MECHANICAL PROPERTIES AND STABILITY TO LIGHT EXPOSURE FOR EGYPTIAN COTTON FABRICS DYED WITH NATURAL AND SYNTHETIC DYES

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Abstract

Synthetic dyes had become more available than natural dyes because of their lower prices and wider ranges of bright shades with considerably improved color fastness properties. Recently, concern for the environment has created an increasing demand for natural dyes which are more friendly to the environment than synthetic dyes. This investigation aims to study the effect of dyeing cotton fabrics with natural dye (henna) and synthetic dye (remazol blue) on some mechanical properties and stability to light exposure. The undyed and cotton fabrics dyed were tested for tenacity (N), elongation %, breaking work (Nm). Shrinkage and crease recovery angle were also tested. The stability to light exposure after 100 hr were examined by investigation of macrostructure (using scanning electron microscope) and reflection spectra. The results proved that the cotton samples dyed with henna have higher mechanical properties, higher shrinkage % and higher recovery angle. Moreover, fabrics dyed with henna showed lower degree of degradation when exposed to the artificial daylight for 100 hr, while the remazole blue showed the highest degradation.

INTRODUCTION

Use of natural dyes for the coloration of textiles has mainly been confined to craft dyes and printers. Recently, more interests have been devoted to use these dyes, so some business have started to look at the possibilities of using natural dyes for dyeing and printing of textiles. Nishida and Kobayashi (1992) reported that natural dyes are less toxic, non–pollutant, less health hazard, very brilliant. On the other hand, Isharat (1993) reported that natural dyes have some disadvantages e.g., only few dyes have good fastness to light and washing, lack of availability of precise technical knowledge of extraction and dyeing technique, higher cost and limited range, some of mordents are harmful to silk. Goodwin (1982) reported that henna is an excellent substantive dye made from Egyptian privet (*Lawsonia inermis*), which has been used for centuries. The dye is made from the henna dried leaves, which are picked, dried and made into a paste or powder containing henna tannic acid. Tommasi (1920) isolated from henna leaves a crystalline coloring matter, which was named lawsone, and he described some of its chemical and physical properties. Trotman (1964) concluded that lawsone is probably identical with 2-hydroxy-1,4 naphthoquinone. Lai and Dutt (1933) separated from henna leaves a compound , which was found to be 2-hydroxy 1,4 naphthoquinone. They also showed that lawsone have an acid dyestuff and formed about 1% of the dry leaves. Cox (1938) analyzed a typical specimen of air dried henna leaves and found that it contains lawsone in concentration of about 1%, he found also that the dry leaf is free from starch and tannin .

The major factors behind the remarkable growth of reactive dyes which were introduced in 1956 has been their specific properties, e.g. they can be applied onto cotton by practically all known methods, high brilliancy of shades and all round fasteners for general use and universal application on pure and regenerated cellulose. On the other hand, the main problems of these dyes are: their light fastness properties compared with the other dyestuffs and the consumption of a large proportion of the dye due to side-reaction specially hydrolysis. These dyes form hydrogen bonds with the cotton fiber substrate (Kamat and Sad, 1991).

The aim of this work is to study the effect of dyeing cotton fabrics with natural dye henna (*Lawsonia alba*)and synthetic dye (remazol blue) on some mechanical properties and stability to light exposure.

MATERIALS AND METHODS

Materials : 100% Egyptian cotton fabric [(Giza 85 variety, fabric structure: plain 1/1, yarn count (warp count 30 tex, weft count 30 tex)and number of threads per centimeter (warp 23/cm, weft 23/cm)]. The fabric was supplied by Misr Spinning and Weaving Company, El-Mahala El-Kobra (season 2001/2002).

Dyeing method: dyeing with reactive dye (remazol blue supplied by Hoechst Company Egypt) was done according to the procedure described by Trotman (1964). The cotton fabrics were immersed in a dye bath containing 1 % reactive dye at a ratio of 1 : 50 ml dyeing solution for each gram sample. While the natural dye was applied by immersing the 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 sulfate was added (2 - 10 g/L), the dyeing obtained were thoroughly washed with water, soaped with a solution containing 2% soap at 60°C, rinsed with water, and then dried at the ambient condition (Abd El-Fatah, 1997).

Measurements:

1. Tenacity (N), Elongation (%) and breaking work (Newton meter =NM) of the preconditioned samples (relative humidity 65 ± 5 % and 20 ± 1°C) were measured using Zwick automatic tensile testing machine of model 1511-Germany, according to A.S.T.M. (1972) D 1682. The testing instrument was adjusted at speed of 100 mm/min.

