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Development of Thai Textile Products from Bamboo Fiber Fabrics Dyed with Natural Indigo

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ABSTRACT

The aim of this research was to develop of Thai textile products from natural bamboo fibers fabrics dyed with indigo. Natural indigo dye was applied at four different timing at pH 12 to fabrics prepared from bamboo fibre. All of samples were tested for light, washing and perspiration resistance using ISO 105-B02: 1994, ISO 105-C10: 2006 and ISO 105-E04: 2008, respectively. The results showed that bamboo fibers dyed with indigo resisted light at good level, found slightly of staining on the white fabrics and no change of dye intensity after exposure to sweat. It suggested that the indigo is a good choice for dyeing of bamboo fibers. Many kinds of products including mad-mi, four handles (si-taklo) blanket and turtle flaky shell (kled-tao) fabric can be created from the dyed bamboo fibers.

Key words: Bamboo, indigo, fabric, textile product, natural fiber

INTRODUCTION

"Fabrics" is an important factor for human life maintenance. It has long historical evidence over 7,000 years. Those of natural fibers such as marijuana, hemp, paul and bamboo used in the textile products (Wannajun *et al*., 2011). In Thailand, a lot of ridges made from animal bones or crab shell were also found. These are indicated that the human in that period were known to extract fibers and spinning. It is suggested that the prehistorically people has been created his own culture and gradually developed until the historical era.

Recently technology has been developed to design the synthetics fibers instead the natural fibers. However, the chemical used in the preparation process is harmful both to human and environmental. Polyurethane (PU)-based microcapsules containing a flame retardant Diammonium Hydrogen Phosphate (DAHP) or an odorant entity neroline were prepared and reported (Azizi *et al*., 2011). On the other hand, many researchers have been attempted to develop some techniques for improving of textile production such as coated with polymer (Issaoui *et al*., 2011), or mixed with reagent/polymer (Kusuktham, 2011; Muralidharan *et al*., 2011). To impart the desirable properties or value addition on textile fabrics, pretreatments with ofloxacin and ornidazole, enzyme, mordant or functional finishing on fabrics were performed (Elayarajah *et al*., 2011; Raja and Thilagavathi, 2011; Ammayappan and Moses, 2010). With this reason, processors started to develop and use the natural fibers for replacement of the synthetic fibers. Bamboo fibers

are a new kind of fiber. It has a various small pores in the fiber surface, which helped to improve moisture absorption and oxygen vapor permeability. Moreover, the bamboo fibers contained excellent properties including antibacterial, antifungal, UV protection and IR (infrared) absorption (Wannajun *et al*., 2011). Therefore, it is an alternative choice of fiber for the man who bewares in their health and environments. Indigo is a natural dye and believe to impart antimicrobial efficacy (Raja and Thilagavathi, 2011). In this work, bamboo fibers dyed with Thai herb indigo and used as a resource material for the production of bamboo fabrics.

MATERIALS AND METHODS

The bamboo fibers were extracted, spun into yarn, dyed and woven into fabrics at Ban Khambong, Tambol Khambong, Amphoe Huaipeung, Kalasin, Thailand.

Dyeing with indigo dye: The process of dyeing divided into 4 groups depending on the number of dyeing time, each for 10 min. Firstly, the bamboo fibers were boiled in mild alkaline solution to exclude some impurities for 10-15 min before washing twice with tab water. They were left in air until dry and then immersed in the prepared indigo dye solution (called 1 dyeing time). The indigo dyed bamboo fibers were air-dried completely before sequentially immersing in the dye solution for other dyeing times. The groups and code of dyeing time summarized in Table 1. The dyed indigo bamboo fibers were prepared in 5 samples per each group.

Chemical test of bamboo fibers after dyeing with indigo: The bamboo fibers dyed with indigo were then tested for standard textile quality by textile development institute, Ministry of industry, Thailand. The investigation of color fastness test can be performed as follow.

The stability of color to light (ISO-105-B02): The method uses a filtered Xenon-arc light source with a spectrum approximating that of solar radiation. Assessment is against a prescribed set of dyed wool standards by comparing a sample's level of fading against a scale of 1-8, denoting very poor to very good.

