MODIFIED BLEACHING OF FIBERS OF SOME EGYPTIAN COTTON VARIETIES USING SOME ACTIVATORS

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Abstract

An economical hydrogen peroxide bleaching process by reducing time and temperature compared with the conventional high temperature bleaching using some activators is the objective of this investigation. Potassium persulphate or ascorbic acid was used as activator in the bleaching process applied on some Egyptian cotton fibers (Giza 80, Giza 83, Giza 88, and Giza 90). Detailed laboratory experiments were performed to investigate the effect of the activators concentration, time required for bleaching, and temperature for the bleaching bath on the measurements of whiteness (WI), tensile strength (T g/tex), and elongation at break (E%) of samples under investigation compared with the values for the same fiber samples using conventional high temperature bleaching. The results obtained revealed that as both potassium persulphate and ascorbic acid concentrations used as activators increase, the WI, T, and E% decrease. The time required to reach the maximum WI was reduced in the presence of the activators than that of the conventional bleaching method. A low temperature (30-60°C) bleaching process has been established in the presence of activators. The presence of activators improved the mechanical properties of the bleached cotton samples used in this investigation. The results obtained by statistical analysis showed that there were highly significant differences between cotton varieties for every treatment. Giza 83 showed the highest response to potassium persulphate treatment while Giza 88 showed the highest response to ascorbic acid treatment.

INTRODUCTION

Bleaching is the removal or lightening of colored material. Hydrogen peroxide and related proxy compounds are the most widely used class of textile bleaching agents. Tyronel (1997) had proposed that bleaching action is due to the hydroperoxide or hydroxy radical in alkaline media by reaction of per hydroperoxy anion with hydrogen peroxide. It has been observed that the rate of bleaching fabrics increases with an increase in concentration of hydroperoxy anion OOH^-. Thus, this species has been frequently proposed as the active bleaching agent. Additional evidence to support this mechanism is deduced from the observation that cellulosic fibers are bleached more effectively in acid media with H_2O_2/HBr system than with other peroxide/acid systems. Under those conditions, it has been demonstrated that both ^{-}OH, and OOH^{-} radicals can also be produced to effectively decolorize impurities by free radical addition across sites of unsaturation (Taher *et al.,* 1975).

In all single-stage bleaching processes for the cotton using hydrogen peroxide, the bleaching bath contains additional chemicals that act as activators, stabilizers, surfactants, and scourers (Trotman, 1984).

The use of stabilizers permits bleaching to be conducted to alkaline *pH* and serves two important functions: they slow the rate of peroxide decomposition under alkaline conditions, and combine with metal impurities which may catalyze peroxide decomposition and induce fiber damage.

Although sodium hydroxide or sodium hydroxide/ sodium carbonate are the most frequently used as economical activators, it has been demonstrated that amides (urea, benzamide, formamide, and N, N dimethylformamide) can be incorporated as activators into bleaching baths at temperature from 30- 90°C to obtain bleaching cotton fabrics with comparable whiteness and strength to those bleached in the presence of alkali (Das *et al.,* 1986).

The mechanism by which cotton is effectively bleached at low temperature (ca 30°C) with peracetic acid containing 2,2′ bipyridine as chelating agent and transition metal salts preferably (Co^{2+} or Fe^{2+}) has been investigated by Rucker *et al.* (1991).

The cold pad-batch bleaching procedure of hydrogen peroxide compared to conventional techniques was described by Yao (1991). The bleaching of cellulosic fibers using Warwick (T 202) activated peroxide can provide whiteness and reduction in fiber strength loss compared to standard peroxide bleaching processes. An alternative method of bleaching at low temperatures with peracetic acid involves use of ultrasonic radiation was described by Poulakis *et al.* (1991).

Lewin (1984) described the various processing conditions and formulations most commonly used to peroxide bleaching of regenerated cellulose fibers. Variation in time, temperature, and concentration of peroxide, stabilizer, and activator are given for each type of fabric.

Salwa *et al.* (1999) described the effect of different methods of bleaching on physical properties and chemical constituent of new Egyptian cotton cultivars. A number of low temperature (25-45°C) batch scouring and bleaching processes are available in the literature (Bille, 1987 and Das *et al.,* 1986) for cotton woven fabrics.

Muresan *et al.* (1989) mentioned the results for low temperature bleaching using sodium persulphate as activator. Trevor *et al.* (1994) prepared cotton nonwoven fabrics at low temperature using hydrogen peroxide activated with sodium persulphate.

