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Preparation of multifunctional medical reusable gowns using TiO_2 nanosol gel /β-CD/triclosan for improvement of self-cleaning and antibacterial properties

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Abstract : To realize the development of medical reusable gowns for bedridden patients using nano-sol-gel coating, a plenty of experiments have been carried out to prepare TiO_2 nano sol-gel for self cleaning cotton treated fabric. On the other hand triclosan,β cyclodextrin and glyoxal were the main modifying agents for cotton fabrics throughout this study under different condition for bearing antibacterial and self cleaning properties. The products are characterized by SEM micrographs,TEM , XRD and EDS analysis. A study of fabric performance and antibacterial properties of treated cotton fabrics and its durability to washing were evaluated .Results revealed that finished cotton fabrics reserved most of their performance including properties in addition to enhanced water permeability, abrasion resistance ,UV protection and stain release (OSR).Finished cotton fabrics treated under these conditions ,exhibited a durable antibacterial characteristic and thus can be categorized as multipurpose medical textiles used in production of reusable gowns required for bedridden patients.

Key words : reusable gowns-bedridden patients-β cyclodextrin-triclosan-sol-gel coating.

1. Introduction

Gowns represent basic clothes for hospitalized, bed ridden patients that should be characterized by their ability to provide protection against penetration of liquids and micro-organisms, abrasion resistance, strength, softness, breathability, stain resistance and thermal insulation properties[1], antibacterial properties and discoloration of stains [2-4].

Functionalization of textile products using nanotechnology involves improvement of their characteristics including soil resistance, wrinkle recovery, water repellence, resistance to micro-organisms, anti-static, self cleaning, flame retardancy, energy storing and other allied properties[5-7].

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Extensive studies on photo-catalytic, self cleaning and bioactive textile industry have been carried out in relation to textile industry, particularly for their less water and detergent demands. Among the photo-catalysts investigated, titanium dioxide which is considered to be superior photo-catalyst due to its outstanding chemical stability, suitable bond gap, blocking UV light, non-photocorrosive nature and its economic value [8].

It islogical to mention that nanoparticles have a large surface area-to-volume in addition to surface energy, i.e. better affinity for textile substrates thereby leading to an increase in durability while maintaining breathability and/or hand feel

The application of nano-sized titanium dioxide in textile finishing has been discussed recently and in some details. More insight has been given to sol-gel technique way of application to impart an effective protection against bacteria and self cleaning due to photocatalytic activity as well [5, 9, 10].

The primary objective of the current work is to prepare titanium dioxide naoparticles following the Sol-gel procedure and then applied to cotton fabric, the finishing process is controlled by two parameters, namely, the use of different finishing formulations and variation in sequence of treatment. The Sol-gel procedure for preparation of titanium oxide nano particles is advantageous due to achievement at low temperature, advanced performance and homogeneity of the breathability.

2. Experimental work

1. Preparation of titanium dioxide nano-sol-gel

Titanium dioxide nanoparticles were synthesized following sol gel procedure as follow:

The aqueous nano titanium dioxide sol-gelwas prepared by mixing titanium isopropoxide (10 g) with absolute ethyl alcohol (100 ml), glacial acetic acid (50 ml) and distilled water (50 ml) at room temperature. The mixture was left for an hour under vigorous stirring before being applied to the cotton substrate.

2. Treatment of cotton fabric with titanium dioxide nano-sol-gel

An aqueous formulation containing titanium dioxide nano-sol-gel in different concentrations ranging from(2.5 g/l to 10 g/l) were prepared. Bleached twill cotton fabric was padded in the already described aqueous formulation to a wet pick-up of about 80 %, dried at 80 °C for 5 minutes and cured at 120 °C for 3 minutes. The cured fabric samples were rinsed with distilled water to remove the excess and un-reacting nano titanium dioxide followed by drying before being evaluated.

3. Treatment of cotton fabric with resin followed by treatment with nano TiO_2 in presence and absence of triclosan

Fabric samples were padded twice in a finishing bath containing glyoxal (50 g/l), β-Cyclodextrin (40 g/l) and aluminium sulphate (5 g/l) to a wet pick-up of ca. 80 %. The treated samples were dried at 50 °C for 5 minutes followed by further padding in nano titanium dioxide sol-gel (10 g/l), curing at 120 °C for 3 minutes.

