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EFFECT OF SOME CHEMICAL TREATMENTS ON DYEING COTTON FABRICS WITH A NATURAL DYE (HENNA)

AMAL, S. MOHAMED

Cotton Research Institute - Agricultural Research Center, Giza, Egypt.

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Abstract

In recent years, concern for the environment has created an increasing demand on natural dyes which are more friendly to the environment than synthetic dyes. This study was carried out to investigate the effect of two chemical treatments mercerization and resin application (DMDHEU) on dye fastness of various fabric structures woven from the yarns of Giza 83 cotton variety. The natural dye henna was utilized in this respect. The findings of the study indicated that, mercerization treatment increased both color strength (K/S) and acidic perspiration fastness expressed in terms of color change (c.c.). On the other hand, resin treatment increased fastness to alkali perspiration, whether in terms of color change (c.c.) or color staining (c.s.). Furthermore, both treatments brought about an increase in either fastness to wash (c.c. and c.s.) or fastness to dry rubbing. Treated and untreated fabrics of different structures (plain, twill and knit) responded differently to dyeing with natural dye.

INTRODUCTION

Natural dyes are dyes obtained from plants, animal, and mineral sources. Until 1956, all dyes were extracted from fruits, flowers, roots, insects, shellfish and minerals. No two batches of natural dye are ever exactly alike in hue and strength. Besides Color fastness varies widely amoung natural dyes, Hatch (1993). In the dyeing process, the material is usually subjected to the following processes: desizing, scouring, bleaching, mercerization, dyeing and finishing. These processes cause some physical and chemical changes in the fibers which appear at the end as increase or decreased in their chemical and physical properties, Samier (1988).

Merceization is one of the most important processes of finishing cotton materials. It imparts gloss to the fiber, increases its hydroscopicity and strength and improves its dyeability, Sadova *et al.* (1973). Changes in the physical and chemical properties of the mercerized fibers are related to changes in structure of cotton fiber, Al-Ashwat (1974).

Hatch (1993) reported that, synthetic-fiber fabrics spoiled consumers because they were wrinkle-free during wear and emerged from laundering ready to hang in closet without ironing. Pleats in skirts and creases in pants made from synthetic-fiber fabrics did not need to be reset. Scientists turned to the magic of chemistry to alter cotton and wool fibers to obtain the maintenance advantages of synthetic-fiber fabrics

with durable-press resins. Durable-press finishing improves the wrinkle resistance of fabric containing cellulosic fibers because the chemicals used build up crosslinks between cellulose polymers. She also added that, mercerized fibers and fabrics are more absorbent and have greater affinity for dyestuff due to the expanded fiber structure (larger voids in the fiber for water and dyestuff to enter). Mercerized fabrics are less expensive to dye because they require only 0.7 as much dyestuff as unmercerized fabrics to achieve a given shade.

The response to different treatments depends on the formation of hydrogen bonds produced, the resin (DMDHEU) treatment have the medium response between the scouring and mercerizing for all the measured properties, Mahmoud (1999).

MATERIALS AND METHODS

This study aims to investigate the effect of merceriztion and resin treatments on dyeing cotton fabric with natural dye extracted from Henna (*Lawsonia alba*) according to Mohamed (2001). The cotton fabrics used were obtained from Misr Spinning and Weaving Company, El Mahalla El Kubra, all fabrics were woven using yarn spun from the fibers of long staple Egyptian cotton variety Giza 83 season 2000-2001. The fabrics considered in the present study are plain (1/1), twill (3/1) and knit (single jersey) fabrics.

Chemical treatments:

1. Resin treatment: the samples were kept in a bath containing (7% v/v) dimethyldihydroxy-ethylene urea (DMDHEU), then dried for 5 min at 70°C and cured for 3 min. at 160°C, according to Gilbert and Smith (1970).

2. Slack merceization treatment: Cotton fabrics were subjected to mercerization by immersing in 23 % NaOH for 30 min, rinsing in cold tap water for 1 hr., and then neutralizing with dilute acetic acid for 15 min. Fabrics were then washed again in cold tap water for 15 min., and air dried, according to Jung *et al.* (1975).

Method of dyeing: The natural dye was applied by immersing the treated cotton fabrics in a dye bath containing the selected dye extract (50%-70%) at a ratio of 1:50 ml dyeing solution for each gram of the sample, a mordant (cupper sulphate) was added according to procedure described by Abd El-Fattah (1997).

Measurements: Color fastness and color strength for dyed fabrics was measured at Misr Spinning and Weaving Company, El Mahalla El Kubra.

Color fastness to light and dry rubbing were determined according to A.S.T.M. D 2053-86 (1998), and D 2054-86 (1998).

