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Multifunctionlization of Viscose Fabric through Loading with Organic and Inorganic Nanostructural Materials

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VISCOSE fabrics were treated with environmentally nano-particles namely; nano-clay, nano-chitosan and nano-cellulose. Each of three nanoparticles was introduced in a solution containing reactive cyclodextrin (RCD) and sodium carbonate (Na_2CO_3) and the treatment was performed using the pad dry-cure technique. Topographical investigation of the said nano-particles was conducted using transmission electron microscopy (TEM). The change of morphological structure of the treated fabrics relative to the native one was examined using high resolution field emission scanning electron microscope. FTIR and nitrogen content of the treated fabrics compared to the untreated ones were assessed. The changes in some physico-mechanical characteristics of the treated viscose fabrics were monitored; namely abrasion, thickness, air permeability and moisture sorption test. The colour strength and washing fastness to dyed fabrics with both direct and reactive dyestuffs were evaluated. The effect of treatment of viscose on its resistance towards various microorganisms was appraised. Radar chart of the treated as well as untreated fabrics was calculated.

Keywords: Viscose fabrics, Eco-friendlynano- materials, (Nano clay nano chitosan and nano cellulose) functional finishing, Antimicrobial activity.

Introduction

Organic and inorganic nanostructural materials in the form of nanohybrid composites are strongly advocated to have a vital role in the modern textile finishing. These materials are made of nanohybrid composite originated from nature such as nanoclay, nanochitosan and nanocellulose particles. Nanoclay particle, as for example montmorillonite, hydrous aluminum silicates group with layer structure of very small size, can be organically modified to render the clay organophilic and to enable its dispersion onto a polymer. Such dispersion refers to a nanocomposite including nano-sized clay particles surrounded by a polymer [1]. Application of the nanocomposites to textiles may be exemplified by: nanoclay particle incorporated with hyper branched polymer [2], nanoclay modified with quaternary ammonium salts for creation of dye sites on polypropylene fibers, nanoclay modified and used as sorbent for nonionic, anionic and cationic dyes [3] as well as in melting and dissolving processes by adding this organic solvent and nanoclay to the polypropylene matrix[4].

Previous reports [5-8] through extensive studies have also described as a natural cationic biopolymer with excellent bioactivity, biodegradability, biocompatibility, nontoxicity and multifunctional groups in addition to solubility in aqueous medium for food packaging film, bone substitutes and artificial skin[9-13].

Other literature, shows that the treatment on viscose fibres with nano silicon dioxide led to

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better antistatic charge and enhanced tear strength [14].

With the foregoing in mind, current research is designed to study the impact of loading viscose fabrics with nanomaterials of natural origin, viz., nanoclay (NKM) (nano Kaolinite), nanochitosan and nanocellulose whisker along with reactive cyclodextrin (RCD) and sodium carbonate (Na_2CO_3). Thus, loaded fabrics are submitted to measure the chemical composition, physico-mechanical properties, particle size and size distribution and dyeability using the state-of-the-art tools and facilities.

Experimental

Materials

Viscose fabric was purchased from Abou El-Ola Company for spinning and weaving, 10th of Ramadan, Egypt. The fabric weight is 110 g/m^{2,} number of warp 375/10 cm and number of weft 320/10 cm.

Chemicals

Clay was obtained from (Sinai desert Egypt) and supplied by Middle East Mining Investments Company (MEMCO), Cairo, Egypt. Chitosan, reactive ß-cyclodextrin (RCD) and nanocellulose whisker were purchased from Aldrich Chemical (Germany).The nonionic detergent obtained from (Hocstapal CV from Clariant, Egypt).All chemicals used were of laboratory grade and used without further purification. Distilled water was used for all preparations.

Dyestuffs

Reactive dye, namely, Remazol Yellow GNL highly conc. (C.I. Reactive yellow 4),and Direct dye, under the commercial name, Solopneyl orange T4R, were used in this study.

Methods

Scouring

Scouring of viscose fabric was carried out in an aqueous solution containing 2g/l nonionic detergent using 1:25material to liquor ratio, at 45°C for 45 min. The fabric was then rinsed with running tap water and finally dried at ambient temperature.

Preparation of the nano-clay

The nanoclay used in this research was Nano kaolinite material (NKM) with a surface area of 48 m^2/g and the chemical structure of KM is ($AL_2Si_2O_7$). Nanoclay was prepared in the National Research Centre of Housing and Building at the Chemical Department by thermally heated the kaolinite material at 800^0 C for 2 hrs. in automatic electrical furnace to assure complete decomposition and to get active amorphous NKM.

Preparation of the nano-chitosan as per the Ionic gelation method

This method is the most accepted method for the synthesis of stable, non-toxic and organic solvent free chitosan nanoparticles(NPS). The synthesis of chitosan NPs is based on electrostatic interactions between positively charged amino groups ($-NH_3^+$) of chitosan and negatively charged cross linkers (15, 16). In this procedure, chitosan was dissolved in weak acidic aqueous solution and mix systematically into aqueous solution of negatively charged cross linkers. Tripolyphosphate (TPP), a polyanion, was added drop wise under steady stirring to acidic chitosan solution. Chitosan underwent ionic gelation and precipitated to form nanoparticles (Fig. 1). The obtained precipitate was then separated centrifuged and washed several times with distilled water.

