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Enhancing nano anti-bacterial treatment of cotton fabrics via UV irradiation

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ABSTRACT:

Different applications used nano materials such as Nano-Oxides or Nano-Salts i.e. silver nanoparticles (Ag NPs.) or zinc oxide Nano-particles (ZnO NPs.) to acquire antibacterial activity for cotton fabrics. In the present study chitosan treated cotton fabrics followed by nano treatment via Ag NPs. or ZnO NPs., or mixture of both nano-materials had been subjected to UV irradiation using medium pressure mercury lamp with a light intensity on the fabric of about 15mW/cm2 to produce an enhancement in the anti-bacterial activity against Gram +ve and Gram –ve bacteria i.e. *St. coccus* and *E. coli*. The produced yield was assured with FT-IR and scanning electron microscope. The best result for Gram negative bacteria (*Escherichia coli*) obtained by using mixture of (Ag NPS (100ppb) + ZnO NPS (8% o.w.s) + UV) as well as for Gram positive bacteria (Staphylococcus Aureus) the best result obtained by using mixture of (Ag NPS (100ppb) + ZnO NPS (8% o.w.s) + UV).

KEY WORDS: Chitosan, Nano silver, Nano oxides, Antibacterial activity, Gram negative and positive bacteria, UV Irradiation.

1. INTRODUCTION:

Microbial damage to raw cotton is a prevalent issue since cotton fabrics have low resistance to germs, which can affect the human body owing to intimate skin-to-textile contact after only a few hours of use. Textiles with antimicrobial treatments are used in a wide range of garments, home furnishings, and commercial and industrial items. Tents, tarpaulins, and car textiles that have been treated with an antibacterial finish that reduces or prevents rot and mildew damage will last longer.

As previously stated, the goal of an antimicrobial finish is to prevent the transmission and spread of pathogenic (disease-causing) bacteria.

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Prevent the development of odors caused by microbial degradation. Prevent the loss of textile performance qualities. According to Holme (2007), antimicrobial coatings should meet the following criteria: (1) The activity's ability to withstand dry cleaning laundry Selective action against microorganisms that are unwanted Moisture transport qualities that are acceptable (2) Easy to use and compatible with different antibacterial agents. (3) There are no hazardous repercussions for both the maker and the consumer. Available with no negative impact on the fabric's qualities, such as wear comfort (4) it should be inexpensive. (5) Immune to bodily fluids and disinfectants (sterilization), starch, chitosan, and its derivatives, Carboxy methyl cellulose, and cyclodextrin, as well as nano-inorganic and nano-organic materials-based finishes. (Hebeish and Guthrie, 2012), (Mohamed and Hassabo, 2015) The requirement to change cellulosic fabric with multifunctional features like antimicrobial, conductivity, and UV protection factor (UPF) is critical for new textile items like upholster mattresses, underwear, and protective apparel to be designed. Hospitals, medical clinics, health centers, sportswear, and laboratories all use these types of items. The long-lasting antibacterial cotton fabrics reduce the cost of treating and diagnosing nosocomial contaminations and post infections, which were one of the leading causes of death until the late 19th century, when antibiotics were discovered, the first of which was penicillin, whose commercial production began around 1940 (Mukherjee et al., 2011). Bacterial growth on cellulosic textiles is one of their intrinsic features, and contamination by bacteria causes pathogen cross-infection, odor, discoloration, and loss of textile performance properties. Hence, antimicrobial finishing chemicals are required for many textiles. As a result, there is a compelling need to generate new antimicrobial medicines and uncover innovative methodologies in order to create the next group of pharmaceuticals or agents to control microbial pollution. So, in recent years, breakthroughs in the arena of Nano science and nanotechnology have brought to the fore nano-sized inorganic and organic components that are finding their way into everyday life, increasing the number of applications (Ravishankar and Jamuna, 2011) .Whereas nanotechnology is one of the fastest growing fields in recent years (Narendhar et al., 2014), it contracts with nanotechnology that has applications in biotechnology, farming, biomedical, medication delivery, and extra fields (Majeed and colleagues, 2014). As a result, biotechnology is directly tied to new processes and goods in many scientific and industrial domains. Where biotechnology is a science and technology frontierbiotechnology also has the ability to produce new manufacturing processes that use less energy and are made from renewable resources. It's vital to remember that biotechnology isn't just about biology; it's an interdisciplinary field that encompasses both natural and engineering sciences. Biotechnology is similar to a massive "factory" that not only generates novel ideas for other industries, but also offers the necessary know-how (Sarkar et al., 2003 and Jothi, 2009).The aim of this work is to enhance the antibacterial finish of cotton fabrics via treatment of cotton fabrics with chitosan followed by different kind of nano compounds and finally subjecting the produced treated fabrics to UV irradiation aiming to get the best bactericidal activity.

2. MATERIALS AND METHODS:

2.1 Fabrics

Pure raw woven cotton fabrics of 500 g/m^2 (was kindly supplied by El-Nasr company (Mehalla Kubra, Gharbia, Egypt), were scoured by boiling in 5 g/l of sodium

hydroxide solution and 1 g/l nonionic detergent (Cibapon® R- Ciba)at 90°C for 60 minutes using liquor ratio 50:1. Then rinsed with hot and cold water successively then neutralized by 1% acetic acid solution and finally dried.

2.2 Chemicals

Chitosan obtained from Chitosan Egypt Lab Qualities, silver nitrate, zinc acetate, hydrogen peroxide, peptone, yeast extract, meat extract, Agar, phenol red mannitol ,caustic soda, acetic acid, sodium Hypophosphite, Citric acid and sodium carbonate were all of analytical grade chemicals, delivered from ADWIC Co, Egypt , the test strain Escherichia coli, Staphylococcus aureus were taken from clinical isolates.

2.3 Methods

2.3.1 Scouring of raw woven cotton fabrics

The cotton fabrics were scoured by boiling in aqueous solution containing 2 g/l of caustic soda and 1 g/l of nonionic detergent (Cibapon R Ciba Co.)(Shaaban et al., 2015) using Liquor Ratio 1:20 for 60 min. at 90°C, then washed with hot and cold water and finally dried(A.Hebeish, Kh. Elnagar and M.F. Shaaban 2014).

