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Enhancing the Fabric Printability with Vat and Direct Dyes via Treatment Using Chitosan and Chitosan Nanoparticles

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Abstract
he current work aims to ensure the environmental protection for future generations, reduce pollution generated by textile printing, and address the challenges connected with the use of synthetic colorants, thickeners, and textiles on natural system and human health. This research aims to study the effect of using chitosan and chitosan nanoparticles in printing cotton, polyester and their blend fabrics with Vat and direct dyes to assist to reaching health and functional features, developing functional characteristics for textiles, and focusing on staying updated with global trends with the use of nanotechnology, Also, to produce antimicrobial fabrics to enhance the quality of the fabrics, by using two methods Conventional Heat (CH) and Ultra sonic (US) for treatment fabric with chitosan and nano chitosan particles. Color strength (K/S), and all fastness properties were measured for each fabric. The results of the tests obtained that the K/S value of the treated fabrics with chitosan and chitosan nanoparticles higher than the untreated fabrics and all treated fabrics have high fastness values for washing, perspiration, and rubbing. All treated fabric printed with vat dye shows high light fastness properties than the treated fabric printed with direct dye. An ultraviolet protection factor (UPF) values of all the treated fabrics, printed with Vat dye and Direct dye are higher than those of the blank ones referring to more ultraviolet protection. The antibacterial activities of treated samples with chitosan and nano chitosan. have been studied using colony forming technique (CFU) against Staphylococcus aureus and Escherichia coli, the Result show that cotton and polyester fabrics treated with chitosan and nano chitosan using US method have high antibacterial activities than the treated fabric using CH method and the blend cotton/Polyester shown that using CH method more effective antibacterial activities than US method. This led to an enhancement in the function, health features, and appearance of end textiles while keeping the balance of nature, as well as an enhancement in the durability and default life cycle of treated natural materials.
Keywords: Chitosan, Chitosan Nanoparticles, Natural dyes, Textile Printing.

1. Introduction

People are attracted to a more comfortable and luxurious living because of fast growth and changes in lifestyle, and also turning toward smaller, safer, cheaper, and faster-working items not only decreased work load but also allow them to do duties at a much faster rate with less efforts.

There has been the development of appliances that are much smaller in size, such as micro-chips, nano capsules, carbon tubes, memory cards, pen drives, etc., which decrease the problems of transport and storage while also being much faster and more reliable, allowing us to complete more of our work in less time. Nanotechnology plays a critical role in the creation and development of such technologies.

The current research gives some in review and analysis of a variety of textile materials suitable for printing with natural dyes and treatment process, Nano science and nanotechnology are also considered to be important technologies for the modern period, with applications in materials science, mechanics, electronics, optics, medicine, plastics, energy, and aerospace. [1-4] It now plays a

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significant role in the functional finishing of textiles and polymers. [5-11]

Among the various uses of nanotechnology, the textile industry is now one of the most benefitted. The use of nanotechnology in the textile industry has enhanced the durability of materials, increased their comfort and cleaning features, and reduced their costs of production. In terms of economics, energy savings, eco-friendliness, control release of chemicals, packaging, isolating, and storing materials on a tiny scale for later use and release under controlled conditions, nanotechnology provides several benefits over traditional processes. [5, 12]

The use of nanoparticles to textile materials has been the focus of multiple investigations aimed at developing completed textiles with various functional performances. Nanoparticles can provide great durability for treated textiles due to their huge surface area and high surface energy, which ensures higher affinity for fabrics and leads to an improvement in the durability of the desired textile performance. The particle size is also important in influencing particle attraction to fibers. It is realistic to expect that the larger particle compacts will be easily removed from the surface of the fiber, but the tiniest particle will dive deeper and attach tightly to the fabric structure. [5, 10, 11, 13-22]

A wide range of new nanomaterials fabrics are currently available on the market. Sporting industries, healthcare, space technology, and clothing, as well as materials technology for greater protection in adverse situations, are already seeing some uses of nano technology enhanced textiles. Nanotechnology enables textiles to become multifunctional and develop materials with particular characteristics such as antimicrobial, UV protection, easy-clean, water- and stain resistant. [5, 13, 22-24]

To eliminate chemical pollutants and their residues from chemical processes, environmentally friendly treatments such as biopolymers are utilized instead of chemical treatments such as chitosan and its nanoparticles. [25] Chitin is the major component of natural sources such as shrimp and crabs, and it also has a non-external structure in mollusks, insects, and certain fungal cell walls. Chitosan is made up of two monomeric units, D-glucosamine and N-acetyl-D-glucosamine, that are joined together by a [1-4]-glycosidic linkage. Chitosan's antibacterial activity is thought to be attributable to the presence of amino groups, which give chitosan a particular characteristic in the destruction of fungi and bacteria. [26] Chitosan's characteristics are determined by the degree of polymerization, molecular structure, degree of substitution, and particle size. To obtain greater chitosan advantages, current research has focused on nanoscale chitosan particles in the textile sector. The usage of chitosan nanoparticles is a fairly unique material because of the nanoparticle's unique features, such as the very high surface area to volume ratio and high surface activity. [27] Because of its superior biocompatibility, biodegradability, ecological safety, non-toxicity, and varied biological effects such as antibacterial, antifungal, anticancer activity, and low immunogenicity, [28-33] it has several uses in biomedical and other fields. Chitosan has been used as an eco-friendly finishing agent in the textile industry to create practical materials. [34, 35]

This article will provide a review of chitosan uses in textile antibacterial, printing and abrasion - resistant finishing. In the current study, we used chitosan and Chitosan nanoparticles in two different treatment methods [conventional heat and ultra-sonic methods] on fabrics [cotton, polyester, cotton/polyester50/50 and 65/35] printed with vat dye and direct dye to enhance fabric quality, such as K/S, fastness properties, and antimicrobial activity.

2. Materials and Methods Materials

2.1. fabrics

four fabrics were used in this study

a) 100% cotton140 g/m^2,
b) 100% polyester149 g\m^2
c) cotton/polyester (50:50) 145 g\m^2
d) cotton/polyester (65:35) 147 g\m^2

fabrics were supplied by El-Mahalla El-Kobra Company, El-Mahalla, Egypt. The fabrics were scoured in aqueous solution with a liquor ratio1:50 containing 2 g/l nonionic detergent solution (Hostapal, Clariant) at 50º C for 30 min to remove impurities, then rinsed thoroughly in cold tap water, and dried at room temperature.

2.2. Dyestuffs and chemicals

The dyes used for this present study are direct dye (Scarlet K-CF) RED and Vat Dye Blue. Sodium tripolyphosphate (TPP) Glycerin, citric acid, sodium hypophosphite, potassium carbonate, sodium carbonate, Urea dioxide, chitosan and nano chitosan are of laboratory grade chemicals.

Natural Gum ST 80 is Anionic thickener was supplied from (ADGUMS private limited, exporter of textile printing thickener). Its viscosity of 8%, the pH has to be adjusted to 9-11 in 8% solution. Structure of tamarind seed polysaccharide was shown in Figure 1.

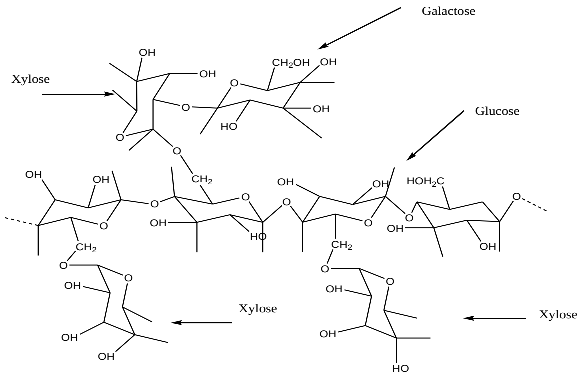


Figure 1: Structure of tamarind seed polysaccharide [TSP] [36]

2.3. Methods

2.3.1. Fabric treatment methods

Cotton, polyester and blend cotton/polyester (50/50 and 65/35) are treated with different concentration of chitosan and nano chitosan particles using two methods for treatment (i) conventional heat method and (ii) ultrasonic method

2.3.2. Synthesis of Chitosan

De-acetylation was achieved by mixing 65% NaOH and then boiling for 1 hour at 100°C. Then comes cooling the samples for 30 minutes at room temperature. The samples are followed by washing with 65% NaOH and filtered to extract the chitosan. Following that, the samples are aired and dried at 101°C for 6 hours. Finally, Chitosan was obtained in the form of a white creamy powder. [37] Chemical structure of chitosan was shown in Figure 2.