2. The shrinkage % of both dyed fabrics were tested according to A.S.T.M. (1972) .

3. Crease recovery angles were measured according to A.S.T.M. (1972) D: 1295-67.

4. Stability to light exposure after 100 hr exposure for undyed and cotton fabric dyed were examined using the following techniques:

a. The morphological investigations were carried out using scanning electron microscope (SEM) manufactured by Jeol Co. Japan at the National Research Center. The cotton fibers were adhered to the sample-holder, coated with a layer of gold by means of thermal evaporation in a vacuum coating unit, and examined in the SEM using an accelerating voltage of 20 KV. Ten pictures from each sample were taken at a magnification of 750 X.

b. The reflectance spectra presented in this work were obtained on a Perkin-Elmer (PE) Lambda 25 spectrophotometer equipped with an integrating sphere and operating without a gloss trap. The spectra were recorded between (400 - 800 nm) with a slit width of 5 nm. The scan speed was 120 nm/min. The samples were subjected to the reflectance measurement in form of a 4 folds.

RESULTS AND DISCUSSION

1. Tenacity, elongation (%) and the breaking work:

The data given in Tables 1 and 2 illustrate the values of tenacity (N), elongation % and the breaking work of weft and warp directions of undeyed and cotton fabric dyeds. These data showed that the cotton fabrics dyed with natural dye (henna) revealed the low decrease in fabric tenacity relative to the cotton fabric dyed with synthetic dye (remazol blue). While the elongation % for both dyed fabrics was increased, but the cotton fabric dyed with remazol revealed high increase in elongation % than cotton fabric dyed with henna. On the other hand, the breaking work (Nm) for cotton fabric dyed with natural dye was higher than the breaking work for both undyed and cotton fabric dyed with synthetic dye. This may be due to dyeing cellulosic fibers with natural or reactive dyes at various temperatures and various conditions produces a polymorphic change in cellulose, these changes affected some physical properties of the cellulosic fibers. These results are in agreement with Tyrone (1994) .

Table 1. Effect of dyeing cotton fabric with natural and synthetic dyes on the tenacity, elongation (%) and the breaking work of the weft direction.

Sample No.	Un dyed cotton fabric			dyed fabric with remazol blue			dyed fabric with henna		
	Tenacity (N)	Elongation (%)	Breaking work (Nm)	Tenacity (N)	Elongatio (%)	Breaking work (Nm)	Tenacity (N)	Elongation (%)	Breaking Work (Nm)
1	469.0	3.80	4.8	420.0	5.17	4.5	463.6	4.78	4.0
2	516.6	4.15	4.9	381.7	5.49	3.3	465.7	4.51	5.0
3	512.5	4.13	5.4	472.8	5.45	4.5	460.2	4.70	5.0
4	451.1	3.89	4.5	419.0	4.73	4.2	465.2	4.83	3.9
5	516.0	3.35	4.7	419.6	4.81	3.8	466.4	4.77	4.0
6	481.8	3.63	4.4	416.0	4.69	4.6	455.4	5.09	4.2
Averag	491.17	3.83	4.83	438.1	5.06	4.2	462.75	4.8	4.35

Table 2. Effect of dyeing cotton fabric with natural and synthetic dyes on the tenacity, elongation (%) and the breaking working of the warp direction.

Sample No.	Un dyed cotton fabric			dyed fabric with remazol blue			dyed fabric with henna		
	Tenacity (N)	Elongation %	Breaking work (Nm)	Tenacity (N)	Elongation %	Breaking work (Nm)	Tenacity (N)	Elongation %	Work break (Nm)
1	441.0	3.9	3.8	390.1	4.7	3.6	403.2	4.2	3.5
2	394.0	3.5	2.7	400.0	4.7	2.8	330.2	4.9	3.8
3	456.2	3.8	4.5	417.3	5.4	3.7	432.9	4.8	3.6
4	455.4	3.9	4.2	401.1	5.3	3.8	410.4	4.0	3.9
5	415.5	3.7	4.2	406.3	5.4	3.2	416.0	5.0	3.6
6	446.5	3.7	3.6	415.2	5.2	3.5	422.0	4.8	3.7
Average	434.77	3.74	3.83	405.44	5.12	3.43	402.5	4.60	3.7

2. Shrinkage Behaviors :

The data recorded in Table 3 clearly reveal that the shrinkage in width direction of fabric dyed with henna was higher than those dyed with remazol. This may be due to dyeing cotton fabrics with natural or reactive dyes at various conditions (temperatures, chemicals and time) produces change at some physical properties of the cotton fabrics. These results are in agreement with Troman (1964) and Tyrone (1994) .