MATERIALS AND METHODS

Materials

Unbleached raw cotton fibers of Egyptian cotton varieties namely Giza 80, Giza 83, Giza 90, and Giza 88 were purchased during the season 2003-2004 and used throughout this study. Hydrogen peroxide (30%. LR grade) came from Aldrich Sodium carbonate (LR grade). Sodium silicate (136°Tw, 27% Sio_2), potassium persulphate (97%), and ascorbic acid Aldrich grade were used without purification. The wetting agent was the commercially mercerol supplied by Merck. The hydrogen peroxide bleach liquor for each bleaching process was analyzed by titration with potassium permanganate.

Bleaching treatment

For each of the experiments, 1 g of the unbleached cotton fibers was immersed in an alkaline bleach liquor (180 ml deionized water) containing sodium carbonate (0.2 g/l), sodium hydroxide (1.5 g/l), magnesium sulphate (0.2 g/l), sodium silicate (0.4 g/l), wetting agent (0.5 g/l) and a known concentration of sodium persulphate or ascorbic acid. Hydrogen peroxide (10 ml/l) was added to the bleach liquor and bleaching was done. The samples were removed from the liquor and washed with glacial acetic acid, followed by hot water (80-85°C) washing to ensure removal of residual chemicals. Samples were dried in an oven at 100°C for 60 minutes. The treatment conditions for the bleaching processes involved a range of sodium persulphate or ascorbic acid concentration (5-10 g/l), times (30-90 min.), and temperatures (30 - 90°C).

Measurements

The bleached product was tested for whiteness on Perkins- Elmer double beam spectrophotometer model Lambda 35 equipped with integrating sphere according to CIE 1996 method

$$W_{10} = Y + 800\,(x_n - x) + 1700\,(y_n - y)$$

Where Y, x, and y are the Y tristimulus value and the chromaticity coordinates of the sample respectively. x_n, y_n and the chromaticity coordinates for the perfect diffuser calculated for illuminant D 65 and the 10° standard observer.

Tensile strength and elongation at break were measured by the stelometer according to A.S.T.M. (1994).

Statistical analysis was carried out according to Snedecor (1987) according to the ANOVA analysis for all properties to every treatment to study the response of cotton fiber varieties to different chemical treatments.

RESULTS AND DISCUSSION

Whiteness index (WI), tensile strength (T g/tex) , and elongation at break (E%) for Giza 80, 83, 90, and 88 cotton fiber varieties are given in Table 1 using the high temperature bleaching treatment (traditional or conventional bleaching)

Table 1. HVI measurements of Giza 80, 83, 90, and 88 cotton fiber

Varieties	Giza 80	Giza 83	Giza 90	Giza 88
Whiteness index (WI)	71.85	74.34	75.18	53.61
Strength T (g/tex)	37.5	36	35	44.9
Elongation at break (E %)	7.8	7.5	7.5	6.1

1- Effect of concentration of potassium persulphate and temperature on Whiteness

As shown in Figures 1 and 2, and compared with the data obtained in Table 1 for the conventional bleaching method, it has been noted that the whiteness index of the cotton varieties in the presence of potassium persulphate as activator were higher. Slight increase of whiteness index as potassium persulphate concentration increase from 0.5% to 1%. As temperatures increase till 90°C, the whiteness index of all cotton varieties used increase also. Statistical data shows highly significant differences between the cotton varieties used. Giza 83 was the highest response variety followed, in descending order, by Giza 80, Giza 88, and Giza 90, respectively.

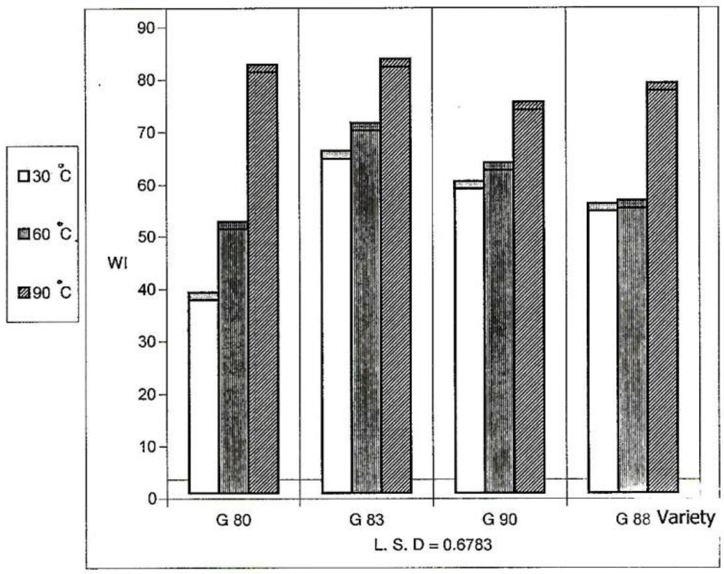

Figure 1. Temperature effects on Whiteness index of cotton fibers varieties using 0.5% potassium persulphate for 60 min.