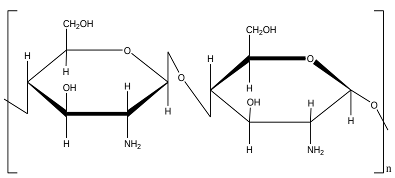


Figure 2: chemical structure of chitosan [37]

2.3.3. Synthesis of Chitosan Nanoparticles

Chitosan nanoparticles were prepared using ionic gelatin of chitosan with tripolyphosphate anions via dissolve chitosan in 1% acetic acid [v / v]. [38] Then Chitosan NPS was obtained by adding a 1% drop of TPP [w / v] using a drop under magnetic stirring of 700 rpm at room temperature for 60 minutes. Followed by Conduct centrifugation of the compound nanoparticle solution at 10,000 rpm for 10 minutes. Finally, remove the supernatant and dry the particles. [39] Ionic crosslinking with chitosan and TPP was shown in Figure 3.

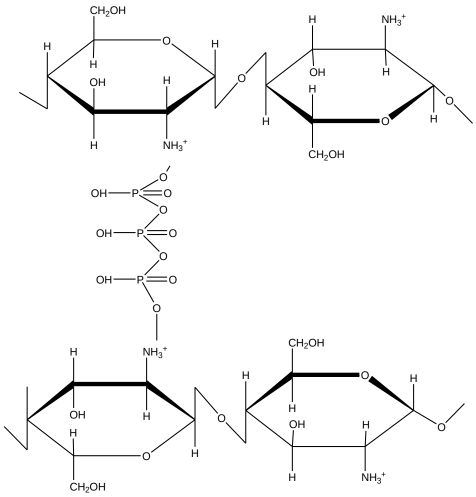


Figure 3: Ionic crosslinking with chitosan and TPP [40]

2.3.4. Treatment Method with Chitosan and Nano Chitosan

Samples fabrics were treated with freshly prepared aqueous solutions containing different concentrations (0.5, 1, 2% W.O.F) of chitosan high molecular weight and nano chitosan obtained in liquid form by dissolving in distilled water and 2% acetic acid using liquor ratio (120) for 120 min at 60°C using two methods conventional Heat (CH) and ultrasonic (US) in presence of citric acid (1%) and sodium hypophosphite (0.5 %) then squeezed, dried at room temperature

2.3.5. Preparing Printing Paste

2.3.6. Printing with Vat Dye

2.3.6.1.1. Preparation of stock thickener

Thickener (Tamarind)	600 g
Glycerin	80 g
Potassium carbonate	150 g
Urea dioxide	150 g
Water	20 g
Total	1000 g

2.3.6.1.2. Preparation of printing paste

Vat dye	20 g
Water	180 g
Stock thickener	800 g
Total	1000 g

The required amount of dyestuff was pasted with warm water and stirred well to make homo suspension paste. the previously prepared stock thickening was added into the paste and mixed thoroughly.

2.3.6.2. Printing with Direct Dye

2.3.6.2.1. Preparation of stock thickener

Thickener (Tamarind)	650 g
Sodium carbonate	150 g
Urea dioxide	150 g
Water	50 g
Total	1000 g

2.3.6.2.2. Preparation of printing paste

Direct dye	30 g
Water	220 g
Stock thickener	750 g
Total	1000 g

The required amount of dyestuff was pasted with warm water and stirred well to make homo suspension paste. the previously prepared stock thickening was added into the paste and mixed thoroughly.

2.3.7. Printing technique

In this study the aforementioned four fabrics i.e., cotton, polyester, cotton/polyester 50/50 and cotton/polyester 35/65 were printed using flat silk screen printing technique. After printing and drying, the printed fabrics were subjected to steaming at 100-102°C for 10 minutes.

2.3.8. Washing process

The washing process was done as follow: After fixation, all printed samples were washed to remove excess material from the fabric surface and to ensure the stability of the printed material as follow:

- The samples were rinsed by cold water
- Rinse samples by hot water
- Soap samples with a solution containing 2 g/L (TERGITOLTM NP-9 Surfactant) (non-ionic detergent) for 15 min at 60°C
- Wash samples by hot water, followed by washing with cold water.
- The washed samples are left to dry at ambient temperature.

Finally, fabrics assessed for measuring of color strength (K/S), fastness properties, antibacterial properties, and UV protection, etc.

2.4. Measurements and Analyses

After finishing of the treatment of the fabrics with conventional heat method and ultrasonic method and printing them with the previously specified dyes, the color strength of printed samples is measured as K/S and overall fastness properties (washing, rubbing and perspiration) according to standard methods.

2.4.1. Morphology study of chitosan and chitosan Nano particles

Scanning electron Microscope (SEM): An electron Microscope (SEM) was used to scan the surface morphology of the treated printed fabrics by using scanning electron Microscope (SEM), with a JSMT-20, JEOL-Japan. **Transmission Electron Microscope (TEM)** TEM works on the same principle as SEM. Transmission electron Microscope (scope (TEM) is many techniques for analyzing the size, morphology, crystal structure, and chemical composition of a wide range of Nano materials (NM). Transmission electron Microscope was performed with JEOL (TEM-1230, Japan).

2.4.2. Determination of antibacterial activity by measuring colony forming unit (CFU)

The antibacterial properties of treated textiles with chitosan and chitosan nanoparticles against Staphylococcus aureus and Escherichia coli were investigated using the colony forming method (CFU). The number of active bacteria on the agar plate under treated and untreated conditions was counted, and the results of bacteria decrease were calculated using the equation R (%) = B-A/B x 100. Where A represents the CFU/ml for the treated sample after 16 hours of incubation and B represents the CFU/ml for the untreated sample after the same time period. [41]

2.4.3. Measurements of Color strength (K/S value) & Fastness properties

The color strength (K/S) of the samples was determined using the light reflectance method and a Shimadzu UV/Visible spectrophotometer. [42] K/S, where K and S are the absorption and scattering coefficients. Rubbing, washing, sweating, and light exposure were all applied to the printed samples. according to standard ISO methods, ISO 105-X12 (1987), ISO 105-C01 (1989), ISO105-EO4 (1989), ISO 105-BO2 (1988) respectively. [43-48]

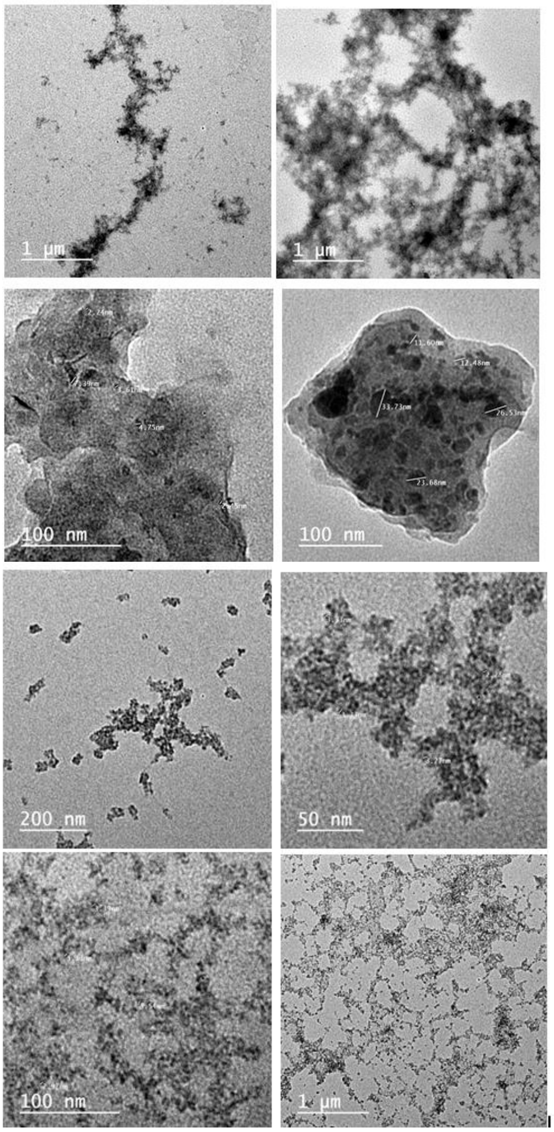
2.4.4. Measurement of UPF for Printed Fabrics

This test was carried out according AATCC TM 183-2010 and Australian/New Zealand Standard AS/NZS 4399:1996. [49-51]

3. Results and Discussion

3.1. Morphology study of chitosan and chitosan Nano particles

Chitosan and Nano chitosan were monitored using transmission Electron Microscopy (TEM) which analyzing the size, morphology, crystal structure, and chemical composition. Figure 4 represents the structural changes occur as a result of nano chitosan particles.



