.08	2.2720
70	-24.43	10.27	19.39	3.0013
80	-26.45	11.70	20.31	3.3310
90	-30.58	12.92	20.18	4.0187
100	-30.59	12.93	20.18	4.0169
Dyeing Temperature (°C) for 1 Hour	Colour measurement (Cotton fabric)			
	ΔL^*	Δa^*	Δb^*	K/S
30	-14.89	8.39	19.19	1.0615
40	-15.79	8.56	19.07	1.0600
50	-16.85	9.33	18.72	1.0654
60	-16.35	9.83	18.80	1.0674
70	-17.73	7.81	17.33	1.0674
80	-13.98	7.94	15.95	0.7553
90	-14.30	7.92	15.98	0.7736
100	-14.68	7.59	15.64	0.8004

Remark: Light source = D65, Observe degree = 10°, K/S (λ = 400 nm)

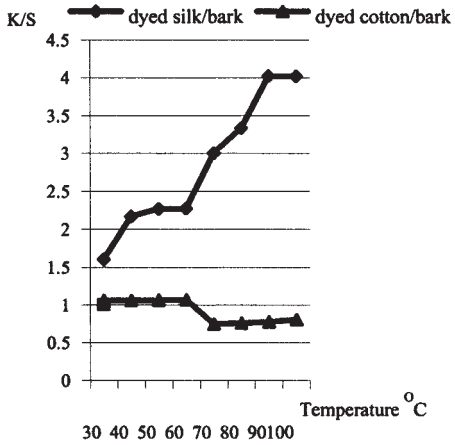

Figure 1. K/S value dyed silk and cotton fabrics by varying temperature of dyeing

Table 2 The ΔL^*, Δa^*, Δb^* and K/S value of dyed silk and cotton fabrics by varying time of dyeing

Dyeing time (minutes) (90°C for cotton)	Colour measurement (Silk fabric)			
	ΔL^*	Δa^*	Δb^*	K/S
10	-20.44	8.60	18.08	2.2720
20	-27.48	10.61	18.66	3.3477
30	-26.93	10.65	18.65	3.3563
40	-30.56	12.91	20.15	4.0180
50	-30.59	12.90	20.17	4.0160
60	-30.60	12.87	19.96	4.0157
Dyeing time (minutes) (90°C for cotton)	Colour measurement (Cotton fabric)			
	ΔL^*	Δa^*	Δb^*	K/S
10	-11.86	5.51	13.49	0.5883
20	-12.00	6.58	15.22	0.6544
30	-13.59	7.68	16.65	0.8059
40	-16.30	9.81	18.80	1.0674
50	-16.85	9.33	18.72	1.0654
60	-15.79	8.56	19.07	1.0600

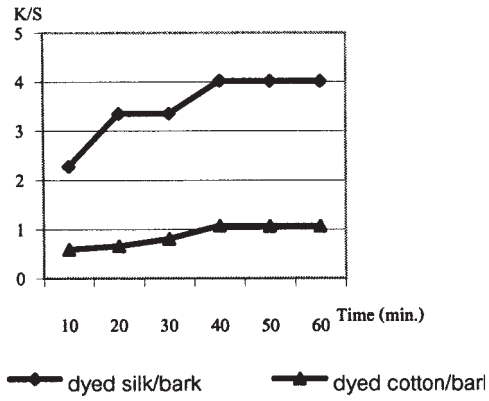

Figure 2. K/S value dyed silk and cotton fabrics by varying time of dyeing

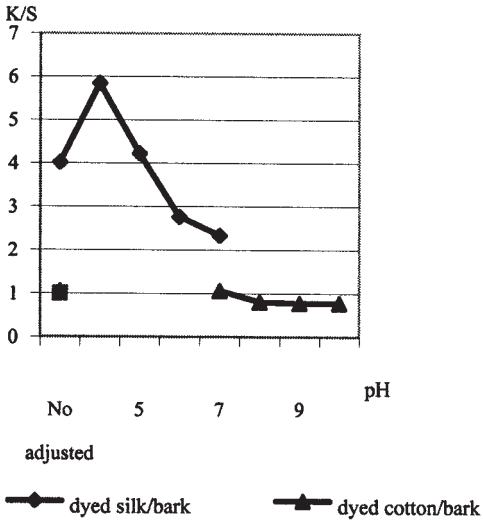

Table 3 The ΔL*, Δa*, Δb* and K/S value of dyed silk and cotton fabrics by varying pH value of dyeing

