

NEW TECHNIQUES FOR PRETREATMENT, DYEING AND FINISHING OF SOME EGYPTIAN COTTON FABRICS IN ONE- BATH

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Abstract

The present study was taken up as an exploratory study to test the possibility of using one-bath scouring, dyeing and finishing (OSBDF) by the exhaustion and pad-dry techniques as an economical treatment process of fabrics made from two Egyptian cotton varieties namely Giza 89 and Giza 80. Detailed laboratory experiments were performed to investigate the feasibility of this process. The treated and untreated fabric samples were tested for their mechanical properties expressed as tensile strength (g/tex) and elongation %. Dyeing performance in terms of color parameters (K/S, ΔE), and fastness properties (wash, perspiration, and crocking) were also studied.

The results of this investigation showed that ,The K/S value of the treated fabrics by the conventional method is slightly better than the cotton fabrics treated by the one-bath method. The K/S value of the treated fabrics increased with the increase in concentration of NaOH and Na₂SO₄, addition of finishing agent and pretreatment time. The tensile strength, elongation, and color difference of the treated fabrics by this method are of the acceptable limit. The addition of soluble chicken feather as a finishing agent (2g/l) increase the K/S value and maintain the tensile strength, and elongation from degradation. The wash, perspiration, and crocking dye fastness properties of the cotton fabrics are of the acceptable standards

Keywords: Egyptian cotton, conventional method, one-bath method, finishing agent.

INTRODUCTION

Textile wet processing is one of the most polluting industrial processes. It is a complex process. The same result can be achieved by applying some different technologies and with the use of some different kinds of chemical materials and machines. The complexity of the process also depends on the composition of textile material, (Gailutè *et al.* 2004).

The concept of one-bath dyeing and finishing (ODF) is to combine the two steps of dyeing and finishing. The ODF process has been studied using cotton fabrics dyed with reactive and direct dyes. The advantages of the ODF process are reduced energy, water consumption and time of operation, (Siriwan. 2006).

Conversion of raw cotton fabrics to dyeing fabrics by conventional process involves four distinct steps namely, desizing to reduce the size, scouring to remove fats, waxes and pectins, bleaching to remove coloring matters and dyeing. During these various steps the overall energy, water consumption and follow up wastewater processing will be quite high.

Gailutė *et al.* (2004) reported that reducing pollution in wet processing of cotton/polyester fabrics by using new technologies should be evaluated not only from the economical point of view but also from the environmental impact which can be assessed by comparison of environmental performance indicators: water and energy consumption, and consumption and emissions of chemical materials.

Over the last fifteen years, energy conservation was emphasized and different approaches were made to reduce energy consumption. One of these approaches involves combination of certain steps together, thereby shortening the processing steps and consequently conserving energy. For instance, Hafiz *et al.* (1991) have studied the combined desizing, scouring, and bleaching of loomstate cotton fabric and loomstate cotton/polyester blended fabric using $\text{NaClO}_2/\text{KMnO}_4$ or $\text{NaClO}_2/\text{H}_2\text{O}_2$ oxidizing system.

Yen, and Huang, (1997) have focused primarily on one bath treatments for desizing, scouring and bleaching, rather than mercerization. This is primarily because the former treatments are conducted primarily at high temperatures. However, high temperatures are disadvantageous to mercerization. In a one-step desizing, scouring and bleaching treatment the process is conducted in alkaline liquors, as indeed is mercerization. Thus, this study combined these four treatments by dipping the fabrics into highly alkaline sodium hydroxide solutions at various temperatures, and then curing the fabrics at high temperature. Consequently, the complete process could be shortened to save energy and thereby lower the cost. The results indicate the feasibility of a one-step process for desizing, scouring, bleaching and mercerizing cotton fabrics.

Sekar, (1999) reported that it is possible to scour and bleach cotton fabric at 60°C with sodium chlorite in a single-stage based on an emulsified solvent scouring agent and a trichloroethanolamine hydrochloride activated sodium chlorite bleaching agent. Min and Haung (1999) confirmed that the feasibility of one – step process for desizing, scouring, bleaching and mercerizing of cotton fabrics. Single stage bleaching process using hydrogen peroxide requires some additional chemicals that can act as activator, stabiliser, surfactant and scouring agents. Strongly alkaline solution of hydrogen peroxide has been advocated for such combined processes. Sodium persulphate and potassium persulphate boost the single stage operation in presence

of hydrogen peroxide. Other compounds which accelerate the peroxide reactions are urea, methyl carbonate and tetraacetythylenediamine.

Mortazavi, (2008) introduced potassium permanganate as an oxidizing agent for simultaneous desizing and bleaching of greige cotton fabric for the first time. The results have demonstrated that the fabric properties including the whiteness index of this method are comparable with those of the conventional hydrogen peroxide bleaching method. One of the major advantages of this method relative to the other methods is its potentiality for simultaneous desizing and bleaching of greige cotton fabric, which will save energy, water and time.