(a) (b)

Figure 4: TEM images of (a) chitosan, (b) Nano chitosan

3.2. Scanning by Electron Microscope Analysis (SEM) for Treated Samples

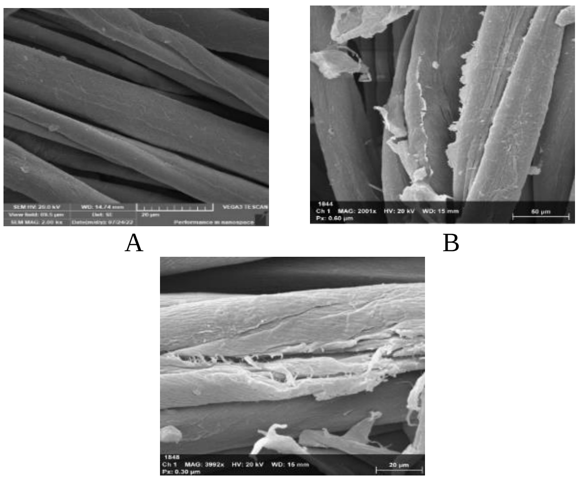
The surface morphology of samples (cotton 100%, polyester 100%, blend C/PET 50/50, 65/35) were illustrated from Figure 5 to Figure 8.

Studies show that the chains swell during the treatment, that hydrogen bonds break and form in various location and that's gaps widen, all of which are huge improvements for textiles in terms of their correct hydrophobicity and printability, further, clumps were seen on the fibers' surface. The SEM show that chitosan and nano chitosan connect to the textiles well, both on the surface and between the gaps in the fabric.

3.2.1. SEM for untreated and treated cotton fabrics

In case of cotton samples results shows a great improvement in case of nano chitosan comparing with chitosan treatment for this reason we select the samples as follows (a) untreated cotton sample (b) treated cotton sample with nano chitosan (CH), while (C) treated cotton sample with nano chitosan (US). All SEM images are illustrated in Figure 5. Also, when we have a look in Figure 5 with a little comparison between the three scans, it's clearly obvious that nano chitosan treatment has a significance improving effect on cotton surface.

The samples in Figure 5 show that treated cotton fabric (b) with nano chitosan (CH) show direct consequence of loading the active ingredients onto the fabric surface and the effective coating of nano chitosan to sample, compared to treated sample (c) with nano chitosan (US).



A B

C

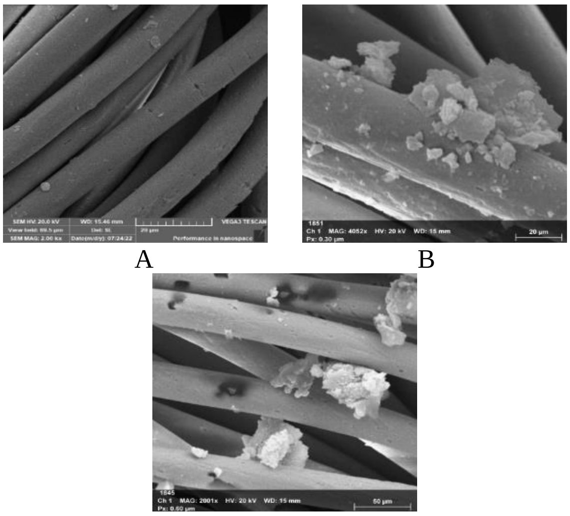
Figure 5: SEM images of untreated and treated cotton fabrics with nano chitosan where (a) untreated (b) treated nano chitosan CH and (c) treated with nano chitosan US

3.2.2. SEM for untreated and treated polyester fabrics

The SEM images of Untreated polyester fabrics (a) and treated polyester samples with chitosan in normal size at concentration 1 % W.O.F using CH process (b) as well as 2% chitosan using US process (C) are all illustrated in Figure 6 .

Samples show that chitosan connect to the textiles well, on the fabric surface and between the gaps. When we compare the three pictures were of Figure 6, we can easily illustrate that treating polyesters samples with chitosan (CH) process as well as chitosan treated sample (US) show more ingredients on the fabric surface in addition to the etching occurred between the gapes of polyesters fabrics

And also, studies in Figure 6 the treated fabric with chitosan using CH process (b) show more of ingredients on the fabric's surface and between the gaps in the fabric compared to treated fabric with US process (c) which are huge improvement for samples printability.

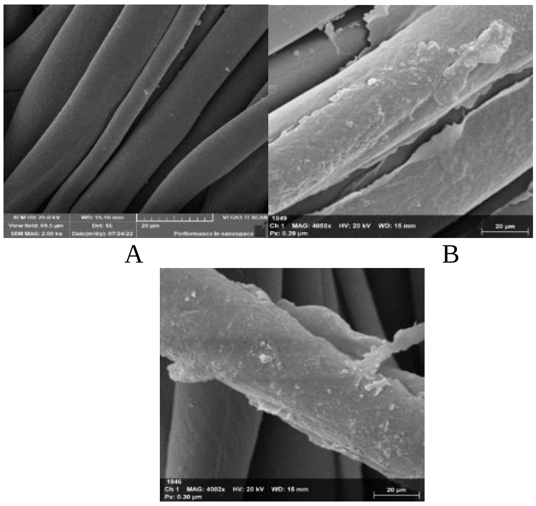


A B C

Figure 6: SEM images of untreated and treated polyester fabrics with chitosan where (a) untreated (b) treated with chitosan CH, and (c) treated chitosan US

3.2.3. SEM for untreated and treated cotton/polyester (50/50) fabrics

The SEM images of Untreated cotton/polyester (50/50) and treated cotton/polyester (50/50) with nano chitosan at concentration 2 % W.O.F using US process and 1% using CH process are all show in C Figure 7. As clears from comparing the three images show that treated fabric using CH process using nano chitosan with clears image (b) show more effective coating to nano chitosan and more of active ingredients onto the fabric surface compared to treated fabric with US process (c) as well as both images are acquiring an improved surface when compared to the untreated sample (a).

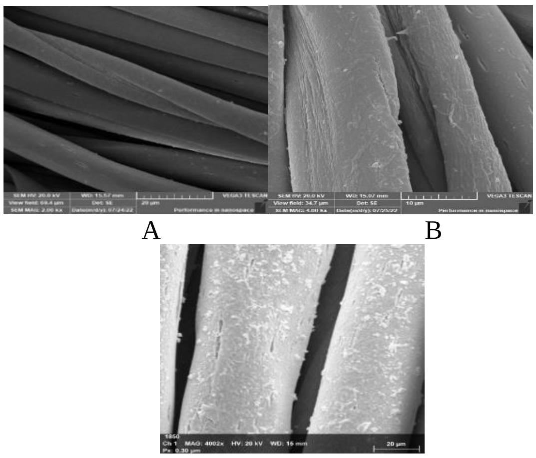


A B C

Figure 7: SEM images of untreated and treated blend 50/50 fabrics with nano chitosan where (a) untreated (b) treated with nano chitosan CH, and (c) treated with nano chitosan US

3.2.4. SEM for untreated and treated cotton/polyester (65/35) fabrics

The SEM images of Untreated cotton/polyester (65/35) sample and treated sample with chitosan in normal size at concentration 2% W.O.F using CH process (b) in addition to 1 % using US process (c) are all listed in Figure 8. When we have a quick look on Figure 8 with its three images we can clearly clarify that treated fabric by US process (c) show more positive results from where coating and load of the active ingredient on the surface compared to treated fabric with CH process (b).



A B C

Figure 8: SEM images of untreated and treated blend 35/65 fabrics with chitosan where (a) untreated (b) treated with chitosan CH, and (c) treated chitosan US

3.3. Determination of Antibacterial Activity by Measuring Colony forming Unit (CFU)

One of our aims is to improve the functional properties of fabric on question for this reason it's a must to measure the improvements occur in their fabrics after treating with either chitosan or nano chitosan CH or US process. The antibacterial activities of treated samples with chitosan and nano chitosan. have been studied using colony forming technique (CFU) against Staphylococcus aureus and Escherichia coli.