2.3.2 Bleaching of scoured cotton fabrics

Bleaching of the scoured cotton fabrics was carried using a bleaching solution involving 2 g/l of caustic soda, 6 ml/l of Hydrogen peroxide (50%), 1 g/l of sodium silicate and 1g/l nonionic detergent (Cibapon R) using L.R. 1:20 at 50 °C for 60 min. Then washed with warm and cold water and finally dried (Mohamed Hashem et al., 2009).

2.3.3 Preparation of Chitosan Solution

Different chitosan concentrations were prepared using (0-4% o.w.f) by dissolving the chitosan in a solution of 1% acetic acid using magnetic stirrer until complete dissolution (Hebeish et al., 2013).

2.3.4 Chitosan Treatment of Cotton fabrics

Different concentrations of chitosan were prepared (0-4% o.w.f) using 1% acetic acid for dissolution. Then the samples were padded in previously prepared chitosan solutions each containing (8 g/l CA and 4 g/l SHP). Squeezing the treated samples to a wet pick-up of 100% and dried at 85°C for 5 min, then cured at 170°C for two min.

The treated samples were washed several times with cold water, and then dried at ambient condition (temperature of 25±2°C and relative humidity 65%±5).(El-Alfy *et al.,*2015).

2.3.5 Treatment of Chitosan treated cotton (CTC) with $AgNO_3$ NPs.

CTC (2%) was padded into solutions of (0.003-0.1 ppm) of the $AgNO_3$ NPs separately using lab Padder with a pick up 100% and pressure of 1 bar then cured at 110°C for 1 minute ,washed thoroughly with distilled water, dried at 90°C, weighed and tested against microorganisms(El-Alfy et al.,2015).

2.3.6 Treatment of CTC with ZnO NPs.

CTC (2%) was padded into solutions of (1-10% or 1000-10000 ppm) of the ZnO NPs separately using lab Padder with a pick up 100% and pressure of 1 bar then cured at 110°C for 1 minute ,washed thoroughly with distilled water, dried at 90°C, weighed and tested against microorganisms. (El-Alfy et al.,2015).

2.3.7 Treatment of CTC with a mixture of $AgNO_3$ and ZnO NPs

CTC (2%) was padded into solution mixture containing (8% or 8000 ppm) of the ZnO NPs mixed with (100 ppm) of $AgNO_3$NPs. using lab Padder with a pick up 100% and pressure of 1 bar then cured at 110°C for 1 minute ,washed thoroughly with distilled water, dried at 90°C, weighed and tested against microorganisms.

2.3.8 Treatment of CTC treated with Nano particles with UV-Irradiation

Each of the above three types of solutions (2.3.5, 2.3.6 and 2.3.7) samples were then subjected to UV light for 1 hour, 30 minutes on each side according to in a tiny box with a quartz window using a moderate pressure mercury lamp with a light intensity on the fabric of about 15 mW/cm2 and distance from UV lamp 11 cm, and the antibacterial power was assessed using the Baur Kirby disc diffusion method (Ferreo F., Periolatto M.,2012).

2.4 Testing and Analysis

2.4.1Scanning Electron Microscopy (SEM)

Examination of the surface morphology of the chitosan-cellulose blend films using a JEOL–840X scanning electron microscope, from Japan, magnification range 35–10,000, resolution 200 Å, acceleration voltage 19 kV. The films were deposited onto a copper holder with conductive carbon paint and coated with gold under vacuum before observation.

2.4.2. The nitrogen content

It is measured according to Kjldahle's method. The following equation was used to calculate the nitrogen content on sample weight (Wt.).

$$N\% = \frac{0.014 \times N \times V \times 100}{Wt}$$

Where; V= Volume of HCl; N= Normality of HCl and Wt. = Sample's weight.

2.4.3. Sensitivity Test by Kirby Bauer disc diffusion method

Kirby Bauer disc dispersion technique (Bauer et al., 1966) was achieved in which, the organized antibacterial cotton textile discs (1 cm in diameter) with diverse treatment were used. The colonies from the overnight rising plate were transferred aseptically in disinfected distilled water and vigorously disturbed to give turbidity that equals the 0.5 Macfarlane values (approximately 108 CFU/ml). Antiseptic cotton swab immersed into the culture suspension of E. coli and S. arues was used for inoculation the surface of a hardened nutrient agar plate (NCCLS/CLSI, 2007). Antibacterial cotton discs were distributed onto the inoculated plate surface and softly pressed down using disinfected forceps to insure the whole contact with agar. Within 15 min of smearing discs, the inverted plates were incubated at 37 °C for 24 h. the resulted from widths of inhibition zones everywhere the antibacterial cotton discs were slow with slipping calipers to nearest whole mm and read according to protocols standardized for the assay as shown by the national commission for clinical laboratory values "NCCLS" (Handler, 1998 and NCCLS/CLSI, 2007).

3. RESULTS AND DISCUSSION:

3.1. Morphological Structure

3.1.1. Scanning electron microscope micrographs (SEM)

SEM micrographs of scoured cotton, chitosan-treated cotton (CTC), and Silver NPs-CTC are shown in Figure (1). As can be seen from the micrographs, cotton fabrics undergo morphological changes, the size of which is dependent on the treatment applied to the cotton fabric. Scanning electron microscopy was used to characterize the surface images of all textiles (Fig. 1). The surface of the untreated sample (Figure 1a) displayed grooves and parallel ridges in SEM

micrographs where Figure (1b) clearly shows the fiber surface with adherent chitosan coating. The chitosan-coated cloth develops a veil-forming effect similar to that seen on cellulose fibers. The homogenous CTC-Ag Nano composite was applied by padding technique. In comparison to untreated or chitosan-treated fabrics, the distribution of CTC-Ag nanocomposite in the coating layer rendered the treated fabric surface smoother. Fibers treated with chitosan, for example, have a higher degree of entanglement. (Hebeish et al., 2013 and He et al., 2014)

