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Herbal Textile Finishes – Natural Antibacterial Finishes for Cotton Fabric

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IMPROVEMENT of physical properties in an addition to imparting antimicrobial properties to cotton fabric and modified cotton fabric by using herbal in the presence of softeners is the target of the present work, first of all modification of cotton fabric was done during cationization process by the means of cationized agent, namely, 3-chloro-2-hydroxypropyl trimethyl ammonium chloride (Quat-188); also, cotton fabric was modified during carboxymethylation process of it. Then treatments of cotton and modified cotton fabrics were carried out by different concentration of both Neem and Tulsi Extract as essential oil in the presence of Silicon Micro Emulsion (SiME) or Nonionic softeners for improving the performance of the treated fabric. Physical properties evaluations of the treated fabric were done by monitoring tensile strength, elongation, roughness, water absorbency (wettability). Finally, the treated fabrics were evaluated as antimicrobial and characterized by the mean of Scanning Electron Microscope (SEM).

Keywords: Cotton, Antibacterial, Textile Finishing, Herbal, Medical textile, Essential oil.

Recently, it has been observed that antimicrobial finishing of textile fabrics have a great interest in scientific researches [1-4]. Currently, a lot of materials based textile used in hospitals or hotels are conductive to cross infection or transmission of diseases caused by micro-organisms. In the textile industry, fabrics for hygienic or medical use have a great importance. Generally, imparting antimicrobial characteristics to textile materials may be done by chemical methods or by incorporating functional agents physically onto fabrics in addition to textile finishing using nano-materials [5,6]. The antimicrobial characteristics of such textile fabrics may be classified into two categories, temporarily or durably functional fabrics. It’s easy to achieve temporary biocidal properties in the finishing process of textile fabrics, but it's also easy to lose during fabrics laundering [7]. Generally, durability has been achieved by a common technology, a slow releasing technique. According to such technique,

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incorporation of sufficient antimicrobial agents onto fabrics may be done by the process of wet finishing. Deactivation of bacteria by slowly releasing the biocide from the substances will be done by the treated fabrics. However, if the antibacterial agents are impregnated in materials without covalent bond linkages it will be completely vanish. Many successful examples of chemically incorporated technique have been noted. In the textile industry, cotton is widely utilized due to its super properties. The final step of chemical process is the finishing process, improving quality and serviceability of materials. Textile softening considered one of the most important finishing processes of many after treatment steps in a fabric chemical processing industry [8].

Silicon finishes consider one of the most important softeners which are recognized as the best finishing agents for improving the fabrics softening, increasing textiles aesthetic feel and also imparting best hand softening. Silicon finishes have many advantages as it has been responsible for imparting softening to textile over the years, in addition to producing the optimum handle for apparel textiles with comfort characteristics [9,10].

Presented an interesting challenge amino silicon is known for imparting extremely soft handle properties. Nowadays, amino silicon elastomers consider one of the most efficient softeners in textile finishing field. In the application of such amino softeners onto fabrics, these amino groups are belongs to cationic species that have attraction ability to the negatively charged fabric.

This fact is true for fabrics based cotton, because it demands a negatively charged surface in aqueous medium, leading to improve performance, deposition and durability of softener coating [11]. There is very important demand for antibacterial fabrics based on eco-friendly agents which not only associated because of microbial growth on fabrics.

The utilization of the products of natural herbal such as Eucalyptus, aloe Vera and leaf of tulsi......etc as antimicrobial agent for imparting antibacterial properties to textile fabrics is very limited. Natural herbals can be exploited as an attractive eco-friendly instead of synthetic antimicrobial agents for textile application due to its low cost and its lower incidence of adverse reactions compared with synthetic agents.

The cotton clothes, by virtue of its characterization and proximity to human skin, provide perfect medium for the adherence, propagation and transfer of infection causing microbial species, in cases where work wears are worn, in places e.g. food industry, clinics, hospitals, and hygiene as bullies and elders wears who need more care. The presence and also growth of such microorganisms can lead to problem of elder health, and textile deterioration [11].

As we know, the additives applied to fabrics may be attacked by microbes in addition to such fabrics can lose its functional properties e.g. tensile strength, color strength and elasticity, so a special type of finishing agent which may called antimicrobial finishing is required to overcome the deleterious effect of microorganisms on fabrics. Hence, these is an urgent demand for antibacterial fabrics based on eco-friendly natural agent which help for reducing effectively the ill effects associated cause by the growth of microbes on fabrics in addition to comply with the requirements imposed by regulating agencies [12].

Essential oils and plant extracts are included to natural biocides which may be used in textile as antimicrobial finishing because it play an even growing role and widely known for fungicidal and bactericidal [13]. Natural antimicrobial agents have many advantages because it has non toxic nature and non-allergenic and do not lead to microbial resistance problems.

Neem consider one of the richest source of antimicrobial compounds, neem leaves yield glycerides of saturated and also unsaturated fatty acids, stearic and oleic acid are the main fatty acid [14]. Leaves mainly yield quercetin and neem bacterial as well as a number of liminoids. Quercetin is known to have anti-malarial, antifungal, antibacterial and antiviral properties. This may perhaps account for curative properties of leaves for scabies and sores. Medicinal effect derived from neem in effective against skin diseases, cough and breathing problem.

