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Deposition of Silver Nanoparticles on Nylon Fabric and Dyeing through Green Synthesis with White Sugar

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Abstract

This research focuses on green synthesis of AgNPs using environmentally benign reagents in minimal time paves the way for future studies on AgNPs toxicity without risking interference from potentially toxic reagents and capping agents. The use of this technique to treat nylon fabric may lead to new coloration technique and other functional improvement. Our method a totally green approach toward the rapid synthesis and evergreen protocol for the green synthesis of silver nanoparticles AgNPs from aqueous solution of silver nitrate using available sugar as reducing agents in a single-pot, in the presence of sunlight . Green synthesized AgNPs were characterized by Scaning electron microscopy (SEM) , Transmission electron microscopy (TEM), , Energy dispersive spectroscopy (EDS), Fourier transform infrared (FTIR) and x-ray diffraction (XRD) analysis. The dyeing behavior of green AgNPs treated nylon fabric with Acid Black 172 (AB 172) has been studied and the build up of dye, measured as exhaustion percentage (E%) , increases the dye affinity (from 77.38 % to 99.79 %) towards the fabric. Dye adsorption rate constants according to pseudo-first order, pseudo-second order, and intra-particle diffusion kinetic models were calculated. Moreover, the dye adsorption equilibrium data were fitted well to the Freundlich isotherm rather than Langmuir isotherm. The overall adsorption process follow pseudo-second order kinetics, Intraparticle diffusion and Elovich model. The green synthesized AgNPs treatment produces a nylon fabric with advanced color fastness and antibacterial properties enabling them to improve human health care and reducing temperature, the environmental impacts, fabric damage, amount of dyestuff used and saving energy of conventional dyeing of nylon fabrics.

Keywords: green synthesis; Silver nanoparticles; nylon fabric; acid black 172 ; antimicrobial ;dyeing process.

1. Introduction

Nowadays, nanoparticles have been used commercially for a wide variety of coating areas including electronics, energy contact actions, and medicines. Although different techniques have been used successfully to produce nanoparticles, they remain expensive and often they involve the use of hazardous chemicals [1] which pose potential environmental and biological risks [2]. The desire to develop an eco-friendly approach for the synthesis of nanoparticles has arisen as a result of growing awareness of green chemistry and other biological processes. This approach has several advantages, including simplicity, cost effectiveness, compatibility for biomedical and pharmaceutical applications, and large-scale commercial production. To improve nylon dyeing, physical properties and antibacterial properties, it can be treated in several different ways including hydroxyapatite, titanium dioxide, zinc oxide, magnesium oxide nanoparticles [3], microwave irradiation [4], polyvinyl alcohol, Sio2 PNs [5], chitosan and silver nanoparticles [6] and green copper synthesized using black tea extract [7]

Commercial applications of these nanoparticles in the pharmaceutical and other medical disciplines rely heavily on AgNPs. Because of their greater biocompatibility, biosynthesized AgNPs are preferred for medicinal applications over chemically synthesized AgNPs. Three basic requirements should be evaluated from a green chemistry standpoint in the green synthesis of nanoparticles: (i) the choice of a cheap and environmentally benign solvent; (ii) the choice of an eco-friendly and cost-effective reducing

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agent; and (iii) the choice of renewable stabilizing agents used to protect the nanoparticle surface [8] .

The inhibitory and antibacterial actions of silver bio-nanoparticles (AgNPs) have long been known. Pathogenic bacteria have developed resistance to antimicrobial drugs in recent years, and this has become a major public health issue [9]. Among biological methods, the synthesis of AgNPs using plant extracts is the best eco-friendly alternative to available traditional chemical and physical methods [10-12]. This method is mainly used for reducing the toxicity and development of green chemistry.

They are now used as part of clothing, food containers, wound dressings, ointments, and implant coatings. On the contrary, the treatment of nylon fabric with inorganic nanoparticles before dyeing process proved to be more rapid, uniform, efficient, while also increasing the dye affinity and improving the fastness properties of nylon fabric towards washing, light, rubbing and perspiration. It is considered a better alternative to the conventional dyeing technique due to the reduction of environmental impact, and energy consumption [13].

In the present research, we report for the first time that green based AgNPs have been used to functionalize nylon fabrics employing using white sugar as a reducing and capping agent (green pathways). Green synthesized AgNPs were applied to nylon fabric by exhaustion which involves in three different steps i.e., initially nylon sample was scoured well then impregnated with freshly prepared Ag-NPs colloids under optimized condition and finally rinsed out to remove unfix nanoparticles. Their antibacterial activity was also evaluated. Dye adsorption rate constants, the diffusion coefficients and the activation energy of diffusion of AB 172 into nylon fabrics were calculated.