In the same approach to reduce energy and water consumption, Polonca and petra (2007) studied bioscouring and bleaching of cotton with pectinase enzyme and peracetic acid in one bath with the addition of a chelator. Tetrasodium pyrophosphate, which does not deactivate pectinases, has proved an efficient chelator. The analyses of a cotton fabric treated in a single bath with acidic and alkaline pectinases confirmed the efficiency of such treatment. A sufficient quantity of wax and pectin was removed and, because of that, the absorbance of the treated fabric was improved. The damage to the cotton fibres was negligible and the degree of whiteness obtained was uniform and adequate for further dyeing.

Subramanianeral. (2005) reported that enzyme treatment paves way for a new, unconventional technique of dyeing within the bleaching bath. from this new approach in the textile wet processing industry, it was possible to reduce the huge amount of water (by avoiding the extensive washing cycle after bleaching and dyeing in the catalase-treated bleached bath), considerable energy and time.

Huang and Yen, (1997) proposed that desizing, scouring bleaching and dyeing can be done in one bath and the aforesaid defects will be overcome.

This study is focused on the possibility of scouring, dyeing, and finishing of Egyptian Cotton Fabrics in One-Bath using Reactive Dyes

MATERIALS AND METHODS

A. Fabric

Untreated cotton fabrics of Egyptian cotton varieties namely Giza 89, and Giza 80 were purchased from Misr- El- Mehala for Spinning and Weaving Company.

The Specific properties of raw cotton fabrics for both Giza 80, and Giza 89 respectively are: Plain weave 1/1, Weight of square meter: 190.8 g. Number of threads per cm of warp: 26, Number of threads per cm of weft: 26, Count number of yarn : 20 and Plain weave 1/1, Weight of square meter: 130.8 g. Number of threads

per cm of warp: 44, Number of threads per cm of weft: 32 and Count number of yarn : 40 .

B. Chemical reagents

Chemicals used in this study were sodium hydroxide, sodium sulfate, sodium carbonate (LR grade), Hydrogen peroxide (30% LR grade) from Aldrich, acetic acid, sodium sulphate, mercerol as surfactant and soap. The dye used in this work was Remazole reactive R.R. finishing agent used was soluble chicken feather as described by Khaled *et al* (2006).

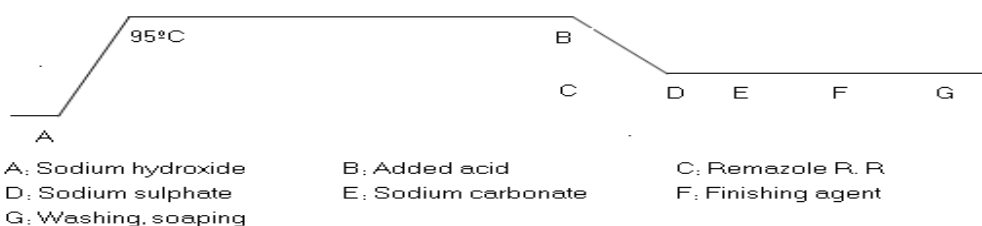
Methods

A. Conventional method

Scouring, bleaching and dyeing were carried out according to the procedure described by Huang (1999).

B. One-Bath method

Treatment was done with NaOH (2g/l -4g/l – 6g/l, 8g/l) and 0.2 g/l surfactant, with bath ratio1:30 at 95°C and times (15- 30- 45) minutes, the solutionremained from pretreatment was not thrown away. Acetic acid was used to neutralize it into weak alkaline, after which 1% of remazol reactive yellow R.R was added, followed by sodium sulfate as a catalyst (10 g/l – 20 g/l – 30 g/l) and sodium carbonate 15g/l, then a known concentration (0.5%- 3.0%) of the soluble chicken feather was added as a finishing. The dyed samples removed from dyeing bath and rinsed in water at 25°C and then air-dried as shown in the curve below.



Measurements and Analysis:

Evaluation of the properties of the treated fabrics

The color strength (K/S) of the treated samples was determined using Perkin Elmer Spectrophotometer, Model Lambda 35 equipped with integrated sphere according to Kubelka-Munk equation:

$$K/S = [(1-R)^2 / 2R].$$

Color difference (ΔE) was measured by using the Win lab software CIE CMC (1995).

Tensile strength (g/tex) and elongation (%) were measured according to ASTM D412-98a using Zwick testing machine of model Z010 and equipped with 10Kn load cell and the testing was conducted at speed of 100mm/min. The results obtained were based on an average of ten tests in the wrap direction of each sample.

Fastness properties:

- (a) Washing fastness (WF), was done according to ISO 105-C01:1998(E). Two single fiber adjacent fabrics complying with the relevant sections of F01 to F08 of ISO 105-F: 1989.
- (b) Synthetic perspiration fastness (PF) was measured according to ISO-E04: 1994.
- (c) Crocking fastness both dry and wet examined according AATCC method-8-1989.

RESULTS AND DISCUSSION

Effect of NaOH concentration on color strength (K/S):

The results shown in figs. 1 and 2, revealed that the K/S value of treated fabrics increased with increasing NaOH concentration due to more removal of starch and impurities from the test fabric, allowing the dye to infiltrate the fabric more easily until it reach 6%. The dyebility of the fabric samples decreased with increased NaOH concentration more than 8%, due to the formation of the oxycellulose, that cause degradation of the fiber.

