EFFECT OF SOME CHEMICAL TREATMENTS ON FIBER PROPERTIES OF THREE EGYPTIAN COTTON VARIETIES

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Abstract

This study was carried out on the cotton varieties; Giza 45, Giza 77, and Giza 85, to investigate the effect of the chemical treatments; scouring, mercerization and resin treatment on fiber properties. The Infrared reflectance spectroscopy was used to analyze the treated fiber and study the Infrared bonds characteristics of the hydrogen bonded structure of cellulose to qualitatively evaluate the changes in the structure, that are reflected in differences in the physical properties of the treated fibers.

It was found that the response to different treatments depends on the formation of hydrogen bonds produced, the resin treatment have the medium response between the scouring and mercerizing for all the measured properties.

INTRODUCTION

No simple chemical method exists for evaluating the changes in molecular structure which occur in the finishing of cotton and which are of considerable interest to the chemist whose goal is to improve the fabric performance. Information concerning these structural changes may be obtained from Infrared absorption spectra by the identification of new functional groups which are present after modification, in addition spectra data may be used to evaluate changes in crystallinity and polymorphic form.

Rowland et al. (1970) emphasized the importance of the state of the micro structure of the fiber during the cross link reaction and the structure of the reagent residues in the product, which may be present as simple crosslinkages or simple substituents or substituent composed of two or more units of reagent.

Accessibility % = M.S x 100/1.53.

The formaldehyde residual measured by using chromotropic acid method by hydrolysis in 12 N_2SO_4 at 60°C, according to Roff (1954), nitrogen content using Kgeldahl method, Crystallinity index using the Infrared spectrum according to Miller (1956), The degree of substitution was calculated from the position band (1375) for CH bending to band (2900) for CH stretching, this ratio was referred to as crystallinity index, pH degree (according to A.A.C.C. 81, 1992), and wax content by shocxelt for 5 hours using chloroform as solvent according to Segal and Timpa (1973).

RESULTS AND DISCUSSION

Discoloration of the treated fibers (Rd%, + b) and pH

Reflectance percent (Rd%) and degree of yellowness (+b) measurement, (Table 1) showed that highest color changes occurred for scoured samples, it gave the highest reflectance for all varieties, with average of + 23.5%. This might be due to the removal of non cellulosic materials (Al-Ashwat 1974), The resin treatment showed a slight decrease in reflectance, and an increase in yellowness for all varieties used. There are several possible explanations for this discoloration which is correlated with the degree of pH. The first explanation may be the increae in degree of methylation (Vail et al 1954), while the second is that the formaldehyde may react with the substituent hydroxyl groups instead of the amido hydrogen, thus yielding a low degree of N-methylol substitution (Steven and Smith 1970). Additional possible explanation, is that aldols loose water readily and both basic acidic condition form thermodynamically stable conjugated α and β unsaturated ketones or aldehydes, thus making unstable chromophoric groups.

The effect of slack mercerizing on lint color was decreasing reflectance % with an average of - 5.2% and increasing degree of yellowness than the control samples of all varieties studied with average of + 9.2%. These results may be due to that mercerizing causes changes in cross sectional area and removal of some ridges along fiber length, increase in spiral angle, decrease in crystallinity and lumen becoming more prominent and less transparent (Buch and Cord-1949, Fourt et al. 1953, Warwicker et al. 1966, and Al-Ashwat 1974). These results are in agreement with Al-Ashwat (1974), Rucker et al. (1994) and Azza M. (1996).

Table 1. Physical properties of fibers of carded and combed slivers of six Egyptian extra-long staple cotton varieties.