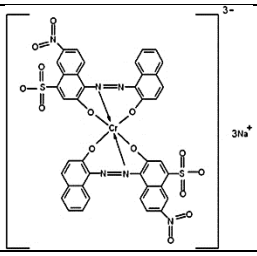
2.Materials and methods

2.1Materials

Nylon fabric was supplied by El-Nasr Company, Acid Black 172 (AB172) was kindly supplied by New Trend Co. Egypt. The characteristics of the dye are listed n Table 1.

Commercially available white sugar was purchased from Market. All chemicals used, were purchased with high purity from Merck Darmstad, Germany .White sugar was carefully sieved to obtain homogeneous sugar crystals. All aqueous solutions were prepared by using double-distilled water.

Table 1: The characteristics of dye

Dye	Molecular Formula	Molecular weight	λmax	Structure
Acid Black 172	$C_{40}H_{20}CrN_6Na_3O_{14}S_2$	**993.71 gmol^{-1}**	**572nm**	

2.2. Methods

2.2.1 Synthesis of green AgNps

According to a previous publication [14], green synthesis of green AgNPs was carried out. In a 250 ml conical flask, 50 ml of 0.2 percent white sugar solution was challenged with 25 ml of 1 mM silver nitrate salt solution and thoroughly mixed. Later 0.1 ml of 0.1 M NaOH solution was added slowly to the reaction mixture and mixed thoroughly. The resulting solution was then kept in bright sunlight for 10 min and observed for the color change.

2.2.2. Characterization of green AgNPs

The primary detection was carried out by visual observation. The change in color of solution from colorless to bright yellowish, indicated the formation of green synthesized AgNps and control (without treatment with 1mM silver nitrate) remained colorless after keeping in bright sunlight for 10 min. The green synthesized AgNPs were characterized by Fourier transform infrared (FTIR), Transmission electron microscopy (TEM), Scaning electron microscopy (SEM) , Energy dispersive spectroscopy (EDS) and x-ray diffraction (XRD) analysis, to confirm their nano size.

2.2.3 Dyeing procedures

Untreated and pretreated nylon fabrics with green synthesized AgNPs were dyed with AB 172 by applying batch technique under the dyeing recipe: dye concentration 25, 50, 75, 100 and150 (ppm), Liquor ratio (L:R) 1 : 50 , time 2 hours and temperature 90 ºC. At the end of dyeing, both the initial and equilibrium dye bath concentrations were measured with an UV-vis spectrophotometer (Model

T60, United Kingdom) at λmax = 572 nm,to be ready for calculation of the percentage of dye exhaustion (E%) .The dyed samples were removed, and rinsed in distilled water to remove the loosely fixed dye on the surface of dyed fabric, and were allowed to dry in the open air to be ready for the determination of nylon fabric properties. The percentage of dye exhaustion (E%) was calculated by using the Equation (1):

$$E\,\% = \frac{C_o - C_e}{C_o} \text{ x } 100 \qquad (1)$$

where C_0 is the initial dye concentration, C_e is the dye concentration at equilibrium.

2.2.4 Determination of nylon Fabric Properties

2.2.4.1 Color fastness properties

Color Fastness properties The untreated and pretreated dyed cotton samples at dyeing recipe were tested for various fastness properties such washing, light and perspiration according to ISO standard test methods [15].

2.2.4.2 Antibacterial investigation

The antibacterial activity was quantitatively evaluated against Staphylococcus aureus, a Gram-positive organism, and Escherichia coli, a Gram-negative organism, in accordance with AATCC 100 test method [16] using nutrient agar and an incubation period of 24 hours at 37 ºC. Colonies of bacteria recovered on the agar plate were counted, and the reduction percentage of bacteria, R (%), was calculated [17,18] using the following Equation (2) :

$$R\ (\%) = B - A / B \text{ X } 100 \qquad (2)$$

where A is the number of bacteria colonies from treated specimen after inoculation over 24 hours contact period and B is the number of bacteria colonies from untreated control specimen after 1 h contact time.