It is clear that in one-step methods, fabrics had lower color strength than the conventional method. This is plausible because during the one-bath treatment, the solution used in the treatment contained pretreatment chemicals and post-treatment residual impurities, and with the effectiveness of the reactive dye itself, some form of reaction would have occurred, resulting in the reduction of the color strength of the fabrics.

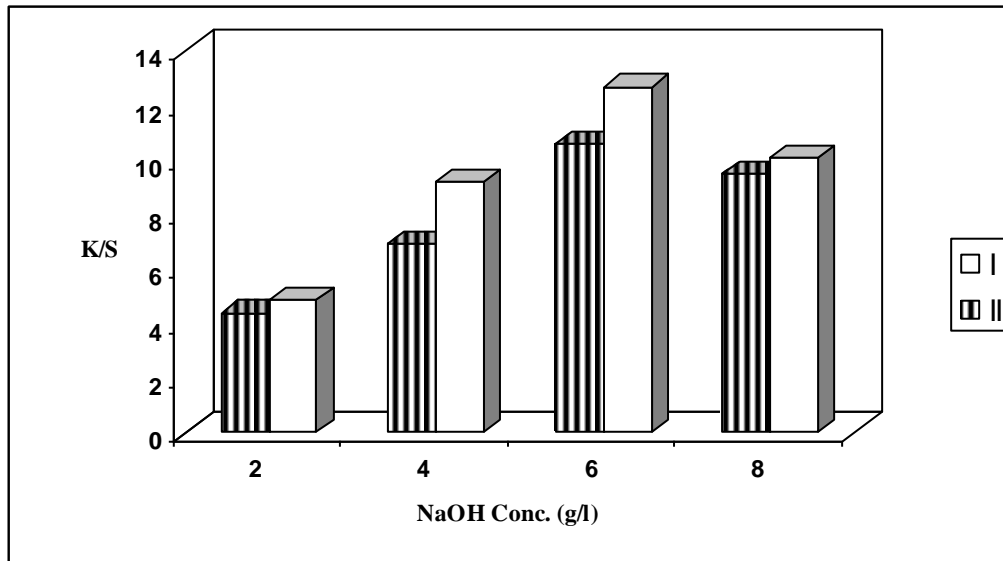


Figure 1. Effect of NAOH concentration on the color strength of Giza 89 cotton fabric. (I: conventional processes, II: one- bath process time: 30 minutes Na_2SO_4 concentration: (30g/l), finishing agent: none).

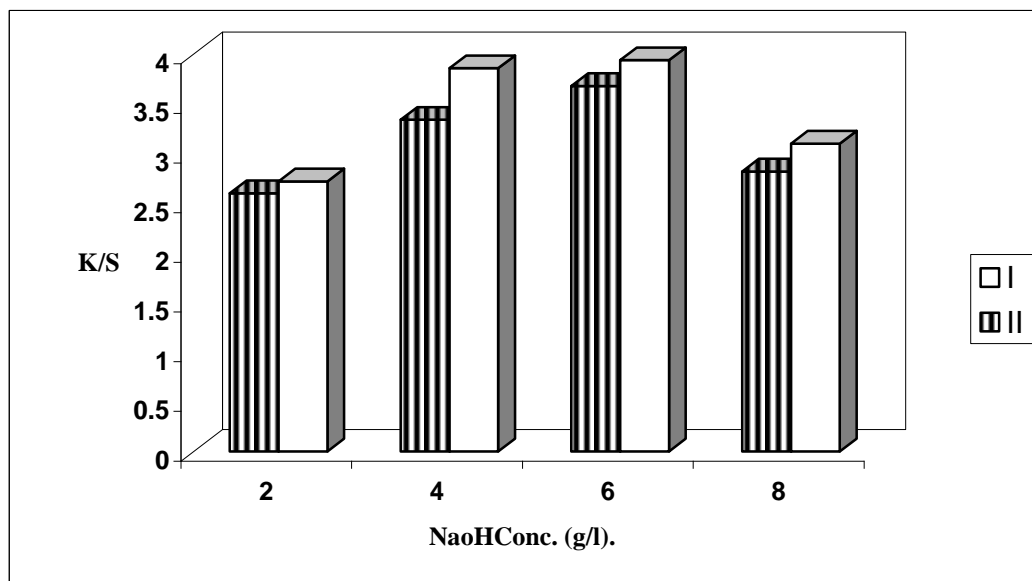


Figure 2. Effect of NAOH concentration on the color strength of Giza 80 cotton fabric (I: conventional processes, II: one- bath processes time: 30 minutes Na_2SO_4 concentration: (30g/l), finishing agent: none).

These results indicate that the color strength of Giza 89 was higher than that of Giza 80 due to its higher Fiber maturity forming more free hydroxyl groups by the addition of NaOH and thus leads to more dyeability.