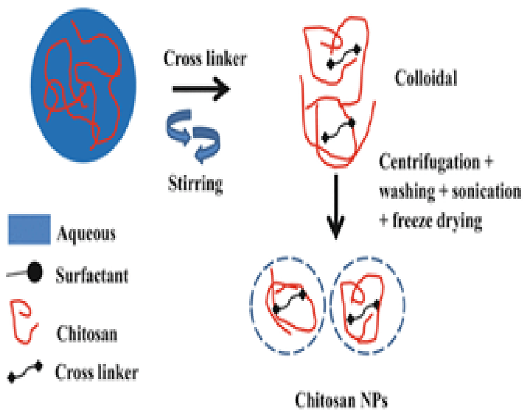

Fig. 1. preparation of nanochitosan by ionic gelation method.

Treatments viscose fabrics with nanomaterials

The viscose fabrics were independently treated with nanochitosan, nano clay and nanocellulose using two methods.

The first-step method: In this method viscose fabrics were immersed in a treatment bath containing 0.2% of the nanomaterials, 3% RCD in presence of 3% Na_2CO_3. The mentioned fabrics were padded in two dips and two nips to a wet pick up of 100% followed by drying at 80 °C for 5 min then cured at 150 °C for 3 min.

The second two-step method: In this method viscose fabrics were pretreated with a solution containing RCD and Na_2CO_3 (3% each) in two dips and two nips to a wet pickup of 100%

followed by drying at 800C for 5 min then cured at 150°C for 3 min. The pretreated fabrics were then treated by solutions containing the mentioned nanomaterials (0.2% each), then padded to wet pick up of 100% followed by drying and curing under the conditions mentioned before.

Dyeing Process

Dyeing with reactive dyes

The dye bath solution was prepared by pasting the required amount of the dye C.I. Reactive yellow 4 (Remazol Yellow GNL highly conc.) with water to give the prescribed shade 1% (o. w. f.) and diluting with water to completely solubilize the dye. The dye solution was adjusted to pH 8. The dye bath was heated to 60^{o}C and added the sample (viscose fabric) to the dye bath, the temperature was then raised gradually up to 90^{o}C through 30 minutes then added 20g/l sodium sulphate after 30 min., the dyeing continued for 60 min., at liquor ratio 1:50. The dyed sample was thoroughly washed and left to air-dry.

Dyeing with direct dye

The dye solution of direct dye (Solopneyl orange T4R) was prepared by dissolving 1 gm of the dye in 1000 ml of tap water. The dyeing process was conducted using material to liquor ratio of 1:50 and the pH of the dyeing bath was adjusted to 8. The dyeing was started at 90 ºC, after 20 min sodium chloride (10 g/L) was added to the dyeing bath and dyeing continued to 60 min. The dyed samples were withdrawn, rinsed with water and air dried.

Measurements

- Abrasion (ASTM-D 4966): stander test method for abrasion resistance of textile fabrics (Martindale Abrasion tester method)
- Thickness (mm) was measured according to (ASTM-D1777).
- Moisture Regain was measured according to (ASTM – D2654).
- Infrared Spectra were recorded on FT-IR Nicolet 5 DX Spectrophotometer. The samples were examined as 1.5% KBr pellets.
- Color strength (intensity): K/S Color intensity of the dyed fabric (K/S) was measured at the wave length of the maximum absorbance using a SF600+-CT Data colors spectrophotometer [17].
- Washing fastness: the colorfastness to washing was determined according to the AATCC test method (AATCC Technical Manual, Method 36, (1972), 68, 23, (1993)) using Launder Ometer[18].
- *Transmission electron microscopy (TEM)*

The morphology of selected samples of nanoclay, nanochitosan and nanocellulose powders was investigated using TEM (JEOL, JEM-1230, and Japan, with an acceleration voltage of 120 kV). The sample for TEM analysis was obtained by placing a drop of the colloid dispersion onto a carbon coated copper grid. The samples were dried at room temperature and examined using a TEM without further modification or coating.

- *Scanning electron microscopy (SEM)*

ZEISS LEO 1530 Gemini Optics Lens scanning electron microscopy (SEM) with 30 kV scanning voltages was employed to observe the morphological structure of untreated and treated fabrics. Zeiss LEO 438 VP with Oxford Instruments EDX with INCA software system.

Biological Activity

The antibacterial and antifungal activities were carried out in the Microbial Department, National Research Centre, by measuring the optical density (OD) at 600 nm. The method can be described as follows: The bacterial cultures maintained on nutrient agar slants were aseptically incubated into 5 ml of sterile nutrient broth. The samples were thoroughly shacked and then incubated at 37°C for 24 h. This was designated as the working stock that was used for antibacterial studies. 5mL of nutrient broth medium were taken in different test tubes and autoclaved. Each tube was inoculated with 100 µL of bacterial suspension and a disc of the tested specimen then incubated at 37°C for 24 h. The growth of the selected bacteria was detected by optical density (OD) at 600 nm. The antimicrobial activity of the tested compounds was examined with gram positive bacteria, *Bacillus cereus, staphylococcus aureus* ATCC 6538, and gram-negative bacteria *Escherichia coli* NRRN 3008, *pseudomonas aeruginose* ATCC 10145 and fungus *Candida albicans* EMCC105. The obtained results are compared with the reference antibiotic Cephradine that was purchased from Egyptian markets.