3.Results and discussions

3.1. Characterization of green synthesized AgNPs

The production of green synthesized AgNPs is indicated by the color change from yellow to yellowish brown [19]. The rate of synthesis was very slow at room temperature in the presence of 0.1 ml 0.1 M NaOH. The color change took about 2–3 hours. However, when the reaction mixture was exposed to direct sunshine for 10 minutes, it turned bright yellow. It's because sunlight provides the activation energy that catalyses the fast breakdown of sucrose while also increasing the pace of AgNps production. A UV–vis spectrophotometer in the wavelength range of 200–800 nm was used to confirm the synthesis of green AgNps. In the solution of green synthesized AgNPs generated with white sugar Figure 1, a prominent sharp peak at 409 nm was seen.

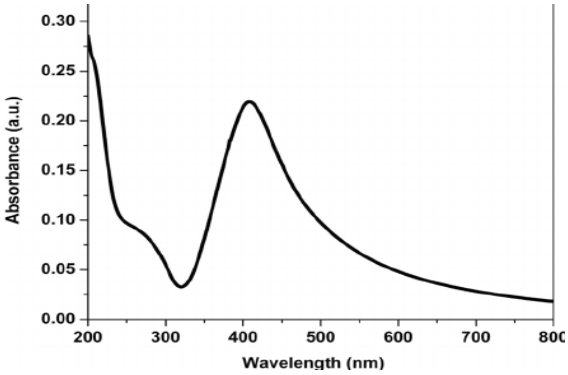


Fig.1: UV-vis absorption spectrum of green synthesized silver nanoparticles.

3.2 Photographic image

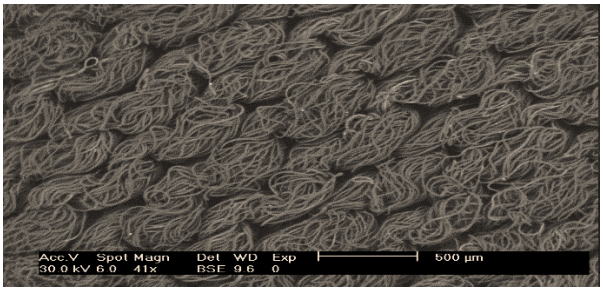
The photographic images of untreated nylon fabric and pretreated AgNPs nylon fabric are shown in Figure 2 (a,b) . The white color of the untreated nylon fabric changed into slightly yellowish color after synthesized green AgNPs deposition confirming that the green synthesized AgNPs is uniformly deposited on the nylon fabric.

(a) **(b)**

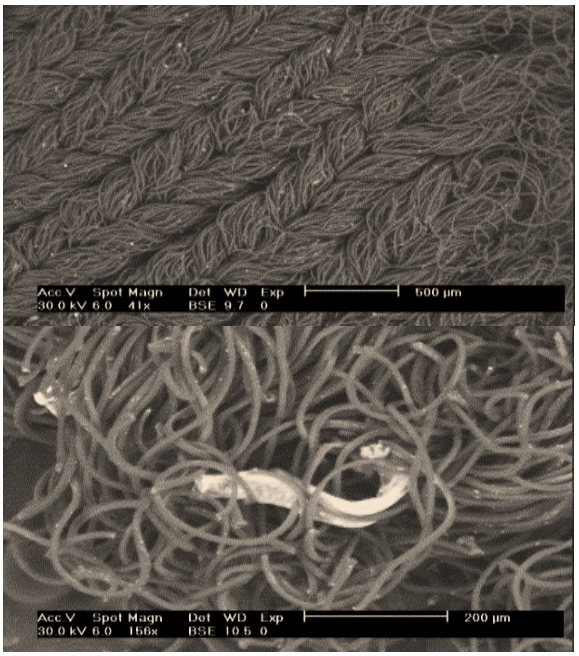
Fig. 2 :Photographic image of (a) untreated nylon fabric (b) green synthesized AgNPs - pretreated nylon fabric .

3.3 SEM analysis

The SEM images of untreated nylon fabric and green synthesized AgNPs -pretreated nylon fabric, were shown in Figure 3 (a , b) respectively. SEM analysis shows uniformly distributed silver nanoparticles on the surfaces of nylon fabric .



(**a**)



(**b**)

Fig. 3: SEM image of (a) untreated nylon fabric (b) green synthesized AgNPs – pre-treated nylon fabric.

3.4 TEM analysis

TEM images and their sizes were used to deduce the topology of green synthesized AgNPs. With a size of 200 nm, the green synthesized AgNPs produced with white sugar were spherical and monodispersed. Figure 4.