Effect of time on color strength (K/S)

It is clear from figs. 3, and 4 that the K/S values of the treated samples increased according to the time from pretreatment until the treatment it reached 45 minutes. This is because with longer time taken for treatment, more impurities were eliminated and there were increasingly less opportunities for obstruction of dyeing infiltrating the fabrics. Since the time treatment effect of 45, and 60 minutes were similar, it would be more economical to use 45 minutes as it would still achieve the purpose of eliminating nearly all the fabric sample impurities (wax, undesired materials, etc...). The results showed that the color strength of Giza 89 was higher than that of Giza 80 due to its higher maturity that formed more free hydroxyl groups with longer time leading to more dyeability.

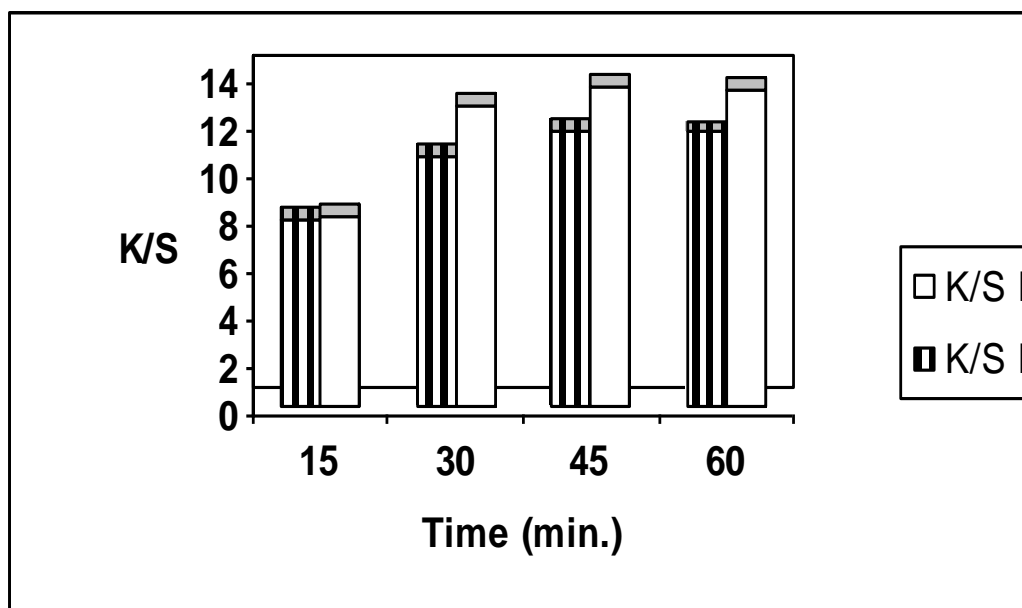


Figure 3. Effect of time on the color strength of Giza 89 cotton fabric (I: conventional processes, II: one- bath processes NaOH concentration: (6g/l) Na_2SO_4 concentration: (30g/l), finishing agent: none).

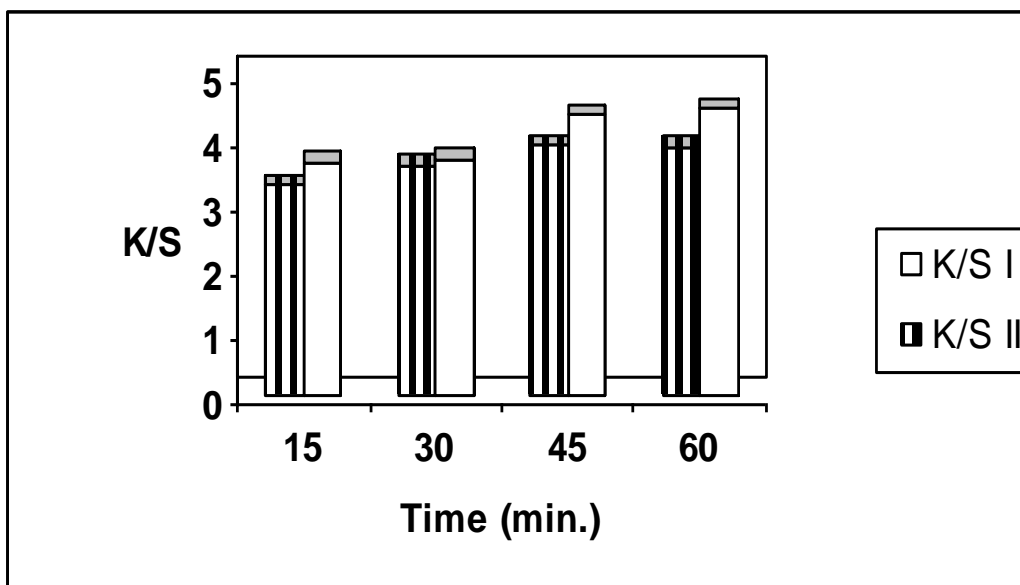


Figure 4. Effect of time on the color strength of Giza 89 cotton fabric (I: conventional processes, II: one- bath processes NaOH concentration: (6g/l) Na_2SO_4 concentration: (30g/l), finishing agent: none).