Dyeing pH value	Colour measurement (Silk fabric)			
	ΔL*	Δa*	Δb*	K/S
No adjusted	-30.57	12.88	20.12	4.0157
4	-43.35	15.68	18.73	5.8372
5	-38.07	14.61	18.17	4.2163
6	-30.00	11.38	18.45	2.7612
7	-27.89	10.93	17.67	2.3321
Dyeing pH value	**Colour measurement (Cotton fabric)**			
	ΔL*	**Δa***	**Δb***	**K/S**
No adjusted	-16.33	9.85	19.12	1.0618
7	-14.89	8.30	19.10	1.0610
8	-14.68	7.59	15.63	0.8000
9	-14.30	7.92	15.90	0.7735
10	-13.98	7.90	15.90	0.7730

Remark: Light source = D65, Observe degree = 10°, K/S (λ = 400 nm)

Table 4 The DL*, Da*, Db* and K/S value for pre-mordanting and dyeing of silk and cotton fabrics

Silk Fabric	ΔL*	Δa*	Δb*	K/S
Un-mordant	-43.35	15.68	18.73	5.7061
$AlKO_8S_2$ or Al	-36.39	12.34	21.94	5.8372
$CuSO_4$ or Cu	-38.68	8.00	21.35	6.4992
$FeSO_4$ or Fe	-48.55	3.98	9.18	7.1239
$SnCl_2$ or Sn	-23.48	9.09	22.22	3.6380
Cotton fabric	**ΔL***	**Δa***	**Δb***	**K/S**
Un-mordant	-16.33	9.85	19.12	1.0618
$AlKO_8S_2$ or Al	-14.66	6.86	19.10	1.3222
$CuSO_4$ or Cu	-20.27	8.70	18.79	1.5357
$FeSO_4$ or Fe	-27.23	4.91	11.13	1.6502
$SnCl_2$ or Sn	-25.94	5.75	28.12	4.4001

Remark: Light source = D65, Observe degree = 10°, K/S (λ = 400 nm)

Table 5 The result of colour fastness to light (Standard: ISO 105-B02: 1994)

Dyeing description	Colour change
Silk fabric	
Un mordant	4-5
Al mordant	4-5
Cu mordant	4-5
Fe mordant	4-5
Sn mordant	4-5
Cotton fabric	
Un mordant	3
Al mordant	3
Cu mordant	3
Fe mordant	3
Sn mordant	3

Table 6 The result of colour fastness to rubbing (Standard: ISO105-X12: 2001)

Dyeing description	Colour staining			
	Warp direction		Weft direction	
	Dry	Wet	Dry	Wet
Silk fabric				
Un mordant	4	3-4	4	3-4
Al mordant	3-4	3	3-4	3
Cu mordant	3-4	3	3-4	3
Fe mordant	3-4	3	3-4	3
Sn mordant	3-4	3	3-4	3
Cotton fabric				
Un mordant	4-5	4-5	4-5	4-5
Al mordant	4-5	4	4-5	4
Cu mordant	4-5	4	4-5	4
Fe mordant	4-5	4	4-5	4
Sn mordant	4-5	4	4-5	4

Remark: Un = Un mordant, Al = $AlKO_8S_2$, Cu = $CuSO_4$, Fe = $FeSO_4$ and Sn = $SnCl_2$

Table 7 The result of colour fastness to washing (Standard: ISO 105-CO6 A1S: 1994)

Dyeing description	Mordant				
Silk fabric	**Un**	**Al**	**Cu**	**Fe**	**Sn**
Colour change	4-5	4-5	4	4-5	4
Colour staining					
-Acetate	4-5	4-5	4-5	4-5	4-5
-Cotton	4-5	4-5	4-5	4-5	4-5
-Nylon	4-5	4-5	4-5	4-5	4-5
-Polyester	4-5	4-5	4-5	4-5	4-5
-Acrylic	4-5	4-5	4-5	4-5	4-5
-Wool	4-5	4-5	4-5	4-5	4-5
Cotton fabric	**Un**	**Al**	**Cu**	**Fe**	**Sn**
Colour change	3-4	3-4	4	3-4	4
Colour staining					
-Acetate	4-5	4-5	4-5	4-5	4-5
-Cotton	4-5	4-5	4-5	4-5	4-5
-Nylon	4-5	4-5	4-5	4-5	4-5
-Polyester	4-5	4-5	4-5	4-5	4-5
-Acrylic	4-5	4-5	4-5	4-5	4-5
-Wool	4-5	4-5	4-5	4-5	4-5