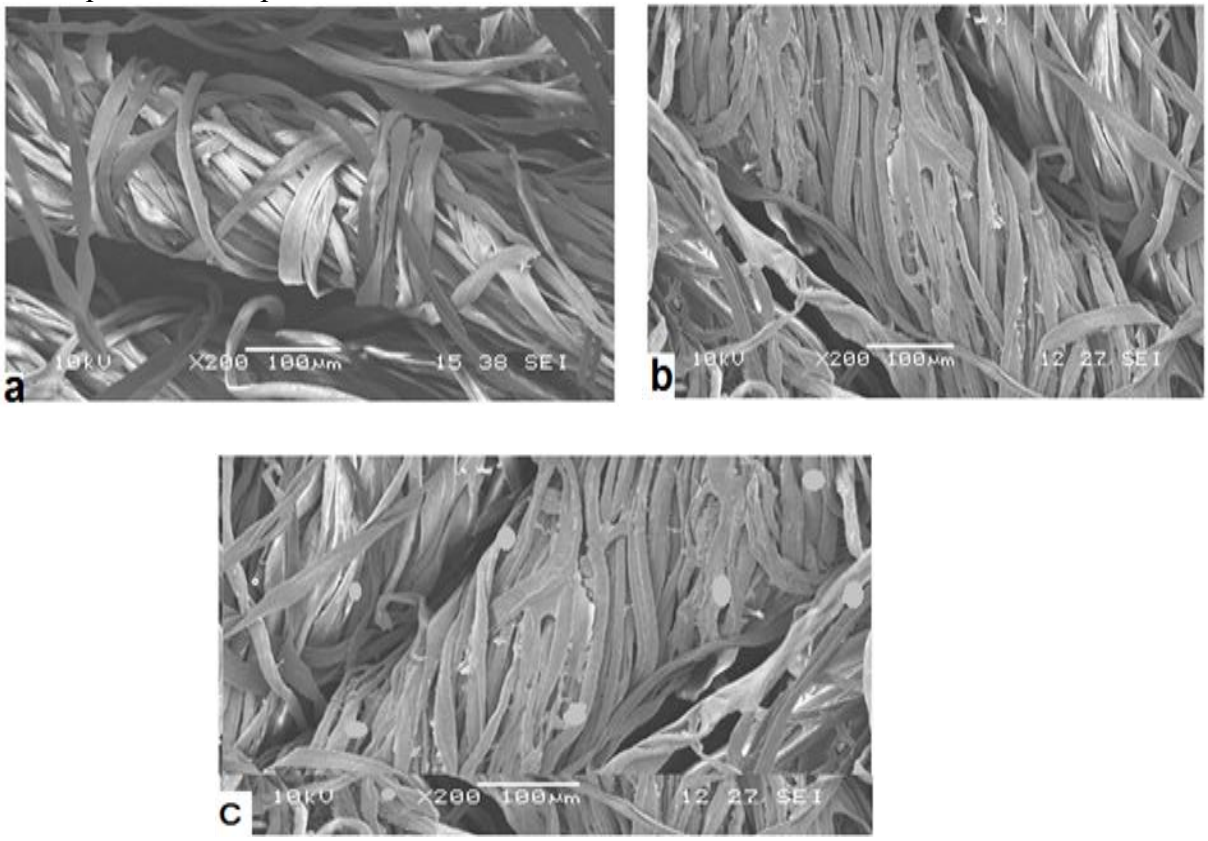


Fig. 1. SEM micrograph of (a) scoured cotton, (b) Chitosan-Cotton (CTC) and (c) CTC-Silver NPs

3.1.2. FT-IR Analysis

Figures (2 and 3) show the FTIR spectra of all fabrics. The stretching vibration peaks of the –NH_2 and –OH groups coincided to the absorption band at 3330 cm $^{-1}$ in the chitosan spectrum. Asymmetric stretching of –CH_3 and –CH_2 was attributed to the bands around 2930 cm $^{-1}$. The peak at 1630 cm $^{-1}$ corresponds to the –NH_2 chitosan groups' distinctive peak. The CH_3 symmetrical deformation was given to the absorption bands at 1388.C–O stretching vibrations related to the vibration at 1024 cm $^{-1}$. The presence of the –CH_2– group created the band at 2960 cm $^{-1}$. Around 1400 cm $^{-1}$, the bands of amide groups (amide I and amide II) may be seen in the spectra of chitosan (Figure 2). The C–O and C–N stretching were ascribed to the vibrations around 1070 cm $^{-1}$ for chitosan. The C–O and C–N groups were connected with Zn coordination in the Chitosan-ZnO nanocomposite, as evidenced by these distinctive peaks with increased intensity. The bands of principal NH_2 groups at 1400–1600 cm $^{-1}$ and 3300–3500 cm $^{-1}$ were

reduced in intensity. The immobilization of ZnO NPs onto CTC is shown by the decrease in the intensities of these bands and the new peak at 668 cm $^{-1}$ (Figure 2).

The FTIR spectra of Ag NPs, on the other hand, revealed that the NPs had absorption peaks at 3431(2), 1635(6), and 1390(8), which correspond to amide linkage groups (Figure 3) (Qingbo et al., 2019). Moreover, the peaks near 3431 cm^{-1} corresponded to OH group stretch vibrations. Because of the carbonyl stretch in proteins, the band at 1635 cm^{-1} corresponded to amide I. The peak at 1390 cm^{-1}(8) belonged to the symmetric deformation vibration mode of CH_3, while the peak at 1274 cm^{-1} (9) matched to carboxylic acid stretching vibration. The stretch of alkyl halides had the highest peak at 556 cm^{-1}(13). The results showed that primary amino groups were involved in the contact with the metal surface, and that the amino groups worked as sites for the Ag NPs stabilization. 1650 Cm^{-1}(6) (C=O str), 714 Cm^{-1} (C-S str), and 1413 Cm^{-1} (7) are the characteristic peaks (-CH_3 bend) (Figure 8). (Potara et al., 2012).