As clear from data of Table 1 that antibacterial activity was found to be depending on (a) kind of fabric used (b) kind of modification for all sample treated in the four different kinds of fabrics used their all were found to acquire improvement in antibacterial properties specially when compared to the untreated samples.

The results of all treated fabrics show a great antibacterial improvement reach up to 97.77 for Gram -ve (Escherichia Coli) and 93 and 98 ,47% for Gram +ve (Staphylococcus). This result for in case of polyester/cotton blend 50/50 when treated with nano chitosan with (CH) process and (US) respectively. When we compare the four samples under investigation, we can easily illustrate that: the maximum antibacterial activity for blend 50/50 treated with nano chitosan using US process against Staphylococcus aureus were 98.47%. Similarly, the maximum antibacterial activity against Escherichia coli was 97.77% for blend 50/50 treated with nano chitosan using CH process.

The lowest antibacterial activity obtained through polyester treated with bulk chitosan using US process for Gram +ve and cotton sample treated with nano chitosan using CH process for Gram –ve bacteria were 63.99 and 51.81respectively. This recommends that bacterial adhesion is affected by surface characteristics such as surface charge, hydrophobicity, and so on. In general, chitosan's antibacterial activity is associated with the negatively charged bacterial cell wall, causing cell disruption and changing membrane permeability, followed by an association with DNA that inhibits DNA proliferation. As a result, cell death and microbiological growth are inhibited. [52]

3.4. Color Measurement of The Treated Fabrics

Samples treated with Chitosan and nano chitosan within the two process CH ana US as well as the untreated samples for all kind of fabrics using vat dyes or/and direct dyes, dried, steamed and washed as detailed in the experimental section. finally, all samples are subjected to color measurement.

The results obtained are set out from Table 2Table 2 to Table 9. According to the K/S value, we can generally say that untreated samples showed a lower dye uptake compared to the treated samples. the presence of active primary amino (cation) groups in chitosan can disperse the negative surface charge on sample and drive dye molecules to the fiber, thus why color strength has increased. On the other side, the addition of carboxylic groups from citric acid may have also increased the dye absorption. [53]

3.4.1. On Using Vat Dye

Vat dye was applied to cotton, polyester, cotton/polyester (50/50) and (65/35) treated fabrics with chitosan and nano chitosan. The K/S values of the samples are shown from Table 2 to Table 5 as said before.

3.4.1.1. Color strength for cotton fabric printed with Vat dye

Printed cotton fabrics untreated and treated using chitosan/nano chitosan. The results obtained are set out in Table 2 and Figure 9. According to the K/S value, it can be seen that the K/S value were found to be depending on:

- Chitosan treatment process
- Chitosan particle size
- Concentration used.

Table 2 shows that cotton textiles treated with chitosan nanoparticles have much higher K/S values than cotton fabrics treated with normal chitosan. And also using CH process in treated cotton with nano chitosan show high K/S values compared to using US process in treatment method.

Table 1: Determination of Antibacterial Activity by Measuring Colony forming Unit (CFU)

fabric	treatment material	treatment method	Test strains		
			Escherichia coli	Staphylococcus aureus	Candida albicans
cotton	nano chitosan	CH process	51.81	78.82	48.23
		US process	82.23	92.29	79.19
polyester	chitosan	CH process	56.75	76.54	85.04
		US process	92.99	63.99	90.34
C/P 50/50	nano chitosan	CH process	97.77	93.19	83.64
		US process	79.45	98.47	88.76
C/P 65/35	chitosan	CH process	77.86	85.28	94.13
		US process	72.43	73.93	80.01

Blank			0	0	0

Table 2: Effect of chitosan and Nano chitosan on K/S of cotton fabrics printed with Vat dye

Chitosan Concentration		Chitosan Treatment	
		CH process	Ultrasonic
Blank		0.45	
Normal Size	0.50%	0.3	0.4
	1%	0.25	0.63
	2%	0.2	0.52
Nano size	0.50%	0.41	0.54
	1%	0.69	0.67
	2%	0.47	0.5

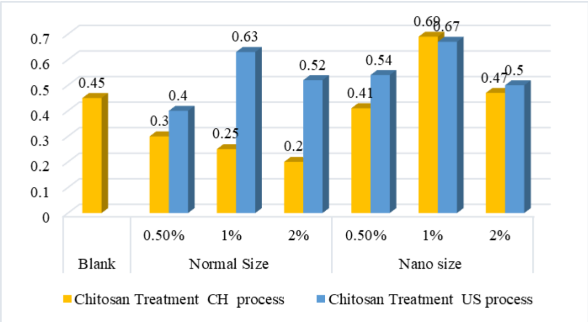


Figure 9: Effect of chitosan and Nano chitosan on K/S of cotton fabrics printed with Vat dye

From all value we can easily illustrate that treating cotton sample with chitosan irrespective of concentration used or particle size used, samples treated with US process acquire K/S in most cases higher than that of CH process and also higher than the blank and untreated sample. These values are higher increase in K/S which reaches in some cases to 64% increase was expected, since chitosan hold in its structure additional group means more site and active site to react with vat dyes.

Additionally, it has been found that various citric acid concentrations have an impact on color strength values. For color strength, 1% citric acid is the ideal concentration. Crosslinking reaction of chitosan was illustrated in Figure 10.

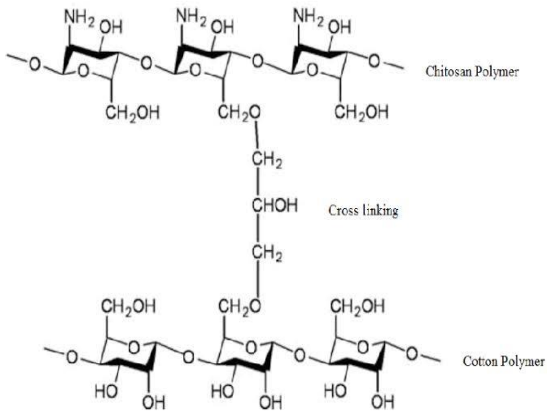


Figure 10: Crosslinking reaction of chitosan

3.4.1.2. Color strength for polyester fabric printed with Vat dye

Samples of polyester fabrics 100% were prepared by different concentration of chitosan and nano chitosan (0 0.5 ,1 and 2 %) as detailed before then samples propose to undergo screen printing using vat dyes, are dried and finally steamed. The aforementioned samples were adjusted to color strength measurements and the data were illustrated in Table 3 and Figure 11.

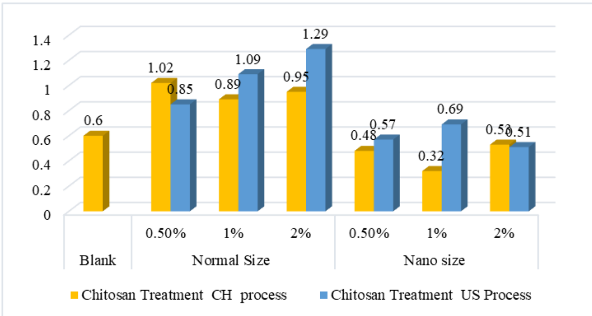


Figure 11: Effect of chitosan and Nano chitosan on K/S of polyester fabrics printed with Vat dye

Table 3: Effect of chitosan and Nano chitosan on K/S of polyester fabrics printed with Vat dye

Chitosan Concentration		Chitosan Treatment	
		CH process	Ultra-Sonic
Blank		0.6	
Normal Size	0.5%	1.02	0.85
	1%	0.89	1.09
	2%	0.95	1.29
Nano size	0.5%	0.48	0.57

	1%	0.32	0.69
	2%	0.53	0.51

While the highest K/S value was achieved by treating polyester fabrics by 2% chitosan with its normal size by using US method. In this case we find that the Value of K/S was 1.29 compared with 0.6 in case of the blank one. i.e., increase by 0.5% (by almost more than double). this result may be due to the active hydroxyl group created in polyester surface as a result of its modification with chitosan as shown in Figure 12 (which shows the reaction occurs between chitosan and polyester fabric).