Effect of Na_2SO_4 concentration on color strength (K/S)

It is clear from figs. 5, and 6 that, the K/S value of the treated samples increased according to Na_2SO_4 increase until it reached 30 g/l. when immersed in dye bath, the cellulosic fabrics assume a negative charge and so repel the reactive dye anions. The degree of repulsion between cellulosic fabrics and dye anions depends on the overall negative charge created on the cellulosic fibers and on the negatively charged substitutes of each dye ion. Reactive dye reacts chemically with cellulosic fabrics through the formation of covalent bonds. A particular problem with the application of the reactive dye was the competing reaction with the hydroxide ions in the dye bath to produce a hydrolysed non-reactive form of the dye. Sodium sulphate was added to the dye bath to promote exhaustion of the dye by reducing the electrical potential on the cellulosic fabrics. Na_2SO_4 allowing the dye ions to approach the fibers sufficiently closely for nonionic molecular interactions to become operative. Since the effect of Na_2SO_4 30 g/l, and 40 g/l was similar, it would be more economical to use 30 g/l as it still allow the dye ions to approach the fibers sufficiently. The results show that the color strength of Giza 89 was higher than that of Giza 80.

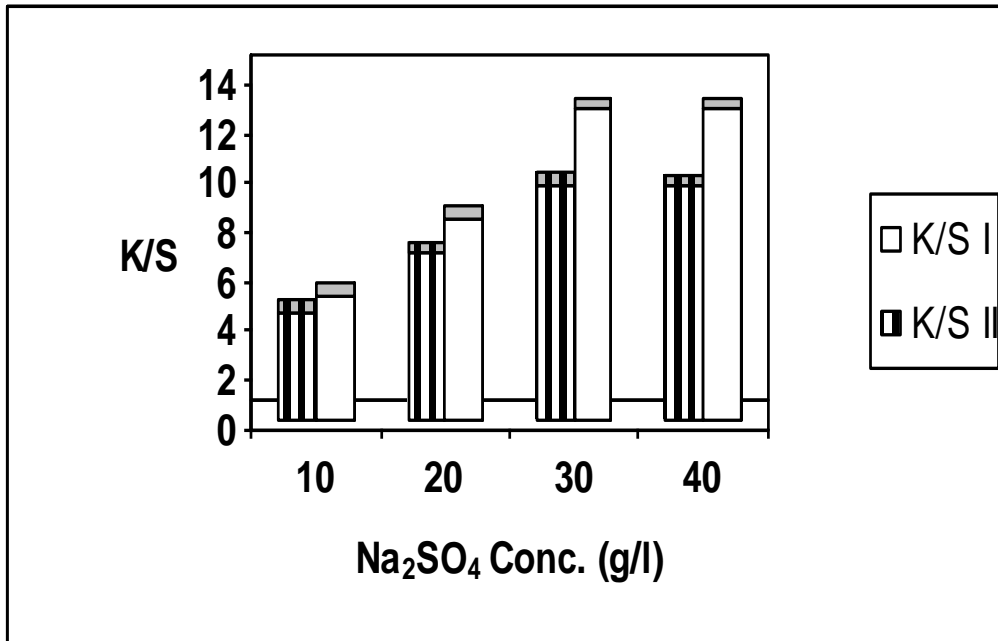


Figure. 5. Effect of Na₂SO₄ concentration on the color strength of Giza 89 cotton fabric (I: conventional processes, II: one- bath processes time: 30 minutes NaOH concentration: (6g/l), finishing agent: none).

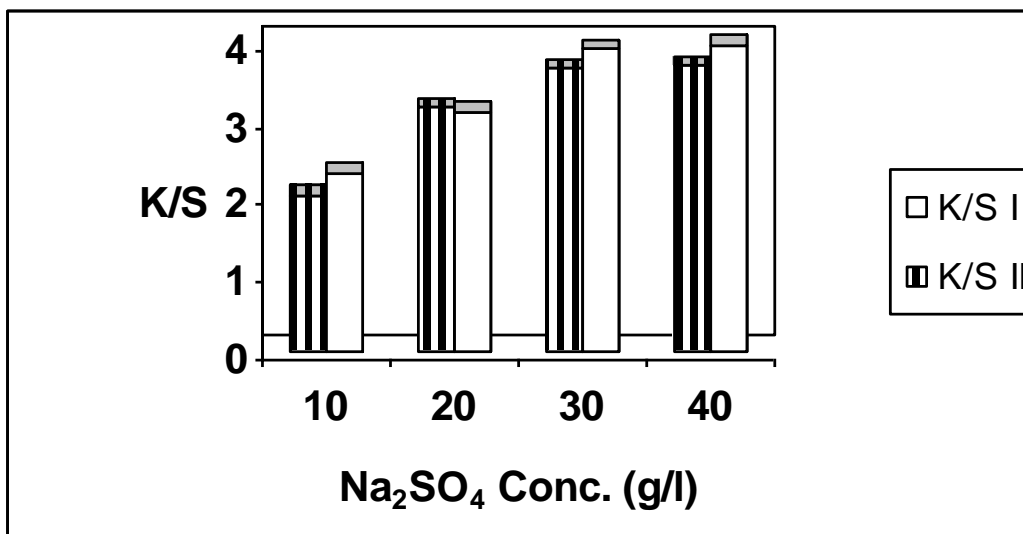


Figure 6. Effect of Na₂SO₄ concentration on the color strength of Giza 80 cotton fabric (I: conventional processes, II: one- bath processes time: 30 minutes NaOH concentration: (6g/l), finishing agent: none).