The stability of color to wash (ISO-105-C10): The samples were cut into 40×100 mm^2 and then mounted to the fiber cloth. The pieces of cloth were then washed in the solution contained in the testing machine followed the designation time points. The samples were washed again with distilled water and left in air-dried. The changes of color and the staining of dry to fiber cloth were determined using spectrophotometer.

The stability of color to acidic and basic solutions (ISO-105-E04): The samples were weighed and lie out in a flat-bottomed dish and cover with acidic or basic solution at the liquor ratio of 50:1. The condition was set at room temperature for 30 min. They were pressed and moved from

Table 1: Groups and code of dyeing

Groups	No. of dyeing	Code
1	1	IB-1
2	5	IB-5
3	10	IB-10
4	15	IB-15

IB: Indigo bamboo

time to time to ensure uniform penetration of liquor. The solution was poured off and wiped the excess liquor off from the sample. The samples were weighed again before placing in the test device. The test device was taken in an oven for 4 h at 37°C. The samples were dried in air. Finally, the changes of color and the staining of the adjacent fabrics were determined using instrumental.

Production of bamboo fibers dyed with indigo: The bamboo fibers dyed with indigo were used as material for fabrics production of mad-mi, si ta-klo blanket and turtle flaky shell. All of process was created by the local people at Khambong village.

RESULTS AND DISCUSSION

Bamboo fibers dyed with indigo: As shown in Fig. 1, the bamboo fibers can be stained with indigo. The level of indigo color on the bamboo fibers were gradually increased when the number of dyeing time increased (1 to 15 times). The color was homogeneous throughout the fibers. Generally, bamboo fibers are formed with different materials in variable proportions including cellulose, hemi-cellulose, lignin and pectin (Baley, 2002; Lin *et al*., 2002). Therefore some liquids including dye can penetrate the fiber by sorption and diffusion (Barsberg and Thygesen, 2001; Deshpande *et al*., 1999). Those of composites composed in bamboo fiber have various hydroxyl (-OH) groups in its structure. The hydroxyl groups helped to interact very well to the amine (-NH) or carbonyl (C = O) groups of the indigo via hydrogen bonds resulted to easy dyed with indigo.

Chemical test results

Color fastness test: Light (ISO-105-B02): Light is an important factor on the color of fabric. All of bamboo fibers dyed with indigo showed the changes of color at over 4 levels (Table 2). This means the fibers have good absorbed with indigo dye. The results also indicated that the stability of dye in case of 1 time dyeing was the same dyeing time for other groups. Since the bamboo fiber composed of different kinds of molecules and there are composed of unique functional groups, therefore, they should be absorbed the light. This is special property of the bamboo fiber for UV protection.

Fig. 1: Bamboo fibers dyed with indigo for different dyeing times. The number 1-15 shows the level of indigo color, which is gradually increased

Table 2: The stability of dye on bamboo fiber exposure to light

Test items	IB-1	IB-5	IB-10	IB-15
Color retention to color change (level)	Very good	Very good	Very good	Very good

IB: Indigo bamboo

Color fastness test: Washing (ISO-105-C10): Washing is an important process after wearing the textile. With the washing test, all of samples obtained the level at 4. This result indicated that all of samples have good stability of dye to wash. Moreover, the washed-out of dye on six fabrics; acetate, cotton, nylon, polyester, acrylic and wool was also tested. The dye washed out on the tested fabrics, except nylon has level 4 (Table 3). This means the small quantity of dye washed out from the bamboo fibers. In case of nylon fabric, the washed out of dye was level of 3-4. The result was also the same other samples. It is suggested that the stability of dye on the bamboo fibers was similar even staining for 1 or 15 times. The obtained result related to previous report (Lecher, 1955). From the results, it is promising that the bamboo fibers much be reacted to the indigo dye via strongly chemical bonds. The formed bonds should be enhanced the stability of dye when exposed to wash or water. Moreover, it is clarified that the bamboo fiber composed of macromolecules which helped for trapping the molecules of dye (Lin *et al*., 2002).