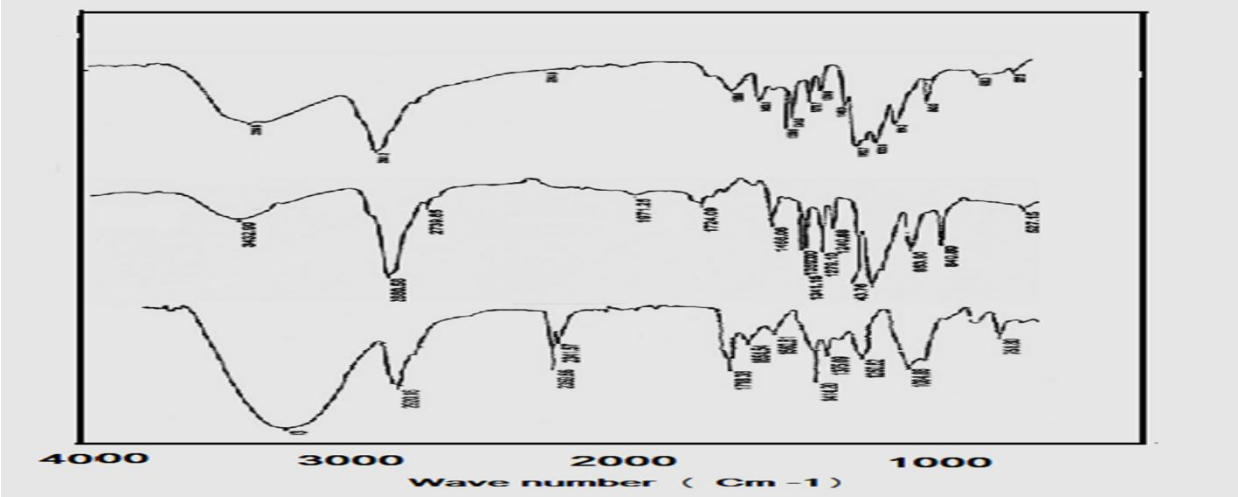


Fig. 2. FT-IR spectrum for (a) Scoured cotton, (b) Chitosan-Cotton (CTC) and (c) CTC-ZnO NPs

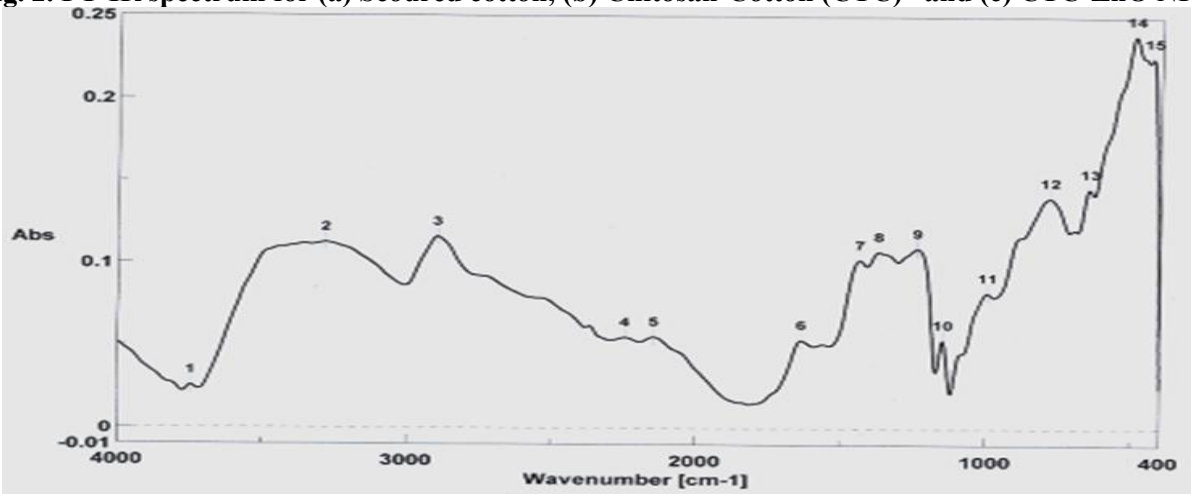


Fig. 3. FT-IR spectrum of CTC-Ag NPs

3.2. Chitosan Concentration versus Nitrogen Content

Different concentrations of chitosan (0.5–4% o.w.s) were used to treat cotton garments, and the nitrogen content of the chitosan-treated fabrics was calculated and plotted against the chitosan concentrations used in fabric treatment and the optimum concentration of chitosan which give highest nitrogen content was 2% as shown in Figure (4) then occur drop in nitrogen content. The drop in nitrogen content on fabrics when utilizing chitosan concentrations higher than 2% can be explained in terms of stronger interaction of chitosan molecules at higher concentrations. As a result, huge volumes of chitosan are formed on the surface of the fabrics, impairing further major chitosan deposition and this result agree with Hebeish et al.(2014) were observed that optimum concentration of concentration of chitosan which give highest nitrogen content was 2%.

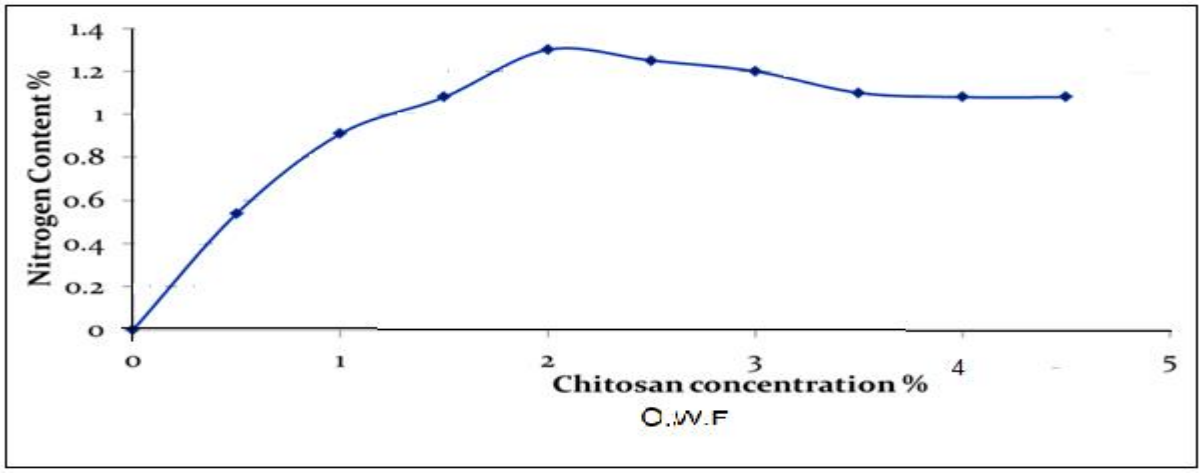


Fig. 4. Effect of Chitosan Concentration on Nitrogen Content on Cotton treated fabric

3.3 Antibacterial activity towards different treatments

3.3.1 Effect of CTC on antibacterial activity

The results obtained from Table (1) and Figure (5) showed antibacterial activity for chitosan treated cotton fabric on S. aureus due to amino group found on chitosan which acquired an effect on inner cell membrane and organelles such as mitochondria and thus killing bacteria .and scoured cotton fabric and UV cotton fabric have no antibacterial activity this explain that the amination process added antibacterial properties for cotton fabric than scoured (no treatment) and UV cotton fabric.