Treatment / Variety	Reflectance percent Rd%							Degree of yellowness (+b)							pH							F.R.
	C	Sc.	±%	R	%	M	%	C	Sc.	±%	R	%	M	%	C	Sc.	±%	R	%	M	%	
Giza 45	74.3	88.0	+18.4	71.2	-4.2	64.1	-13.7	10.4	3.0	-71.2	12.8	+23.1	12.3	+18.3	7.2	7.8	+8.3	7.2	0.0	7.2	6.9	0.05
Giza 77	63.9	88.3	+38.2	61.8	-3.3	61.8	-5.5	12.6	3.0	-76.2	13.0	+3.2	13.0	+3.2	7.2	7.9	+9.7	7.5	+4.2	7.5	+15.3	0.07
Giza 85	76.4	87.3	+14.0	70.1	-8.2	76.9	-8.2	10.9	1.9	-82.6	11.2	+2.7	11.2	+2.7	7.0	7.8	+11.4	7.4	+5.2	7.4	+25.7	1.06
Mean	71.5	87.9	+23.5	67.7	-5.2	67.6	-9.1	11.3	2.6	-76.7	12.3	+9.7	12.3	+8.1	7.1	7.8	+9.8	7.4	+3.13	7.4	16.0	0.39

C = Control Sc. = Scouring R = Resin (DMDHEDU)
M = Mercerizing F.R. = Formaldehyde residual

Moisture regain and accessibility

Table 2 gives a quantitative indication of the response to different treatments in moisture regain, accessibility and crystallinity index. It was found that Giza 45 showed the highest response in moisture regain ranged from -5.25% to + 34.89% for different treatments due to changes in amorphous regions percentage. Steven and Smith (1970) mentioned that the amorphous region can be viewed simpley as being of lesser order than the crystalline regions. From this data it was found that Giza 85 showed the lowest response for all treatments, ranged from + 4.21% to +29,177% followed by Giza 77. Rowland and Post (1966) found that the O_3H and O_6H are partially restrained from reaction by intra molecular hydrogen bonds, the O_2H in cellulose is always most available, free of restraining hydrogen bonds. This happened in scouring and mercerizing treatments, also treatment with resin DMDHEU can be due to the introduction of methylene bridges from free formaldehyde in the treating solutions increasing the degree of substitution with respect to ethylene urea cross links.

IR Crystalinity Index

The chemicals used in treating the cotton may react with the cellulose or may polymerize and be physically held within the fiber. To analyze the different cross linking bonds, the absorption bands in the IR regions associated with the functional groups present in the cross-linking agents, which are CH_2OH, CHOH, and C=O were measured according to Ghosh and Cannon (1990), to determine the changes of degree of substitution in the structure of cellulose and illustrated in Figure 1. In mercerization, the bonds change during conversion of cellulose I to cellulose II, therefore changing the crystalline properties of cellulose, that are due to the hydrogen-bonding capacity of its hydroxyl groups.

O'connor et al. (1958) observed that the cheical modification involving reaction with OH groups of the cellulose caused the hydroxyl stretching band, and the ratio is independent of the lattice type of the sample. These figures evaluate separately the changes due to crystallinity and those to change in lattice form.

There are three OH groups on the anhydroglucose unit of the cellulose molecule that provide sites for reactions or introduction of an intermolecular cross link between the chains, The resin treatment with DMDHEU reacts with the inter molecular hydrogen bonds between the C_6 hydroxyl parallel chains and the bridge oxygen of anti parallel chains and also with the intra molecular hydrogen bonds between C_3 hy-

Table 2. Effect of different chemical treatments on moisture regain, accessibility % and IR Crystallinity Index measurements.

Treatment / Varietiy	Moisture regain %							Accesibility %							pH			
	C	Sc.	±%	R	±%	M	±%	C	Sc.	±%	R	±%	M	±%	C	Sc.	R	M
Giza 45	6.85	6.49	-5.25	4.60	-32.84	9.24	+34.89	39.6	38.2	-5.25	4.87	-87.24	54.1	+36.61	1.05	3.2	2.30	1.66
Giza 77	6.70	6.35	-5.22	4.41	-34.17	8..96	+33.73	39.4	37.3	-5.22	4.66	-87.74	52.7	+33.75	1.00	3.5	2.46	1.77
Giza 85	6.65	6.37	-4.21	4.20	-36.84	8.59	+29.17	39.1	37.3	-4.21	4.50	+87.93	50.5	+29.15	1.00	3.6	2.54	1.88
Mean	6.73	6.40	-4.89	4.40	-34.62	8.93	+32.59	39.36	37.6	-4.89	4.67	87.63	52.43	+33.17	1.02	3.4	2.43	1.74

C = Control Sc. = Scouring R = Resin (DMDHEDU)
M = Mercerizing

droxyl and the ring oxygen of adjacent anhydroglucose units, also included the bonded between C_6 and C_2 hydroxyls of the same chains. The treated fibers showed higher crystallinity indices than the control for all treatments with lower increases in Giza 45 followed by Giza 77, and finally Giza 85. These increases indicate that intermolecular bonds were formed because of the addition of OH groups within the resin molecule simultaneously, and removal of cellulosic OH groups by crosslinking. This explanation is in agreement with Steven and Smith (1970).