Fabric samples were padded twice in a finishing bath containing glyoxal (50 g/l), β-Cyclodextrin (40 g/l) and triclosan (10 g/l) to a wet pick-up of ca. 80 %. The treated samples were further padded in nano titanium dioxide sol-gel (10 g/l) and curing at 120 °C

4. Mechanism of TiO_2 nanosol-gel formation, fixation and self-cleaning of cotton treated fabric

According to previous reports [11-13].Preparation of titanium dioxide nano sol, formation of the gel and fixation of titanium cluster onto cotton fabric, a number of interactions are thoroughly explained. These stages of reactions are represented below:

$$\equiv Ti(OR) + H_2O \longrightarrow \equiv TiOH + ROH \quad \text{Hydrolysis} \quad [1]$$

$\equiv$TiOH + $\equiv$TiOH $\longrightarrow$ $\equiv$Ti – O – Ti + H_2O condensation [2]

and/or

$\equiv$ TiOH + $\equiv$ Ti(OR) $\longrightarrow$ $\equiv$Ti – O – Ti + ROH condensation [3]

Where

R is an organic group and,

Ti – O – Ti is a colloidal oxid network in the sol form.

Gel formation / fixation – cluster onto cotton fabric

TiO_2 – nano sol network $\xrightarrow{\text{heat}}$ gel formation [4]

Titania ≈≈≈≈ OH + Cell – OH $\xrightarrow{\text{heat}}$ Nano –TiO_2 – loaded cotton fabric [5]

Photo – catalysis / self cleaning [14]

TiO_2 + hv (energy ≥ 3.2 ev) $\xrightarrow[\text{Excitation}]{\text{Heat}}$ $h^+ + e^-$ [6]

H_2O + hv $\longrightarrow$ $^{\bullet}OH + H^+$ [7]

$O_2 + e^-$ $\longrightarrow$ $O_2^{\bullet}$ + H^+ $\longrightarrow$ $HO_2^{\bullet}$ [8]

2 $HO_2^{\bullet}$ $\longrightarrow$ O_2 + H_2O_2 [9]

H_2O_2 + O_2 $\longrightarrow$ $^{\bullet\bullet}OH$ + OH^- + O_2 [10]

Oily stain + Reactive oxygen species ($^{\bullet}OH$, $HO_2^{\bullet}$, H_2O_2, etc)

- $\longrightarrow$ Photo catalytic degradation products of TiO2 nanosol gel [11]

5. Analysis, testing and finished fabric evaluation

- Tensile strength (TS) was tested in the warp direction according to ASTM: D 1296 – 98.
- Water vapour permeability (Moisture vapor transmission, MVTR or breathability. It is determined with the HRN: EN 20811:2003.
- X- Ray Diffraction (XRD) patterns of TiO_2 nanoparticles sol-gel coated cotton fabrics were recorded on a Philips PW 3050/10model. The samples were recorded on a Philips X-Pert MMP diffractometer. The diffractometer was controlled and operated by a PC with the programs P Rofit and used a MoK source with wavelength 0.70930˚A, operating with Mo-tube radiation at 50 kV and 40 mA.

- Oil stain release;(OSR,AATCC test method 130-1993)will be assessed after UV-irradiation using a UV-light lamp (Philips TLOS8w with a maximum intensity, wave length (λmax at 365nm) for 30 minute at room temperature

6. Result and Discussion

The current work is undertaken with view of development of desired functionalities and to improve cotton attributes as an added value to the textile product. Hence, a target is designed to fulfil these requirements covering self cleaning and antibacterial properties of cotton fabrics using titanium dioxide nanoparticles. Methodology of the treatment involving finishing formulation composition and sequence of treating steps has been thoroughly investigated. A number of analyses, assessments and evaluations of the finished fabrics have been carried out. Results obtained and their appropriate discussions in some details are given below

6.1Factor affecting the treatment of cotton fabric

6.1.1. Variation in aluminium sulphate concentration

A study of the influence of using different concentrations of aluminium sulphate $Al_2(SO_4)_3$. 18 H_2O (5 g/l – 15 g/l) in the treating formulation in presence of glyoxal (50 g/l)and β- CD (40 g/l)at pH 4 on the performance of cotton fabric as compared with the untreated cotton has been systematically carried out. Results of these experiments, as given in table 1, revealed that increasing the aluminium sulphate causes marginally lower values of fabric performance most probably due to increasing acidity of the treating medium. From the results arrived at from this study it can be concluded that using aluminium sulphate in 5 g/l concentration and at pH 4 are considered to be optimal conditions for carrying out these treatments.

Table 1: Effect of variation in aluminium sulphate concentration at pH 4

$Al_2(SO_4)_3$ concentration (g/L)	T.S (Kg)	Lose in T.S. (%)	Elongation at break	Tear strength (gm)	Water vapour permeability g/m2/24hrs MVTR
Untreated cotton	77	-	18	2000	430
5	57	25.97	16	1500	1227
10	56	27.27	16	1500	1250
15	55	28.57	15	1400	1245

Glyoxal (50 g/l); β- CD (40 g/l); drying (80 ^oC / 5 minutes); curing (120 ^oC / 3 minutes)

6.1.2.Effect of Titanium dioxide nano sol-gel concentration

The influence of variation in titanium dioxide nano sol-gel concentration on the fabric performance of the treated samples using pad-dry-cure method of application has been examined.

