The Effects of Cationization on Dyeing Properties of Cotton Fabric Dyed with Marigold and Rose

Matrikan Nutchawanit, Chutimon Satirapipathkul, and Rattanaphol Mongkholrattanasit

***Abstract*—A cationizing agent was used for increasing the color yield, in terms of the Kubelka–Munk values (color strength, *K*/*S*). Cotton fabrics were dyed using the extract of waste marigold and rose. This work was to study the optimum of time, temperature and concentration in cationizing process on dyed cotton. The *K*/*S* and color values (*L**, *a**, *b**) were measured to discover the suitable condition from color value and color strength estimation, cotton fabric cationized with 10 g/L of cationizing-agent concentration for 30 minutes at the 50 ℃ showed the highest *K*/*S*. In case of roses, the best condition is treated with cationizing-agent concentration of 15 g/L for 15 minutes at 50 ℃. The obtainable results revealed that the color strength of cationized cotton fabrics were increased when compared to *K*/*S* of untreated cotton up to 34.26% and 331.91% for marigold and rose dyes, respectively, and the obtainable color of cationized cotton fabrics were brighter as compared to the untreated cotton.**

***Index Terms*—Cationization, cotton dyeing, marigold dye, rose dye.**

I. Introduction

Cotton fabric is natural cellulose fiber, which produces slightly negative charge as being contacted with water owing to the ionization of the hydroxyl group [1], [2]. Because of its electrolyte, anionic dyes are suitable for intensified dye uptake, whereas anionic dyes leads to the waste water and environmental problems [3]. Natural dyes are more interesting due to sustainability, bio-degradability [4] and low toxicity [5]. In this study, marigold and rose were extract for dyeing cotton fabric. Because large amounts of red rose and marigold are major of flowers offered in Thai Temples, the offered flowers increasingly create the huge amount of biological waste. However, these wastes can produce the natural pigment for dyeing fabric.

Natural dyes are one of the alternatives friendlier for the environment, but the natural dyes are low absorbed on cotton [6]. The cationizing agent is used to modify the cationization process to improve dye ability of cotton-dyeing process, color yields and fastness properties compared to the conventional dye process [2], [7].

The objective of this work was to investigate the effects of cationizing agent on the dyeing properties of cotton for marigold and rose extracts. The influences on color values and intensity of cationizing-agent concentration, time and temperature compared to the untreated cotton were studied. The color values and color strength were determined by spectrophotometer.

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II. Materials and Method

A. Materials

Marigolds and roses were waste flowers from Trinity and Ganesha offered at Central World Shopping Plaza, Bangkok. The bleached cotton fabric was received from Thai Phuan community, Ban Mi district, Lopburi, Thailand. The soaping agent was supplied by Boonthawee Chemephan Co, Ltd. (Thailand) and the cationizing agent used in this experiment was STARCAT PD (Polyethylene polyamine) from Star Tech Chemical Industrial Co., Ltd., Bangkok, Thailand.

B. Cationization of Cotton Fabric

The bleached cotton was treated by being soak in cationizing-agent solution with the variation of cationization concentrations, time and temperatures at a fabric-to-liquor ratio of 1:50 using STARCAT PD to insert cationic groups on cotton surface. The effects of time, temperature and concentration of cationizing agent on color strength (K/S) and color values (L*, a*, b*) were studied, then the dyed cationized cotton with the optimum condition of time, temperature and concentration were compared with the cation-untreated, dyed cotton.

1) The Effects of concentration

The bleached cotton fabrics were treated in the different cationizing-agent concentrations of 5, 10, 15 and 20 g/L (in distilled water) at 30 ℃ for 60 minutes, then dried in oven at 60 ℃ for 10 minutes. After that, the cationized cotton was dyed and measured the color value and color strength.

2) The effects of time

The bleached cotton fabrics were treated in various time of 15, 30, 45, 60 and 75 minutes at the 30 ℃ by the concentration with the maximum K/S value, then dried in oven at 60 ℃ for 10 minutes. After that, the cationized cotton was dyed and measured the color value and color strength.

3) The effects of temperature

The bleached cotton fabrics were treated with the selected concentration and time presenting the maximum K/S value at various temperatures of 30, 50, 70 and 90 ℃ by heating the solution in water bath, then dried in oven at 60 ℃ for 10 minutes. After that, the cationized cotton were dyed and measured the color value and color strength.