Results and Discussion

To start with, the nanomaterials of natural origin namely; nanoclay, nanochitosan and nanocellulose, were prepared, characterized and applied to plain weave 100% viscose fabrics. Each of the three nanoparticles along with reactive cyclodextrin(RCD) and sodium carbonate (Na_2CO_3) were used for treatment of the viscose fabrics as per two methods. The treated as well as untreated viscose fabrics were submitted to measure the chemical composition, mechanical properties, physical properties and dyeability in addition to measuring particle size of the used nanomaterials. Results obtained along with appropriate discussion are given below.

Transmission Electron Microscopy

Shape, size and size distribution of the prepared nanosolution samples based on reactive ß-cyclodextrin RCD along with different three nano particles (nanoclay, nanochitosan and nanocellulose) were imaged using High Resolution transmission electron microscopy (JEOL-JEM-1200) operating at an accelerating voltage of 100 kV. Figure 2(a, b & c) shows the nano particle size of nanochitosan, nanoclay and nanocellulose respectively.

Scanning Electron microscopy (SEM)

Figure 3 shows the surface morphology of untreated as well as treated(loaded) viscose fabrics with nanoclay, nanochitosan and nanocellulose using the one-step and two-step methods. The SEM micrograph clarifies the deposition of nano materials/ ß-cyclodextrin (RCD) along the viscose fabric surface due to the treatment of the fabrics. Furthermore, Fig. 3 reveals that the amounts of nano materials/ ß-cyclodextrin (RCD)deposited on the treated fabrics by the one-step method are higher than that when using the two-step treatment.

Fourier Transform Infrared Spectroscopy

Fourier Transform Infrared Spectroscopy (FTIR) was used for monitoring the existence and position of functional groups of RCD and of the nanoparticles as well as of the viscose fabrics loaded with each of the three nano materials along with RCD. The FTIR spectral analysis was performed at region from 4000 to 400 cm^{-1} on a (Thermo Scientific Nicolet iS10, USA).

FTIR data reveals the appearance of bands of the synthesized Monochloro-triazinyl- β-cyclodextrin MCT-β-CD (RCD). The presence of strong bands at 1753, 759 and 1150 cm^{-1} characterizes C=N, C-Cl and C–O groups. Further, the identification of a band at 1018 cm^{-1} accounts for carbon atoms in cyclic ring. The characteristic bands in the IR- spectra of the MCT-β-CD treated viscose was recorded at 2890cm^{-1}(C–H), 1745cm^{-1}(C=N stretching) and 1157cm^{-1} (C–O) in comparison to the untreated viscose. However, the stretching band of C-Cl between 1722 and 1734 cm^{-1} is not observed due to the reaction between triazine and viscose whereby the chlorine atom is involved in the modification process of MCT-β-CD on viscose. (Khanna et al. 2015). The characteristic absorption band at 3622 cm^{-1} is assigned to the stretching vibration of $Al(OH)_3$ and $Si(OH)_2$; plus the presence of band at 840, 974,1630cm^{-1} related to (O-H), (Si-OH),(H-OH) all are related to the nanoclay respectively.

Furthermore, FTIR spectra proved that the including of nanochitosan in RCD. The spectra signify the important absorption bands to identify the characteristic functional groups, which display C–H, are observed at 2924.13 cm^{-1}. The absorption peaks at 1656.88 cm^{-1} are associated with the presence of the C=O stretching of the amide, bending vibrations of the C=N at 1745cm^{-1}, N-H bending, at 1066 cm^{-1}. The peak at 1571 cm^{-1} is assigned for stretching of NH. The FTIR spectrum of microcrystalline viscose demonstrated that the band at 3438.17cm^{-1}, is attributed to the O-H stretching, vibration of hydroxyl group in the cellulose is absent as it reacts with chitosan. The FTIR spectrum of the nano chitosan-RCD shows that, the broad peak for -OH and -NH groups are shifted from 3438.17 $cm^{-1}$to 3631.96 cm^{-1}. This shift indicates that interaction occurs between amine groups in chitosan and hydroxyl groups in cellulose.

Besides, FTIR detected the characteristic bands of the MCT-β-CD for the treated viscose fabrics at 1018 cm^{-1}, accounting for carbon atoms in cyclic ring of RCD in addition to 2890 cm^{-1}(C–H), 1745cm^{-1}, (C=N stretching) and 1157cm^{-1} (C–O) in comparison to the untreated viscose(blank).