Tensile strength, the results displayed in table 2 indicate that increasing the titanium dioxide nano sol-gel concentration in the treating bath up to 10g/l is accompanied by a slight decrement in the tensile strength from 77 kg to 71 kg. The same trend hold true with elongation at break and tear strength as well.

The results revealed that a decrement in the values of water vapour permeability (i.e breathability) is observed upon raising the amounts of titanium dioxide nano sol-gel employed in the finishing bath comparing to untreated cotton fabric . These decrements in (MVTR) are attributable to the formation of nano-sized tetania film causing stiffness and a reduction in the level of extruding surface leading to slight blocking to water vapour transmission on the fabric surface. In addition, the covalent bonding between uncondensed hydroxyl groups of titania and those of cotton cellulose may account for this relation[13, 15]

The titanium dioxide nano sol-gel loaded fabric samples improved self-cleaning properties expressed as oily stains release rating. Results shown in table2 reflect the enhanced stain release rating (3, 5 and 5) with higher concentrations (2.5, 5 and 10 g/l) of titanium dioxide nano sol-gel in the finishing bath respectively. This can be explained in terms of the high photo catalytic activity of the nano-sized titanium dioxide nanoparticles. Such activity participates to enable generation of highly oxidative radicals onto the tetania film and subsequent photo-decomposition of the oily stains on nano titanium dioxide loaded fabric surface and thus prevent them from build up[8]leading to improve self cleaning.

Table 2: Effect of TiO_2 nano sol-gelconcentration on performance properties of treated cotton fabric

Nano sol-gel conc. (g/l)	T.S (Kg)	Loss in T.S. %	Elongation at break	Water vapour permeability g/m^2/24hrs MVTR	OSR	Tear strength (gm)
Untreated cotton	77	-	18	430	-	2000
2.5	75	2.5	17	410	3	1800
5	73	5.1	16	400	5	1700
10	71	7.7	16	400	5	1600

Titanium dioxide nano sol (0-10 g/l); non-ionic wetting agent (2 g/l); wet pick up (80 %); drying (80 ^{o}C / 5 minutes); curing (120 ^{o}C / 3 minutes).Where T.S tensile strength OSR oily stain release rating.

Increasing the titanium dioxide nano sol-gel concentration caused decrement in tear strength as compared with the untreated samples. This can be ascribed to the role of titanium coating film causing stiffness on the fabric surface leading to photo-induced deterioration in tear strength. It is also believed that reduction in tear strength values may be attributed to the acidity encountered with higher concentration of titanium dioxide nanosol-gel.

Higher concentrations of titanium dioxide nano sol-gel(2.5, 5 and 10 g/l) are found to be irreversible proportional to the values of tear strength (1800, 1700and 1600) for treated samples respectively.

6.1.3. Effect of variation in the sequences of treatment by TiO2 nano sol-gelin presence and absence of triclosan on performance and self cleaning properties of cotton treated fabrics

These treatments were performed independently according to the following scheme:

a) Padding / glyoxal and β-CD → drying →padding in titanium dioxidenano sol-gel → drying →Curing →washing

b) Padding in glyoxal , β- cyclodextrin and triclosan → drying → padding in titanium dioxide nano sol → drying → curing →washing

c) NanoTiO2 sol-gel →drying → (resin+ β- cyclodextrin) →drying →Curing →washing →

d) NanoTiO2 sol-gel → drying → (resin+ β- cyclodextrin + triclosan) → drying → Curing → washing

Cyclodextrin moieties bonded to crosslinked cellulose through ether linkage can function to receive antibacterial agents to render its resistant to microorganisms.

Furthermore, these torus – shaped cavities of the cyclodextrin side molecules exhibit the ability to complex varies metal ions and such complexation can be enhanced when cyclodextrin is modified with suitable functional groups. These can be verified through crosslinking of hydroxyl groups outside the interior cavity [13].

The results of the effect of aforementioned treatments on the cotton fabric tenacity properties including tensile strength, elongation at break and tear strength, as given in table 3, indicated that acceptable slight decrementin cotton fabric performance takes place when treated under these conditions. These findings can be explained on the bases of stiffness of the treated fabric caused by titanium dioxide nanoparticles where a rigid layer is formed on the fabric surface. This effect is synchronized with partial decrease in degree of polymerization of the treated fabric due to acidity encountered during the finishing process under the action of curing [13].

Results obtained signify that cotton fabric– loaded with TiO_2 nano sol-gel samples is accompanied with a slight decrease in tensile properties and MVTR as compared with the untreated cotton. On the contrary, a remarkable increase of the oily stain release rating is observed as improved self cleaning character.

Treatment of cotton fabric with resin in the form of glyoxal and with β-cyclodextrin followed by titanium dioxide nano sol-gel in 5g/L concentration produces cotton fabrics with enhanced (MVTR), this probably due to the hydrophilicity of cotton treated fabric and the role of β-CD in forming complexes without affecting the hydrophilic characteristic of treated cotton fabrics [12].