Tulsi (*Ocimum sanctum*) are belongs to labiates family which consist of leaves ocinum santumlin. From ancient times leaves of tulsi are used as an antimicrobial, insecticidal diaphoretic. It has suitable antimicrobial activity for textile materials application. The main chemical constituents of tulsi are: ursolic acid, rosmarinic acid, oleanolic acid, eugenol, carvacrol, linalool, and β-caryophyllene these essential present in the tulsi is responsible for its anti-viral and antibacterial properties [15].

The aim of the present work was focused at investigating the performance of silicon micro emulsion and nonionic softener-in the presence of oil of the herbal like tulsi and neem extract. The essential oil of the herbal products imparts cotton based clothes one or more functional properties in addition to its own softening functions in one step process, these functions as antibacterial activity (oil property) and smoothness(softening agent property). Herbal oil used due to their lesser toxicity and better antimicrobial activity for treating various infectious diseases.

The treated fabrics will monitor for physical-chemical properties like, tensile strength and elongation at break, surface roughness, wettability, and antimicrobial activity. Selected samples will subject to SEM.

Materials and Methods

Cotton fabric

Mill desized, scoured and bleached cotton fabric, plain weave, supplied by El-Nasr Company for spinning weaving and Dyeing El-Mahallah El-Kubra, Egypt. The fabric was further purified in the laboratory by washing at 100^{o}C for 60 min using a solution containing 2 g/L, Na_2CO_3 and 1 g/L, non-ionic surfactant. The fabric was then washed several times with boiling water then with cold water and finally dried at ambient conditions.

Chemicals

Sodium hydroxide, acetic acid, hydrochloric acid, monochloroacetic acid and sodium carbonate were of laboratory grade chemicals. 3-chloro-2-hydroxypropyl trimethyl ammonium chloride (69%), of technical grade chemicals was kindly supplied under the commercial name Quat-188 by Aldrich, amino functional silicon softener, micro emulsion (SiME) and nonionic softener was kindly supplied form by Tex Chem Egypt Co., Ltd.

The Carboxymethylation of cotton fabric (CMC)

Cotton fabric was partially carboxymethylated (CMC) by a method similar to those previously reported [16]. Hence, bleached cotton fabric samples were impregnated with 15 wt. % aqueous NaOH for 5 min at room temperature followed by squeezing to a wet pick up of 100% then dried at 60^{o}C for 5 min. The alkali treated samples were steeped in aqueous solution of ammonium salt of monochloroacetic acid (0-3 mol) for 5 min at room temperature. These samples were then squeezed to 100% wet pick up, sealed in plastic bags and heated at 80 ^{o}C for 1 h then washed and dried at room temperature.

Cationization of the cotton fabric

Cationization of cotton fabric was carried out using pad-dry-cure method. Experimental procedure adopted was as follows, Quat-188 (3-chloro-2-hydroxyl propyl-trimethyl ammonium chloride was mixed in solution with sodium hydroxide. Cotton fabric was padded through this mix and squeezed to wet-pick up of 100%. The fabric was dried at 40^{o}C for 15 min and then cured at 120^{o}C for 15 min. At the end, the sample was washed with water and 1% acetic acid then washed several times with water and finally dried at ambient conditions.

Fabric treatment

The untreated cotton, carboxymethyl cotton and cationized cotton fabric were padded twice to about 100% wet pickup with an aqueous formulation containing either 5% of silicon micro emulsion or 5% nonionic softener in presence of 5, 10, 15 % of either neem extract or tulsi oil for both softener separately, (Homogenizer was used to get homogenous solution) followed by drying at 100^{o}C for 5 min and curing 140^{o}C for 3 min in a circulating air oven. The treated fabric samples were then washed in with 2 g/L Egyptol to remove excess and unfixed reactants as well as products and dried at room temperature.

The treated fabrics characterization was investigated by SEM and in additional to its antibacterial properties.

Testing and analysis

Antimicrobial activity

The antimicrobial activity of the treated fabrics was examined on *staphylococcus aureus,* and *Escherichia coli*, by antimicrobial agar diffusion test according to AATCC Test Method 147-1988.

Wettability: was assessed in terms of drop disappearance, measured by allowing a drop of water to fall on the sample recording the time required for drop disappearance (AATCC standard test method).

Roughness: was measured according to AATCC standard test method using a Surfacoder (1700a).

Scanning Electron Microscopy (SEM): was studied using a scanning electron probe microanalyzer (type JXA-840A) – Japan.

Tensile strength

Tensile strength of the fabric samples was determined by the ASTM Test Method D5035. A Q-Test 1/5 tensile tester was used. Three specimens for each treated fabric were tested in the warp direction and the average value was recorded to represent the fabric breaking load (Lb).

Results and Discussion

Effect of the Neem extract concentration on the performance of the treated fabric in presence of SiME

Table 1 shows the effect of different concentrations (0-15%) of neem extract in formulation bath containing SiME softener with concentration 5% on physical properties of blank and modified cotton fabric such as tensile strength, elongation at break, roughness and wettability it is observed that there is no significant change in tensile strength for the cationized cotton compared with CMC, and cotton fabric. All of substrates have improvements in its elongation at break.