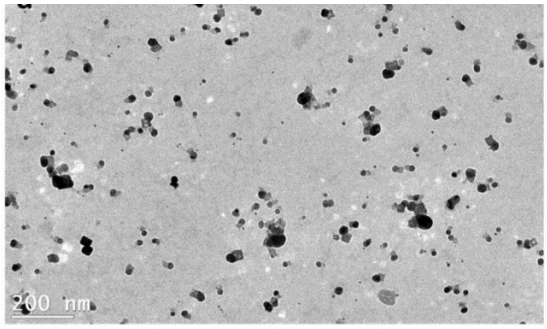
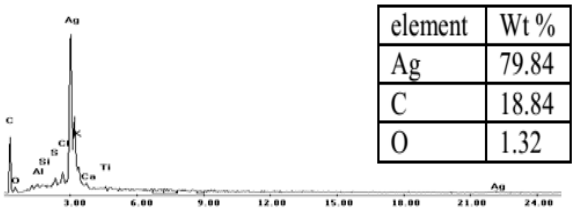


Fig. 4 : TEM analysis of green synthesized AgNPs .

3.5 EDS analysis

Figure 5 illustrates EDX analysis of green synthesized AgNPs the strong peaks observed related to Ag have the weight percentages of 79.84 % . These results confirm the successful synthesis of green synthesized AgNPs .

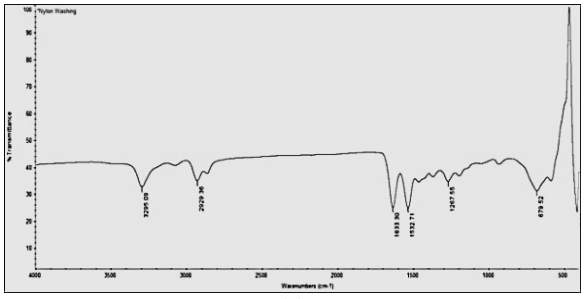


element	Wt %
Ag	79.84
C	18.84
O	1.32

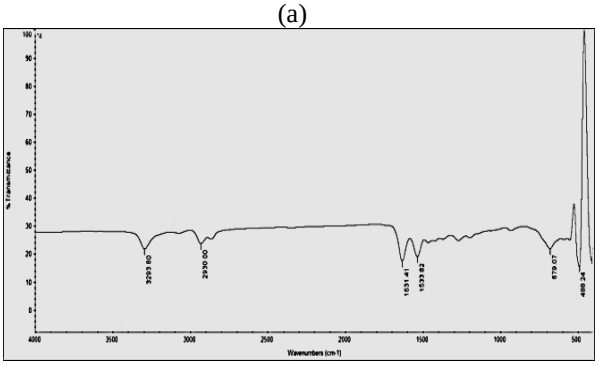
Fig. 5: EDS analysis of synthesized green AgNPs .

3.6 FTIR spectrum analysis

FTIR analysis was carried out to check the capping agent of green synthesized AgNPs. The FTIR spectrum showed the presence of peaks in the range from 400 to 4000 cm−1 prominently at 3295, 2929, 1631, 1532, 1267, 679 and 449.35 cm−1 Figure 6 b. Among these peaks, a peak at 1631 cm−1 is due to bending vibrations of alcoholic −OH groups [20] . This peak may be because of the presence −OH groups of gluconic acid encapsulating the green synthesized AgNps. In process of reduction of silver ions to metallic silver, the released glucose gets oxidized to gluconic acid which encapsulates the green synthesized AgNPs [21]. The adhesion of green synthesized AgNPs into the nylon fabric was recorded and compared with the untreated nylon fabric as shown in Figure 6 a. The FTIR spectra ensure that green synthesized AgNPs were loaded onto the nylon fabric.



(a)



(b)

Fig. 6 : FTIR spectra of (a) untreated nylon and (b) green synthesized AgNPs – pretreated nylon fabric .