C. Dye Extraction

1) Marigold-dye extraction

In this experiment, the flower petals were dried in hot-air

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oven at 45-60 ℃ for 12 hours before being ground. The ground dried marigold petals were extracted by 95% ethanol at 60 ℃ *by* heating the solution in water bath with the ground-dried-petal-to-liquor ratio of 1:5. The mixture was left on the magnetic-bar stirrer for 2 hours then filtered by no.1 Whatman filter paper to remove the residue and dried at 60 ℃.

2) Rose-dye Extraction

In this experiment, the flower petals were dried in hot-air oven at 45-60 ℃ for 12 hours before being ground. The ground dried rose petal was extracted by 50% ethanol at room temperature with the ground-dried-petal-to-liquor ratio of 1:10. The mixture was left on the magnetic-bar stirrer for 90 minutes then filtered by no.1 Whatman filter paper to remove the residue and dried at 60 ℃.

D. Dyeing Process

Marigold and rose extracts were dissolved in distilled water with the dye concentration of 40 g/L. The dye concentrations were determined using a UV-Visible Spectrophotometer based on absorbance at the maximum wavelength, λ_{max} (λ_{max} of 360 nm for marigold dye and λ_{max} of 288.5 nm for rose dye). The marigold extract dyed the cationized cotton and the untreated cotton fabric by soaking them at 50 ℃ for 60 min in water bath. The rose extract dyed the cationized cotton and the untreated cotton fabric by soaking them at the temperature 30 ℃ for 60 min. The fabric-to-liquor ratio of 1:50 was used in both marigold and rose dyes. After dyeing process was done, the dyed samples were rinsed and soaked with non-ionic soaping agent (2 g/L in water) at the fabric-to-liquor ratio of 1:50, 80 ℃ for 15 minutes. The dyed samples were rinsed with cold water, dried at room temperature and then measured the K/*S* and the color values by spectrophotometer (Macbeth Color Eye 7000).

E. Color Measurement

The dyed cotton was determined its color value (*L**, *a**, *b**) and color strength (*K*/*S*) by spectrophotometer following the standard procedure. *L** value is the measure of lightness (*L**= 0 is the darkest black, and *L** = 100 is the brightest white), *a** and *b** are defined the green-red and blue-yellow color components where *a** extends from green (negative sign) to red (positive sign) while *b** from blue (negative sign) to yellow (positive sign). The color strength (*K*/*S*) is automatically analyzed by Kubelka–Munk equation [4] (1).

$$K/S = (1-R)^2 /2R \quad (1)$$

where *K* is the light absorption coefficient, *S* is scattering coefficient and *R* is reflectance value at the maximum wavelength of the dyed sample

III. Results and Discussion

A. The Effects of Concentration for Cationization

The effects of concentration of catiornizing agent to *K*/*S* values of cotton fabric dyed by rose and marigold extracts were shown in Fig. 1. The *K*/*S* values of the cationized cotton fabric with the marigold dye increased as the concentrations of cationization increased from 0-10 g/L which showed that the highest *K*/*S* value (20.38) was higher than the *K*/*S* of the untreated cotton (16.75) up to 17.81%. In case of rose dye, the *K*/*S* values of the cationized cotton fabric increased as the concentrations of cationization increased from 0-15 g/L which displayed that the highest *K*/*S* value (2.89) was higher than the *K*/*S* of the untreated cotton (0.94) up to 2.08 times. The suitable concentration of cationizing agent for marigold and rose dye are 10 g/L and 15 g/L, respectively. The colors achieved at the optimum cationization concentration were shown in Fig. 2. The result presented the bright-yellow and bright-pink shade of cationized fabric.

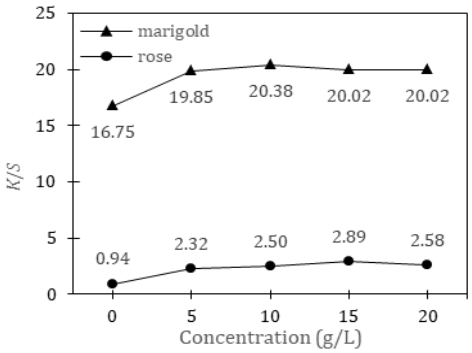


Fig. 1. The K/S values of the dyed cationized cotton fabric by varying the concentrations for cationization.