Table 1. Antibacterial activity of scoured cotton fabric (Cotton without treatment) and scoured cotton fabric exposed to UV (Cotton without treatment + UV) and chitosan treated fabric against Gram positive and Gram negative bacteria

Samples	*E. coli*	*S. aureus*
Cotton without treatment	0.0±0	0.0±0.0b
Cotton without treatment + UV	0.0±0	0.0±0.0b
Cotton treated with chitosan 2% o.w.s	0.0±0	6.0±0.01a
LSD for5%	Nd	1.31

Each value represents mean±standard error. Means sharing the same letters in each column not differ significantly based on the least significant difference (LSD) test at p≤0.05

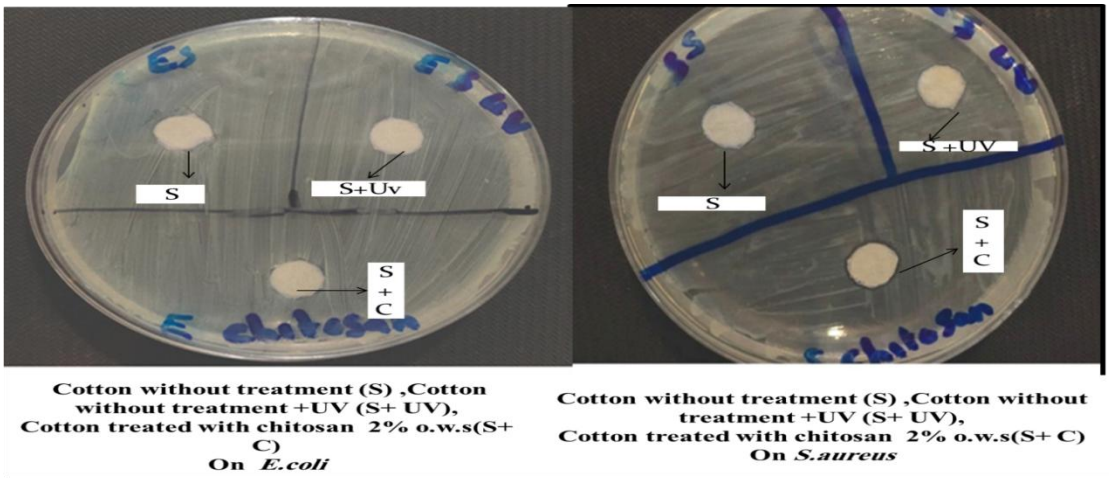


Fig. 5. antibacterial activity for scoured cotton fabric, scoured cotton fabric exposed to UV and chitosan treated cotton fabric against E. coli and S. aureus

3.3.2. Effect of CTC + ZnO NPs on antibacterial activity

As indicated from Table (2)and Figure (6) where different concentrations of ZnO NPs (1-10% o.w.s) were used to show its effect on Gram positive *E. Coli* and Gram negative *S. aureus* bacteria as native material and it was found that by increasing the Nano oxide the antibacterial effect on both kind of bacteria was increased. In Table (2) for *E. coli* and *S. aureus*, the increment in antibacterial activity was found to be directly proportional with increasing the ZnO NPs until an optimum concentration (8%o.w.s) then it constant, this may be ascribed to increased viscosity beyond this point where no more effect can be noticed (El Alfy et al., 2015). The mode of action for zinc oxide NPs on *Staphylococcus aureus* and *Escherichia coli* can be explained by ZnO NPs create reactive oxygen species, which increases membrane lipid peroxidation, allowing reducing sugars, DNA, and proteins to escape through the membrane, lowering cell viability. (Tiwari et al., 2018).

Table 2. Antibacterial activity of ZnO NPs against Gram positive and Gram negative bacteria

Samples	Inhibition zone mm	
CTC+ZnO NPs % o.w.s	***E. Coli***	***S. aureus***
1	6±0.01c	7±0.01d
2	6±0.01c	8± 0.02cd
4	7±0.01bc	9±0.07bc
6	8±0.02ab	10±0 .07ab
8	9±0.07a	11± 0.08a
10	9±0.07a	11± 0.08a
LSD for5%	1.59	1.73

Each value represents mean±standard error. Means sharing the same letters in each column not differ significantly based on the least significant difference (LSD) test at p≤0.05