2- Effect of time on whiteness using potassium persulphate

As shown in Figure 3, it is clear find that the optimum time of bleaching was 60 min. to reach the perfect whiteness in all varieties used. Whiteness index for all cotton varieties decreases as the time required for bleaching increase. This may be due to the presence of the activator which accelerates the oxidation of the colored material with hydrogen peroxide and also slows down the decomposition of hydrogen peroxide. The decrease in whiteness index was obtained as the time of bleaching increases due to the formation of yellow color of oxycellulose. The statistical analysis showed highly significant variables for the cotton varieties used .Giza 83 has the higher response followed in descending order by Giza 80, Giza88 and Giza 90, respectively. These results are in agreement with the results abstained by Muresan *et al.* (1989).

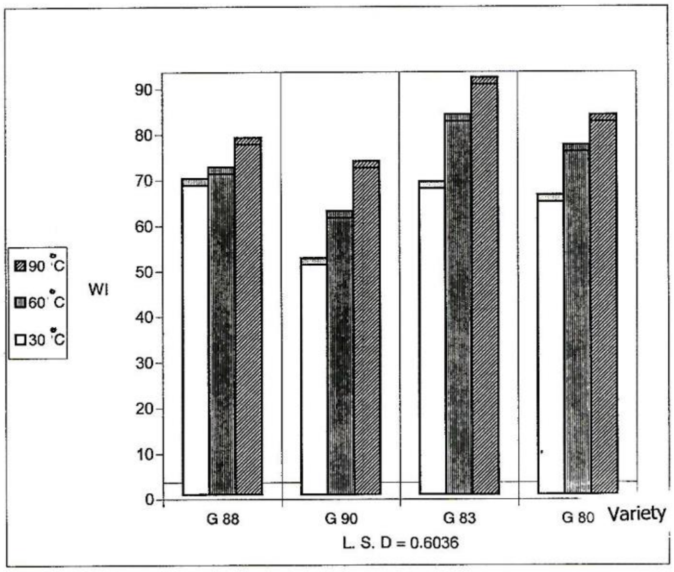

Figure 2. Temperature effect on Whiteness index of cotton fibers using1% potassium persulphate for 60 min.

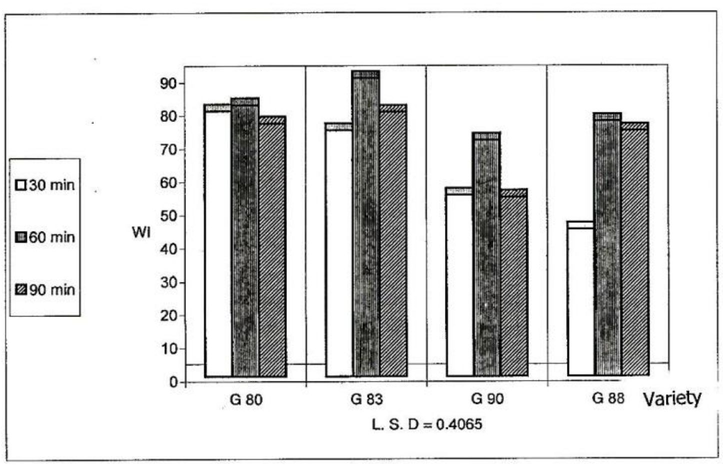

Figure 3. Whiteness index of cotton fiber using potassium persulphate 1% at 90 °C

3- *Effect of concentration of potassium persulphate and temperature on strength and elongation*

Table 2 shows that the presence of potassium persulphate concentration (0.5% and 1%) as activators had a significant effect on the strength and elongation for all cotton varieties. It has been noted that the strength was slightly increased than that of the traditional technique. This could be associated with shrinkage of fibers, causing increment of the fibers in the sample, thereby giving rise to higher tensile strength. Also the fatty matters are removed by the bleaching treatment. Such effect would enhance the fiber friction thereby compensating for or even exceeding the additional size film strength. These results are in agreement with the results obtained by El-Rafie *et al.* (1991). From 30 – 60 °C strength increases up to 90 °C. This could be due to that the high temperature removal of the colored materials would help to damage the fiber causing decrease in tensile strength. The results obtained showed that Giza 80 has the higher response to the treatment followed in descending order by Giza 83, Giza 88 and Giza 90, respectively. This result is in accordance with that reported by Salwa *et al.* (1999).