Effect of finishing agent soluble chicken feather (CF) on color strength (K/S)

The general structural formula of most natural amino acids contain both (COOH) and (-NH₂) groups, which give them ability to exist either as a cation, anion, or Zwitterion ion depending on NaOH concentration.

As shown in Fig. 7, at NaOH hydroxide concentration 6g/l, nitrogen atoms on the amino acid adsorb hydrogen ions to create positively charged sites. These sites have a strong attraction to negatively charged dyes, so that the dye uptake increases considerably and the K/S values increased for both Giza 89, and Giza 80 Fabrics.

At NaOH concentration 8g/l, the hydrogen ion concentration was so low that the amount of dye adsorbed decreased extraordinarily. The treated cotton fabric was not able to adsorb much dye through ionic attraction. So, the K/S values decrease for the cotton samples. Using 10 g/l NaOH, further increase in dye sorption was observed, due to the hydrolysis of the amino acid by cotton.

As shown in Fig. 8, the K/S values of the dyed samples were influenced with the concentration of the soluble chicken feather (CF) as the quantity of finishing (0.5 g/l, 1g/l, 2 g/l, 3 g/l), due to increase of total amino acids concentration and a strong attraction to negatively charged dyes occurred, so that the dye uptake increased considerably and the K/S values increased for both varieties Giza 89, and Giza 80.

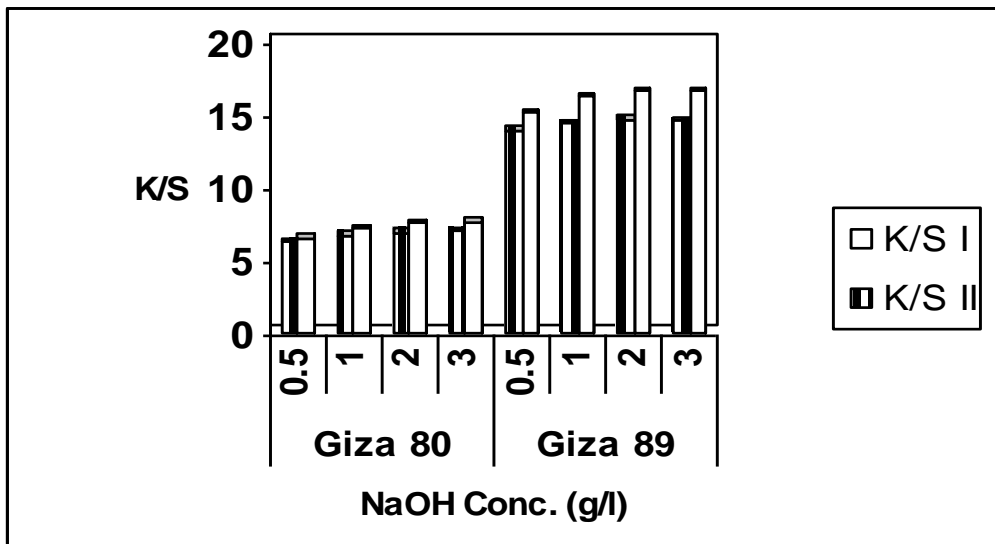


Figure 7. Effect of changing NaOH concentration on the color strength of Giza 89, and Giza 80 cotton fabrics in presence of 1g/l finishing agent (I: conventional processes, II: one- bath processes time: 30 minutes, Na₂SO₄ concentration: (30g/l)).