The roughness was improved by change neem extract concentrations which accompanied by an improvement in the surface roughness at same SiME concentrations this may be related to increasing the surface negativity for the reaction of carboxymethylation which results in an increase adhesion of the fabric. Silicon as finishing agent also imparts textiles soft feeling and water repellent properties, such water repellency character is attributed to methyl groups which are oriented and attracted to the fiber surface via silicon links.

TABLE 1. Effect of concentration of Neem extract in the presence of SiME.

Neem Conc	Cotton				CMC				Cationic			
%	**0**	**5**	**10**	**15**	**0**	**5**	**10**	**15**	**0**	**5**	**10**	**15**
Tensile strength(kg)	77	73	75	76	74	75	75	73	70	70	70	69
Elongation at break (%)	20	18	15	14	28	26	26	26	18	16	16	16
Roughness (µm)	17.6	17.3	16.0	16.0	20.0	16.9	15.9	15.0	17.0	16.3	15.0	15.0
Wettability (Sec)	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	<**3**	**>3**	**>3**	**>3**

Also there's no change in the wettability with changing neem extract concentrations for untreated and CMC cotton from the blank cotton, but the cationized cotton fabric, wettability decreased (more than 3 seconds), this is due to the hydrophobic character of the deposited silicon film onto the treated cationized fabric [17] and also for the adsorbed organic molecules of the neem extract on the fabric [18].

The antibacterial properties of the fabric treated with Neem Extract in presence of SiME softener

Figure 1 shows the effect of neem extract concentration 15g/L on the antibacterial properties of the treated fabric expressed as inhibition zone diameter in presence of silicon micro emulsion for gram +ve bacterial *(staphylococcus aureus)* and gram -ve *(Escherichia coli).* The antibacterial activity for the CMC is higher than the other cationized cotton or blank fabric, this is due to:

(1) The presence of SiME molecules would certainly open up the structure of cotton there by establish better adsorption of neem extract particles.
(2) Hydrophobicity of these molecules by virtue of their carboxylic group enhances the swell-ability of cotton fabric and, therefore, diffusion and adsorption of neem extract.

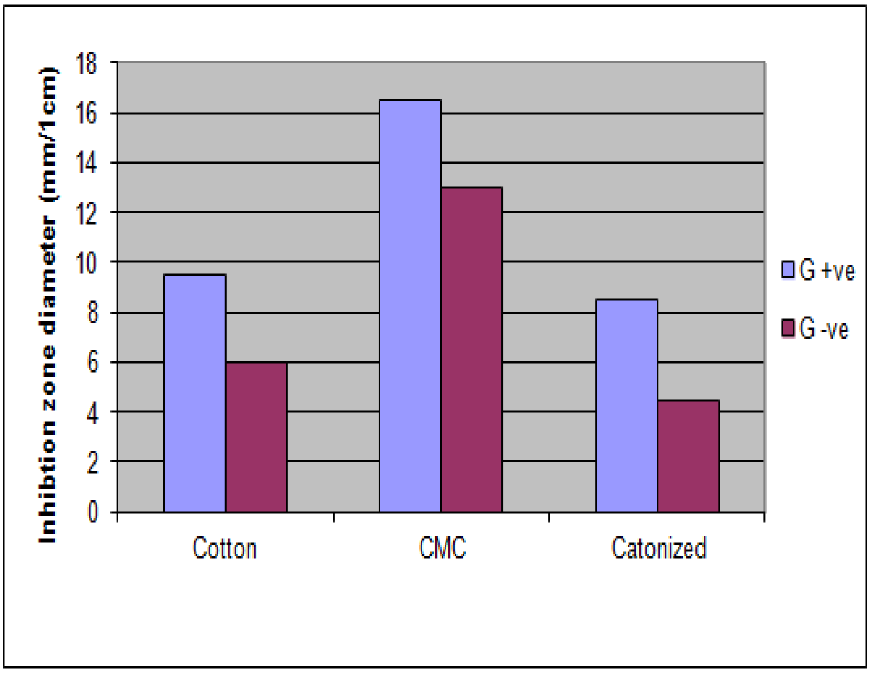

Fig.1. The Antibacterial properties of cotton fabric and modified cotton fabric treated with Neem oil in presence of SiME.

Effect of Tulsi oil concentration of on the performance of the treated fabric in presence of SiME

Table 2 shows the effect of change in concentration of tulsi as essential oil on the performance of cotton fabric and modified cotton fabric at same concentration (5%) of SiME. The tensile strength and elongation at break decrease with increasing the concentration of tulsi oil for the cotton fabric, CMC and also for the cationized fabric. There is no change in the roughness of both cotton and cationized cotton fabric, but there were some improvement in the roughness of CMC which can be attributed to the concept that the amino silicon can form a hydrophilic film on the fabric and reduce the surface roughness [17].

TABLE 2. Effect of concentration of Tulsi extract in the presence of SiME.