Color fastness to wash and perspiration was determined according to A.A.T.C.C. (1998) 15-1960 and 36-1961.

The higher values of color change ranging from (1/5 to 5/5 and 1/8 to 8/8) indicates higher fastness and vice versa.

Color strength is expressed as K/S value for the dyed samples by applying the Kubelka-Munk equation as follows :

$$K/S = (1-R)^2 /2R - (1-R_0)^2 /2R_0$$

Where :

R = Decimal fraction of the reflectance of dyed samples.

R_0 = Decimal fraction of the reflectance of undyed samples.

K = Absorption coefficient.

S = Scattering coefficient.

RESULTS AND DISCUSSION

Tables 1-4 demonstrate the effect of mercerization and resin treatments on color strength and color fastness properties of fabrics dyed with natural dye (Henna).

1.Color strength (K/S):

The value of color strength for dyed knit fabric was higher than this value for dyed plain fabric, dyed plain fabric was slightly better than the dyed twill fabric under each of the treatments considered in this study, i.e. untreated, mercerized and resin treatment. These results are possibly attributed to the type of fabric structures. Knit fabrics are composed of intermeshing loops of yarn, pproducing an open structure thus increasing dye absorbancy. On the other hand both the plain and twil fabrics are more compact resulting in low dye absorbancy. On the other hand color strength (K/S) for mercerized dyed fabric was the highest in all cases. These may be because mercerization imparts gloss to the cotton fiber, increases amorphous cellulose, hydrosopicity and improves its dyeability. So mercerized fiber and fabrics are more absorbent and have greater affinity for dyestuff. This is in agreement with Hatch (1993) and Sadova *et al.* (1973). But resin treatment decreased color strength (K/S), which is in agreement with Mahmoud (1999).

2. Light fastness:

No general trend could be noticed regarding the differential response of the three dyed fabric structures (plain, twill and knit) to light fastness except resin treatment decreased fastness to light. These results are possibly due to resins are known to get linked with cellulose chains in such a way that there would no be free Hydroxile

groups available for other reactions, this is in agreement with Hatch (1993) and Mahmoud (1999).

3. Wash fastness (c.c. and c.s.):

Fastness to wash (color change "c.c." and color staining "c.s.") for the mercerized three dyed fabric structures were the highest and followed in a descending order by untreated and resin treatment, these findings may be because mercerization imparts gloss to the cotton fiber, increases amorphous cellulose, hydroscopicity and improves dyeability. So mercerized fiber and fabrics are more absorbent and have greater affinity for dyestuff. This is in agreement with Hatch (1993) and Sadova *et al.* (1973).

4. Alkali and acidic perspiration fastness:

Resin treatment increased fastness to alkali perspiration (c.c. and c.s.) (5/5), but mercerized treatment caused no change for the three fabric structures (4/5). On the other hand, for fastness to acidic perspiration (c.c.), mercerized treatment increased it (3/5), while resin treatment did not cause any change (1/5). But fastness to acidic perspiration (c.s.) showed the same result in all cases (3/5). These findings are possibly attributed to that resins are known to get linked with cellulose chains in such a way that there would be no free hydroxile groups available for other reactions. This is in agreement with Hatch (1993) and Mahmoud (1999). As such, fabrics treated with resins would resist alkali perspiration. While mercerization imparts gloss to the cotton fiber, increases amorphous cellulose, hydroscopicity and improves dyeability. So mercerized fiber and fabrics are more absorbent and have greater affinity for dyestuff. This is in agreement with Hatch (1993) and Sadova *et al.* (1973).

5. Dry rubbing fastness:

Mercerized and resin treatments increased fastness to dry rubbing (5/5) compared with untreated dyed fabric for twill and knit fabrics (4/5), while this fatness for plain fabric was higher also in all cases (5/5), these may be due to, mercerization treatment would strengthen the weak points in cotton fibers due the relief of strains as a result of swilling. Further, fiber surface would be more uniform due to the removal of groves and ridges and hence they would be more resistant to dry rubbing. This is in agreement with Hatch (1993).

Table 1. Color strength and color fastness properties of untreated fabrics dyed with natural dye.

Dyeing characteristics	Fabric structures		
	Plain	Twill	Knit
Color strength (K/S)	0.477	0.386	0.562
Light fastness	4-5/8	4-5/8	4-5/8
Wash fastness (c.c.)	4/5	3/5	3/5
Wash fastness (c.s.)	4/5	3/5	3/5
Alkali perspiration (c.c.)	4/5	4/5	4/5
Alkali perspiration (c.s.)	4/5	4/5	4/5
Acidic perspiration (c.c.)	1/5	1/5	1/5
Acidic perspiration (c.s.)	3/5	3/5	3/5
Dry rubbing fastness	5/5	4/5	4/5

c.c.=color change, c.s.= color staining

Table 2. Effect of mercerization treatment on color strength and color fastness properties of fabrics dyed with natural dye.