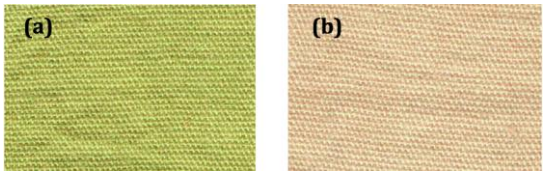


Fig. 2. The colors obtained at the optimum cationic concentration with the marigold dye (a) and the rose dye (b).

B. The Effects of Time for Cationization

Fig. 3 showed the effects of cationization time on *K*/*S* values of the dyed cotton fabric. The *K*/*S* value of the cationized cotton fabric with the marigold dye increased as the process time increased from 0-30 minutes and then insignificantly decreased. At 30 minutes, the cationization dyed fabric show the maximum color strength (20.38) which is 1.22 times of the *K*/*S* of untreated cotton (16.75). In case of rose, the *K*/*S* value of the cationized fabric increased as the process time increased from 0-15 minutes. From 15-75 minutes, there was no significantly change on *K*/*S* values, and the optimum time for cationization of rose dye was 15 minutes. At the optimum time, the color strength was 2.88 that was 3.08 times of the *K*/*S* values of untreated fabric (0.94). The obtained color of the optimum cationization concentration and time at 30 ℃ was bright yellow and pink shown in Fig. 4.

C. The Effects of Temperature for Cationization

From the experiment, the optimum temperature for cationization on cotton fabric was studies to improve the dyeability, and the color strength of dyed cotton at the various temperatures was revealed in Fig. 5. The result presented that the dye fabric showed bright-yellow and bright-pink shades shown in Fig. 6. The result also revealed that increased temperature of cationization to 50 ℃ enhanced the color strength for marigold and rose dye to 22.49 and 4.06, respectively. The color strength of cationic cotton with the

marigold dye and the rose dye at 50 ℃ were bigger than the color strength of cationized cotton at 30 ℃ up to 10.35% and 49.82%, respectively. The result showed that cationization at 50 ℃ was the appropriate temperature for this study.

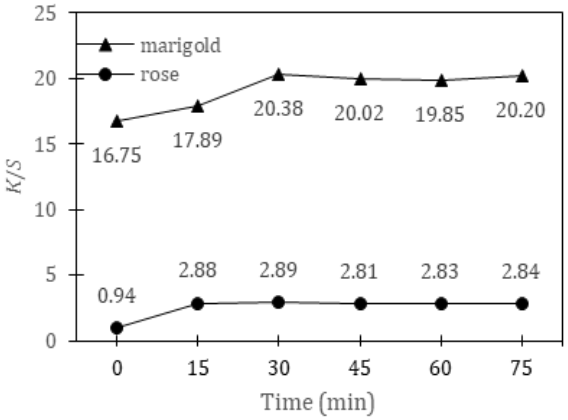


Fig. 3. The K/S value of the dyed cationized cotton fabric by varying time for cationization.

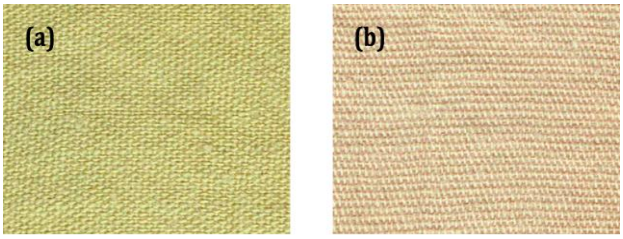


Fig. 4. The colors obtained at the optimum cationization time with the marigold dye (a) and the rose dye (b).

D. Comparison of Color Values and Color Strength of the Chosen Cationization Condition with Color Values and Color Strength of Untreated Cotton

According to the optimum concentration, temperature and time of the cationization process, Fig. 7 showed the comparative of *K*/*S* values for cationized cotton and untreated cotton. *K*/*S* values of cationized cotton was greater than the *K*/*S* values of untreated cotton. Table I showed the *K*/*S* values, color value (*L**, *a**, *b**) and color obtained of dyed cotton. The *L** values of both marigold and rose dyes were decreased when the concentrations of cationization increased, and the untreated cotton gave the lighter shade as compared to those dyed with a cationizing agent. The untreated cotton dyed with marigold and rose showed a lighter-yellow shade and paler-pink shade, respectively. The *K*/*S* of marigold dyeing of the cationized cotton is 1.34 times of the untreated cotton (increased 34.26% from the untreated cotton), and *b** values was increased 11.95% from the conventional processes. The *b** value was raised and showed the positive signs, the color was bright yellow. The *K*/*S* values of the rose dyeing on the cationized cotton is 4.31 times of the untreated cotton (increased 331.91% from untreated cotton) and *a** value showed positive signs, the color was bright pink. The *b** values are slightly increased while *a** values was increased from the conventional processes up to 117.76%.