Upon treating cotton fabric with resin, β- cyclodextrin, triclosan followed by titanium dioxide nano sol-gel in presence of a catalyst, the treated fabrics become more permeable, most probably due to deposition of triclosan on the β- cyclodextrin cavities over the fabric surface.

For a given set of treatments, the data displayed in table 3 signify that fixation of titanium dioxide nano sol-gel onto and / or within the fabric samples results in a remarkable improvement in their self cleaning characteristics expressed as oily stain release rating values.

Table 3: Effect of pre-treatment with resin finishing in presence and absence of triclosan followed by treatment of TiO_2 nano sol-gelon performance of cotton fabric

Sequence of treatments	**T.S (Kg)**	**Elongation at break**	**Tear strength (gm)**	**Water vapour permeability g/m2/24hrs MVTR**	**OSR**
Untreated cotton	77	18	2000	420	2
NanoTiO_2 sol-gel → drying → Curing → washing	71	16	1700	400	5
(resin+ β- cyclodextrin) → drying padding → NanoTiO_2sol-gel → drying → Curing → washing	54	15	1400	570	5
(resin+β-cyclodextrin + triclosan) drying → padding NanoTiO_2 → sol-gel → drying → Curing → washing	52	15	1200	800	5
NanoTiO_2 sol-gel → drying → (resin+ β- cyclodextrin) → drying → Curing → washing	54	15	1400	515	5

NanoTiO_2 sol-gel → drying → (resin+ β- cyclodextrin + triclosan) → drying → Curing → washing	53	15	1300	720	5

Titanium dioxide nano sol-gel (5 g/l); glycoxal (50 g/l); β- cyclodextrin (40 g/l); triclosan (10 g/l); $Al_2(SO_4)_3$ (5 g/l) at pH 4; wet pick up (80 %); drying (80 ^oC / 5 minutes); curing (120 ^oC / 3 minutes).

A study of the physico – chemical properties of cotton fabrics pre – loaded with titanium dioxide nano sol-geland subsequent treatment with glyoxal and β- Cyclodextrin in presence and absence of triclosan was performed.

Results of treatment of cotton fabric preloaded with resin and β-CD in presence and absence of triclosan followed by treatment with TiO_2 nano sol-gelshow a decrement in tensile strength, improvement in MVTR and in oil stain release rating (OSR)

Settlement of titanium dioxide clusters onto / into the cellulose matrix as well as uniform distribution of nanoparticles and tendency to agglomeration play an important role in the trend of results arrived at throughout this investigation

6.2. Characterization and Evaluation

6.2.1Characterization of titanium dioxide nanoparticles

6.2.1.1 Transmission Electron Microscopy

The morphology and size of titanium dioxide nanoparticles have been carefully investigated using Transmission Electron Microscopy (TEM). Micrographs are shown in Figure 1 and indicate that the particle sizesare ranging between 17 nm and 18 nm and exhibit a strong tendency to exist in an agglomerated form.

TEM images in Figure 1demonstrate TiO_2 nano sol-gelmorphology. Since a nanoparticle emulsion was used for observation a network structure was obtained due to the high agglomeration tendency of nanoparticles in the emulsion. However, in spite of agglomeration, individual particles can be identified and it appears as polydisperse in size. The measurements on 100 particles yielded an average particle size diameter of 17 nm - 18 nm.