Tulsi Conc	Cotton				CMC				Cationic			
	0	**5**	**10**	**15**	**0**	**5**	**10**	**15**	**0**	**5**	**10**	**15**
Tensile strength(kg)	77	65	63	60	74	70	68	64	70	67	64	61
Elongation at break (%)	20	18	16	16	28	24	23	23	18	17	17	16
Roughness (µm)	17.6	17.5	17.4	17.3	20	17.9	15.5	14.9	17	17	17.6	17.5
Wettability (Sec)	<3	<3	<3	<3	<3	>3	>3	>3	<3	>3	>3	>3

For the wettability, it is clear that the wetting property of the treated fabric with tulsi oil is less than the untreated fabrics. This is due to adsorbed organic molecules of the tulsi oil on the fabric and also for the hydrophobic character of the deposited silicon film onto the treated cotton [17].

Antibacterial activity of the treated fabrics in presence of tulsi oil and SiME softener

Figure 2 shows the antibacterial activity of the treated fabrics in presence of tulsi oil and SiME softener it was found that all treated fabrics display antibacterial activity regarding both Staphylococcus aureus and Escherichia coli, and cotton fabric display antibacterial activity (14.5 mm) greater than both CMC (13 mm) and cationic fabric (9.5 mm) regarding *Escherichia coli* (G -ve) and also cotton fabric and CMC treated fabric have higher antibacterial activity (17 mm) regarding *Staphylococcus aureus* (G +ve) compared with cataionic fabric (16 mm). It was indicated in research that the agents of antibacterial attach to the surface of fiber by bond formation and then deactivate the cell membrane of microorganisms during ionic and physical phenomenon [19]. In addition, such antibacterial agent penetrates and deactivates the cell wall of the microorganisms via electron chemical mode of action, resulting in the leakage of metabolites that can probably inhabit the reproducing or functionalizing of microorganisms [20].

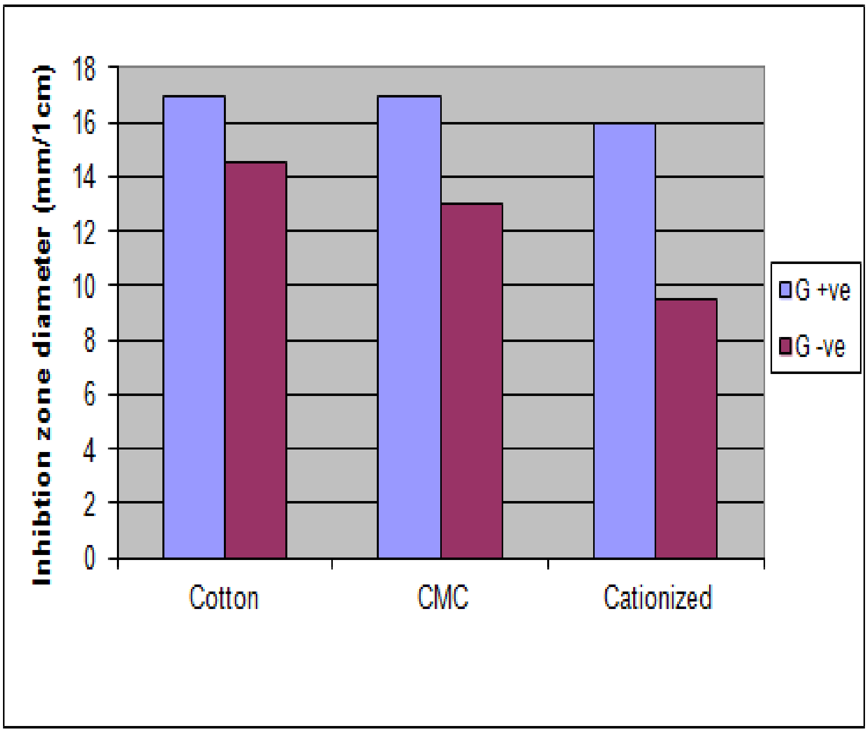

Fig 2. The antibacterial activity of the treated fabrics in presence of tulsi oil and SiME softener.

Effects of the Neem extract concentration on the performance of the treated cotton fabric in presence of Nonionic softener

Table 3 shows that increasing the neem extract concentration from (5-15 %) in the presence of 5% concentration of non-ionic softener is accompanied by decreasing of tensile strength and elongation at break for cotton fabric and modified cotton fabric.

Table 3 also shows that, by increasing the neem extract there was be an improvement on the fabric roughness for the CMC fabric which not attributed for the cotton and cationized cotton. The treatments of CMC fabric with nonionic softener/neem extract lead to improvement of the surface roughness and homogenously all grooves and ditches were covered. This may be explained by the mean of carboxymethylation reaction which leads to increase surface negativity of the fibers causing highly adhesion with nonionic softener/ Neem extract.

TABLE 3. Effect of Neem concentration on the performance of the treated cotton fabric in presence of non-ionic softener.

Neem Conc	Cotton				CMC				Cationic			
	0	5	10	15	0	5	10	15	0	5	10	15
Tensile strength (kg)	77	61	62	64	74	63	63	66	70	59	57	54
Elongation at break (%)	20	16	16	16	28	23	23	16	18	16	16	17
Roughness (µm)	17.6	18	18	17	20	17.3	16.5	15.8	17	17.6	17.1	17.5
Wettability (Sec)	<3	<3	<3	<3	**<3**	**>3**	**>3**	**>3**	**<3**	**<3**	**<3**	**<3**

Table 3 shows decreasing of the wettability for the cotton and cationized cotton, this is may be due to adsorption of the organic molecules in the Neem extract on the fabric and the hydrophobic film of nonionic softener as previously noted. But the wettability is increase for CMC fabric due to hydrophobicity of their carboxylic groups leading to enhancement the smell-ability of cotton fabric.