Color fastness test: Perspiration (ISO-105-E04): The test was performed in acid and basic conditions. In acidic condition, the results found that dyeing bamboo fibers with indigo for 1 time showed the level of color change at level of 4-5. This means the color has changed slightly almost invisible. After staining for 5, 10 and 15 times, the color have changed at 4 levels. This means the color has changed slightly. The color stains on the testing white cloth all 6 samples are level 4. This means the stain was washed out visible slightly (Table 4). The results indicated that indigo dye and bamboo fibers interacted very well via the hydrogen bonds which helped to sustain the color of dye.

Table 3: Changes of color fastness level after washing bamboo fiber dyed

Test items	IB-1	IB-5	IB-10	IB-15
Change in shade	+1	+1	+1	+1
Change in staining				
Acetate	+1	+1	+1	+1
Cotton	+0.5	+0.5	+0.5	+0.5
Nylon	+0.5	+0.5	+0.5	+0.5
Polyester	+1	+1	+1	+1
Acrylic	+1	+1	+1	+1
Wool	+1	+1	+1	+1

+1: Little change, +0.5: Slightly change

Table 4: The stability of dye on the bamboo fiber immersed in acidic solution

Test items	IB-1	IB-5	IB-10	IB-15
Change in shade	+2	+1	+1	+1
Change in staining				
Acetate	+1	+1	+1	+1
Cotton	+1	+1	+1	+1
Nylon	+1	+1	+1	+1
Polyester	+1	+1	+1	+1
Acrylic	+1	+1	+1	+1
Wool	+1	+1	+1	+1

+2: Change, +1: Little change

Table 5: The stability of dye on the bamboo fiber immersed in basic solution

Test items	IB-1	IB-5	IB-10	IB-15
Change in shade	+2	+1	+1	+1
Change in staining				
Acetate	+1	+1	+1	+1
Cotton	+1	+1	+1	+1
Nylon	+1	+1	+1	+0.5
Polyester	+1	+1	+1	+0.5
Acrylic	+1	+1	+1	+1
Wool	+1	+1	+1	+1

+2: Change, +1: Little change, +0.5: Slightly change

Fig. 2: Fabric made from bamboo fiber (mad-mi)

In case of basic condition, the color changed of all samples was the same level as in acidic test. The bamboo fiber dyed showed the good stability in this solution at level 4 (Table 5). However, the level was slightly decreased to 3-4 for nylon and polyester. From the test of perspiration, it is not different result between acidic and basic test. The obtained results were related to previous report (Shim *et al.*, 1998).

Finish production of dyed bamboo fibers fabrics: Bamboo is a typical natural composite material and the fibers are distributed densely in the outer surface region and sparsely in the inner surface region. It composed of many advantage properties such as light-weight, good flexibility and tough (Amada and Untao, 2001). Therefore, it has attracted many workers' interest (Tong *et al.*, 2005). Moreover, the finishing product showed homogeneous dye shade. This was according to the dye was easily penetrated into the bamboo fibers. It is also give more advantage than synthetic fiber like polyester. The last fiber even composed of high strength but it difficult to penetrate of dye from a high degree of crystalline (Muralidharan *et al.*, 2011). In addition, bamboo fiber is deemed to have one of the most favorable combinations of low density and mechanical properties (Fuentes *et al.*, 2011). According to the stability of indigo dye in the bamboo fibers, they were then fabricated into different kinds of fabrics; mad-mi (Fig. 2), si-taklo blanket (Fig. 3) and turtle flaky shell (Fig. 4). The results found that the indigo dyed bamboo fibers have blue color and showed unique pattern in each fabrics. The obtained products are similar to other fabrics made from silk, cotton or synthetic fibers. It is a promising that the bamboo fibers

Fig. 3: Fabric made from bamboo fiber (si-taklo blanket)

Fig. 4: Fabric made from bamboo fiber (turtle flaky shell)

are the good sources of natural fibers which can be used for fabrication of many kinds of products. It is also proved that the fabrics of bamboo fibers should be created and increased of their valuable.

CONCLUSION

The bamboo fibers can be dyed with indigo with high colour value on the fibers. The bamboo fibers dyed with indigo dye in different times showed the same of color change level. The light, washing and perspiration fastness properties indicated that the bamboo fibers can be dyed with indigo that have high stability to water, acidic and basic conditions. The obtained bamboo fibers dyed with indigo can be used as material for various kind of fabrics production. All of products showed the unique characteristics and should be developed to standard models of Thai fabrics for commercial level.

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