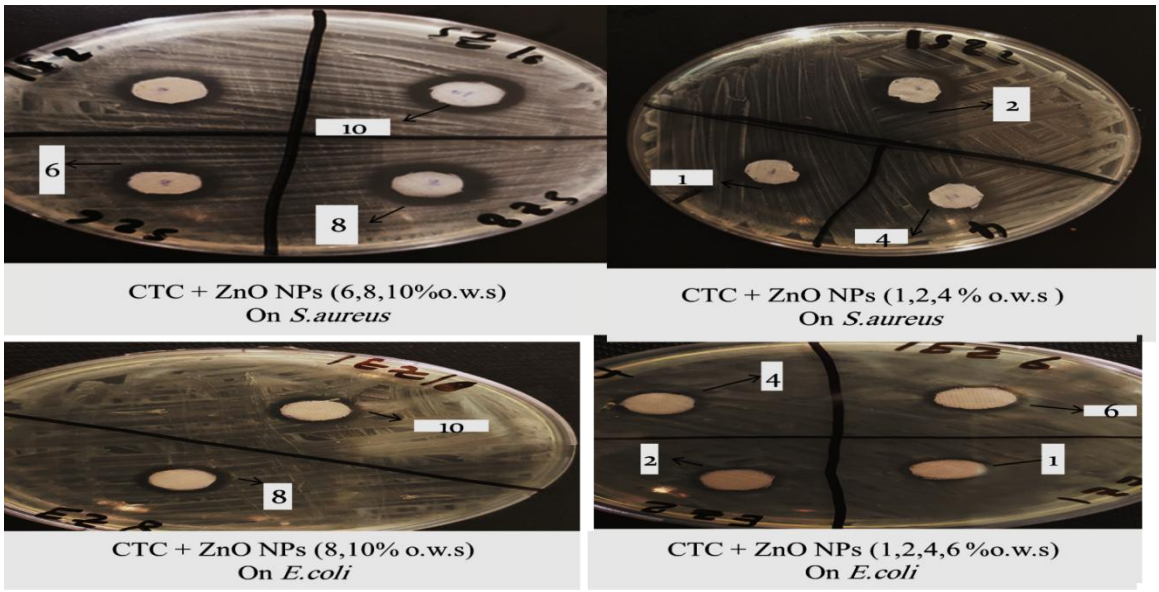


Fig. 6. Antibacterial activity of CTC with ZnO NPs on S. *aureu*s and *E. coli*

3.3.3. Effect of CTC + Ag NPs on antibacterial activity

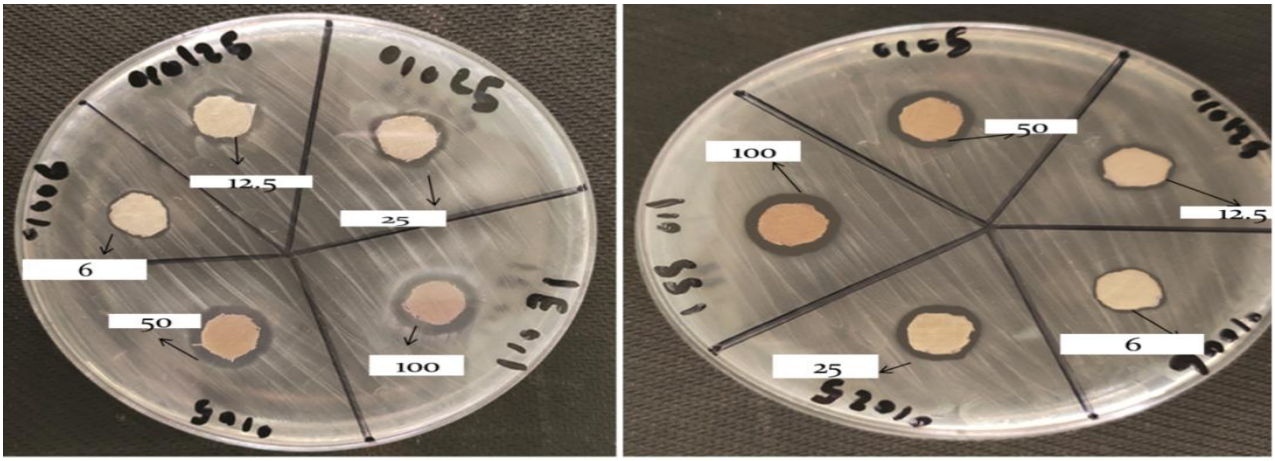
Different concentration (3-100ppb) of silver nano particles were used to treat the scoured cotton fabric to give the fabric antibacterial effect. The results as illustrated from Figure (7) and Table (3) were noticed that silver Nano Particles has great activity against *Escherichia coli* and *Staphylococcus aureus* and the activity for silver is increased by increasing the concentration of silver nanoparticles until maximum concentration (100ppb) which gives maximum antibacterial activity on *E. coli* and *S. aureus* (El Alfy et al., 2015) . The silver ions are thought to bind disulfide (S- S) and sulfhydryl (- SH) groups in the protein of

the microbial cell wall, disrupting metabolic activities and finally causing cell death (Uddin, 2014). It's also been suggested that silver ions can interact with phosphorous moieties in DNA, causing DNA replication to be inactivated and enzyme functions to be inhibited. (Matsumura et al., 2003).

Table 3. Antibacterial activity of CTC Ag NPs on S. aureus and E. coli

Samples	Inhibition zone mm	
CTC + Ag NPs (ppb)	*E. coli*	*S. aureus*
3	6±0.01d	6±0.01c
6	6±0.01d	7±0.01bc
12.5	7±0.01cd	7±0.01bc
25	8±0.02bc	8±0.02b
50	9±0.07ab	11±0.08a
100	10±0.07a	12±0.1a
LSD for5%	1.73	1.69

Each value represents mean±standard error. Means sharing the same letters in each column not differ significantly based on the least significant difference (LSD) test at p≤0.05



CTC +Ag NPs (100,50,25,12.5,6)ppb On *E.coli*

CTC +Ag NPs (100,50,25,12.5,6)ppb On *S.aureus*

Fig. 7. Antibacterial activity of CTC with Ag NPs on *S. aureus* and *E. Coli*

3.3.4. Effect of UV irradiation on CTC-ZnO NPs and on CTC-Mix (ZnO NPs+ Ag NPs) according to antibacterial activity

UV irradiated was used to initiate free radicals on the surface of fabrics treated with Nano materials those catalyze the process of cell wall deformation of the bacterial cell enhancing the antibacterial activity. Data in Table (4) and Figure (9) were illustrating this effect which was increased after UV treatment due to formation of free radicals (Nakamura et al., 2020). Mixture of silver nano particals and Zinc oxide nano particals were developed to reduce the number of bacterial species where

the scoured cotton fabrics were padded into solution contain(100ppb AgNO3 NPs + 8%ZnO NPs) in presence of UV irradiation.padder with apick up 100% and apressure of 1 bar . The data in Table(4) and Figure(11) were showed the incresed of antibacterial effect of CTC+ mix of AgNO3 NPs and ZnO NPs in the presence of UV radiations and give anti bacterial effect better than treating scoured cotton fabric with each of the nanomaterials separately in the presence of UV irradiation. Because of ZnO NPs create reactive oxygen species, which increases membrane lipid peroxidation, allowing reducing sugars, DNA, and proteins to escape through the membrane, lowering cell viability. The silver ions are thought to bind disulfide (S- S) and sulfhydryl (- SH) groups in the protein of the microbial cell wall, disrupting metabolic activities and finally causing cell death. UV initiate free radicals on the surface of fabrics treated with Nano materials those catalyze the process of cell wall deformation of the bacterial cell enhancing the antibacterial activity. (Nakamura et al., 2020 and Uddin, 2014 and Tiwari et al., 2018)

Table 4. Antibacterial activity of CTC +ZnO NPs+UV and mix (Ag NPs+ ZnO NPs+UV) on *S. aureus* and *E. coli*