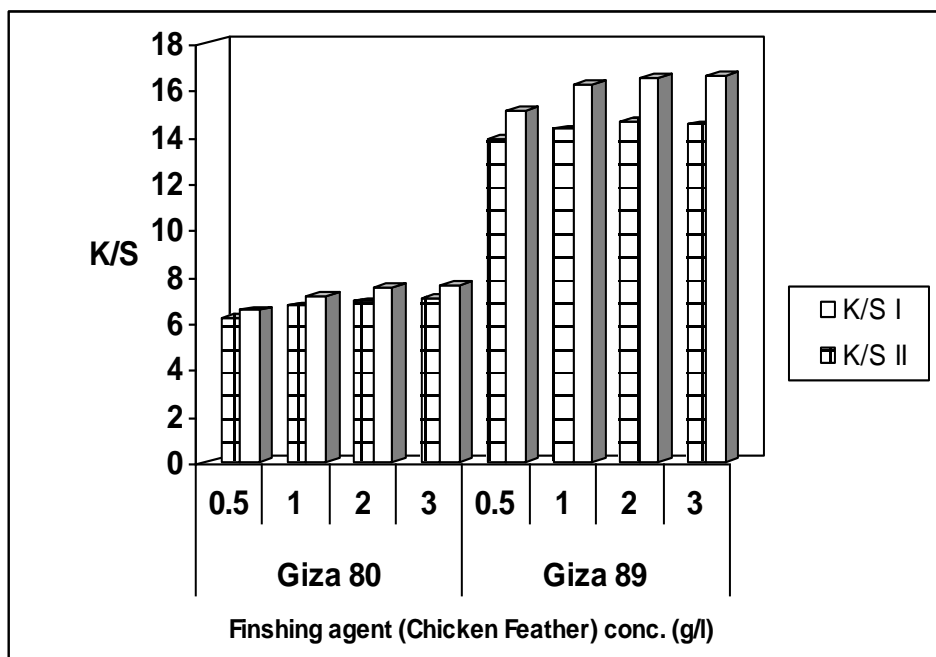


Figure 8. . Effect of changing NaOH concentration on the color strength of Giza 89, and Giza 80 cotton fabrics (I: conventional processes, II: one- bath processes time: 30 minutes Na_2SO_4 concentration: (30g/l), NaOH concentration: (6g/l)).

The foregoing results reveal that, the optimum conditions for the one-bath process are NaOH concentration of (6g/l), Na_2SO_4 concentration (30g/l), finishing agent concentration (2g/l), in 95°C at 30 minutes.

Tensile strength, elongation and color difference of the one-bath treated fabrics of Giza 89, and Giza 80 cotton fabrics

As shown in Table 1, at the optimum conditions, the tensile strength (g/tex), and elongation % for both Giza 89, and Giza 80 cotton fabrics for one-bath process are little lower than that of the conventional processes due to the higher concentration of NaOH in the bath. Little difference, is due to the formation of crosslinks between the finishing agent and the cellulose, which hindered the degradation of the fabrics and allows the fabrics to maintain its tensile strength and elongation.

It is clear from Table 1 that, the values of ΔE for the treated cotton samples in the one-bath treatment are 54.4, and 62.59 for Giza 89, and Giza 80 respectively. This implies that in the one-bath treatment method, wax and other impurities from the raw fabric may be evenly removed during the treatment, even though the treatment time is shorter in this method (as compared with the conventional method).

Table 1. Tensile strength, elongation and color difference of the one-bath treated fabrics of Giza 89, and Giza 80 cotton fabrics

Cotton fabrics		Tensile strength (g/tex)	Elongation %	Color difference ΔE
Giza 89	I	21.1	6.48	58.41
	II	21.00	6.45	54.40
Giza 80	I	21.0	6.48	69.70
	II	21.1	6.45	62.59

I: conventional processes, II: one- bath processes at optimum condition

Fastness properties of the one-bath treated fabrics of Giza 89, and Giza 80 cotton fabrics

It is clear from table 2 that the fastness properties of the treated fabrics are rated quite highly. This is because the reactive dye itself has a strong binding power as it binds to the fibers through the covalent bonds. In addition, the presence of sodium sulphate reduced the electrical potential on the cellulosic fabrics, while finishing agent sites have a strong attraction to negatively charged dyes, so that the dye fixation increased considerably. Another approach is that the impurities have been completely removed from the fabric during the one-bath treatment, the dye will not be fixed on the impurities and so, will not affect the fastness.

Table 2. Fastness properties of the one-bath treated fabrics of Giza 89, and Giza 80 cotton fabrics

Cotton fabrics		Wash		Perspiration				Crocking	
				Acidic		Alkaline			
		St*	Alt**	St*	Alt**	St*	Alt**	wet	dry
Giza 89	I	4-5	4-5	4	4	4	4	3-4	4
	II	4-5	4-5	4	4	4	4	3-4	4
Giza 80	I	4-5	4-5	4	4	4	4	3-4	4
	II	4-5	4-5	4	4	4	4	3-4	4

I: conventional processes, II: one- bath processes

CONCLUSION

This investigation aimed to explore the feasibility of integrating the dyeing and its pretreatment (scouring, and bleaching), then finishing for both Giza 89, and Giza 80 Egyptian cotton fabrics in one-bath processes as compared with the conventional processes. The results of the investigation reveal that:

1. The K/S value of the treated fabrics by the conventional method is slightly better than the cotton fabrics treated by the one-bath method.
2. The K/S value of the treated fabrics increased with the increase in concentration of NaOH and Na₂SO₄, addition of finishing agent and pretreatment time.
3. The tensile strength, elongation, and color difference of the treated fabrics by this method are of the acceptable limits.
4. The addition of chicken feather as a finishing agent (2g/l) increased the K/S value and maintain the tensile strength, and elongation from degradation.
5. The wash, perspiration, and crocking properties of the cotton fabrics axeed the acceptable standards.
6. The revival and optimization of old dyeing techniques for industrial use.
7. The combination of certain steps together, thereby shortening the processing steps and consequently conserving energy.

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تقنيات جديدة للمعالجات الأولية و الصباغة و التجهيز لبعض الأقمشة المصرية في حوض واحد

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يهدف هذا البحث إلى دراسة إمكانية إجراء المعالجات الأولية و الصباغة و التجهيز لأقمشة القطن المصري المصنوعة من صنفي جيزة ٨٩ و جيزة ٨٠ كعوامل اقتصادية لتوفير الطاقة والزمن و الكيماويات المستخدمة و أيضا للحفاظ علي البيئة من التلوث و مقارنتها بالمعالجات التجارية المستخدمة حاليا (غليان ثم تبييض ثم صباغة ثم تجهيز في أحواض منفصلة).