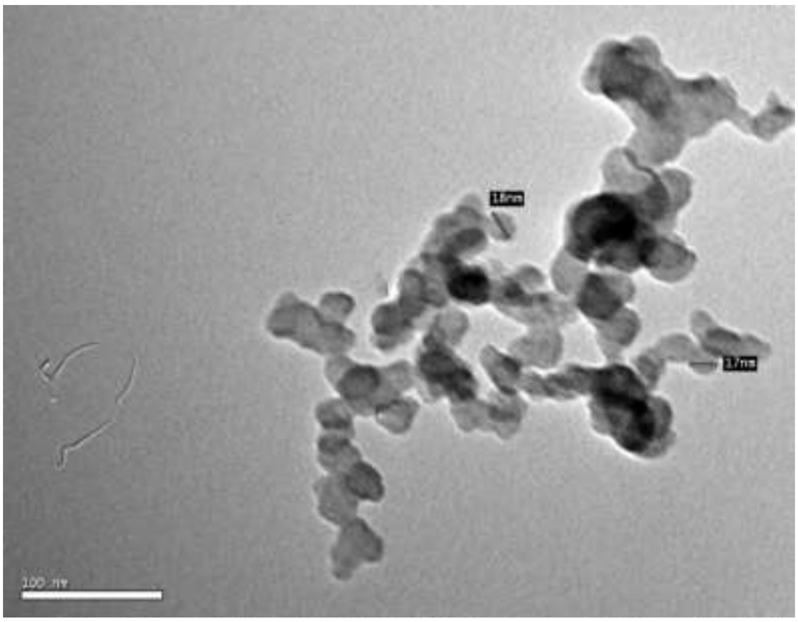

Figure 1: Transmission electron microscope image of TiO_2 nano sol-gel

6.2.2 Characterization and Evaluation of treated fabric

6.2.2.1. Scanning Electron Microscopy

The imaging of untreated cotton fabric and cotton fabric samples treated with titanium dioxide nano sol-gel are performed using Scanning Electron Microscopy (SEM) and illustrated by (figure 2a,b). Evidently, it could be observed that the untreated cotton exhibits a rough surface along with some deposits and protruding fibres (figure 2a) On the contrary, treated fabric samples with TiO_2 nano sol-gel , as represented by Figure 2b, are characterized by an even and smooth surface reflecting the formation of a uniform continues titania layer.

These SEM studies in Figures 2c and 2d proved that the **TiO_2**nano sol-gelare deposited on the β-CD crosslinked cotton. The β-CD crosslinked was creating uniformed surface structure of cotton fabric.

Variation in the sequence of treatment cotton fabric showed uniformed surface and the deposition is also clearly viewed **in figure (2e,f)**

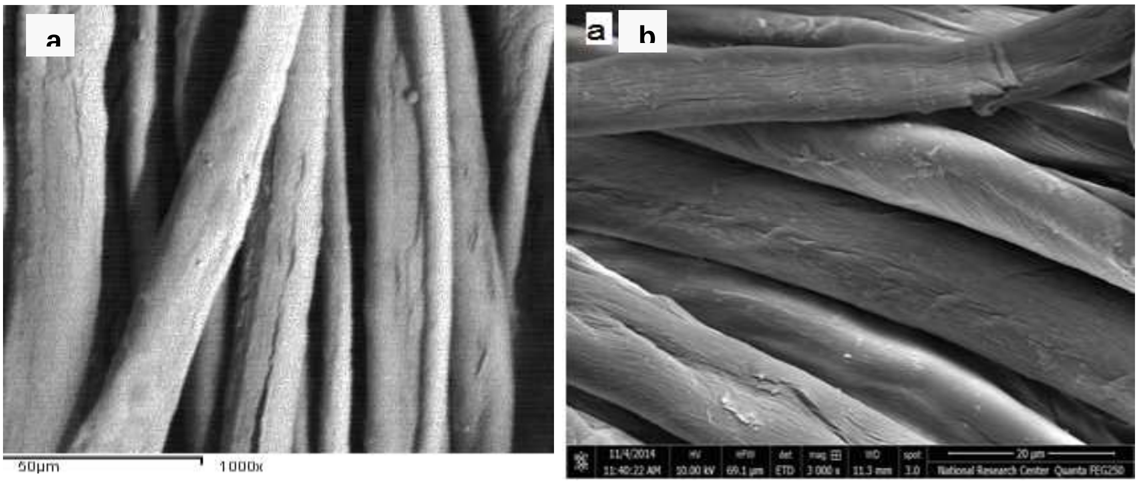

Figure 2: (a) SEM image of untreated cotton fabric (b) SEM image of TiO_2nano sol-gelloaded on cotton fabric

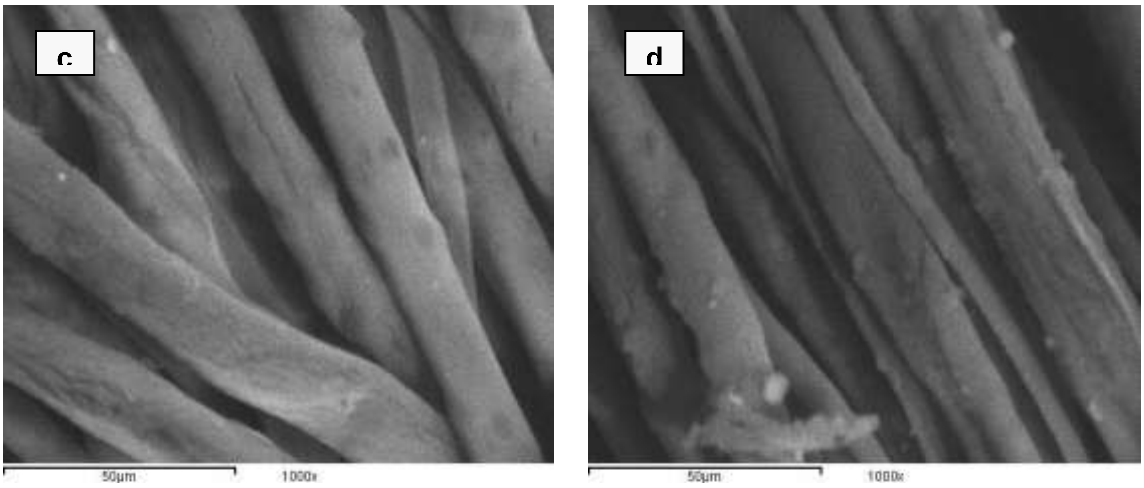

Figure (2c,d). SEM images of cotton fabric treated with , resin, β-cyclodextrin, $Al_2(SO_4)_3$in presence and absecene of triclosan followed by TiO_2 nanosol-gel Condition used : β-cyclodextrin (40 g/l); glyoxal (50g/l); $Al_2(SO_4)_3$ (5 g/l) ; TiO_2nano sol-gel (5 g/l)