4- *Effect of time on strength and elongation using potassium persulphate*

Table 3 shows that the optimum time (60 min.) for the bleaching technique using 0.5% of potassium persulphate affected the highest strength and lowest elongation%. The statistical analysis showed that Giza 80 shows the higher response then Giza 88, Giza 83, and Giza 90, respectively.

5- *Effect of concentration of ascorbic acid on whiteness*

As shown in Figures 4 and 5 it can be noticed that the whiteness index of the cotton varieties in the presence of ascorbic acid as activator were higher than that of the results obtained in Table 1 by the conventional bleaching method. Ascorbic acid concentration 0.5% at temperature 30°C increases the whiteness index of all cotton varieties used. Statistical data shows highly significant variables for the cotton varieties used. Giza 88 shows the highest response followed in descending order by Giza 80, Giza 83, and Giza 90, respectively.

6- *Effect of time on whiteness using ascorbic acid*

As shown in Figure 6 the results obtained revealed that Giza 83 was the highest response variety followeds, in descending order, by Giza 80, Giza 88, and Giza 90, respectively. The optimum time of bleaching for all cotton varieties was 60 min. These results are in agreement with that reported by Das *et al.* (1986).

7- Effect of concentration and temperature using ascorbic acid on strength and elongation :

It is obvious from Table 4 that the concentration of ascorbic acid (0.5%) produced the higher response of strength and decrease the elongation than the concentration 1 % Statistical analysis showed that Giza 83 the higher response then Giza 83, Giza 90 and 88, respectively.

8- Effect of time on the strength and elongation using ascorbic acid 0.5%

Table 5 shows that the optimum time of bleaching for all cotton varieties in one hour, and resulted in the higher strength and lower elongation % for Giza 88, followed, in descending order, by Giza 83, Giza 80, and Giza 90, respectively .

Table 2. Tensile strength and elongation at break for cotton fiber using potassium persulphate (0.5% and 1% concentration) for 60 min.

Variety	Giza80				Giza83				Giza88				Giza90			
Measure-ments	T g/tex		E%		T g/tex		E%		T g/tex		E%		T g/tex		E%	
Conc.	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%
30 °C	26.5	31.5	6.3	5.4	26.5	26.78	5.36	5.36	27.2	28.1	5.83	7.2	28.1	32	6.6	4.
60 °C	30.3	29.5	5.0	6.3	30.0	27.	4.7	6.1	27.7	29.8	6.40	5.4	30.5	28.6	4.81	5.02
90 °C	27.7	29.6	7.98	6.98	28.1	26.0	6.25	6.3	26.1	28.1	6.2	5.67	25.3	27.16	6.6	5.83

L.S.D = 0.6309 and 6.61667 (tensile strength at 1%, and 0.5%, respectively)

L.S.D = 0.4636 and 0.2452 (elongation at break at 1%, and 0.5%, respectively)

Table 3. Tensile strength and elongation at break for cotton fiber using potassium persulphate (0.5 % concentration) at 60 °C

Varieties	Giza80			Giza83			Giza88			Giza90		
Conc.	0.5%			0.5%			0.5%			0.5%		
Time (hour)	1/2	1	1 1/2	1/2	1	1 1/2	1/2	1	1 1/2	1/2	1	1 1/2
T g/tex	28.5	29.9	26.41	27.10	27.12	25.35	28.35	29.75	26.94	27.75	28.35	26.76
E %	6.3	5.7	6.98	6.1	6.0	6.25	5.02	5.95	5.4	6.0	5.02	7.23