Dyeability

The viscose fabrics before and after treatment with the three nanoparticles according to the one-step and two-steps method with and without RCD as control samples were dyed with a reactive and a direct dye as described in the experimental section. Table 1 contains the results of color strength (K/S) and fastness to washing as well as to alteration through cotton staining. It is seen that the values of K/S of

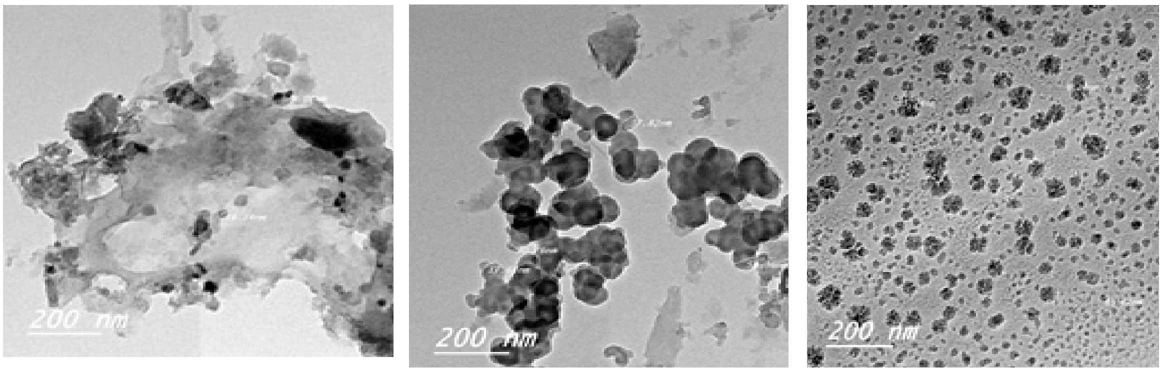

Fig. 2 (a, b, c):TEM micrograph of the nano materials used in the treatment of viscose fabrics
a) nanochitosan b) nanoclay c) nanocellulose

TABLE 1: Colour strength and fastness to washing and to alteration of direct and reactive dyes for untreated as well as treated viscose fabrics

methods	Viscose fabrics loaded with	Direct dye			Reactive dye		
		K/S	Alteration	Fastness to washing	K/S	Alteration	Fastness to washing
	Untreated	2.13	4	3-4	4.17	3-4	4
Control	Nanoclay	5.2	3-4	3	5.01	4	4
	Nano chitosan	3.3	3-4	3-4	4.1	4	3-4
	Nano cellulose	4.1	3-4	3	3.5	4	4
First Method	Nanoclay	7.88	4	3-4	6.42	4	4
	Nano chitosan	4.72	4	3-4	4.87	4	4
	Nano cellulose	4.79	4	3-4	4.71	3-4	4
Second Method	Nanoclay	5.13	4	4	5.24	4	4-5
	Nano chitosan	3.94	4	4	4.69	3-4	4
	Nano cellulose	3.96	4-5	4	4.92	4	4

.Control: Treatment with nano material only
.First Method: Treatment with nano material and RCD in one step
.Second Method: Treatment with nano material and RCD in two steps

the treated samples are much higher than the untreated sample regardless of the method of the nanoparticles treatment. It is certain, however, that values of K/S for the first method are higher than those of the second method.

Treatment with RCD and Na_2CO_3 priors to treatment with the nanoparticles seems to decrease the susceptibility of viscose fabric to interact with the nanoparticles and assume that their interaction with viscose macromolecules involves chemical crosslinking. Once occurred, crosslinking would detract from the chemical reactivity of viscose macromolecules. Nevertheless, the K/S values of the pretreated fabrics are higher than those of the untreated fabrics irrespective of the method of treatment and the dye used within the range studied. This reflects the advantages of the nanoparticles used. Differences in nature and particle size and distribution among the nanoparticles under investigation would account for the differences in K/S values observed with the different nanoparticles. By and large, the K/S value obtained with the clay nanoparticles are the highest while those of chitosan nanoparticles are the least. Cellulose nanoparticles exhibit

