THE QUALITIES IMPROVEMENT OF COTTON PRINTING WITH NATURAL DYE FROM THE NEEM TREE BARK

S. Boonroeng*, P. Boonkerdrum, M. Chadee, and R. Sangkumpra

ABSTRACT

The qualities improvement of cotton printing with natural dye from neem tree bark is an extension of our previous work, Natural Dye Printing on Cotton Fabric. Its objective was to improve the qualities of cotton fabric printed with colorants from the neem tree bark. The prior successful process was preliminarily conducted with mordanting fabric with some chemicals to enhance dye uptake before printing known as pre-mordanting method. The mordanted fabric was then printed with natural dye by using reactive printing method. One of the essential step of the printing process is steaming. It is carried out after drying process in order to re-dissolve dyes penetrating into the cotton fibers. The steaming time of the preceding experiment was only 45 minutes. Thus, the time was enlarged from 45 to 60, 90, and 120 minutes for prospectively higher qualities. Then the samples were subjected to both visual assessment and color strengths (K/S values) measurement for comparative evaluation. The colorfastness properties including washing, rubbing, and light of the samples were also assessed. It was found that the color shade of printed fabric was brown and the printed area was smoothly soft. The color strength was increased with the increase in steaming time and reached a maximum value at 90 minutes then it showed no statistically significant difference. For the colorfastness test, all results exhibited good level to washing and rubbing and fairly poor to light.

Keywords: natural dyes, neem tree bark, printing, color strength, colorfastness
INTRODUCTION

Trend of natural dyes is restored as the result of the awareness of some synthetic azo dyes. As they are reduced or hydrolyzed, they release some arylamine compounds carcinogenic or allergic to human being (Bhattacharayya, 1992). Nowadays, people consciously concern their health and global environment, so they require safe and eco-friendly products (Ali, et al., 2008) According to the demand, various studies on natural dyes have been conducted. The investigated natural dyes were from different parts of plants and lac but mostly related to dyeing process (Deo and Desai, 1999; Cristea, and Vilarem, 2006; Kamel, et al., 2007). There were a few on printing processes. Printing techniques mostly seen were either long or complicated. Although the use of pigment printing technique can give satisfied results, it yields a hard touch on printed area (Gopal, 1992; Chavan, 1992; Agarwal, et al., 2007; Srivastava and Udawat, 2008). Contrarily, reactive printing technique gives smooth touch on printed region and its steps are not complex. In this work, a natural dye from neem tree bark was printed on mercerized cotton fabric by reactive printing method. The printing results were evaluated and an influence of steaming time was also discussed.

MATERIALS AND METHODS

Materials

Mercerized, optical brightener-free, twill weaving, and 100% cotton fabric was used throughout this work. Natural dye from neem tree bark was supplied by the Plant Genetic Conservation Project under the Royal Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn at Khlong Phai, Nakhon Ratchasima Province. Alginate and synthetic thickeners were commercially available. Alum and copper sulfate were laboratory grade.

Dye Solvation

A brown flake-like natural dye from neem tree bark was dried to constant weight at 102 °C and ground into fine particles. The dye powder of 60 grams was dissolved in 1 liter of warm water at 60 °C before filtering with a vacuum suction funnel to get rid of any remaining particles. The dye solution was then measured for an absorbance every 20 nm in the range of 400-700 nm. The absorption spectrum was established to control dye concentration.

Mordanting

Well prepared cotton fabric was dipped separately into 1 g/l of alum and copper sulfate solution, padded at 100% pick up, and dried, respectively. The treated fabric was then washed to remove chemical excess on the surface and dried again.

Printing

The thickener paste was prepared by mixing 35 grams of alginate, soaked overnight in 945 ml of water, with 29 grams of synthetic thickener and then stirring homogeneously. 4 parts of the thickener paste were mixed with 1 part of the neem tree bark dye solution to make printing paste. Its viscosity was measured with Brookfield Digital Viscometer Model DV-I (RV spindle set number 6)
and adjusted to 3,000 centipoise with synthetic thickener. The printing paste was then screen printed on mercerized cotton by hand. The printed fabric was placed in an oven at 100 °C until it dried. The samples were then steamed for 45 minutes followed by washing to remove an excess of printing paste and drying.