Fiber Strength

The data in (Table 3) show that the scouring treatment caused a decrease in fiber strength "tenacity" with average of -3.91%, because of losses arising from molecular degradation. The resin treatment with (DMDHEU) also caused a decreasie in fiber strength ranged from -16.05% to -8.45%, this is probably due to curing effect at higher temperature and the greater number of methelene cross links produced in the treatment. This is in agreement with Steven and Smith (1970) and Azza (1996). Finally in slack mercerizing treatment the decrease in fiber strength ranged from -12.56% to -14.88, which may be due to increasing the spiral angle of cellulose chains in the fibers (Al-Ashwat, 1974).

Wax content

The data in (Table 3) show that the scouring treatment caused the highest decrease in wax content with average of -97.4%. This decrease could be due to the boiling and the chemical action of caustic soda on cotton wax that converts the free fatty acids into soaps, or hydrolyzes the small amount of esters present. The decrease happened through the resin treatment with average of -95.1% is probably due to the curing effect at higher temperature. The decrease due to slack mercerizing treatment may be due to the chemical action of caustic soda.

From the data it was found that Giza 77 showed the lowest value of wax for the control and after all treatments, this is in agreement with Azza (1996).

Table 3. Effect of different chemical treatments on fiber strength and wax content %.

Treatment / Variety	Strength							Wax content						
	C	Sc.	±%	R	±%	M	±%	C	Sc.	±%	R	±%	M	±%
Giza 45	38.59	38.09	-1.29	33.82	-12.36	33.74	-12.56	1.21	0.028	-97.6	0.056	-95.3	0.080	-93.1
Giza 77	36.82	34.69	-5.78	30.91	-16.05	31.34	-14.88	1.01	0.026	-97.4	0.049	-95.1	0.075	-92.5
Giza 85	35.70	33.57	-5.96	32.68	-8.45	31.15	-12.79	1.03	0.027	-97.3	0.052	-94.9	0.080	-92.2
Mean	37.04	35.45	-3.91	32.47	-12.28	32.07	-12.39	1.08	0.027	-97.4	0.052	-95.1	0.079	-92.6