L. S.D (tensile strength) = 0.5940

L. S.D (elongation at break) = 0.4534

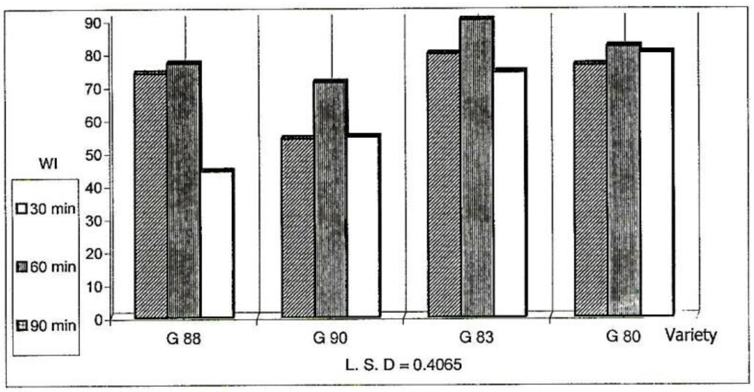

Figure 4. Tensile strength of cotton fiber varieties using ascorbic acid 0.5% for 1 hour

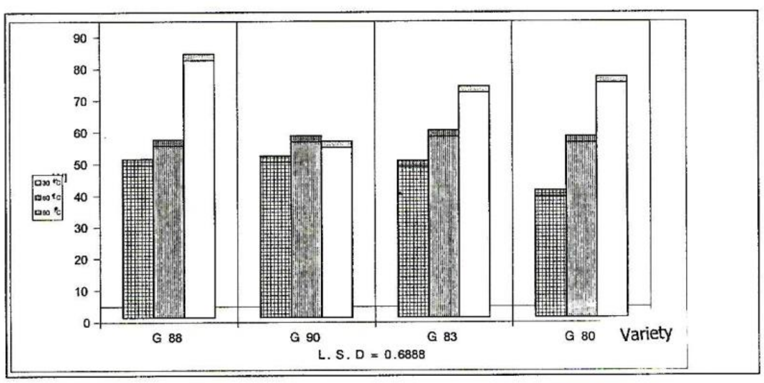

Figure 5. Whiteness index of cotton fiber varieties using ascorbic acid 1% for 1 hour

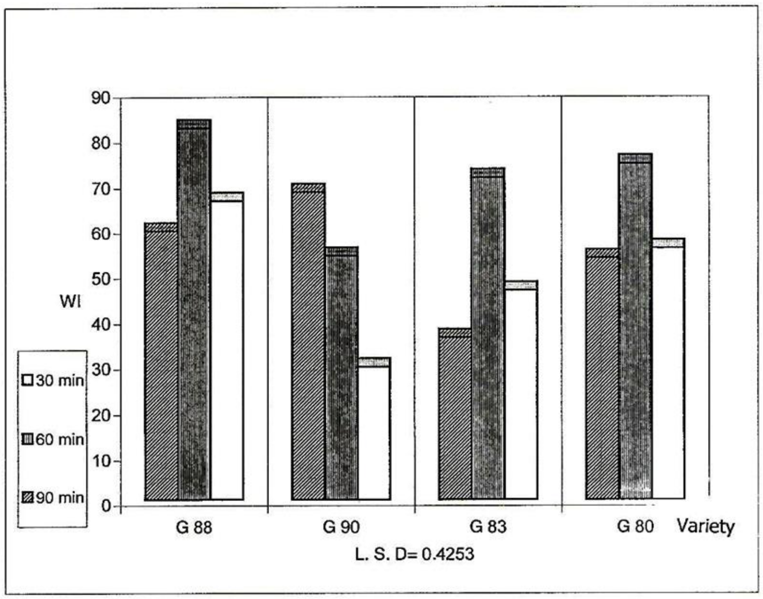

Figure 6. Whiteness index of cotton varieties using ascorbic acid 0.5% at 30 ˚C

Table 4. Tensile strength and elongation at break for cotton fiber using ascorbic acid (0.5% and 1% concentration) for 60 min.

Variety	Giza80				Giza83				Giza88				Giza90			
Measure-ments	T g/tex		E%		T g/tex		E%		T g/tex		E%		T g/tex		E%	
Conc.	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%	0.5%	1%
30 °C	26.57	30.27	6.32,	5.5	25.46	25.37	6.62	7.36	28.29	28.7	6.17	5.7	25.32	26.4	7.73	6.7
60 °C	30.69	29.74	5.51	5.88	31.42	30.26	5.88	5.56	35.23	28.33	5.51	5.61	27.56	31.14	5.61	5.5
90 °C	27.35	27.48	6.61	7.13	24.95	25.24	8.5	8.9	27.52	28.29	5.31	6.17	24.1	25.26	7.35	7.4

Temp. = Temperature T = tensile strength E% = elongation at break

L.S.D = 0.4404 and 0.4056 (tensile at 1%, and 0.5% respectively)