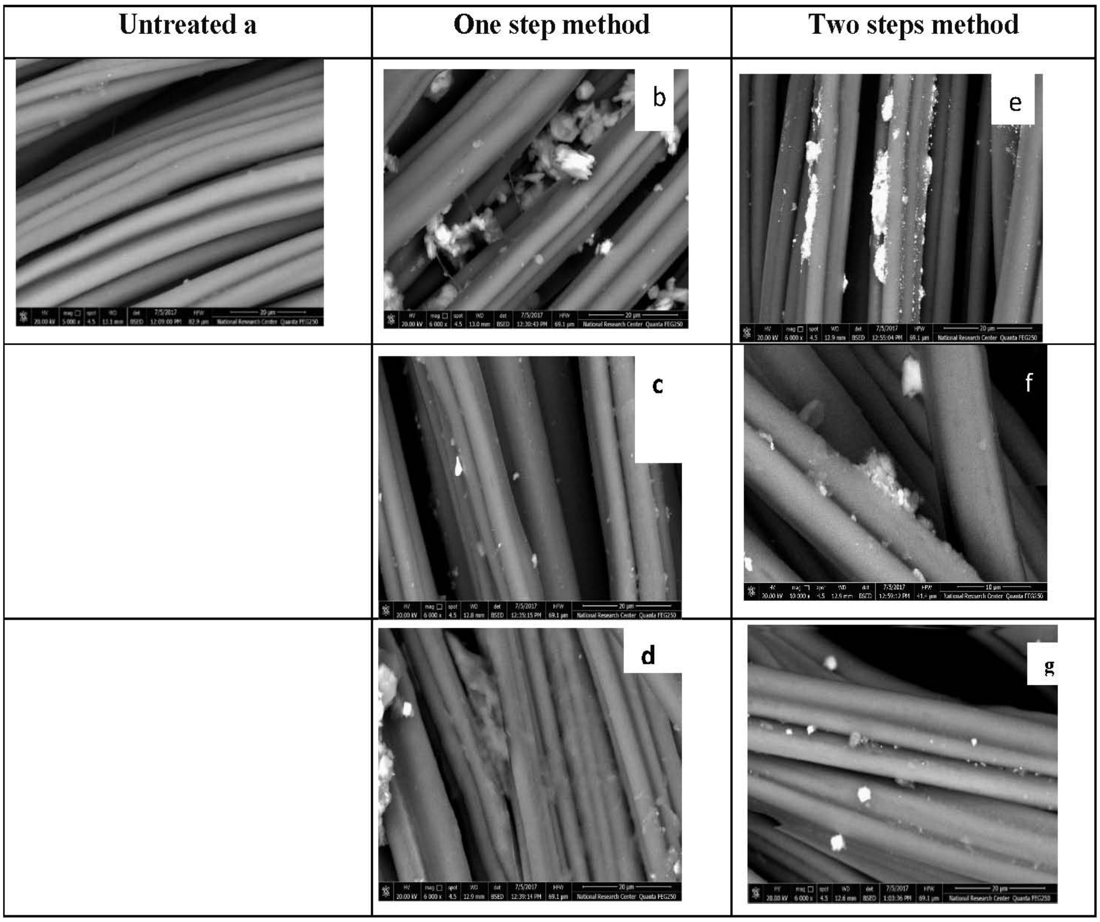

Fig. 3: Scanning electron microscopy of untreated and treated viscose fabrics with nano clay, nano chitosan and nano cellulose
a: untreated **b, e: treated with nano clay**
c, f: treated with nano chitosan **d, g: treated with nano cellulose**
(b, c, d treated with one-step method) **(e, f, g treated with second-step method)**

K/S values that make them stand in the mid-way position.

Various Properties of viscose Fabrics before and after treatment with the three nanomaterials

Viscose fabrics loaded with nanoclay, nanochitosan and nanocellulose materials were submitted to various measurements which brought into focus the following properties: add-on %, air permeability, moisture regain %, thickness and nitrogen content. Some properties were monitored for the untreated viscose fabrics for the sake of comparison. Results obtained are summarized in Table 2. As is evident the add-on % obtained with the three nanomaterials follow the order: nanoclay > nanocellulose > nanochitosan. This indicates that the extent of interaction of the nanomaterials with the macromolecular structure of viscose fabric is a manifestation of diffusion of the nanomaterials in the interior of the structure of viscose which, in turn, rely on size and chemical structure of the nanomaterials. However, presence of RCD along with the nanomaterials during the loading treatment and the role of RCD in accumulation and fixation of the nanomaterials cannot be ruled out.

Differences in values of add-on % due to the variety in nanomaterials is observed irrespective of the method of the loading treatment (Table 2). Nevertheless, the one-step method displayed much higher values of add-on % than does the two-step method. Treatment of the viscose fabric with RCD and Na_2CO_3 in a separate step, in the two-step method, most probably causes changes in the physical and chemical structure

TABLE 2: Air permeability, moisture regain, thickness, Abrasion and nitrogen content for untreated and treated viscose fabrics treated with different methods, different nanomaterial

Method	Samples	Add on %	Air Permeability	Moisture regain %	Thickness mm	Abrasion (cycles)	Nitrogen content %
	Untreated	---	136	9.6	0.32	100	-
Control	Nanoclay	0.164	95.8	9.7	0.4	120	-
	Nano chitosan	0.145	98.5	9.5	0.41	120	0.234
	Nano cellulose	0.156	108	9.6	0.4	125	-
	RCD	0.113	110.5	9.9	0.43	135	0.6873
First Method One-step	Nanoclay	0.63	96.96	10	0.44	130	1.77
	Nano chitosan	0.47	109	9.5	0.45	130	1.6128
	Nano cellulose	0.53	114	9.7	0.43	140	0.6873
Second Method Two steps	Nanoclay	0.182	104	8.6	0.41	100	0.3343
	Nano chitosan	0.138	111.2	8.5	0.41	100	0.5698
	Nano cellulose	0.171	124	8.3	0.44	130	0.3566

.Control: Treatment with nano material only
.First Method: Treatment with nano material and RCD in one step
.Second Method: Treatment with nano material and RCD in two steps

the nanomaterials and methods used for loading. For example, the nanocellulose materials exhibit the least reduction in air permeability while the nanoclay material gave the highest value upon loading as per the one-step method. Similar situation is encountered with the two-step method but with the certainty that this latter method allows for better air permeability than the one-step method. Reduction in air permeability due to loading with the nanomaterials and RCD could be ascribed to thin film formation which prevents ease of air penetration throughout the loaded fabric; by filling in the pores and interstices of the fabric.