**Effect of Steaming Time**

The sequence of printing process was reproduced except that the steaming time was increased from 45 minutes to 60, 90, and 120 minutes. For each steaming time, the process was repeated 3 times. All samples were visually assessed and color strength values were instrumentally measured and calculated. The analysis of variance of the experiment was implemented by using R program.

**Testing**

Color fastness including washing, rubbing, and light fastness was tested by ISO 105-C03, ISO 105-X12, and ISO 105-B02 methods, respectively. The tested samples were selected from 45 minutes steaming time process and from the steaming time process providing optimum color strength values.

**RESULTS AND DISCUSSION**

**Dye Solvation**

The color of neem tree bark dye solution was dark-brown with a pH between 5.27 – 5.33. Its absorption spectrum showed maximum values at 3 different wavelengths: 440, 500, and 540 nm as illustrated in figure 1. This characteristic is similar to that of any trichromatic combination of synthetic dyes.

![Absorption spectrum of 60 g/l neem tree bark dye solution.](image)

**Printing**

After washing to remove an excess of all chemicals used for printing process, the printed fabric was dried and the visual assessment was conducted. It was found that the color on printed portion of non-mordanted fabric was brown. The color of pre-mordanted fabric was also brown but different in secondary color and intensity as seen in Figure 2. The sharpness of the design of all pieces
was considerably good. However, there was a little stain on non-printed area as seen below. For hand evaluation, it was not stiff especially when touch on the printed part. This is possibly due to the less amount of print paste residue left in the fabric.

<table>
<thead>
<tr>
<th>Non-Mordanted</th>
<th>Mordanted with Alum</th>
<th>Mordanted with Copper Sulfate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

![Printed cotton fabric after washing process.](image)

**Figure 2** Printed cotton fabric after washing process.

After measuring samples with the spectrophotometer, their color strength values (K/S) of every 20 nm wavelength interval over the visible range were summed up. The reason for summing up is due to the absorption characteristic of the natural dye as mentioned above. The summation of K/S of 3 cotton fabric types were manifested and compared in figure 3

![Summation of K/S values of 3 kinds of cotton fabric printed with 60 g/l neem tree bark dye solution.](image)

**Figure 3** Summation of K/S values of 3 kinds of cotton fabric printed with 60 g/l neem tree bark dye solution.

Figure 3 showed summation of K/S values of 3 kinds of cotton fabric, non-mordanted, mordanted with alum, and mordanted with copper sulfate, printed with 60 g/l neem tree bark dye solution. As seen above, the values of both pre-mordanted fabrics were higher than that of non-mordanted fabric. It was possibly due to the chelation between the natural dye molecules with some metal ions treated on the cotton fabric. The molecular size of the natural dye became larger increasing in force attraction between dye and fabric. The highest value was from the pre-mordanted fabric with copper sulfate, 36.74.
Effect of steaming time

After enlarging the steaming time from 45 minutes to 60, 90, and 120 minutes, $\Sigma K/S$ values of all printed fabric were collected and depicted as a graph in figure 4.4.

![Graph showing $\Sigma K/S$ values for steaming times of 45, 60, 90, and 120 minutes for Alum and Copper sulfate mordants]

**Figure 4** Summation of K/S values of printed cotton fabrics pre-mordanted with alum and copper sulfate and steamed at various times.