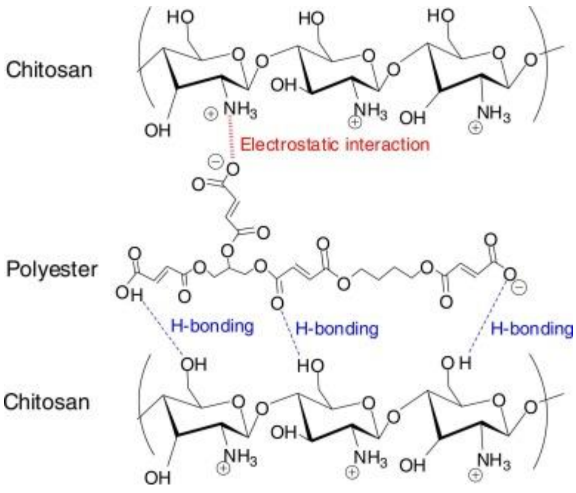


Figure 12: Crosslinking reaction of chitosan and polyester

3.4.1.3. Color strength for C /P (50/50) fabric printed with Vat dye

The aforementioned treated samples cotton/polyester 50/50 with the same concentration of chitosan and nano chitosan either CH process or US process. As discussed before samples treated were subjected to vat screen printing and results of K/S value are calculated in Table 4 and Figure 13.

Table 4: Effect of chitosan and Nano chitosan on K/S of cotton /polyester (50/50) fabrics printed with Vat dye

Chitosan Concentration		Chitosan Treatment	
		CH	US
Blank		0.45	
Normal Size	0.50%	0.52	0.2
	1%	0.52	0.21
	2%	0.41	0.22
Nano size	0.50%	0.54	0.38
	1%	0.49	0.44
	2%	0.48	0.55

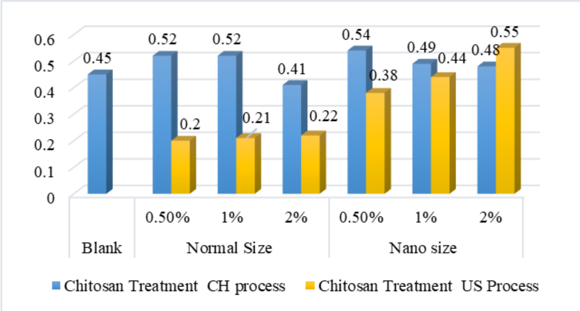


Figure 13: Effect of chitosan and Nano chitosan on K/S of cotton /polyester (50/50) fabrics printed with Vat dye

AS it's clear from the data of Table 4 that the K/S values were found to be depending on the con. Of chitosan used and /or it's particle size. The highest K/S was achieved when treating C/P fabrics with 2% nano chitosan, the percent increase reaches 22% by using US process. While treating the same fabric with 0.5% only of normal size of chitosan case a remarkable decrease in K/S value from 0.45 for the blank sample to 0.2 for treated one. this reversed data was expected since C/P 50/50 as a blend fabric comprise two samples with two different affinity and conditions with variable hinder the penetration of CH particles especially in the polyester portion and this hinderance increase which explain why this decrease in K/S occurs specially with chitosan normal size treatment (see Figure 14).

3.4.1.4. Color strength for C/P (65/35) fabric printed with Vat dye

printed blend C/P 65/35 samples untreated and treated using chitosan and nano chitosan. The results obtained are set out in Table 5 and Figure 15. According to the K/S value, untreated blend C/P 65/35 samples showed a lower dye absorption compared to the treated blend C/P 65/35 samples.

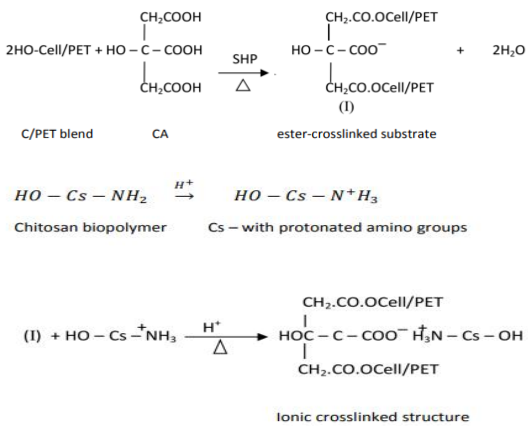


Figure 14: Crosslinking reaction of chitosan and C/PET

Table 5: Effect of chitosan and Nano chitosan on K/S of cotton /polyester (35/65) fabrics printed with Vat dye

Chitosan Concentration		Chitosan Treatment	
		CH	Ultrasonic
Blank		0.45	
Normal Size	0.50%	0.52	0.2
	1%	0.52	0.21
	2%	0.41	0.22
Nano size	0.50%	0.54	0.38
	1%	0.49	0.44
	2%	0.48	0.55

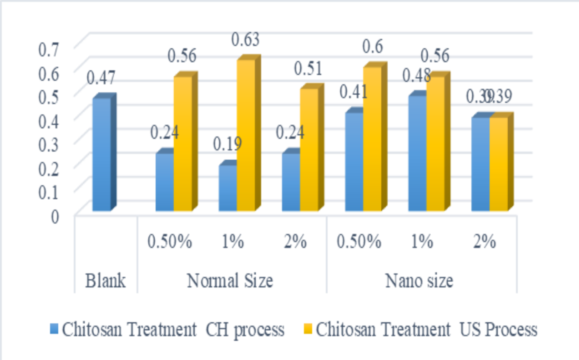


Figure 15: Effect of chitosan and Nano chitosan on K/S of cotton /polyester (35/65) fabrics printed with Vat dye

Table 5 shows that blend C/P 65/35 samples treated with normal `chitosan have much higher K/S values than blend C/P 65/35 samples treated with nano chitosan. Table VIII results show that the process of treating chitosan has a great influence on the K/S values in the most cases, the US process acquire highest K/S values when compare to the CH process as well as when compared to the blank sample. while the highest value was achieved by 1% chitosan in normal size increasing chitosan conc. More than that, i.e., to 2% or even by nano chitosan in accompanied by gradual decrease in K/S values which reaches to a decrease than the blank sample. These results may be due to the nature of polyester fabric which repress 35 % of the blend with its poorness in wettability and absorbance and hence introducing more particles in its tidy surface may cause a hendecane to its original affinity to update dye particles

3.4.2. On printing using Direct Dye

Direct dye was applied to cotton, polyester, cotton/polyester (50/50) and cotton/polyester (35/65) treated fabrics with chitosan and nano chitosan .as detailed before. The K/S values of the samples are shown from Table 6 to Table 9.

3.4.2.1. Color strength for cotton fabric printed with direct dye

Untreated and treated samples using chitosan/nano chitosan. Obtained in Table 6 and Figure 16. According to the K/S value, untreated cotton fabric showed a lower dye absorption compared to the treated cotton fabrics.

Table 6: Effect of chitosan and Nano chitosan on K/S of cotton fabrics printed with Direct dye

Chitosan Concentration		Chitosan Treatment	
		CH	Ultrasonic
Blank		0.9	
Normal Size	0.50%	1.99	1.23
	1%	1.76	1.69
	2%	1.65	1.27
Nano size	0.50%	2.54	4.56
	1%	3.12	5.64
	2%	3.5	4.89

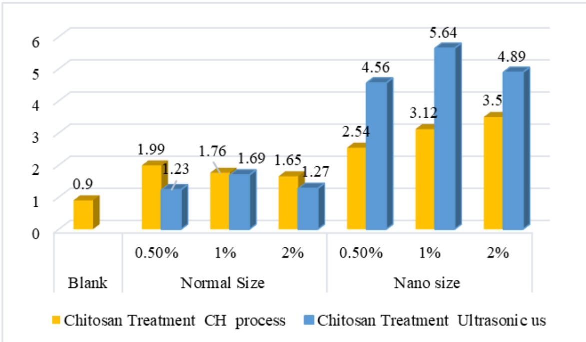


Figure 16: Effect of chitosan and Nano chitosan on K/S of cotton fabrics printed with Direct dye

Table 6 shows that cotton treated samples with chitosan nanoparticles have much higher K/S values than cotton samples treated with normal chitosan. And using US process in treated samples show high K/S values compared to using CH process. The increase in K/S reaches to 5.64 in case of 0.5% nano chitosan treatment against 0.9 to the blank sample. i.e., five times increase which high light the efficiency of introducing hydroxyl as well as amino groups to the cotton fabrics. Additionally, it has been found that various citric acid concentrations have an impact on color strength values. For color strength, 1% citric acid is the ideal concentration. By increasing the active sites as cleared before from the equation of its reaction with chitosan. Which in terms increase the active size to react with more and more dye particles causes this remarkable increase in K/S values.

3.4.2.2. Color strength for polyester fabric printed with direct dye

untreated and treated samples using chitosan/nano chitosan. Obtained in

Table 7 and Figure 17. According to the K/S value, untreated polyester fabric showed a lower dye absorption compared to the treated polyester fabrics.