Table 2 depicts that values of moisture regain % of viscose tend to increase after loading the viscose fabrics with the nanomaterials and RCD as per the one-step method. The opposite holds true for loading according to the two-step method. This is in accordance with the occurrence of crosslinking during the first step in the two-step method as already stated.

It is also seen that (Table 2) the viscose fabric acquires higher thickness after treatment according to the one-step and two step methods compared to the untreated fabrics, but with tendency that thickness obtained with the latter are lower than those for the former. This is observed with other properties and could be tackled on similar lines.

It is as well to refer to the data of nitrogen content given in Table 2. As expected the untreated (unloaded) viscose fabric is free of nitrogen. On the other hand, loaded fabrics exhibit substantial amount of nitrogen particularly upon using the one-step method for loading with solutions containing nanoclay or nanochitosan together with RCD. Loading as per the two-step method with solutions containing RCD and nanochitosan brings about the highest nitrogen content%.

Differences in ability of the nanomaterials to help transfer RCD from loading solution to the fabric may be looked upon to account for this. Needless to say, that the main source of nitrogen is RCD with all samples plus chitosan whenever nanochitosan was used.

Table 2 shows the results of abrasion resistance of untreated and treated viscose fabrics with nanomaterial by different methods. It was found that the treatment by one step led to increase cycles of abrasion overall, and the highest increased in cycles of abrasion of treated viscose fabrics that the one treated with nanocellulose. The increase in abrasion cycles about 50% for the treated fabric than untreated one. Also, the treatments with both nanoclay and nanochitosan increased in cycles of

TABLE 3: Optical density of untreated and treated viscose with nano material

Microorganism	Gram Stain Reaction	Optical Density (OD 600 nm)					
		Ut	T1	T2	T3	T4	T5
Bacillus cereus	Positive	0.44	0.87	1.19	1.11	1.3	0.94
Staphylococcus aureus	Positive	0.89	1.1	1.2	1.3	1.2	1.0
Escherichia coli	Negative	0.49	0.57	0.76	0.71	0.79	0.66
Pseudomonas aeruginosa	Negative	0.56	1.1	1.2	1.2	1.1	1.12
Candida albicans	Yeast	0.38	0.46	0.42	0.41	0.43	0.47

samples description

.Ut: Untreated viscose

.T1: Treated with reactive cyclodextrin

.T2: Treated nano clay/ reactive cyclodextrin

.T3: Treated with nano clay only

.T4: Treated with nano chitosan/ reactive cyclodextrin

.T5: Treated with nano chitosan only

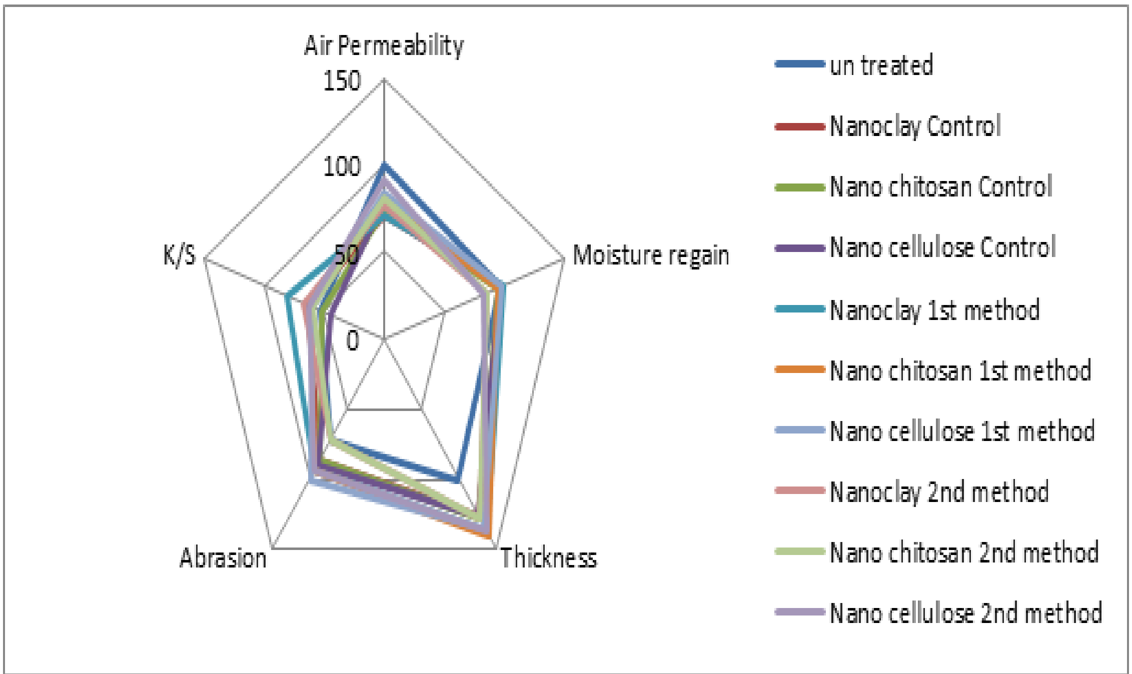

Fig. 4: Radar chart of treated viscose fabrics dyed with direct dyes

of viscose in such a way that viscose has become less susceptible to loading with nanomaterials when the latter was applied as a second step. Crosslinking of viscose molecules perhaps occurs among other interactions during treatment with RCD in presence of Na_2CO_3 there by decreasing the susceptibility of viscose to nanomaterials.