Figure 4 showed the color strength values at 4 different steaming of both types of fabric, mordanted with alum and with copper sulfate. Analysis of variance (ANOVA) and Tukey HSD were introduced to analyze the above data with program R. It was found that the color strength was increased with steaming time for both types of cotton fabric. For the fabric pre-mordanted with copper sulfate, the maximum value was obtained at 90 minutes steaming time. After that there was no statistically significant difference at 0.05 levels. Contrarily, the color strength value of fabric pre-mordanted with alum showed statistically significant difference at 0.05 levels only when the steaming time was enlarged to 120 minutes. It is likely that the natural dye molecules primarily attached to the fabric surface were re-dissolved during steaming process. With an increase in steaming time, the amount of dye molecules left on the surface could be re-dissolved increasingly until there was no more dye molecule available on the surface.

**Fastness Properties**

The printed fabric was tested for washing, rubbing, and light fastness. The results of 45 minutes steaming time fabric was compared with that of 120 minutes steaming time in case of mordanting with alum and with 90 minutes for copper sulfate mordant. It was revealed that all results were not different except for color change. The fabric having longer steaming time showed better color change. All fabrics exhibited good level to washing and rubbing fastness tests and fairly poor to light fastness.
Table 1: Light and rubbing fastness of printed cotton fabric

<table>
<thead>
<tr>
<th>Printed Specimen</th>
<th>Steaming time (minutes)</th>
<th>Light fastness</th>
<th>Rubbing fastness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dry</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Warp</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weft</td>
</tr>
<tr>
<td>Alum</td>
<td>45</td>
<td>2-3</td>
<td>4-5</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>2-3</td>
<td>4-5</td>
</tr>
<tr>
<td>Copper sulfate</td>
<td>45</td>
<td>3</td>
<td>4-5</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>3</td>
<td>4-5</td>
</tr>
</tbody>
</table>

Table 2: Washing fastness of printed fabric

<table>
<thead>
<tr>
<th>Printed Specimen</th>
<th>Steaming time (minutes)</th>
<th>Color change</th>
<th>Color stain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Acetate</td>
<td>Cotton</td>
</tr>
<tr>
<td>Alum</td>
<td>45</td>
<td>3</td>
<td>4-5</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>3-4</td>
<td>4-5</td>
</tr>
<tr>
<td>Copper sulfate</td>
<td>45</td>
<td>4</td>
<td>4-5</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>4-5</td>
<td>4-5</td>
</tr>
</tbody>
</table>

Light and rubbing fastness values of printed cotton fabric are indicated in Table 1. The light fastness values were fair (3) for samples mordanted with copper sulfate and fairly poor (2-3) for samples mordanted with alum. For rubbing fastness, the printed fabric possessed slightly to noticeably stained evaluated as 3-4 and 4 for wet condition and 4-5 for dry condition on grey scale. Table 2 showed washing fastness of printed cotton fabric. The washing fastness values in color change of fabric mordanted with copper sulfate were good to excellent. Its values were better than those of fabric mordanted with alum graded as fair to fairly good. However, all samples were equally evaluated as good to excellent for washing in color stain. For perspective on fastness properties, an improvement due to increasing steaming time could be noticeable only in color change of washing fastness regardless of steaming time.

CONCLUSION

The neem tree bark dye could be printed on both non-mordanted and pre-mordanted cotton fabric with reactive printing process. Their primary color was similarly brown but different in secondary color and intensity. The color strength of pre-mordanted fabric was much higher than that of non-mordanted fabric. For fabric pre-mordanted with alum and copper sulfate, their light fastness was graded as fairly poor to fair. Their rubbing fastness was good. The washing fastness in color change of fabric pre-mordanted with alum was fair and lower than that of fabric pre-mordanted with copper sulfate. Their washing fastness in color stain was good. With an increase in steaming time, the color
strength was statistically significant improved for all samples. The optimum value was obtained from 90 minutes steaming time for the fabric pre-mordanted with copper sulfate and 120 minutes for the fabric pre-mordanted with alum. Besides the color strength, an improvement could be observed in color change of washing fastness.

ACKNOWLEDGEMENTS

The authors of this paper are thankful to the Plant Genetic Conservation Project under the Royal Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn at Khlong Phai, Nakhon Ratchasima Province for supplying the neem tree bark dye and RMUTK for their financial support.

REFERENCES