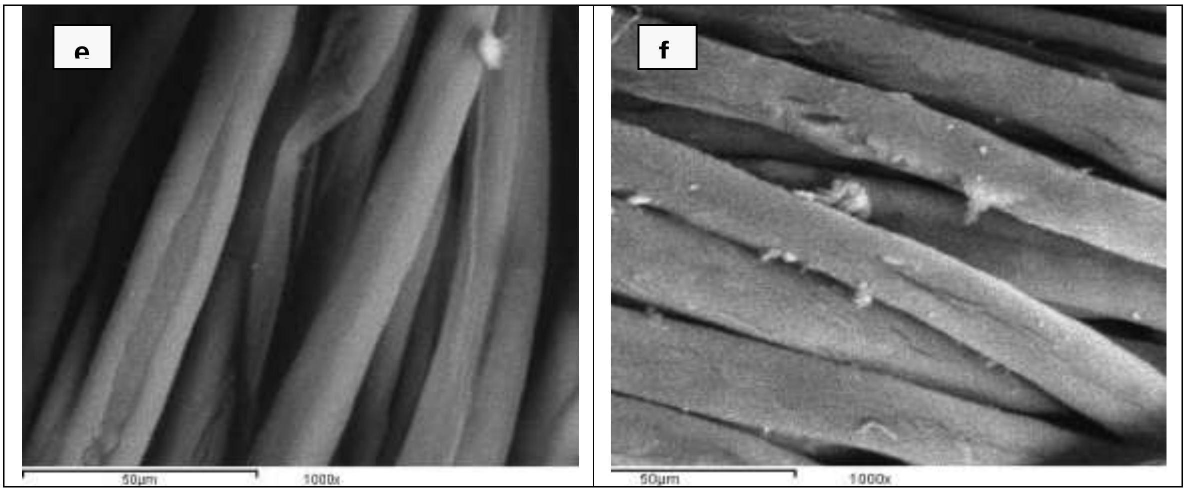

Figure 2 e,f SEM images of cotton fabric treated with TiO_2nano sol-gel followed by β-cyclodextrin , resin , catalyst in presence and absence of triclosan Condition used :[TiO_2] nano sol –gel (5 g/l) ; β-cyclodextrin (40 g/l); resin (50g/l); $Al_2(SO_4)_3$ (5 g/l) ,triclosan (10g/l).

6.2.2.2.X-Ray diffraction (XRD) analysis& X-ray spectroscopy EDS analysis

The x-Raydiffractionpatterns of titanium dioxide nanoparticlesas well as **EDS analysis**are shown in(figure 3a,b). It can be observed in figure 3a that the major peak of spectrum is anatase (2y ¼ 23.2), therefore, the coated fabrics with nano TiO_2 particles have anatase crystallite phase.

On the other hand, the chemical composition of the film coating the surface of cotton fabric was studied by energy X-ray spectroscopy EDS analysis in figure3b and it is found that titanium,oxygen and carbon were the only detected elements .