Figure 3 shows the antibacterial activity based on inhibition zone for *S. aureus* and *E-Coli,* It was found that for *S-aureus* inhibition zone for CMC is higher (12.5 mm) compared with both the cotton fabric (2.5 mm) and cationized fabric (3.5 mm). But regards E-Coli it was found that both cotton fabric and cationized fabric which was treated with the neem extract did not affected and doesn't show antibacterial activity against E-coli compared with CMC which show antibacterial properties with 9.5 mm inhibition zone.

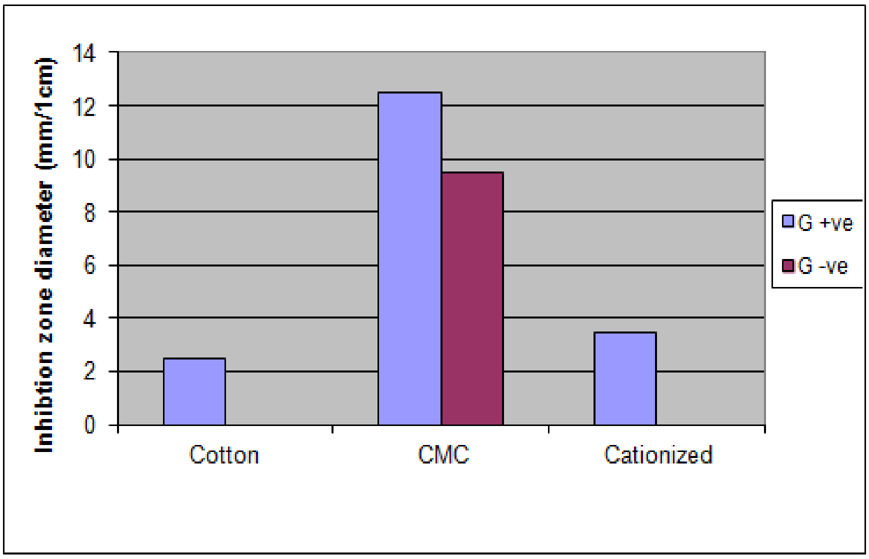

Fig.3. Antibacterial properties of the cotton and modified cotton in presence of Neem extract and nonionic softener.

Table 4 shows the effect of non-ionic softener on the performance of cotton fabric in presence of essential oil (Tulsi). There is no significant change in the values of the tensile strength and elongation for modified cotton fabric while for cotton fabric there is decreasing in both tensile strength and elongation while for the roughness there is no decrease in the value of the cotton fabric and there is some improvement for the cationized cotton. Table 4 also shows the wettability of the cotton fabric, CMC and cationized cotton fabric. The results shows that the water absorption decrease by using the Tulsi oil for the CMC and cationized cotton fabric compared with the modified cotton which has a good wettability.

TABLE4. Effect of Tulsi essential oil concentration on the performance of the treated cotton fabric in presence of non-ionic softener.

Tulsi Conc	Cotton				CMC				Cationic			
	0	5	10	15	0	5	10	15	0	5	10	15
Tensile strength (kg)	77	67	66	52	70	71	70	70	70	69	68	65
Elongation at break (%)	20	15	15	14	28	26	24	23	18	18	18	18
Roughness (µm)	17.6	18.7	17.4	17.8	20	17.9	15.5	15.9	17	16.1	16.6	15.9
Wettability (Sec)	<3	<3	<3	<3	**<3**	**>3**	**>3**	**>3**	**<3**	**>3**	**>3**	**>3**

The results presented in Fig. 4 shows that the antibacterial activity of cotton blank and treated cotton in presence of tulsi in the nonionic softener formulation bath, it was recognizing for cotton fabric treated with the essential oil (tulsi) than CMC and cationized cotton fabric. The maximum inhibition zone was found for *S-aureus* (24.5 mm) for cotton fabric, (22mm) for CMC, (14.5 mm) for cationized cotton fabric and for E-coli (20 mm) for cotton fabric, (20.5 mm) for CMC, (11 mm) for cationized cotton fabric.