Samples	Inhibition zone mm	
CTC+ ZnO NPs %o.w.s+ UV	*E. coli*	*S. aureus*
1	7±0.01e	8±0.02e
2	8±0.02de	9±0.07de
4	9±0.07cd	10±0.07cd
6	10±0.07bc	11±0.08bc
8	11±0.08b	12±0.10b
10	11±0.08b	12±0.10b
CTC +Mix(8% o.w.s ZnO NPs +100ppb AgNPs+ UV	14±0.13a	16± 0.2a
LSD for5%	1.90	1.78

Each value represents mean±standard error. Means sharing the same letters in each column not differ significantly based on the least significant difference (LSD) test at $p \leq 0.05$

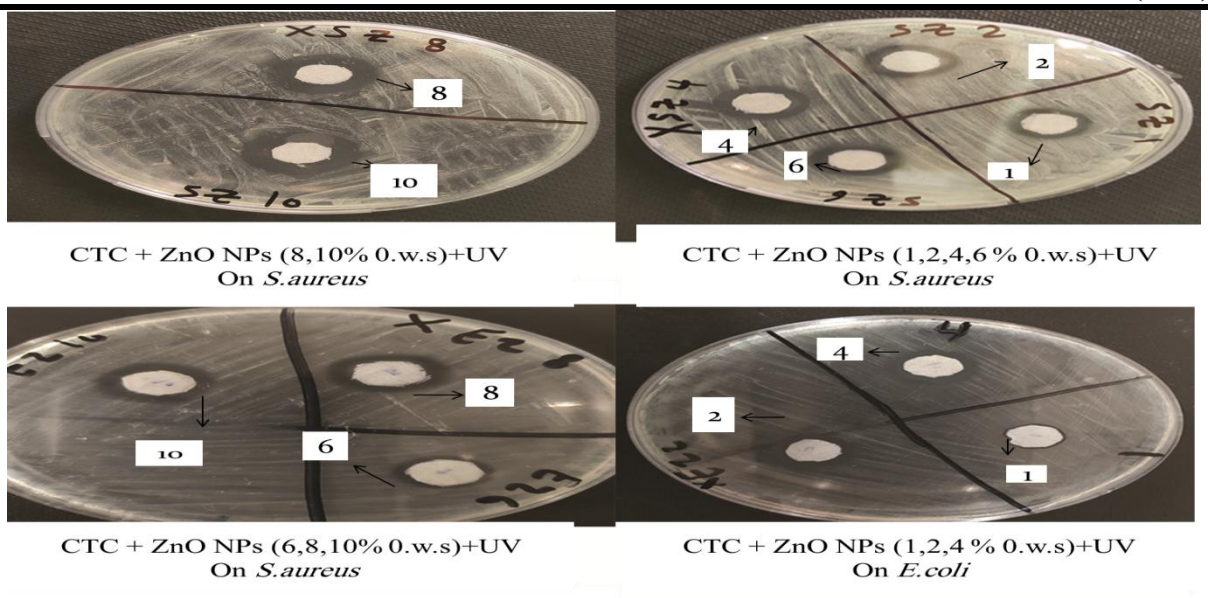


Fig. 8. Antibacterial activity of CTC with ZnO NPs + UV on *S. aureus* and *E. coli*

3.3.5. Effect of UV irradiation on CTC-Ag NPs and on CTC-Mix (ZnO NPs+ Ag NPs) according to antibacterial activity

UV irradiated sample using UV lamp with power 15 mW/cm^2 and distance 11cm for 30min was used to initiate free radicals on the surface of fabrics treated with Nano materials those catalyze the process of cell wall deformation of the bacterial cell enhancing the antibacterial activity. Table (5) and Figure (10) illustrate such effect which was increased after UV treatment due to formation of free radicals. (Nakamura et al., 2020). Mixture of silver nano particals and Zinc oxide nano particals were developed to reduce the number of bacterial species where the scoured cotton fabrics were padded into solution contain(100ppb AgNO3 NPs + 8%ZnO NPs) in presence of UV irradiation.padder with apick up 100% and apressure of 1 bar . The data in Table(5) and Figure(11) were showed the incresed of antibacterial effect of CTC+ mix of AgNO3 NPs and ZnO NPs in the presence of UV radiations and give anti bacterial effect better than treating scoured cotton fabric with each of the nanomaterials separately in the presence of UV irradiation. Because of ZnO NPs create reactive oxygen species, which increases membrane lipid peroxidation, allowing reducing sugars, DNA, and proteins to escape through the membrane, lowering cell viability. The silver ions are thought to bind disulfide (S- S) and sulfhydryl (- SH) groups in the protein of the microbial cell wall, disrupting metabolic activities and finally causing cell death. UV initiate free radicals on the surface of fabrics treated with Nano materials those catalyze the process of cell wall deformation of the bacterial cell enhancing the antibacterial activity. (Nakamura et al., 2020 and Uddin, 2014 and Tiwari et al., 2018)

Table 5. Antibacterial activity of CTC with Ag NPs+ UV and mix (Ag NPs+ ZnO NPs+UV) on S. aureus and E. coli

Samples	Inhibition zone mm	
CTC+AgNPs(ppb)+UV	*E. coli*	*S. aureus*
3	8±0.02f	8±0.02e
6	8±0.02f	9±0.07e
12.5	9±0.07e	11±0.08d
25	10±0.07d	12±0.1cd
50	11±0.08c	13±0.11bc
100	12±0.1b	14±0.13b
CTC +Mix(8% o.w.s ZnO NPs +100ppb AgNPs+ UV	14±0.1a	16±0.2a
LSD for5%	0.87	1.29

Each value represents mean±standard error. Means sharing the same letters in each column not differ significantly based on the least significant difference (LSD) test at p≤0.05