تم في هذا البحث القيام بالدراسات الآتية:

١- دراسة تأثير تركيز كل من هيدروكسيد الصوديوم- كبريتات الصوديوم- الزمن و كذلك تركيز عامل التجهيز النهائي علي كل من

٢- الصفات الميكانيكية (شدة المتانة والاستطالة) للأقمشة المستخدمة في البحث و مقارنتها بالطريقة التجارية

٣- دراسة قياس الخواص اللونية مثل قيم درجة عمق الصباغة K/S و أيضا درجة اختلاف اللون ΔE للأقمشة المستخدمة في البحث و مقارنتها بالطريقة التجارية

٤- دراسة قيم ثبات اللون لخواص الغسيل و العرق و الاحتكاك للأقمشة المستخدمة في البحث وقد أظهرت التجارب النتائج الآتية :

١- أظهرت قيم درجة عمق الصباغة K/S للعينات المعالجة بالطريقة التجارية إنها أعلى بنسب بسيطة من تلك العينات المعالجة في حوض واحد و ذلك لوجود بقايا المواد الغير سليولوزية بالحوض و الذي من المحتمل أن تتفاعل مع الصبغة بدلا من تفاعل الصبغة مع جزيئات الهيدروكسيل الحرة علي سطح الأقمشة مسببة بعض التناقص في قيم عمق اللون

٢- بزيادة تركيز هيدروكسيد الصوديوم تزداد قيم درجة عمق الصباغة K/S حتى ٦% نتيجة التخلص من المواد الغير السليولوزية (شموع- بكتين- الخ ...). و لوحظ إن قيم المتانة تناقصت و لكن بنسب بسيطة و ذلك نتيجة وجود عامل التجهيز و الذي أدى إلي تكوين روابط عرضية حدثت من تناقص المتانة الشديد. و بزيادة تركيز هيدروكسيد الصوديوم إلي ٨% نلاحظ تناقص هذه القيم (عمق الصبغة و شدة المتانة) لاحتمال تحول السليولوز إلي الاوكسي سليولوز و الذي يعمل علي تدهور الألياف مسببا هذا التناقص إضافة إلي تحلل الروابط العرضية المتكونة نتيجة زيادة الأس لهيدروجيني pH.

- ٣- بزيادة تركيز كبريتات الصوديوم تزداد قيم درجة عمق الصباغة K/S حتى ٣٠ ج/ل حيث تعمل جزيئات كبريتات الصوديوم علي خفض الجهد الأيوني لجزيئات السليلوز فتزيد عمليات الاتحاد بين جزيئات السليلوز مع الصبغة المستخدمة.
- ٤- الزمن اللازم لإجراء المعالجات في حوض واحد كانت ٤٥ دقيقة و بزيادة الزمن الي ٦٠ دقيقة وجد ان هذه القيم لا تتغير و هي كافية للتخلص من المواد الغير السليلوزية (شموع- بكتين- الخ (...) لتسمح للتفاعل التام بين جزيئات السليلوز مع الصبغة.
- ٥- وجد انه لا يوجد تقريبا اختلاف عند مقارنة نتائج المعاملات بالحوض الواحد مع المعاملات التقليدية والتي تم الحصول عليها بالنسبة لدرجة اختلاف اللون و ثبات اللون للغسيل او العرق او الاحتكاك.
- ٦- إضافة عامل التجهيز بالإضافة إلي أنه من المخلفات تم الاستفادة منه (اعادة التدوير) و تحويله من مادة ضارة للبيئة إلي مادة صديقة للبيئة و تستخدم كمواد طبيعية في التجهيز فأنها عملت علي زيادة درجة عمق الصبغة و أيضا الحد من تناقص المتانة كنتيجة لتكوين الروابط العرضية بين جزيئات السليلوز وهذه المادة.
- ٧- كانت النسب القياسية التي تم الحصول عليها للمعالجات الأولية مع الصباغة و التجهيز في حوض واحد لتعطي نفس النتائج مقارنة بالمعالجات التجارية مع الأخذ في الاعتبار المميزات التي تم الحصول عليها هي:
- هيدروكسيد صوديوم بتركيز ٦% - كبريتات صوديوم بتركيز ٣٠ ج/ل- عامل التجهيز بتركيز ٢ ج/ل فو درجة حرارة ٩٥ و زمن قدره ٣٠ دقيقة.

و كنتيجة نهائية لهذا البحث فإنه أمكن استخدام تقنية جديدة للمعاملات الأولية و الصباغة و التجهيز في حوض واحد للأقمشة المصرية لصنفي جيزة ٨٩ و جيزة ٨٠ بهدف العمل علي تطوير الطرق المستخدمة حاليا إلي طريقة صديقة للبيئة و ذات تكلفة قليلة و جودة عالية بالإضافة إلي أن دمج المراحل المختلفة في مرحلة واحدة أدت إلي توفير الوقت و الكيماويات المستخدمة و مساحة المصنع و تخفيض العمالة مما يؤدي إلي زيادة الأرباح.