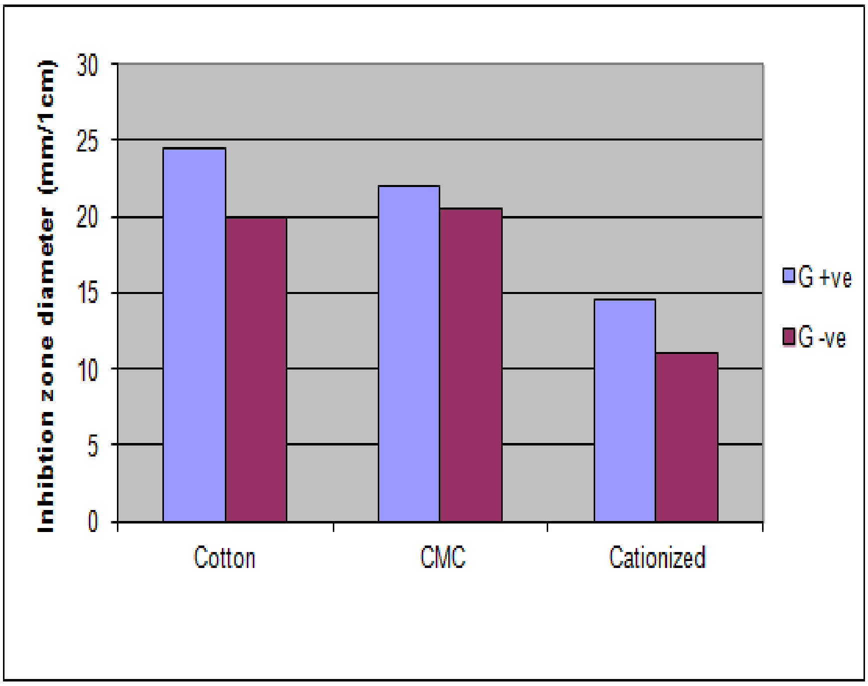

Fig. 4. Antibacterial properties of the treated cotton fabric in presence essential oil (Tulsi) and nonionic softener.

Scanning Electron Microcopy (SEM)

In this research, the effects of SiME and tulsi herbal treatments on the cotton fabrics were investigated by comparing the SEM images of cationic cotton, CMC before and after treatment with the same concentration of SiME, in presence and absence of either softeners or tulsi Herbal. Figure 5a displays SEM of CMC. It is evident from SEM image that the fibers are swollen and have flat ridges, rough surface and concave grooves.

From the SEM image of CMC (Fig 5a), the change is comparatively notable in the structure of fibers surface, the surface of cellulose fibers become loose, striated and harsh after carboxymethylation treatments. Figure 5b shows SEM image of CMC after treatment using SiME. It is shown that, the surfaces the treated CMC using SiME were swollen and have circulated ridges and became very smooth surface with no protruding fibrils or concave grooves. Although the fiber smoothness reduces and the surface ditches increases by carboxymethylation reaction as shown in Fig. 5a, it was found that using SiME in CMC fabric treatment lead to highly improvement on the surface roughness and homogenously all grooves and ditches were covered. This may be explained by the mean of carboxymethylation reaction which leads to increases surface negativity of the fibers causing highly adhesion with SiME. The extent of surface modification, expressed as coating of loose fibers, smoothness, in addition to disappearing of grooves and ditches, was determined by the mean of the kind of treated substrate, distribution extent, and location in addition to fixation degree of SiME onto and / or within this substrate.

The presence of Tulsi herbal between fibers treated with SiME was shown in Fig.5c in which the change is comparatively notable in the structure of fibers surface.

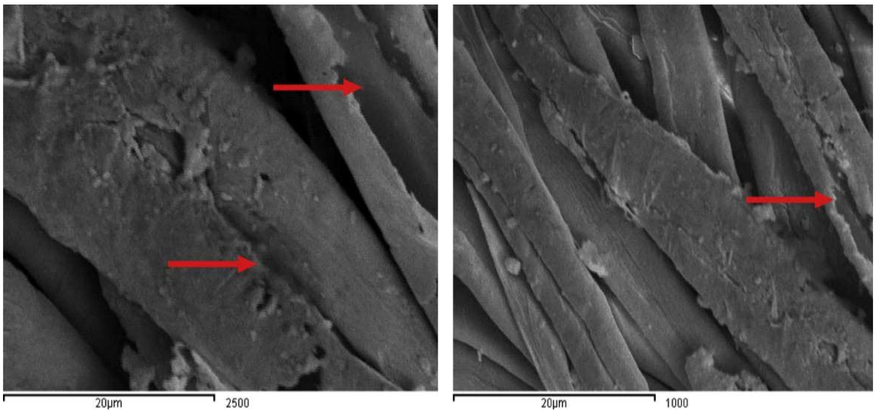

Fig 5a. SEM of CMC fabric

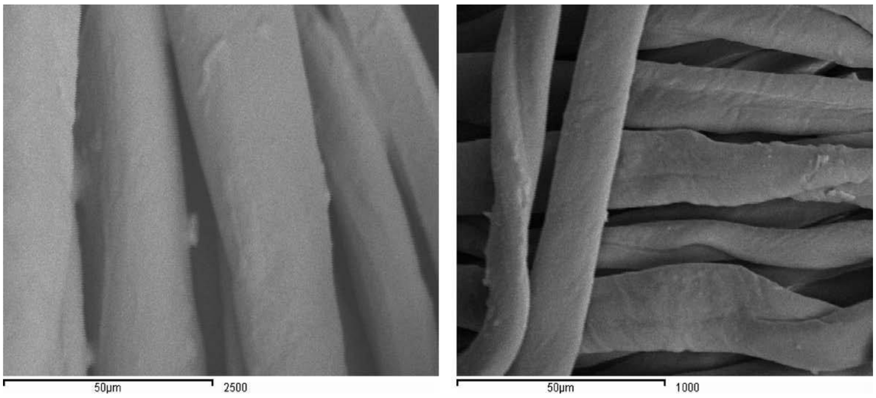

Fig 5b. SEM of CMC Cotton treated with SiME.