Table 3. Effect of dyeing with natural and synthetic dyes on the dimensional stabilities of the cotton fabrics.

Sample	Shrinkage %	
	Width	Length
Dyed fabric with remazol dye	6.33	7.6
Dyed fabric with henna	8.86	7.6

3. Crease recovery angle:

Table 4 represents the effect of dyeing with natural and synthetic dyes on crease recovery angle of the cotton fabric. The results depict that the dyeing with the natural dyes has a higher recovery angle than that of undyed and Remazol dye. This can be attributed to the rigid hydrogen bonds between remazol dye and cellulose of cotton fabric. This result is also in agreement with Troman (1964).

Table 4. Effect of dyeing with natural and synthetic dyes on crease recovery angle of the cotton fabric.

Sample	Crease recovery angle (Å)	
	Weft	Warp
Undyed fabric	111	126
Dyed fabric with remazol dye	115	107
Dyed fabric with henna	143	117

4. Stability to light exposure:

Stability to light exposure after 100 hr exposure for undyed and dyed cotton fabrics were examined using two techniques revealed :

1. The reflection spectra in the wavelength range (400-800 nm) as shown in Figure 1, the fabrics dyed with henna as natural dye exhibited the lowest damage when it was exposed to the artificial daylight for 100 hr. this can be easily noticed by comparing the dyed and undyed ones. These data were approved by scan electron microscope investigation.

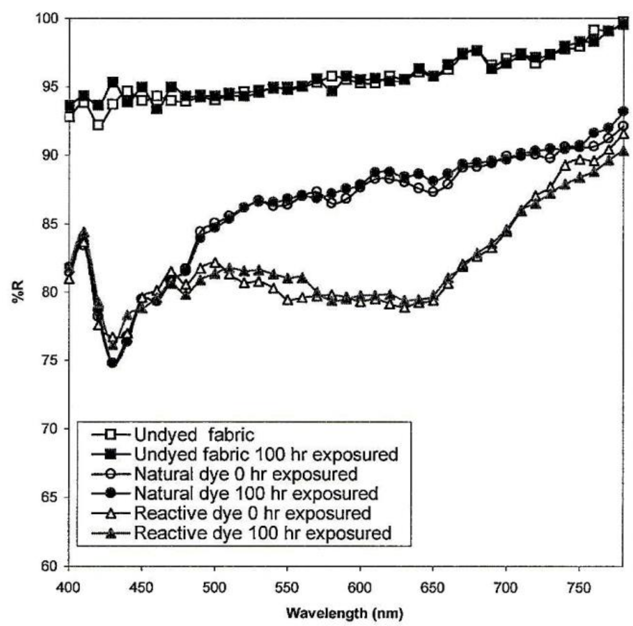

Figure 1. Reflection spectra of the undyed and cotton fabrics dyed with henna and remazol blue before and after exposure to artificial daylight for 100 hr.

2. Scan electron microscope in the photographs in Figure 2 it may illustrate the changes of fibers surface arising from exposure to the artificial daylight; the fibers became more obscure and their surfaces roughness are increased and number of depressions were formed, but the dyed fabric with natural dye (henna) showed the less changes in their surface morphology, (Tera *et al.,* 1997).