Table 7: Effect of chitosan and Nano chitosan on K/S of polyester fabrics printed with Direct dye.

Chitosan concentration		Chitosan Treatment	
		CH process	Ultra-Sonic process
Blank		0.01	
Normal Size	0.50%	0.02	0.02
	1%	0.04	0.03
	2%	0.07	0.05
Nano size	0.50%	0.06	0.03
	1%	0.06	0.05
	2%	0.05	0.04

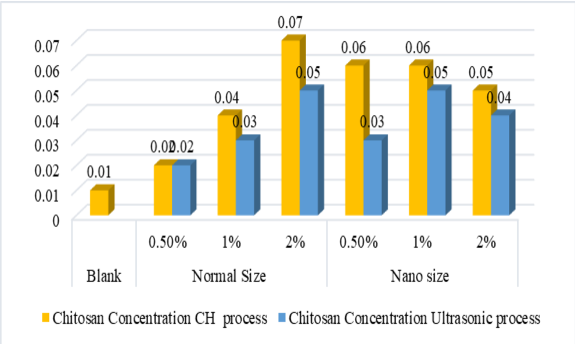


Figure 17: Effect of chitosan and Nano chitosan on K/S of polyester fabrics printed with Direct dye

Table 7 shows that treated samples with chitosan in normal size have high K/S values compered to samples treated with nano chitosan. And using CH process have much higher K/S values than US process. And the highest K/S value at concentration 2%.

3.4.2.3. Color strength for C/P 50/50 fabric printed with direct dye

Printed blend C/P 50/50 samples untreated and treated using chitosan and nano chitosan. The results obtained are set out in Table 8 and

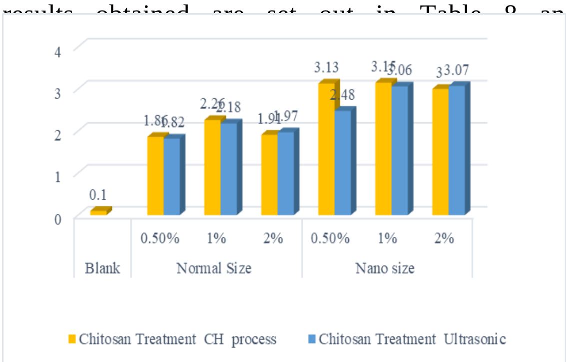


Figure 18. According to the K/S value, it can be seen that untreated blend C/P 50/50 samples showed a lower dye absorption compared to the treated blend C/P 50/50 samples.

Table 8 shows that blend C/P 50/50 samples treated with nano chitosan have much higher K/S values than blend C/P 50/50 samples treated with normal chitosan. And using US process while treating the samples with nano chitosan show high K/S values compared to CH process .and the ideal concentration of citric acid For color strength is 2%. this result was expected as discussed before in case of vat dye

Table 8: Effect of chitosan and Nano chitosan on K/S of cotton/ polyester (50/50) fabrics printed with Direct dye

Chitosan Concentration		Chitosan Treatment	
		CH	Ultrasonic
Blank		0.1	
Normal Size	0.50%	1.86	1.82
	1%	2.26	2.18
	2%	1.91	1.97
Nano size	0.50%	3.13	2.48
	1%	3.15	3.06
	2%	3	3.07

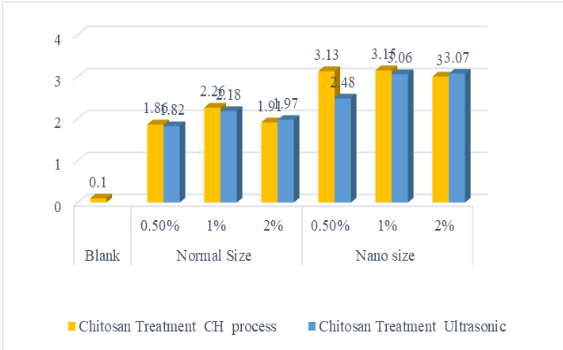


Figure 18: Effect of chitosan and Nano chitosan on K/S of cotton/ polyester (50/50) fabrics printed with Direct dye

3.4.2.4. Color strength for C/P 65/35 fabric printed with direct dye

Printed blend C/P 50/50 samples untreated and treated using chitosan and nano chitosan. The results obtained are set out in Table 9 and

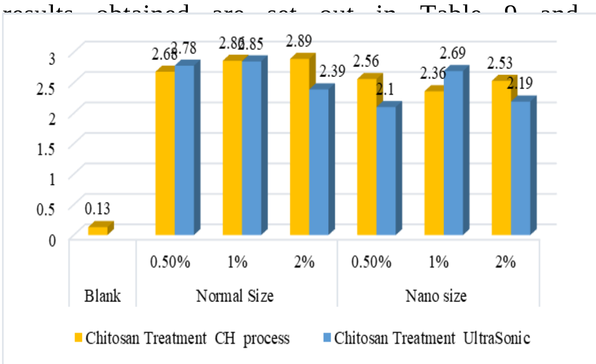


Figure 19. According to the K/S value, it can be seen that untreated blend C/P 50/50 samples showed a lower dye absorption compared to the treated blend C/P 50/50 samples.

Table 9: Effect of chitosan and Nano chitosan on K/S of cotton/ polyester (35/65) fabrics printed with Direct dye

Chitosan Concentration		Chitosan Treatment	
		CH	Ultrasonic
Blank		0.13	
Normal Size	0.50%	2.68	2.78
	1%	2.86	2.85
	2%	2.89	2.39
Nano size	0.50%	2.56	2.1
	1%	2.36	2.69
	2%	2.53	2.19

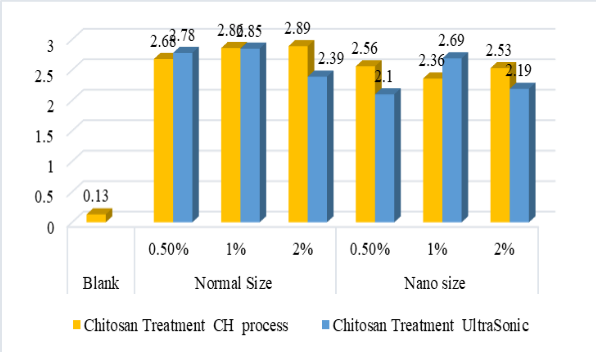


Figure 19: Effect of chitosan and Nano chitosan on K/S of cotton/ polyester (35/65) fabrics printed with Direct dye

Table 9 shows that blend C/P 50/50 samples treated with nano chitosan have much higher K/S values than blend C/P 50/50 samples treated with bulk chitosan. And using US process while treating the samples with nano chitosan show high K/S values compared to CH process .and the ideal concentration of citric acid for color strength is 2%.

When we have a brief look on Table 9 and

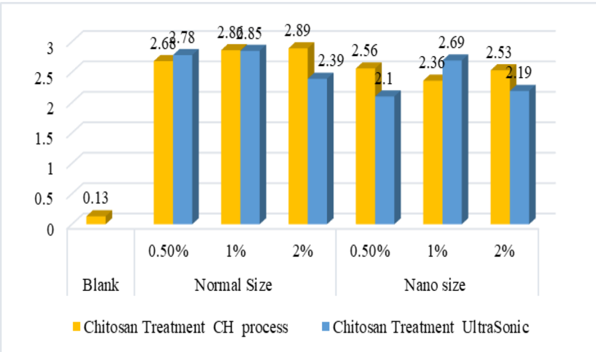


Figure 19 we can easily conclude that chitosan treatment by various size and /or concentration cause a remarkable increase in K/S values in all cases. these results refers to nature of direct dye it's self since direct dye depends only on its affinity, when printing blend fabric 35% polyester portion this means that the K/S will be so poor (0.013) while introducing chitosan particles in fabric surface case a difference and incorporation.

3.5. Color Fastness Evaluation

The printed samples treated with chitosan and Nano chitosan by Vat and direct dyes for all treatment method which acquire the highest K/S were chosen and subjected to overall color fastness measurements. The printed untreated samples fabrics were also measured under the same conditions for the sake of comparison. Tables represent the data of overall color fastness properties, i.e., for, rubbing (wet and dry), perspiration (acidic and alkaline), lighting, and washing are settled below.