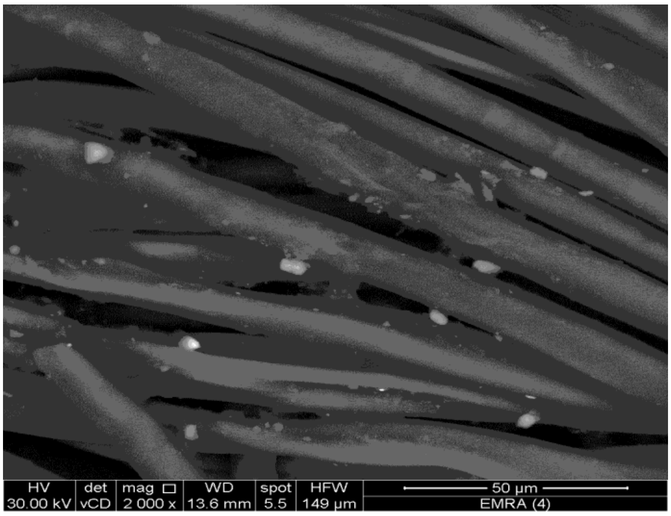

Fig 5c. SEM of CMC Cotton treated with SiME/tulsi herbal.

The same discussion may be investigated with non-ionic softener in CMC treatment in the presence of tulsi herbal, and the presence of tulsi herbal between CMC fabric treated non-ionic softener may be shown in Fig. 6.

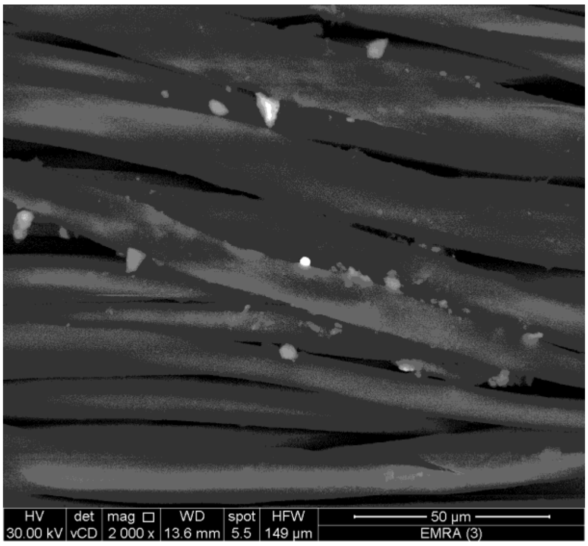

Fig 6. CMC fabric treated non-ionic softener and tulsi herbal.

Figure 7a displays scanning electron microscopy of cationized cotton fabric. It is evident that the fibers displays rough surfaces whereas concave grooves appear clearly. Fig. 7b displays scanning electron microscopy of cationized fabrics treated with SiME. It is evident form SEM images that, the fibers are swollen and have flat ridges, few protruding fibrils, concave grooves, and rough surface. From SEM images (Fig 7a,b), it can be seen that the change is comparatively notable in the structure of fibers surface. It’s noted that the cellulose fibers surface become harsh, striated and loose after cationization treatment. It was also noted that there is partially exfoliated in the external fibrillation of modified cellulose fibers. Also there are some helical ditches orientated along the direction of micro-fibril appeared on the surface of cellulose fibers. It should be mentioned that increasing the concentration of sodium hydroxide in the cationization reaction lead to fiber swelling.

The presence of Tulsi herbal between cationic fibers treated with SiME was shown (Fig.7c) in which the change is comparatively notable in the structure of fibers surface.

Fig.7a. SEM of cationized cotton

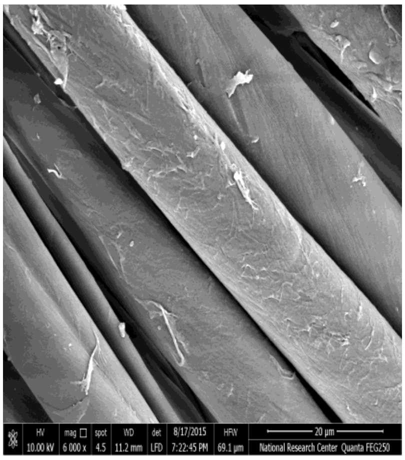

Fig 7b. SEM of Cationized cotton treated with SiME.

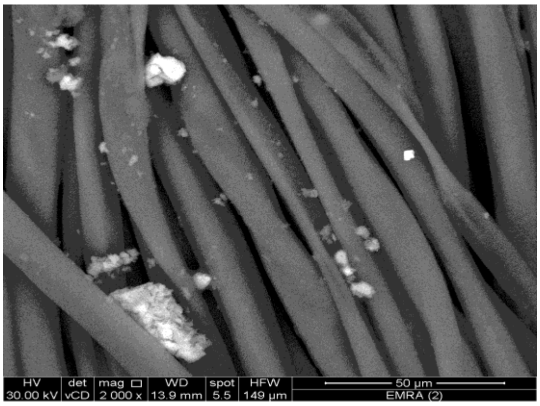

Fig 7c. SEM of Cationized cotton treated with SiME and Tulsi herbal.