3.7 XRD analysis

x-ray diffraction analysis was used to investigate the crystallographic behavior , Figures 7,8 shows XRD patterns for green synthesized AgNPs . The Four main characteristic diffraction peaks for Ag were observed at 2θ = 38.45, 46.35, 64.75 and 78.05, which correspond to the (111), (200), (220) and (311) crystallographic
planes of face-centered cubic (fcc) Ag crystals, respectively (JCPDS 00-004-0783). No peaks from any other phase were observed showing that single phase Ag with cubic structure nanoparticles have been obtained directly. The peak intensity of the (111) planes was very high due to the preferential adsorption of the Ag atom on that plane during the growth process. Moreover, there were no impurities evident , which indicated that the nano-silver generated by this method had a cubic crystal structure [22]. Also , the sharp peaks suggest the formation of highly crystalline silver particles

The two peaks situated at 2θ values of 20.92° and 23.60° for nylon fabric [23] , still present after the treatment with green synthesized AgNPs. This observation suggests that the grafting of green synthesized AgNPs on nylon fabric did not change the basic structure of the treated nylon fabric.

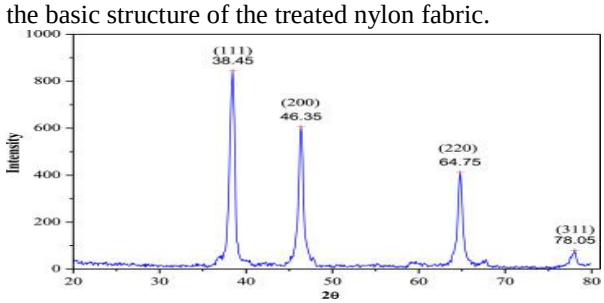


Fig. 7. XRD analysis of of green synthesized AgNPs

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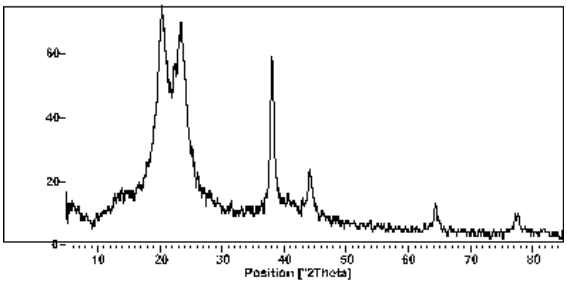

Fig. 8. XRD analysis of green synthesized AgNPs nylon fabric .

4. Dyeing kinetics

The green synthesized AgNPs pre- treated nylon fabric was dyed with AB 172 and compared with the untreated nylon fabric .It is observed from Figure 9, that the E% values of the green synthesized AgNPs pre-treated nylon are higher than those of the corresponding untreated nylon fabric. The higher E% values of nano-treated nylon indicate that the presence of nano metal particles increases the dye affinity (from 77.38 % to 99.79 %) towards the fabric. Because of the polarity created in the metal particles by induction, the negatively charged dye anions are drawn to the fabric, resulting in improved bonding between the dye and the fabric. Because of their small size, green synthesized AgNPs can get between polymer molecules and act as a filler or crosslinking agent, contributing to the load sharing phenomena when a load is applied to the fabric [24].

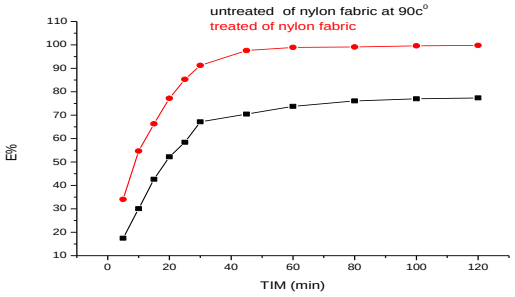

Fig. 9: Time-Exhaustion isotherms of AB 172 dye adsorption onto untreated and pre-treated nylon fabric with green synthesized AgNPs [dyeing recipe: LR 1:50, 150 ppm, 90^{0}C].

5. kinetic of adsorption

In order to examine the mechanism and rate controlling step in the overall adsorption process, four kinetic models, pseudo-first-order, pseudo-second-order and intra-particle diffusion , are adopted to investigate the dyeing kinetics of cotton fabric with AB 172 in absence and presence of synthesized nanostructured materials
are expressed, respectively, as follows:

A simple kinetic analysis of adsorption is the Lagergren Equation (3) [25,26], a pseudo-first-order type, written as follows:

$$\text{Log } (q_e - q_t) = \log q_e - k\, t / 2.303 \qquad (3)$$

where q_e is the amount of adsorbate adsorbed per unit mass of adsorbent at equilibrium (mg/g), q_t is the amount of adsorbate adsorbed at contact time t (mg/g), k_1 is the pseudo-first order rate constant (min-1). A plot of log (q_e-q_t) versus t gives a linear line Figure 10 (a,b) from which the values of k_1 and q_e were determined from the slope and intercept respectively and presented in Table 2.