3.5.1. On Using Vat Dye

Table 10 show the various fastness categories (washing, rubbing alkali perspiration, acid perspiration and light fastness) of treated printing fabrics using chitosan and Nano chitosan with Vat dye.

3.5.1.1. Color Fastness to Washing

Color fastness to washing is one of the most essential features of textiles and clothing in the consumer's mind. This test detects discoloration and loss during the washing process, as well as the staining behavior of light garments or other washable materials. From the results it is observed that the printed cotton fabrics show decrease in wash fastness with chitosan and nano chitosan. The printed fabrics show good wash fastness where the color change was found from 3-4 to 4 for chitosan and nano chitosan.

3.5.1.2. Color Fastness to Perspiration

The color fastness of Perspiration is an important test of fabrics, especially those directly on skin cells according to

Table 10, color fastness of printed samples treated with chitosan and Nano chitosan showed more stability of alkaline perspiration than acidic in discoloration of printed fabrics that's due to vat is stable at an alkaline pH but unstable at an acidic

3.5.1.3. Color Fastness to Rubbing

In the color fastness of rubbing, check the color transferred from the surface of the stained fabric to another surface by rubbing it with water and dry. Results of color fastness with rubbing were reported in Table 10 as The results showed that all printed textiles treated with chitosan and nano chitosan had good color fastness of rubbing. This shows that the bulk of the dye molecules are strongly bonded to the fibers, with only a few surface dye molecules remaining. As previously noted, the dye molecules may have created bonds between themselves and the treated material and textiles.

3.5.1.4. Color Fastness to Light

According to

Table 10, the light fastness of the samples printed with vat dye and treated with chitosan and Nano chitosan showed high of light stability, as the light stability of the printed fabrics is affected by the physical state, the concentration of the dye, chemicals, the nature of the fibers and the treatment materials and their ability to absorb light and refraction**.**

Table 10: Effect of chitosan and Nano chitosan on color fastness values of cotton and polyester and P/C blended fabrics printed with vat Dye

Treatment material	type of fabric	treatment method	washing fastness			Perspiration fastness						Rubbing fastness		Light fastness
						acidic			alkaline					
			St.(c)	St.(w)	Alt.	St.(C)	St.(W)	Alt	St.(C)	St.(W)	Alt	Dry	Wet	Degree
chitosan	cotton 100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3	3	5
		US	4	4	4	4	4	4	4	4	4	2-3	2	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	4	3-4	5
		US	4	4	4	4	4	4	4	4	4	3	2-3	3-4
	p/c50/50	without	4	4	4	3-4	4	4	4	4	4	3	3	4
		CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	4	3-4	6
	P/C35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	3-4	3-4	5
nanochitosan	cotton100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3-4	3	6
		US	3-4	4	4	3-4	4	4	4	4	4	3	2-3	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	3	2	5
		US	4	4	4	4	4	4	4	4	4	4	3	4

3.5.2. On Using Direct Dye

3.5.2.1. Color Fastness to Washing

	p/c50/50	without	4	4	4	3-4	4	4	4	4	4	3	3	4
		CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3	4
	P/C35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3`	4-5

Key: Alt: Color Alteration St (C): Staining of Cotton St (W): Staining of Wool

Table 11 show the various fastness categories (washing, rubbing alkali perspiration, acid perspiration and light fastness) of treated printing cotton fabrics using chitosan and Nano chitosan with direct dye. From the results it is observed that the printed cotton fabrics show low washing fastness for samples treated with chitosan where the color change was found from 4 to 3- 4 and good washing fastness for samples treated with Nano chitosan the color change was found from 3 to 4.

3.5.2.2. Color Fastness to Perspiration

Table 10: Effect of chitosan and Nano chitosan on color fastness values of cotton and polyester and P/C blended fabrics printed with vat Dye

Treatment material	type of fabric	treatment method	washing fastness			Perspiration fastness						Rubbing fastness		Light fastness
			St. (c)	St. (w)	Alt.	acidic			alkaline			Dry	Wet	Degree
						St. (C)	St. (W)	Alt	St. (C)	St. (W)	Alt			
chitosan	cotton 100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3	3	5
		US	4	4	4	4	4	4	4	4	4	2-3	2	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	4	3-4	5
		US	4	4	4	4	4	4	4	4	4	3	2-3	3-4
	p/c 50/50	without	4	4	4	3-4	4	4	4	4	4	3	3	4
		CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	4	3-4	6
	P/C 35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	3-4	3-4	5
nano chitosan	cotton 100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3-4	3	6
		US	3-4	4	4	3-4	4	4	4	4	4	3	2-3	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	3	2	5
		US	4	4	4	4	4	4	4	4	4	4	3	4

	p/c50/50	without	4	4	4	3-4	4	4	4	4	4	3	3	4
		CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3	4
	P/C35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3`	4-5

Key: Alt: Color Alteration St (C): Staining of Cotton St (W): Staining of Wool

Table 11 show that color fastness of treated printed samples with chitosan and Nano chitosan is more stability of acidic perspiration than alkaline in discoloration of printed fabrics, also showed good stability against staining on cotton and wool fabrics.

Table 10: Effect of chitosan and Nano chitosan on color fastness values of cotton and polyester and P/C blended fabrics printed with vat Dye

Treatment material	type of fabric	treatment method	washing fastness			Perspiration fastness						Rubbing fastness		Light fastness
						acidic			alkaline					
			St. (c)	St. (w)	Alt.	St. (C)	St. (W)	Alt	St. (C)	St. (W)	Alt	Dry	Wet	Degree
chitosan	cotton 100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3	3	5
		US	4	4	4	4	4	4	4	4	4	2-3	2	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	4	3-4	5
		US	4	4	4	4	4	4	4	4	4	3	2-3	3-4
	p/c 50/50	without	4	4	4	3-4	4	4	4	4	4	3	3	4
		CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	4	3-4	6
	P/C 35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	3-4	3-4	5
nano chitosan	cotton 100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3-4	3	6
		US	3-4	4	4	3-4	4	4	4	4	4	3	2-3	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	3	2	5
		US	4	4	4	4	4	4	4	4	4	4	3	4
	p/c50/	without	4	4	4	3-4	4	4	4	4	4	3	3	4

3.5.2.3. Color Fastness to Rubbing

Results of color fastness with rubbing were reported in

	50	CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3	4
	P/C 35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3`	4-5

Key: Alt: Color Alteration St (C): Staining of Cotton St (W): Staining of Wool

Table 11 and show high color fastness of rubbing for printed fabrics treated with chitosan and Nano chitosan in dry compared to wet.

Table 10: Effect of chitosan and Nano chitosan on color fastness values of cotton and polyester and P/C blended fabrics printed with vat Dye

Treatment material	type of fabric	treatment method	washing fastness			Perspiration fastness						Rubbing fastness		Light fastness
						acidic			alkaline					
			St.(c)	St.(w)	Alt.	St.(C)	St.(W)	Alt	St.(C)	St.(W)	Alt	Dry	Wet	Degree
chitosan	cotton 100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3	3	5
		US	4	4	4	4	4	4	4	4	4	2-3	2	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	4	3-4	5
		US	4	4	4	4	4	4	4	4	4	3	2-3	3-4
	p/c50/50	without	4	4	4	3-4	4	4	4	4	4	3	3	4
		CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	4	3-4	6
	P/C35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	3-4	3-4	5
nano chitosan	cotton 100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3-4	3	6
		US	3-4	4	4	3-4	4	4	4	4	4	3	2-3	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	3	2	5
		US	4	4	4	4	4	4	4	4	4	4	3	4
	p/c50/	without	4	4	4	3-4	4	4	4	4	4	3	3	4

3.5.2.4. Color Fastness to Light

According to

	50	CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3	4
	P/C 35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3`	4-5

Key: Alt: Color Alteration St (C): Staining of Cotton St (W): Staining of Wool

Table 11, the light fastness of printed fabrics with direct dye and treated with chitosan and Nano chitosan showed high degree of light fastness after treated with chitosan and nano chitosan.

3.6. Measurement of UPF for Printed Fabrics

The printed samples treated with chitosan and Nano chitosan by vat and direct dye for optimum treatment method which acquire the highest K/S were chosen and subjected to UPF measurements. The printed untreated samples fabrics were also measured under the same conditions for comparison.