L.S.D) =0.5223 and 0.3805 (elongation at 1% and 0.5% respectively)

Table 5. Tensile strength and elongation at break for cotton fiber using ascorbic acid (0.5% concentration) at 60°C

Varieties	Giza80			Giza83			Giza88			Giza90		
Conc.	0.5 %			0.5 %			0.5 %			0.5 %		
Time (minute)	30	60	90	30	60	90	30	60	90	30	60	90
T g/tex	27.29	30.69	29.38	28.17	31.42	29.21	28.52	35.23	28.33	26.41	31.14	30.26
E%	6.07	5.57	5.5	5.5	5.88	5.95	6.61	5.51	6.08	5.67	5.5	5.73

L. S.D Strength = 0.4056

L.S.D. Elongation = 0.3805

CONCLUSION

Based on the results obtained, a bleaching formulation consisting of potassium persulphate as activator (1 %), at 60 °C for 60 minutes using a scale pad-batch system provides a potential method for bleaching the cotton varieties for Giza 80, Giza 83, Giza 88 and Giza 90, respectively, with higher whiteness and no evidence of damage in strength and elongation. On the other hand, and ascorbic acid used as activator (0.5 %), at 60 °C for (60 min) using a scale pad-batch system provides a potential method for bleaching method for Giza 80, Giza 83 and Giza 90, respectively, with higher whiteness and no evidence for damage in strength and elongation. The results obtained revealed that the conventional high temperature bleaching would be replaced with an economical hydrogen peroxide bleaching process using potassium persulphate or ascorbic acid as activators to reduce time and temperature for all Egyptian cotton fibers used in this investigation. The statistical analysis showed a higher significant difference (LSD), for every treatment carried out and also a higher difference response for every cotton variety.

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استخدام بعض المواد المنشـــــــطة في تطـــــــوير عمليـــــــــــات التبييـــــــــض لتيلة بعض أصناف القطـــــــن المصرى

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تهدف هذه الدراسة إلى استخدام بعض المواد المنشطة لبعض أنواع القطن المصري في عمليات التبييض و ذلك للحصول علي أعلي درجات للبياض في درجات الحرارة المنخفضة لتوفير الطاقة المستخدمة في عمليات الغليان و في اقـل وقـت لتـوفير الـزمن الـلازم لعمليـات التبيـيض.
استـــخدم في هذه الدراســـة أربعة أصناف من الأقطان المصرية التجارية وهى جيزة ٨٨،وجيزة ٨٣ ،وجيزة ٨٠ ،وجيزة ٩٠ . فى عمليات التبييض باستخدام كبريتـات الصـوديوم الفوقية أو حمض الأسكوربيك و ذلك كمواد منشطة بتركيزات مختلفة و تمت عملية التبييض فـي أزمنة مختلفة و أيضا في درجات حرارة مختلفة مقارنة بعملية التبييض الشائعة التي يستخدم فيهـا فوق أكسيد الهيدروجين في درجات الغليان و في أزمنة لا تقل عن ٩٠ دقيقة.
تم قياس بعض الصفات (درجة البياض ،المتانة ،الاستطالة) للأصناف القطنية المستخدمة في هذا البحث و تم مقارنة النتائج التي تم الحصول عليها بالقياسات التي تم قياسـها بالطريقـة التقليديـة للتبييض وقد تم الحصول علي النتائج التالية :

- اظهر الصنف جيزة ٨٠ أعلى قياسا لدرجة البياض ،المتانة ،الاستطالة تليه جيزة ٨٣ ، ثم جيزة ٨٨ وأخيرا جيزة ٩٠ باستخدام كبريتات الصوديوم الفوقية كعامل منشط مقارنة بالقيم التي تم الحصول عليها بطريقة التبييض التجارية المعتادة
- جيزة ٨٨ سجل أعلى استجابة يليه جيزة ٨٠ ثم جيزة ٨٣ و أخيرا جيـزة٩٠ باسـتخدام حمض الأسكوربيك كعامل منشط مقارنة بالقيم التي تم الحصول عليها بطريقة التبيـيض التجارية المعتادة.

يتضح مما سبق إن استخدام مادتين مثل حمض الاسكوربيك أو كبريتات الصوديوم الفوقية ذو أهمية تطبيقية في صناعة تجهيز المنسوجات القطنية في مصر حيث تعمل على توفير الوقت والطاقة في الوقت الذي يعطى قيم افضل النتائج.