The pseudo-second-order kinetic model is another important model to investigate the kinetic of adsorption of dyes on textile fabrics [27,28]. The pseudo-second order kinetic model can be expressed in linear form as follows:

$t/q_t = 1/ k_2 q_e^2 + t / q_e$ (4)

where k_2 is the rate constant of pseudo-second order adsorption (g/mg min). A plot of t/q_t versus t gives a linear relationship Figure 10 (c,d), from which qe and k_2 were determined from the slope and intercept of the plot respectively and presented in Table 2. The correlation coefficients R^2 higher than 0.99 suggest that adsorption of AB 172 onto untreated and pre-treated nylon fabric predominantly follows the pseudo-second order kinetic model . The pseudo-second order rate constants for adsorption of AB 172 onto the untreated and pre-treated nylon fabric show a steady increase with an increase in the solution concentration.

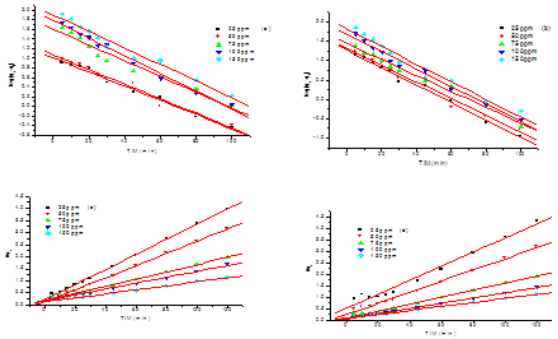

Fig. 10 : Kinetic plot for the adsorption of AB 172 onto nylon fabric at 90 ^{0}C .
a. Pseudo-first order of untreated nylon fabric.
b. Pseudo-first order of pre-treated nylon fabric.
c. Pseudo-second order of untreated nylon fabric.
d. Pseudo-second order of pre- treated nylon fabric.

6. Diffusion mechanism

The two models above cannot identify the diffusion mechanism during the adsorption process, so the experimental data are tested by the intra-particle and Elovich diffusion models.

6.1 Intra-particles diffusion

Intra-particle diffusion can be expressed by following Equation (5) :

$q_t = K_P t^{1/2} + C$ (5)

Where q_t (mg/g) is the amount of AB 172 adsorbed at time t, K_P (mg/g $min^{1/2}$) is the intra-particle diffusion rate constant obtained from the slope, of the plot q_t versus

$t^{½}$ shown in Figures 11 . The plots were linear over a detectable time range but with marked deviation from the origin; this indicates that the intra-particle diffusion is not only the rate controlling step, but also some other processes may control the rate of dye adsorption [29]. The intra-particle diffusion rate constant k_p and C are given in Table 2 . The intra-particle diffusion rate constants k_p increase with rising concentration because increasing concentration results in an increase of the driving force, which will increase the diffusion rate of AB 172 . While the C value gives an indication of the thickness of the boundary layer. The larger C shows greater boundary layer effect that account greater contribution of the surface sorption in the rat-limiting step [30].

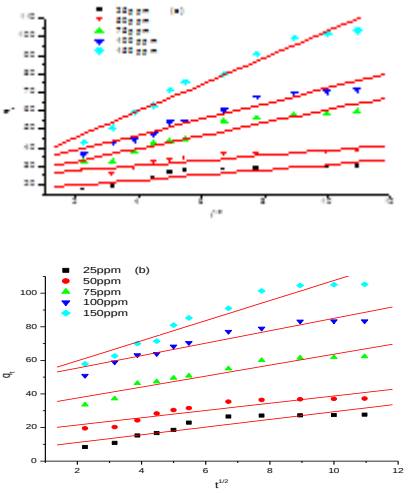

Fig. 11: Intra-particle diffusion kinetics of AB 172 into
(a) untreated nylon fabrics (b) pre-treated AgNPs nylon fabrics at various concentrations.[Dyeing recipe : L:R 1:50, 90 ^{0}C].

6.2 Elovich diffusion

The Elovich equation was first applied to the chemisorptions kinetics of gases on solids [31] it has also been successfully used in recent years to describe the adsorption of the solutes from a liquid solution. The linear form of the Elovich Equation (6) is given as :

$q_t = 1/\beta \ln(\alpha\beta) + 1/\beta \mathrm{Lnt}$ (6)

Where α is the initial adsorption rate constant (mg/(g min) and the parameter β is the desorption constant(g / mg) . The constant can be obtained from the slope and the intercept of the plot of q_t versus ln t at different concentrations, as shown in Figure 12. The value of β decreases while that of α increases as the concentration rises as shown in Table 2.