Table 10: Effect of chitosan and Nano chitosan on color fastness values of cotton and polyester and P/C blended fabrics printed with vat Dye

Treatment material	type of fabric	treatment method	washing fastness			Perspiration fastness						Rubbing fastness		Light fastness
						acidic			alkaline					
			St. (c)	St. (w)	A lt.	St.(C)	St.(W)	A lt	St.(C)	St.(W)	A lt	Dry	Wet	Degree
chitosan	cotton 100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3	3	5
		US	4	4	4	4	4	4	4	4	4	2-3	2	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	4	3-4	5
		US	4	4	4	4	4	4	4	4	4	3	2-3	3-4
	p/c 50/50	without	4	4	4	3-4	4	4	4	4	4	3	3	4
		CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	4	3-4	6
	P/C 35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	3-4	3	5
		US	4	4	4	4	4	4	4	4	4	3-4	3-4	5
nano chitosan	cotton 100%	without	4	4	4	4	4	4	4	4	4	3	3	4-5
		CH	4	4	4	4	4	4	4	4	4	3-4	3	6
		US	3-4	4	4	3-4	4	4	4	4	4	3	2-3	6
	polyester	without	4	4	4	4	4	4	4	4	4	2-3	3	5-6
		CH	4	4	4	4	4	4	4	4	4	3	2	5
		US	4	4	4	4	4	4	4	4	4	4	3	4
	p/c 50/50	without	4	4	4	3-4	4	4	4	4	4	3	3	4
		CH	4	4	4	4	4	4	4	4	4	3-4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3	4
	P/C 35/65	without	3-4	4	4	4	4	4	4	4	4	3-4	3	5-6
		CH	3-4	4	4	4	4	4	4	4	4	4	3	5
		US	3-4	4	4	4	4	4	4	4	4	3	3`	4-5

Key: Alt: Color Alteration St (C): Staining of Cotton St (W): Staining of Wool

Table 11: Effect of chitosan and Nano chitosan on color fastness values of cotton and polyester and C/P blended fabrics printed with Direct Dye

Treatment material	type of fabric	treatment method	washing fastness			Perspiration fastness						Rubbing fastness		Light fastness
						acidic			alkaline				Wet	Degree
			St.(c)	St. (w)	Alt.	St.(C)	St. (w)	Alt	St.(C)	St.(W)	Alt	Dry		
chitosan	cotton 100%	without	3-4	4	4	3-4	4	4	3-4	4	4	3-4	2	3-4
		CH	3	3-4	4	3-4	4	4	3-4	3-4	4	3	2	4
		US	3-4	4	4	3-4	4	4	3-4	4	4	3-4	2-3	3-4
	polyester	without	4	4	4	4	4	4	4	4	4	4	3	6
		CH	4	4	4	4	4	4	4	4	4	3-4	3	6
		US	4	4	4	4	4	4	4	4	4	4	3-4	6
	p/c 50/50	without	3-4	4	4	4	4	4	4	4	4	4	3-4	4-5
		CH	3-4	4	4	4	4	4	3-4	4	4	4	3-4	5
		US	4	4	4	3-4	4	4	3-4	4	4	4	3-4	6
	P/C 35/65	without	4	4	4	4	4	4	3-4	4	4	4	3-4	4
		CH	3-4	4	4	3-4	4	4	3-4	4	4	3	3	5-6
		US	4	4	4	4	4	4	4	4	4	3-4	3	4-5
nano chitosan	cotton 100%	without	3-4	4	4	3-4	4	4	3-4	4	4	3-4	2	3-4
		CH	3-4	4	4	3-4	4	4	3-4	4	4	3-4	2	3-4
		US	3-4	4	4	3-4	4	4	3-4	4	4	4	2	4
	polyester	without	4	4	4	4	4	4	6	4	4	4	3	6
		CH	4	4	4	4	4	4	4	4	4	4	3	6
		US	4	4	4	4	4	4	4	4	4	4	3-4	6
	p/c 50/50	without	3-4	4	4	4	4	4	4	4	4	4	3-4	4-5
		CH	4	4	4	4	4	4	4	4	4	4	4	6
		US	3-4	4	4	4	4	4	3-4	4	4	4	3-4	5-6
	P/C 35/65	without	3-4	4	4	4	4	4	3-4	4	4	4	3-4	4
		CH	4	4	4	4	4	4	3-4	4	4	3-4	3-4	4-5
		US	3-4	4	4	3-4	4	4	3-4	3-4	4	3-4	3	4

Key: Alt: Color Alteration St (C): Staining of Cotton St (W): Staining of Wool

3.6.1. On Using Vat Dye

Table 12 show The UPF values of all the treated printed fabric samples are higher than the untreated samples, referring to more UV protection, printed cotton showed poor UV protection degree (24.9) after treatment with 1% Nano chitosan using CH process respectively. Treated printed C/P 65/35with 1% chitosan using US process showed excellent protection (33.6) by AS/NZ S43991996 and Test Method 1832010 respectively. Treated printed C/P (50/50) and (65/35) show the highest protection by AS/NZ S4399-1996 and Test Method 183-2010, This could be due to it has more amorphous area and more absorbent than cotton and polyester fabrics. Treated polyester showed more protection with (26.1) treated with 2% chitosan than cotton with (24.9) treated with 1% nano chitosan by AS/NZ S4399-1996 and Test Method 183-2010 respectively

3.6.2. On Using Direct Dye

Table 13 show The UPF values of all the treated printed fabric samples with direct dye are higher than the untreated samples, printed cotton treated with nano chitosan using US process showed poor UV protection degree (10.9) and polyester treated fabric with bulk chitosan at 2% using CH process 1% chitosan using US process showed excellent protection (33.9) by AS/NZS 4399-1996 and Test Method 183-2010 respectively, due to it has more amorphous area and more absorbent than cotton and blended C/P fabrics. Treated blend 65/35showed more protection with (15.5) treated with 2% chitosan than 50/50 with (14.2) treated with 1% nano chitosan by AS/NZS 4399-1996 and Test Method 183-2010 respectively.

Table 12: Effect of chitosan and Nano chitosan on UPF of treated and untreated printed with Vat dye

type of fabric	treatment material	treatment method	Test Method of UPF					
			AS/NZ S4399-1996			AATCC 183-2010		
			AS/NZ UPF	AS/NZ UVA	AS/NZ UVB	AATCC UPF	AATCC UVA	AATCC UVB
cotton	nano chitosan	CH process	24.9	24.5	4.1	24.9	24.6	4.1
polyester	chitosan	US process	26.1	7.4	9.7	26.1	7.7	9.4
C/P 50/50	nano chitosan	US process	27.7	12.9	7.1	27.7	12.3	7
C/P 65/35	chitosan	US process	33.6	19.3	5.1	33.6	18.3	5.1

Table 13: Effect of chitosan and Nano chitosan on UPF of treated and untreated printed with Direct dye

type of fabric	treatment material	treatment method	Test Method of UPF					
			AS/NZS 4399-1996			AATCC 183-2010		
			AS/NZ UPF	AS/NZ UVA	AS/NZ UVB	AATCC UPF	AATCC UVA	AATCC UVB
cotton	nano chitosan	US process	10.9	10	9.8	10.9	10	9.7
polyester	chitosan	CH process	33.9	8.7	8.1	33.9	9	7.8
C/P 50/50	nano chitosan	CH process	14.2	6.6	12.6	14.2	6.7	12.3
C/P 65/35	chitosan	CH process	15.5	7.7	11.2	15.5	7.8	11

4. Conclusions

Chitosan has acquired uses in textiles that have attracted the attention of many researchers. The polymer chitosan's high viscosity and small molecular size limit its uptake through fiber. Reduced particle size of chitosan leads to nano-level absorption in the fiber structure while conserving the unique qualities of natural fibers. Using chitosan and nano chitosan in treatment of cotton and polyester and their blend by two methods conventional heat and Ultra-sonic was studies their dyeing and characteristics of stability and tensile strength and elongation and surface morphology. The results showed highly improvement in the properties of treatment fibers. K/S values of treated fibers show higher value comparing to untreated one and good fastness properties also. When compared to bulk chitosan and nano chitosan the nano chitosan shown superior qualities due to its larger surface area and smaller size, and all treated materials have excellent fastness values for washing, perspiration, and rubbing. Cotton and blend C/ PET 50/50 treated fabric with nano chitosan show higher value compared to treated with bulk chitosan and using US method show high K/S, UPF and fastness properties value compared to CH process, however another fabric polyester and blend C/PET 65/35 treated with bulk chitosan have excellent light fastness values compared to treated with nano chitosan. The UPF values of all the treated fabrics printed with vat and direct dye are higher than those of the blank.

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