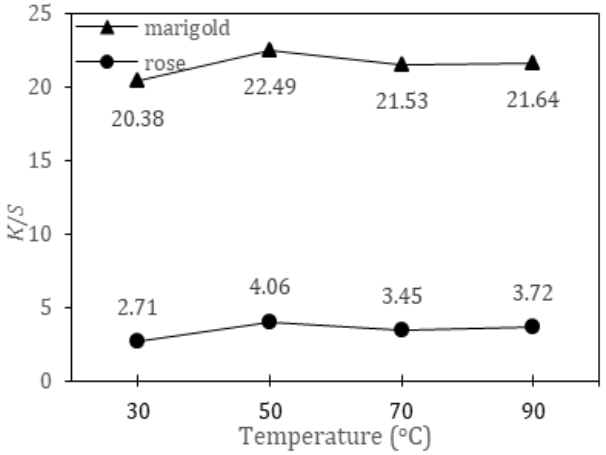


Fig. 5. The K/S values of dyed cationized cotton fabric by varying the temperatures for cationization.

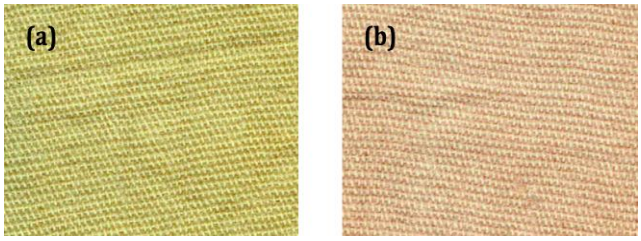


Fig. 6. The colors obtained at the optimum cationization temperature with the marigold dye (a) and the rose dye (b).

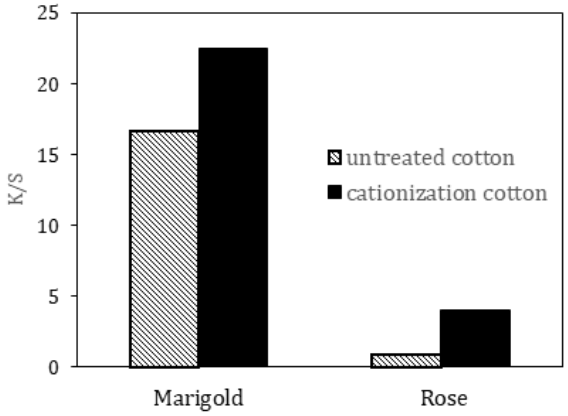
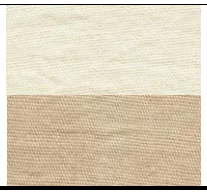


Fig. 7. Comparative of color values and color strength values of cationized cotton and untreated cotton dye with marigold and rose.

TABLE I. THE COLOR VALUES AND COLOR STRENGTH OF DYED UNTREATED COTTON AND CATIONIZED COTTON

CONDITION		*L**	*A**	*B**	*K*/*S*	COLOR OBTAINED
MARIGOLD DYE	UNTREATED COTTON	72.38	-1.42	38.28	16.75	
	CATIONIZED COTTON	66.25	0.52	41.66	22.49	

ROSE DYE	UNTREATED COTTON	76.68	3.66	12.81	0.94	
	CATIONIZED COTTON	61.90	7.97	20.26	4.06	

IV. CONCLUSION

The results presented the cationizing agent increased the color strength (*K*/*S*) and *a**, *b** values for marigold and rose dyes when the *L** value was reduced because of the darker shade of dye fabric. The best condition of cationizing process for marigold dye was 30 minutes with the concentration of cationizing agent of 10 g/L at 50 ℃. In case of rose dye, the most advantageous condition was 15 minutes with the concentration of cationizing agent of 15 g/L at 50 ℃. Besides, the result reveals that cationization increased the *b** values (yellow shade) for marigold dye up to 11.95% and increased *a** values (red shade) up to 117.75% for rose dye. While the *K*/*S* of marigold dyeing of the cationized cotton is 1.34 times of that of untreated cotton, and for the rose dyeing, *K*/*S* values of the cationized cotton was 4.31 times of untreated cotton.

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