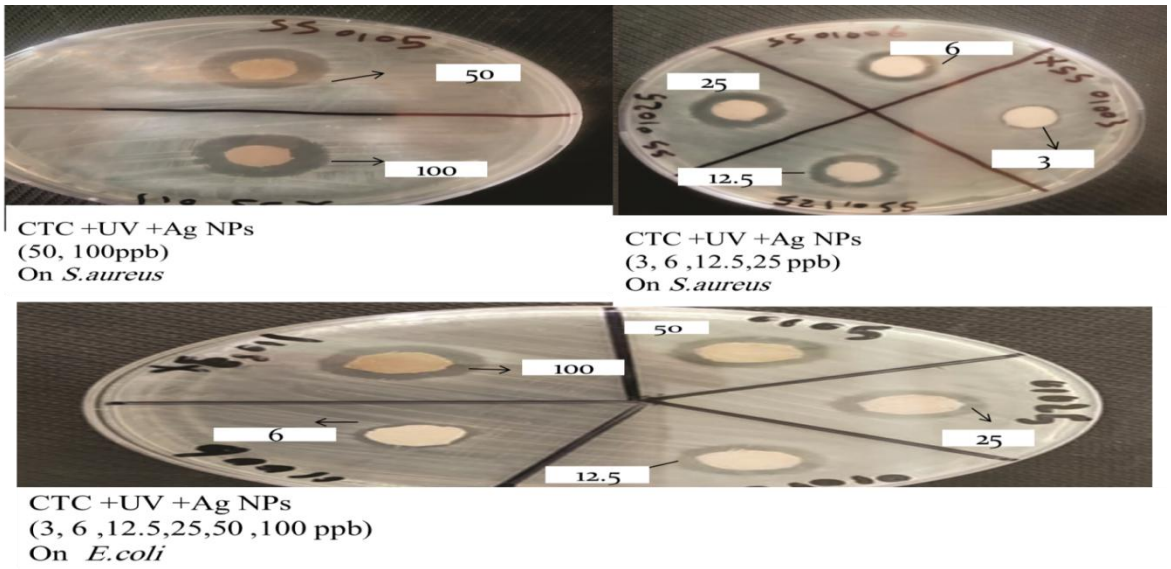
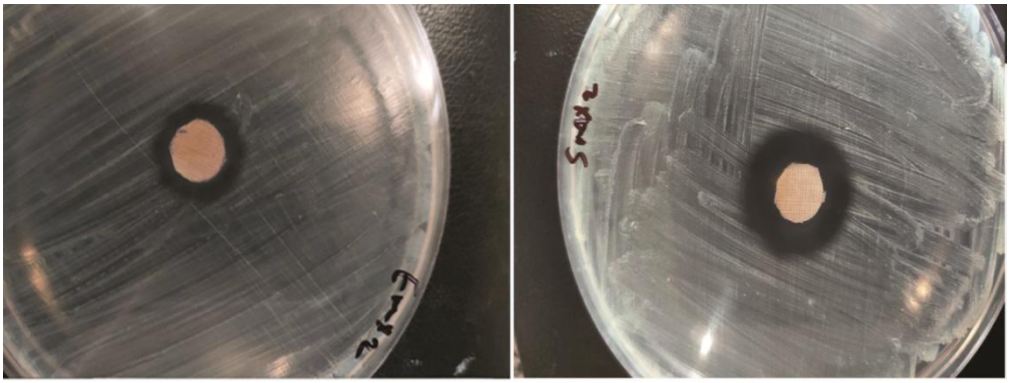


Fig. 9. Antibacterial activity of CTC with Ag NPs on *S. aureus* and *E. coli*



CTC +mix(ZnO NPs(8% o.w.s) +Ag NPs(0.1 ppm) +UV On *E.coli*

CTC +mix(ZnO NPs(8% o.w.s) +Ag NPs(0.1 ppm) +UV On *S.aureus*

Fig. 10. Antibacterial activity of CTC+ Mix(Ag NPs+ZnO NPs)+UV on *S. aureus* and *E. coli*

CONCLUSION:

The goal of this study or test is to determine more about the best antibacterial agents that can be used in cotton textiles for protection. The whole samples of the previous treatments were tested against Escherichia coli (Gram negative bacteria) and Staphylococcus aureus (Gram positive bacteria), with the bacterial strain's sensitivity determining the best agent. As a result of prior findings, the best results for Gram negative bacteria (Escherichia coli) were obtained by using:

CTC<CTC-ZnO NPs<CTC-Ag NPs<CTC-ZnO NPs+UV < CTC-Ag NPs+UV< CTC– mix (Ag NPS (100ppb) + ZnO NPS (8% o.w.s) + UV)

While for Gram positive bacteria (Staphylococcus Aureus):

CTC<CTC-ZnO NPs < CTC-Ag NPs <CTC- ZnO NPs +UV <CTC-Ag NPs+UV< CTC – mix (Ag NPS (100ppb) + ZnO NPS (8% o.w.s) + UV)

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الملخص العربي

تحسين النشاط المضاد للبكتريا للأقمشه القطنيه المعالجه بمواد النانو باستخدام الإشعه الفوق بنفسجيه

استخدمت التطبيقات المختلفه مواد النانو مثل اكاسيد النانو واملاح النانو مثل جزيئات الفضه النانويه واكسيد الزنك النانوى لأكساب نشاط مضاد للبكتريا للاقمشه القطنيه . فى هذه الدراسه تمت معالجه الاقمشه القطنيه بالشيتوزان متبوعه بمواد الفضه النانويه و اكسيد الزنك النانوي ثم المعالجه بخليط من تلك المادتين النانويتين متبوعا بالتعرض للإشعاع فوق البنفسجي باستخدام مصباح زئبق متوسط الضغط بكثافة ضوئية على القماش تبلغ حوالي 15 ميجاوات / سم 2 لإنتاج تعزيز في النشاط المضاد للبكتيريا للاقمشه القطنيه ضد البكتريا موجبه الجرام والبكتريا سالبه الجرام مثل St. Coccus (Gram +ve) and E. coli (Gram –ve). وتم تأكيد النتائج باستخدام المجهر الإلكتروني الماسح و جهاز "فوريه" لتحويل طيف الأشعة تحت الحمراء. تم الحصول على أفضل نتيجة للبكتيريا سالبة الجرام *(Escherichia coli)* باستخدام خليط من (Ag NPS (100ppb) + ZnO NPS (8 %o.w.s) + UV) وكذلك بالنسبة للبكتيريا موجبة الجرام *(Staphylococcus Aureus)* كانت أفضل نتيجة هي استخدام خليط من (Ag NPS (100ppb) + ZnO NPS (8% .(o.w.s) + UV

الكلمات الدالة: الشيتوزان ، الفضة النانوية ، أكسيد الزنك النانوي ، التطعيم بالأشعة فوق البنفسجية , مضاد للبكتريا, بكتريا موجبه وسالبه الجرام.