Table 2 shows that loading viscose fabrics with the nanomaterials reduces air permeability of the fabrics. This is observed irrespective of

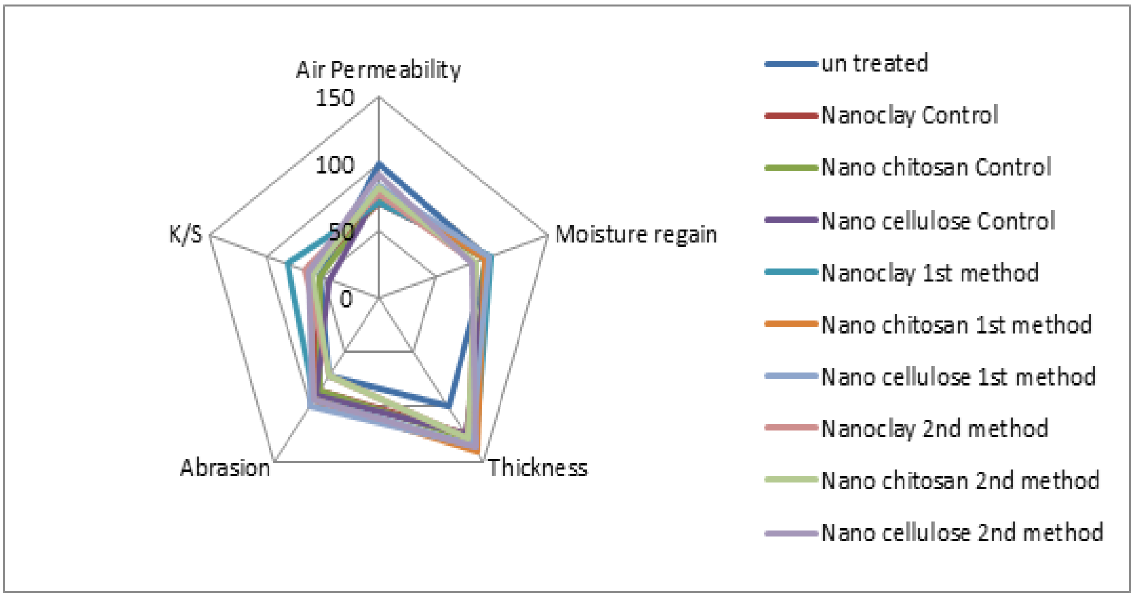

Fig. 5: Radar chart of treated viscose fabrics dyed with reactive dyes

TABLE 4: Calculating of Radar chart area for all treated samples and dyed with direct and reactive dyes

Sample Description	Radar area value (Direct dyes)	Radar area value (reactive dyes)
Untreated	14729.36	16838.91
T. Nanoclay	19008.83	18829.15
T. Nano chitosan	17493.86	18262.6
T. Nano cellulose	18811.38	18200.11
1st method Nanoclay	23804.28	22357.97
1st method Nanochitosan	21108.16	21265.28
1st method Nanocellulose	21766.01	21265.28
2nd method Nanoclay	17296.49	17394.14
2nd method Nanochitosa	16476.76	17169.48
2nd method Nanocellulose	19493.04	20558.85

abrasion of treated viscose fabrics as compared with the untreated fabrics.

Antimicrobial activity

The obtained results in Table 3 clearly showed that some pathogens extensively affected and inhibited by the tested viscose fabrics specimens. These pathogens include the gram-positive bacterium *Bacillus cereus* and the yeast pathogen *Candida albicans*. The most active specimen against *Bacillus cereus* was specimen T4 (viscose fabrics treated with nanochitosan/ RCD) followed by specimen T2(viscose fabrics treated with nano clay/ RCD) and both T3 (viscose fabrics treated with nano clay) and T5 (viscose fabrics treated with nanochitosan) respectively. In the meantime, specimen T1 and T5 were the highest inhibitory against *Candida albicans*. Gram negative bacteria *E. coli* was moderately inhibited by specimens T4, T2 and T3. It was found that *Pseudomonas aeruginosa* and *Staphylococcus aureus* were resistant to all treatments. Finally, it is noticed that all results are comparable to each other.

Selection of the best Treatment condition

Figures 4 and 5 show the Radar chart for all treated samples dyed with direct and reactive dyes respectively. It was found that treated samples have better garment performance compared to the untreated one.

Radar chart areas were calculated and tabulated in Table 4. Data of Table 4 illustrated that all samples treated with one step method have better properties for garment performance than that have the treated samples using two step method. Figures 4 and 5 show that samples treated with nanoclay and nanochitosan by one step have the best results for air permeability and thickness, which mean that the treatment improves greatly durability and comfort properties for the garments. Table 4 demonstrated also that the samples treated with nanocaly have the best results irrespective of the presence or absence of RCD using the one step method, while nanocellulose have the largest radar chart area when using the two step method treatment. Finally, it can concluded that samples treated with nanoclay, nanoclay/RCD and nanocellulose/RCD are the most recommended fabrics to be used as summer and winter garment.