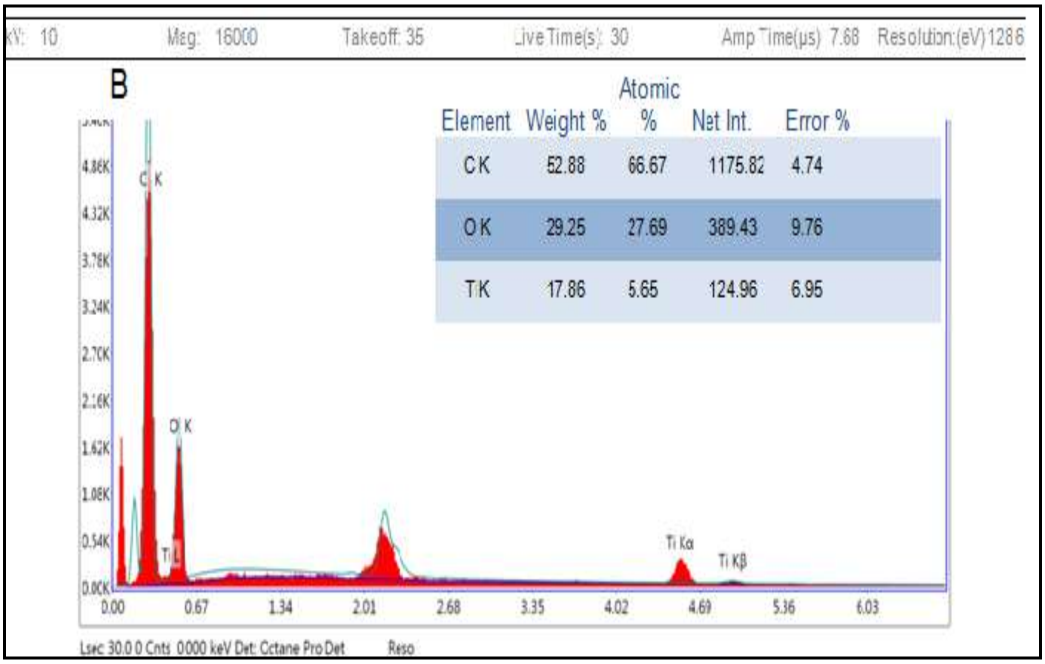

Figure 3a: EDS analysis of TiO_2 nanoparticles on cotton fabric

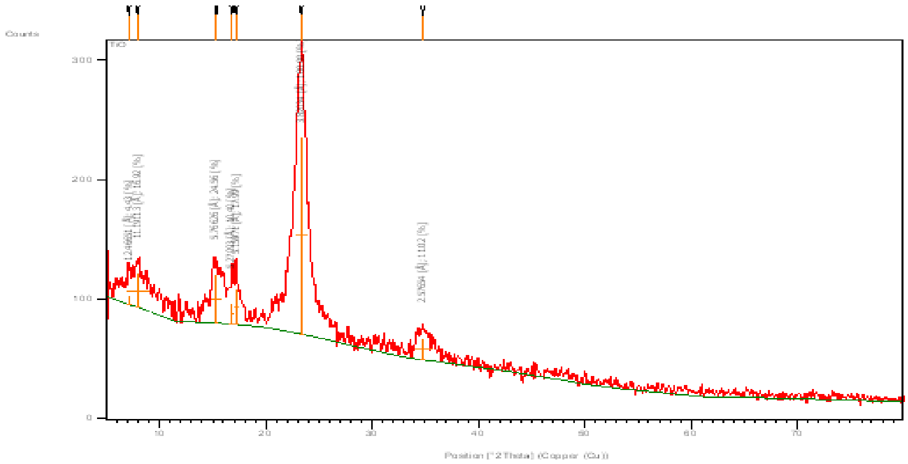

Figure 3b: x-ray diffraction (XRD) analysis of TiO_2 treated fabric

6.2.2.3. Ultraviolet protection factor

The values measured for ultraviolet protection factor (UPF) represent the ability of finished fabrics to protect the human skin against sun burning. The protection factor values also indicate how long a person can stay exposed to sun light with a given covering on the skin as compared to uncovered response.

In the present work, a target for improving UV blocking properties in cotton fabric with TiO_2nano sol-gel is undertaken. The sol-gel application technique for preparation of this coating was employed.

Titanium dioxide is categorized as a kind of semiconductors with a large band gap between its low energy valence band and its high energy conduction band. When TiO_2 is illuminated by light with energy higher than its band gaps or with wavelength shorter than the absorption edges, the electrons will absorb the energy of the photons and will be excited to cross the band gap, so as to produce pairs of electrons and holes. These excited electrons and holes will then combine with other holes or electrons. This explains how the TiO_2 functions as UV protector [13].

It is seen table 4 that, increasing the concentration of TiO_2 nano sol-gel from 5g/l up to 10g/l is accompanied by a noticeable increase in the ultraviolet protection factor (UPF).Evidently using TiO_2nano sol-gel at a concentration of 10 g/l along with the other reagent in the finishing bath is advantageous UPF from 8.54(non-ratable) up to 50 (excellent) which reflects the positive impact of TiO2nano particles on the extent and efficiency of UV protection .

Subsequent treatment of resin treated fabric samples in presence of β-cyclodextrin and triclosan followed by TiO_2nano sol-gel resulted in remarkable amelioration in UPF characteristics. The same hold true of the pre-loaded samples with nano-TiO_2 followed by treatment with resin finishing in presence of β-cyclodextrin and triclosan

Table 4: Effect of titanium dioxide nano sol-geltreatment on UV protection properties of cotton fabrics

Treatment	**UPF**	**Protection level**
Untreated	8.54	Non ratable
5 g/l nano TiO_2	40.0	Very good
10 g/l nano TiO_2	50	Excellent
50g/lGlyoxal -40g/l βCD – 10 g/ltriclosan– 10g/lTiO_2	50+	Excellent
10 g/l TiO_2-50g/l Glyoxal -40g/l βCD – 10 g/ltriclosan	50+	Excellent

Where UPF range,(good(15-24),very good(25-39) and excellent (40-50)

It was concluded that nano – sized titanium dioxide showed higher efficiency in absorbing and scattering UV radiation due to large surface area and, thus, being more capable to block UV radiation. This can be explained in terms of the fact that nano particles exhibit larger surface area per unit mass and volume than the normally sized materials, leading to increased effectiveness of blocking UV radiation, i.e., the application of UV – blocking treatment to fabric samples using nanotechnology was achieved. UV blocking treatment of cotton fabric using the sol – gel process led to the formation of a thin layer of TiO_2 on the surface of treated fabric which provides excellent UV - protection[16].