Table 8 The result of colour fastness to water (Standard: ISO 105-EO1: 1994)

Dyeing description	Mordant				
Silk fabric	**Un**	**Al**	**Cu**	**Fe**	**Sn**
Colour change	4-5	4-5	4	4-5	4
Colour staining					
-Acetate	4-5	4-5	4-5	4-5	4-5
-Cotton	4-5	4-5	4-5	4-5	4-5
-Nylon	4-5	4-5	4-5	4-5	4-5
-Polyester	4-5	4-5	4-5	4-5	4-5
-Acrylic	4-5	4-5	4-5	4-5	4-5
-Wool	4-5	4-5	4-5	4-5	4-5

Table 8 (Con.) The result of colour fastness to water (Standard: ISO 105-EO1: 1994)

Dyeing description	Mordant				
Cotton fabric	**Un**	**Al**	**Cu**	**Fe**	**Sn**
Colour change	4	4	4-5	4-5	4-5
Colour staining					
-Acetate	4-5	4-5	4-5	4-5	4-5
-Cotton	4	4-5	4-5	4-5	4-5
-Nylon	4-5	4-5	4-5	4-5	4-5
-Polyester	4	4-5	4-5	4-5	4-5
-Acrylic	4	4-5	4-5	4-5	4-5
-Wool	4	4-5	4-5	4-5	4-5

Table 9 The result of colour fastness to perspiration (acid solution) (Standard: ISO 105-EO4: 1994)

Dyeing description	Mordant				
Silk fabric	**Un**	**Al**	**Cu**	**Fe**	**Sn**
Colour change	4-5	4-5	4-5	4	4
Colour staining					
-Acetate	4-5	4-5	4-5	4-5	4-5
-Cotton	4-5	4-5	4-5	4-5	4-5
-Nylon	4-5	4-5	4-5	4-5	4-5
-Polyester	4-5	4-5	4-5	4-5	4-5
-Acrylic	4-5	4-5	4-5	4-5	4-5
-Wool	4-5	4-5	4-5	4-5	4-5
Cotton fabric	**Un**	**Al**	**Cu**	**Fe**	**Sn**
Colour change	4	4-5	4	4	4-5
Colour staining					
-Acetate	4-5	4-5	4-5	4-5	4-5
-Cotton	4-5	4-5	4-5	4-5	4-5
-Nylon	4-5	4-5	4-5	4-5	4-5
-Polyester	4-5	4-5	4-5	4-5	4-5
-Acrylic	4-5	4-5	4-5	4-5	4-5
-Wool	4	4-5	4-5	4-5	4-5

Table 10 The result of colour fastness to perspiration (alkaline solution) (Standard: ISO 105-EO4: 1994)

Dyeing description	Mordant				
Silk fabric	**Un**	**Al**	**Cu**	**Fe**	**Sn**
Colour change	4-5	4	4-5	4	4-5
Colour staining					
-Acetate	4-5	4-5	4	4-5	4-5
-Cotton	4-5	4-5	4	4-5	4-5
-Nylon	4-5	4-5	4	4-5	4-5
-Polyester	4-5	4-5	4	4-5	4-5
-Acrylic	4-5	4-5	4	4-5	4-5
-Wool	4-5	4-5	4	4-5	4-5
Cotton fabric	**Un**	**Al**	**Cu**	**Fe**	**Sn**
Colour change	4	4	4	4	4
Colour staining					
-Acetate	4-5	4-5	4-5	4-5	4-5
-Cotton	4-5	4-5	4-5	4-5	4-5
-Nylon	4-5	4-5	4-5	4-5	4-5
-Polyester	4-5	4-5	4-5	4-5	4-5
-Acrylic	4-5	4-5	4-5	4-5	4-5
-Wool	4-5	4-5	4-5	4-5	4-5

Remark: Un = Un mordant, Al = $AlKO_8S_2$, Cu = $CuSO_4$, Fe = $FeSO_4$ and Sn = $SnCl_2$

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6. References

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