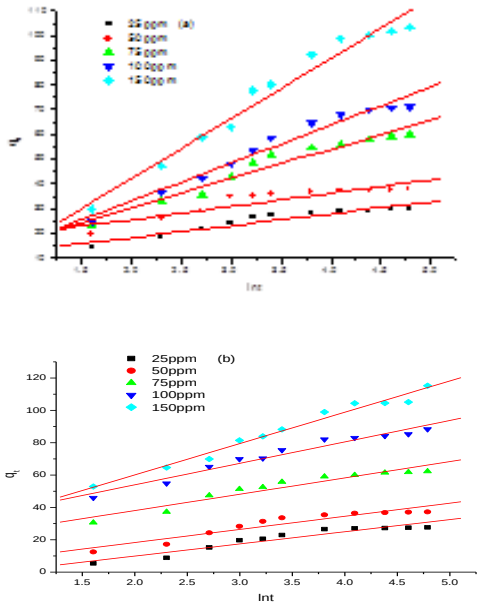

Fig.12 :Elovich diffusion kinetics plots of adsorbed AB 172 into:

(a) untreated nylon fabrics (b) pre-treated AgNPs nylon fabrics at various concentrations.[Dyeing recipe : L:R 1:50, 90 ^{0}C].

7. Adsorption isotherm

Adsorption isotherm models are widely used to describe and investigate mechanisms of adsorption. The equilibrium data was analyzed by the Langmuir and Freundlich isotherm model.

7.1 Langmuir adsorption isotherm

The Langmuir model describes monolayer sorption on distinct localized adsorption sites. It indicates no transmigration of the adsorbate in the plane of the surfaces and assumes uniform energies of monolayer sorption onto the sorbent surface [32]. The linear form of Langmuir Equation (7) can be written as follows:

$$C_e / q_e = 1/q_{max}\ K_L + C_e/ q_{max} \qquad (7)$$

where Ce (mgL^{-1}) is the concentration of AB 172 at equilibrium, q_e (mgg^{-1})is the amount of AB 172 adsorbed by the fabric at equilibrium, q_{max} (mgg^{-1}) is the maximum adsorption capacity corresponding to monolayer coverage, and K_L (L/mg) is the Langmuir constant. The values of q_{max} and K_L can be calculated from plotting C_e /q_e versus C_e . The Langmuir plots for AB 172 adsorption onto the fabric are obtained in Figure 13, and the parameters are shown in Table 3 . The values of the correlation coefficient for the Langmuir plots changed in the range 0.77 to 0.80 . This suggests that the adsorption of AB 172 onto the fabric did not follow the Langmuir model .

Table (2) : Kinetic parameters of the dyeing process of AB 172 onto untreated and pre-treated nylon fabrics at different concentrations .

Conc. of dye (ppm)	First-order kinetic model			Second-order kinetic model			Elovich			Intraparticlediffusion		
	qe,cal (mg/g)	k_1 (1/min)	R^2	q_e,cal (mg/g)	k_2 x10^{-4} (g/mg min)	R^2	β(g/mg)	α x10^{-3} mg/g min)	R^2	ki (mg/g $min^{1/2}$)	c	R^2
Untreated nylon fabric												
25	42.18	0.071	0.87	31.18	41.00	0.99	0.12	2.03	0.87	1.85	7.03	0.85
50	50.03	0.074	0.88	36.90	44.00	0.97	0.11	2.34	0.85	2.01	16.99	0.84
75	55.97	0.076	0.86	59.91	46.00	0.98	0.087	2.51	0.88	3.77	17.79	0.86
100	77.88	0.079	0.85	72.30	49.00	0.95	0.058	2.88	0.86	4.56	21.47	0.88
150	117.8	0.083	0.87	102.90	51.00	0.98	0.039	3.19	0.87	7.44	22.92	0.85
Pre-treated nylon fabric												
25	36.15	0.046	0.82	27.91	45.00	0.97	0.13	3.27	0.95	2.99	16.71	0.97
50	45.90	0.066	0.80	38.07	48.00	0.99	0.10	3.95	0.96	3.56	21.18	0.99
75	77.21	0.068	0.84	63.33	50.00	0.98	0.090	4.21	0.96	4.71	31.05	0.96
100	95.19	0.072	0.88	84.23	52.00	0.98	0.075	5.39	0.97	5.89	47.03	0.98
150	111.50	0.075	0.85	106.02	55.00	0.99	0.051	6.04	0.99	7.86	48.78	0.99