Conclusions

Nanoclay, nano-chitosan and nanocellulose structural materials were prepared and applied to viscose fabrics in presence of reactive cyclodextrin (RCD) and Na_2CO_3 according to two different methods. The latter include the one-step loading method whereby the viscose fabrics were treated with one solution containing all ingredients and; the two-step loading method involving treatment first with the RCD and Na_2CO_3 followed by treatment with the nanomaterial. The single treatment entailed in the one-step method and the double treatments entailed in the two- stop method were performed according to the convention pad-dry-cure technique.

Besides characterization of the nano-sized particles, the loaded viscose fabrics were evaluated for their technical properties vis-a-vis those of the untreated fabrics. These properties encompass dyeability, add-on %, air permeability, moisture regain %, thickness and nitrogen content %. SEM, TEM and FTIR were also used to shed insight on the morphology and chemical structures of the loaded viscose fabrics. Of the conclusions arrived out from current studies, mention is made of the following:

1) SEM micrograph illustrates the deposition of nanoparticles on the viscose fabric surface due to loading this fabric with one of the nanomaterial together with RCD as per the one-step method.

2) FTIR reveals the appearance of bands synthesized through treatment of RCD (MCT-B-CD) with nanoclay.

3) Important absorption bands are shown by FTIR spectra of nanochitosan/RCD loaded viscose fabrics.

4) The viscose fabrics loaded with the nanomaterials under investigation are much more amenable to dyeing with direct and reactive dyes than the pretreated as well as untreated fabrics.

5) Nanoclay induces the highest dyeability among the three nano materials examined.

6) The magnitude of dyeability, expressed as color strength, fastness to washing and fastness to alteration, obtained with the one-step loading method is higher than those of the two-step loading method.

7) The abrasion is better when treatment viscose fabrics with Nanocellulose, Nanochitosan and Nanoclay respectively at first method that means improving the durability of treated viscose fabrics.

8) The moisture regain % and thickness of the loaded viscose fabrics are improved while their air permeability is reduced.

9) Fabrics treated with nano materials in respective to the used method show a good antimicrobial resistance compared to the fabrics treated with only cyclodextrin as well as untreated one, this will be suitable to use in medical fabric as sheet, garment in hospital or applications in children's clothing.

10) Radar chart of the treated samples reveals that samples treated with both nanoclay and nanocellulose are the most recommended fabrics to be used as summer and winter garment.

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خواص وظيفية متعددة لأقمشة الفسكوزمن خلال معالجة بمواد نانومترية عضوية وغير عضوية

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تهدف هذه الدراسة إلى معالجة أقمشة الفسكوز لإكسابها بعض الخواص الوظيفية الجديدة مثل مقاومة الاحتكاك و السمك و نفاذية الهواء وسمة استرجاع الرطوبة. وايضا مقاومته لأنواع مختلفة من الفطريات والبكتيريا.

ولذلك تم معالجة اقمشة الفسكوز بمواد متناهية الصغر (نانو مترية) صديقة للبيئة مثل النانو كلى و النانو كيتوزان و النانو سليلوز. وقد تم تحضير محلول معالجة يحتوى على مادة السيكلودكسترين النشطة و كربونات الصوديوم مع احدى مواد النانومترية السابقة و اجراء المعالجة للاقمشة بهذا المحلول باستخدام تقنية الغمر و العصر و التجفيف و التحميص. و تم قياس حجم المواد النانومترية المستخدمة(TEM) .

تم فحص سطح الألياف المعالجة باستخدام الميكروسكوب الإليكتروني والذي أوضح وجود المواد تغيرعلى سطح الأنسجة نتيجة للمعالجة.

تم تحديد التغير فى تركيب اقمشة الفسكوز المعالج بالاشعة تحت الحمراء والتي أوضحت وجود مجموعات السيكلودكسترين النشطة على سطح الأنسجة وتم أيضا قياس المحتوى النيتروجينى ومقارنتها باقمشة الفسكوز غير المعالجة.

تم دراسة الخواص الفيزيقية و الميكانيكية لاقمشة الفسكوزالمعالجة واقمشة الفسكوز غير المعالجة وقد أثبتت النتائج تحسن واضح في مقاومة الاحتكاك و السمك و نفاذية الهواء وسمة استرجاع الرطوبة.

قد تم صباغة اقمشة الفسكوزالمعالجة و غير المعالجة بصبغة مباشرة و اخرى صبغة نشطة وتم قياس شدة اللون و ثبات الصبغة للغسيل وقد أثبتت النتائج تحسن ملحوظ في شدة اللون و الثبات للغسيل.

اكتسبت ايضا اقمشة الفسكوزالمعالجة مقاومة لبعض انواع الفطريات والبكتريا بنوعيها السالبة والموجبة

و قد تم عمل دراسة احصائية (Radar chart) لجميع الخصائص المدروسة لتعين افضل ظروف معالجة .