Dyeing characteristics	Fabric structures		
	Plain	Twill	Knit
Color strength (K/S)	0.535	0.530	0.611
Light fastness	4-5/8	5/8	4-5/8
Wash fastness (c.c.)	4/5	4/5	4/5
Wash fastness (c.s.)	4/5	4/5	4/5
Alkali perspiration (c.c.)	4/5	4/5	4/5
Alkali perspiration (c.s.)	4/5	4/5	4/5
Acidic perspiration (c.c.)	3/5	3/5	3/5
Acidic perspiration (c.s.)	3/5	3/5	3/5
Dry rubbing fastness	5/5	5/5	5/5

c.c.=color change, c.s.= color staining

Table 3. Effect of resin treatment (DMDHEU) on color strenght and color fastness properties of fabrics dyed with natural dye.

Dyeing characteristics	Treatments		
	untreated fabrics	mercerized fabrics	resin-treated fabrics
Color strength (K/S)	++	+++	+
Light fastness	++	++	+
Wash fastness (c.c.)	+	+++	++
Wash fastness (c.s.)	+	++	++
Alkali perspiration (c.c.)	+	+	++
Alkali perspiration (c.s.)	+	+	++
Acidic perspiration (c.c.)	+	++	+
Acidic perspiration (c.s.)	+	+	+
Dry rubbing fastness	+	++	++

c.c.=color change, c.s.= color staining

Table 4. Ranking of different treatments, in accordance with their effect on dyeing characteristics of various fabric structures.

Dyeing characteristics	Fabric structures		
	Plain	Twill	Knit
Color strength (K/S)	0.423	0.332	0.469
Light fastness	4/8	4/8	4/8
Wash fastness (c.c.)	4/5	3-4/5	3-4/5
Wash fastness (c.s.)	4/5	3-4/5	4/5
Alkali perspiration (c.c.)	5/5	5/5	5/5
Alkali perspiration (c.s.)	5/5	5/5	5/5
Acidic perspiration (c.c.)	1/5	1/5	1/5
Acidic perspiration (c.s.)	3/5	3/5	3/5
Dry rubbing fastness	5/5	5/5	5/5

The increments of (+) signs connotes (implies) enhancements of ranking.

From these results, it appears that the use of a natural dye friendly to the environment such as henna could be effective in dyeing chemically modified cotton fabrics. Also the mercerization and resin treatments improved the natural dyeing characteristics of cotton fabrics. In such a case, there would not be much reliance on synthetic dyes known to induce environment pollution.

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تأثير بعض المعاملات الكيميائية على صباغة الاقمشة القطنية بالصبغة الطبيعية (الحناء)

أمل صابر محمد

معهد بحوث القطن، مركز البحوث الزراعية ، الجيزة

أستهدف هذا البحث دراسة تاثير بعض المعاملات الكيميائية (المرسرة والمعاملة بالراتنج المسمى باركوفكس أو ثنائى ميثايل ثنائى هيدروكسى اثيلين يوريا) على صباغة الاقمشة القطنية (صنف جيزة ٨٣) مختلفة التراكيب النسيجية بالصبغات الطبيعية (الحناء). صبغت ثلاث انواع من التراكيب النسجية (السادة ، المبرد ، التريكو) قبل وبعد هذة المعاملات الكيميائية وأظهرت النتائج ما يلى:

النسيج التريكو تميز عن النسيج السادة و المبرد فى درجة عمق اللون وذلك فى كلتا المعاملتين "المرسرة والراتنج".

بصرف النظر عن التركيب النسجى وجد أن عملية المرسرة أدت الى زيادةعمق اللون والثبات ضد العرق الحامضى (تغير اللون) ، ولكن المعاملة بالراتنج أدت الى زيادة الثبات ضد العرق القاعدى (تغير اللون و التبقع) وانحفاض الثبات للضوء و انخفض عمق اللون ايضا.

بينما أدت كل من المرسرة و المعاملة بالراتنج الى زيادة الثبات للغسيل (تغير اللون و التبقع) والثبات للاحتكاك الجاف.

ونأمل بأن تكون لهذة النتائج أهمية خاصة لكل من مربى القطن ولصناعة الغزل والنسيج وذلك لانتاج منتجات صديقة للبيئة كاتجاة عالمى فى هذة الآونه، خاصة أنه يمكن زيادة جودة الصباغة باستخدام بعض المعاملات الكيميائية مثل المرسرة أو المعاملة بالراتنج مع اكساب القماش المصبوغ خواص أفضل للمستهلك.