C = Control Sc. = Scouring R = Resin (DMDHEDU)
M = Mercerizing

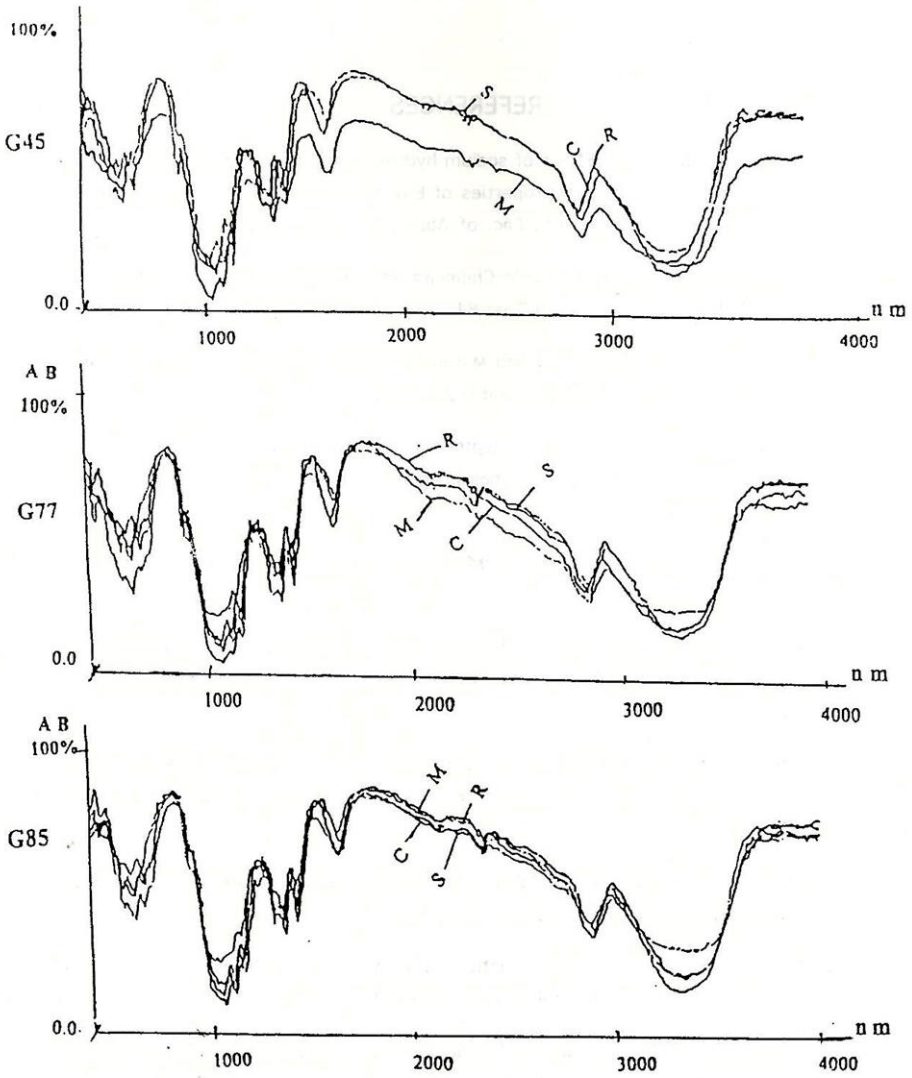

Figure 1. Ratios of (IR) absorbances for different chemical treatments: R - resin (DMDHEU), SC- Scouring, M- mercerizing, and C- control.

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تأثير بعض المعاملات الكيمائية على خواص ثلاثة أصناف من القطن المصرى

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استخدم ثلاثة أصناف وهى جيزة ٤٥ ، جيزة ٧٧، جيزة ٨٥ من رتبة جود للموسم التجارى ١٩٩٧ أجرى عليها عمليات الغلى فى محلول أيدر وكسيد صوديوم ٤٪، عمليه المرسرة بأيدر وكسيد صوديوم ٢٠٪، كذلك الراتنج وهو (اركوفكس) أو داى ميثايل وادى هيدروكسى إيثلين يوريا ٧٪، واستخدامت الأشعة تحت الحمراء فى تقدير درجه التبلور والنشاط الكيمائى.

تدل النتائج المتحصل عليها وجود اختلافات فى الاستجابة بالنسبة للأصناف وكذلك بالنسبة للمعاملات على الأقطان المستخدمة.

١ وجد أن المرسرة أعطت أقل القيم بالنسبة لدرجة الانعكاس وأكبر القيم بالنسبة لدرجة الاصفرار.

٢ فى تقدير محتوى الرطوبة ودرجه النشاط الكيائى ودرجه الارتباط بين سلاسل السليلوز (التبلور) بالأشعة تحت الحمراء، وجد أن جيزة ٨٥ أعطى أقل زيادة نتيجة للمعاملات الكيمائية المستخدمة كما وجد أن أكثرها استجابة هو جيزة ٤٥ ويرجع ذلك لاختلاف درجه الاستبدال على وحده الانهيدروجلوكوز مع المواد المستخدمة.

٣ بالنسبة لتقدير صفة المتانة وجد أن جيزة ٤٥ أعطى أعلى القيم بالنسبة لكل المعاملات وهى نتيجة متوقعة لارتفاع متانته أصلا قبل المعاملات.

٤ أما بالنسبة لمحتوى الشمع، وجد أن جيزة ٨٥ أعطى أقل القيم بالنسبة لكل المعاملات ويرجع ذلك إلى تأثير المواد المستخدمة على الشموع بتحليلها إلى استرات أو أحماض دهنيه حرة وأدت معامله الغليان فى الصودا الكاوية إلى أكبر نسبة إزالة للشمع عن باقى المعاملات.