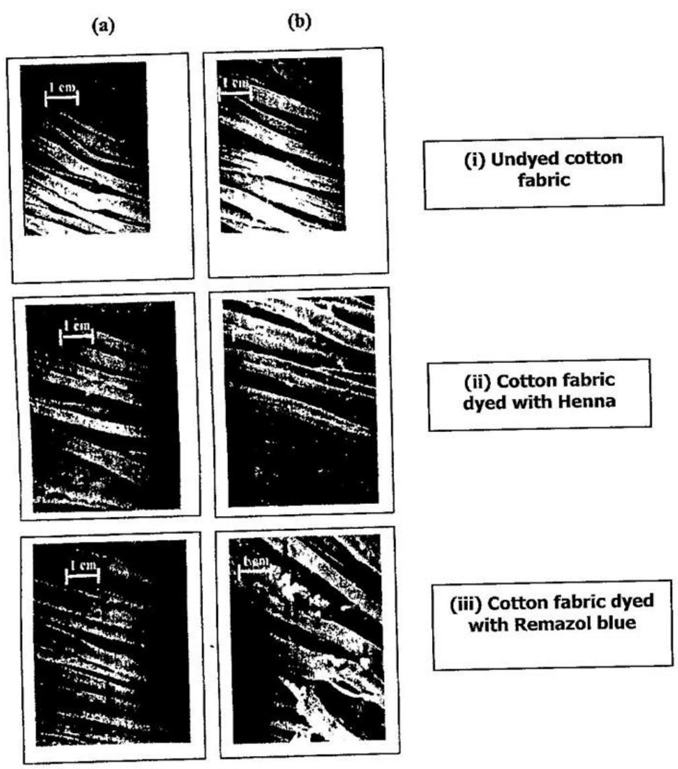

Figure 2. Scan electron microscope for (i) undyed, (ii) dyed with Henna and (iii) dyed with reactive dye.

(a) Before exposure to artificial day light for 100 hours.

(b) After exposure to artificial day light for 100 hours.

CONCLUSION

Fabrics dyeing with henna (as a natural dye) showed higher mechanical properties, higher shrinkage % and higher recovery angle. Moreover they showed lower degree of degradation when exposed to the artificial daylight for 100 hr, while the remazole blue showed the highest degradation.

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الصفات الميكانيكية و الثبات للتعرض للضوء للمنسوجات القطنية المصرية المصبوغة بالصبغات الطبيعية و الصناعية

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الصبغات الصناعية أكثر تداولاً عن الصبغات الطبيعية لأنها أرخص و تعطى ألوانا كثيرة جذابة بالإضافة للثبات العالى لها .إلا انه في ا لآونة الأخيرة نظرا للاهتمام الكبير للحفاظ على البيئة زاد الإقبال على أستخدام الصبغات الطبيعية التى تكون صديقة للبيئة أكثر من الصبغات الصناعية. والهدف من هذا البحث دراسة تأثير الصباغة بالصبغات الطبيعية (الحناء) والصبغات الصناعية (الريمازول الأزرق) على بعض الخواص الميكانيكية (المتانة – الاستطالة) ودرجة الانكماش وزاوية التجعد وكذلك التأثير على درجة الثبات للضوء بعد التعرض لـ١٠٠ ساعة ضوئية. وقد أجريت دراسة على مورفولوجيا السطح باستخدام الميكروسكوب الألكترونى .وكذلك دراسة المنحنى الطيفي في المدى من ٤٠٠–٨٠٠ نانوميتر والفحص بأشعة إكس وذلك لبعض المنسوجات القطنية المصرية (صنف جيزة ٨٥).

وقد أوضحت النتائج ما يلى

١–الصباغة بصبغة الريمازول الصناعية أدت إلى تدهور فى متانة هذه المنسوجات بدرجة أكبر من التدهور الذى حدث فى المتانة نتيجة الصباغة بالحناء كصبغة طبيعية وهذا ما أكده الفحص الميكروسكوبى والفحص باشعة إكس .

٢– زادت استطالة المنسوجات بعد صباغتها بكلتا الصبغتين الطبيعية والصناعية ولكن كانت الإستطالة أكبر بعد الصباغة بالصبغة الطبيعية .

٣–كانت درجة إنكماش المنسوجات القطنية المصبوغة بالصبغة الصناعية فى إتجاه العرض أكبر من درجة الإنكماش الناتجة عن الصباغة بالصبغة الطبيعية .

٤– وجد أن زاوية التجعد للمنسوجات القطنية المصبوغة بالحناء اكبر من زاوية التجعد للمنسوجات غير المصبوغة والمصبوغة بالريمازول وبذلك تكون مقاومة التجعد للمنسوجات المصبوغة بالصبغة الطبيعية أعلى من المصبوغة بالصبغة الصناعية .

٥- ووجد من دراسة درجة الثبات للتعرض للضوء بمقارنة المنسوجات المصبوغة بغير المصبوغة بالفحص بالميكروسكوب الألكترونى والفحص الضوئى والفحص باشعة إكس أن صبغة الحناء كصبغة طبيعية حمت المنسوجات القطنية من التدهور نتيجة التعرض للضوء علـــى العكـــس مـــن صـــبغة الريمازول الزرقاء التى أدت إلى تدهور هذه المنسوجات عند تعرضها للضوء وبذلك تكون هذه صفة هامة تضاف لمميزات صبغة الحناء كصبغة طبيعية لما في ذلك من أهمية خاصة لكل مـــن مربـــى القطن ولصناعة الغزل والنسيج بالإضافة إلى إن الصبغة الطبيعية صديقة للبيئة.