The same discussion may be investigated with non-ionic softener in cationic cotton treatment in the presence of tulsi herbal, and the presence of tulsi herbal between cationic fabric treated non-ionic softener may be shown in Fig 8.

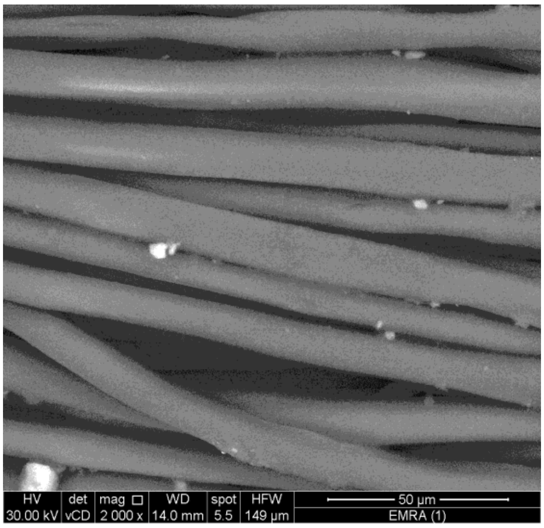

Fig 8. Cationic fabric treated non-ionic softener and Tulsi herbal.

Conclusion

Improvements of finishing properties of the treated fabric was achieved by enhancing added value of it's physical properties included tensile strength, elongation at break , roughness , water absorbency (wettability) by treating the modified cotton (Cationized and CMC) with different concentrations of neem extract and tulsi herbal (essential oil) in the presence of silicon micro emulsion

(SiME) and nonionic softeners with, the treated fabric also accepted high evaluation as antimicrobial fabric due to presence of such extract and essential oils, the produced treated fabrics were evaluated as antibacterial fabric and characterized by Scanning Electron Microscopy (SEM) and it is recommended to be use in the field of medical textile because it has excellent softening and antimicrobial properties.

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استخدام الاعشاب الطبيعيه كمواد تجهيز للنسيج – لإكساب الاقمشه القطنية خصائص مضادة للبكتيريا بصوره طبيعيه

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شعبة بحوث الصناعات النسيجيه -المركز القومي للبحوث- القاهرة – مصر.

اكتسبت تجهيزات الاقمشه القطنيه المضاده للميكروبات فى الاونه الاخيره اهميه كبيره من الناحيه العلميه والصناعيه على حد سواء. ونظراً لما قد تنقله هذه الاقمشه من عدوى بكتيريه نتيجه الأستخدام الواسع لهذه الاقمشه فى المجالات المختلفه كالمستشفيات والفنادق والعيادات الطبيه بالاضافه لالتصاقها المباشر بالاجسام, اصبح اكساب مثل هذه الاقمشه خصائص مضاده للميكروبات والبكتيريا امر فى غايه الاهميه لتجنب حدوث اى عدوى ميكروبيه او بكتيرية.

لذا يهدف هذا البحث الى تحسين الخصائص الفيزيائيه للاقمشه بالاضافه لتحسين خاصيه مقاومه هذه الاقمشه للميكروبات، ويتم ذلك من خلال المعالجه باستخدام الزيوت الاساسيه لبعض الاعشاب الطبيه الطبيعيه فى وجود مواد تنعيم مختلفه.

وتم تحقيق الهدف الرئيسى للبحث من خلال المراحل الثلاث التاليه:

اولاً: مرحله تحضير الاقمشه القطنيه وتحويرها

- توفير اقمشه قطنيه 100%.
- تحوير بعض الاقمشه القطنيه الى كربوكسى ميثيل سيليلوز بإستخدام احادى كلورو حمض الاسيتك .
- تحوير بعض الاقمشه القطنيه الى كاتيون السيليلوز باستخدام الكوات-188.

ثانياً: مرحله المعالجه:

- تم معالجه الاقمشه القطنيه والاقمشه السابق تحويرها بإستخدام تركيزات مختلفه الزيوت الاساسيه لعشبى النيم والريحان (0-15%) فى وجود مواد تنعيم مختلفه لتحسين الخصائص الفيزيائيه للاقمشه .

ثالثاً: مرحله التقييم والتوصيف.

- تم تقييم الخصائص الفيزيائيه للاقمشه المعالجه من خلال قياس قوه الشد والاستطاله ودرجه الخشونه ودرجه الذوبانيه بالاضافه لتقييم هذه الاقمشه كمواد مضاده للبكتيريا.
- اخيراً تم توصيف الاقمشه المعالجه من خلال الميكروسكوب الاليكترونى الدقيق للتعرف على التغيرات الحادثه فى الشكل الداخلى لخيوط الاقمشه.
- جميع النتائج مدرجه تفصيلياً فى البحث وتوضح النجاح فى تحقيق الهدف من البحث فى تحسين الخصائص الفيزيائيه للاقمشه بالاضافه لتحسين خاصيه مقاومه هذه الاقمشه للبكتيريا من خلال المعالجه باستخدام الزيوت الاساسيه لبعض الاعشاب الطبيه الطبيعيه فى وجود مواد تنعيم مختلفه.