6.2.2.4. Antibacterial activity of titanium dioxide – loaded cotton fabrics.

Cotton fabrics having the antibacterial properties were prepared according tothe procedure described in the experimental section. Treated samples were evaluated for antibacterial properties against (gram +ve) and (gram –ve) bacteria up to 10 washing cycles following the standard diffusion disk method. Samples of untreated cotton were also exposed to the same evaluation for comparison.

Table 5: Effect of treatments Sequence of cotton fabric on the antibacterial activities and abrasion resistance

Sequence of treatments	**IZD**				**Abrasion resistance**
	After one washing cycle		**After ten washing cycle**		
	G –ve E-coli	**G +ve S-aureus**	**G –ve Ecoli.**	**G +ve S-aureus**	
Untreated cotton	0	0	0	0	483
1. 1. TiO_2 2.5 g/l	0	0	0	0	581
2. TiO_2 5 g/l	12	12	11	10	560
3. TiO_2 10 g/l	14	13	12	11	539
4. glyoxal + β- CD + triclosan padding → $TiO_2$10g/L	26	30	22	27	374
5. padding10g/LTiO_2 → glyoxal + β- CD+ triclosan	25	29	22	26	366

Titanium dioxide nano sol-gel (0-10 g/l); glycosal (50 g/l); β- cyclodextrin (40 g/l); triclosan (10 g/l); $Al_2(SO_4)_3$ (10 g/l) at pH 4; wet pick up (80 %); drying (80 ^oC / 5 minutes); curing (120 ^oC / 3 minutes).

The results displayed in Table 5 show the inhibition zones observed with cotton samples loaded with different concentrations of titanium dioxide nano sol –gel (2.5, 5,10 g/l). Results, as given in Table 5, revealed that the inhibition zone diameter (IZD) of the untreated cotton is zero, while different values of IZD were obtained with treated samples depending upon the titanium dioxide nano sol concentration as well as the additives employed in the finishing process.

The data reflect the influence of using different amounts oftitanium dioxide nano sol-gelon the level of antibacterial activity, as expressed by IZD values, and signifies that higher levels of this property are observed when the concentration of titanium dioxide nano sol-gelare increased.The extent of enhancement the antibacterial efficiency is in accordance with the photocatalytic effect of titanium dioxid nano sol-gel resulting in destruction of bacteria cell in addition to the bactericidal character of triclosan as a component incorporated in the treating bath. These differences in efficiencies reflect the variation in membrane structure for S-aureus (gram +ve) and E-coli (gram –ve) and their amenability to destruction[17]

Table 5 shows also that, a number of experiments are conducted to determine how far the antibacterial activity of cotton fabric loaded with Titanium dioxide nano sol-gel in presence of glyoxal and β-Cyclodextrinunder the catalytic effect of aluminium sulphate is durable to repeated washing cycle. Increasing repeated laundering up to 10 washing cycles (table 5) has practically slight effect on the antibacterial properties of treated samples. This can be attributed to the covalent bonding between free hydroxyl groups of titania cluster and / or among the cellulose hydroxyls and those of β- Cyclodextrin as well as presence of triclosan in the treating medium. These findings can be clarified in terms of the roll of β- Cyclodextrin in hosting the antibacterial agent molecules, keeping them as inclusion complexes in the cavity and slow release of the finish over long time and withstanding this number of washing cycles [18].

Table 5contains the effect of variation in TiO_2 nano sol-gel concentration on the abrasion resistance of the resulting treated samples. Results of table 5 revealed that increasing TiO_2 concentration is accompanied by an increment in abrasion resistance of the treated fabric as compared with untreated fabrics. A significant decrease in abrasion resistance of the treated samples was due to finishing treatment. It is also found that the abrasion resistances of the treated samples are slightly improved for samples past treated with TiO_2nano sol-gelas compared with those pretreated with TiO_2.

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Conclusion

Plenty of experiments were conducted to functionalize cotton fabrics to impart enhanced textile performance and bactericidal properties. Titanium dioxide nano sol-gelwas the main finishing agent to modify twill- weave cotton fabric under a variety of reaction conditions. Glyoxal, β- Cyclodextrin and triclosan were used also in the treating bath under the catalytic effect of aluminum sulphate. Products are characterized by TEM micrographs, SEM imaging, EDS and X-Ray diffraction. Textile performances of finished fabrics areevaluated. Results revealed that finished products reserved most of their functional performance can be considered as potential requisite for various applications.

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