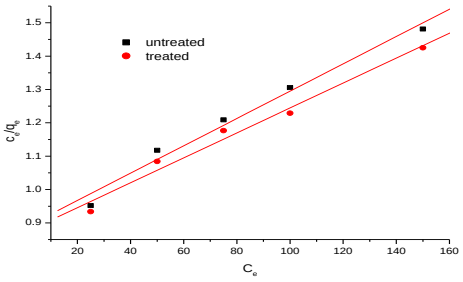

Fig .13: Langmuir adsorption isotherm of AB172 onto untreated and pre- treated nylon fabric at [L:R 1:50, 90 ^{0}C].

7.2 Frendlich adsorption isotherm

The Freundlich isotherm is used to describe adsorption processes that occur on heterogeneous surfaces and active sites with different energies based on multilayer adsorption and equilibrium [33].The linear form of Freundlich Equation (8) is given as:

$$\log q_e = \text{Log } K_F + 1/n \log C_e \qquad (8)$$

where q_e is the AB 172 concentration on the fabric at equilibrium, C_e (mgL^{-1}) is the concentration of AB172 in solution at equilibrium, and K_F ($dm^3\ g^{-1}$) and 1/n are Freundlich constants related to adsorption capacity and adsorption intensity, respectively .Freundlich constants are calculated from the slope and the intercept in Figure 14 , and are given in Table 3 The correlation coefficients (R^2 > 0.99) reflect that the experimental data agree well with the Freundlich model. The values of 1/n (0.70 and 0.80) are smaller than 1, so they represent the favorable adsorption conditions [34].

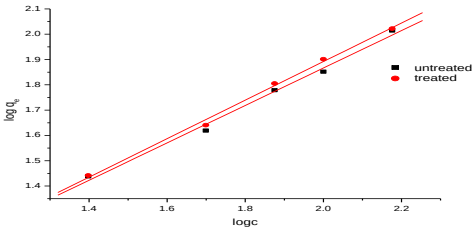

Fig.14: Freundlich adsorption isotherm of AB172 onto untreated and pre- treated nylon fabric at [L:R 1:50, 90 ^{0}C] .

8. Determination of nylon fabric properties

8.1 Color fastness properties

The effect of green synthesized (AgNPs) treatment on physical properties has been studied. The dye and nanoparticles should have penetrated into the Nylon fabric, but stay mostly on the internal side of the surface since dyed fabrics possess very good crocking fastness. However lower washing fastness was achieved Table 4, which can be due to the polymeric structure of polyamide fabrics because they have high crystallinity and low swelling ability in water in comparison to other polymeric fabrics, such as wool and cellulose**.** The data assist the important requirement for comfort properties which base the fundamental of medical fabrics. In general, the results give very good indication for enhancement the functionality of nylon fabric with nanomaterials that became a smart treatment applied as a novel approach to textile dyeing and finishing [35,36] .

Table 3: Langmuir, Freundlich isotherm constants of the dyeing process of AB 172 onto untreated and pre-treated nylon fabrics at [L:R 1:50, 90 ^{0}C] .

Fabric type	Langmuir adsorption isotherm			Freundlich adsorption isotherm		
	$X10^2 q_{max}$ (mg g^{-1})	K_L x10^{-3} (dm^3 mg^{-1})	R^2	K_F (dm^3 g^{-1})	n/1	R^2
Untreated nylon	**2.42**	**2.62**	**0.77**	**1.96**	**0.70**	**0.99**
Pre-treated nylon	**2.77**	**3.07**	**0.80**	**2.82**	**0.80**	**0.99**

Table (4): Fastness properties of untreated and pre-treated nylon fabric in presences of various AB172 dye concentration at 90^{0}C.

Conc. of dye (ppm)	Untreated nylon				Pre-treated AgNPs nylon			
	Washing	Light	Perspiration		Washing	Light	Perspiration	
			Acid	Alkali			Acid	Alkali
25 PPm	3-4	3-4	3-4	3-4	4	4-5	4-5	4-5
50 PPm	3-4	3-4	3-4	3-4	4	4-5	4-5	4-5
75 PPm	4	3-4	3-4	3-4	4	5-6	4-5	4-5
100 PPm	4	4	4	4	4-5	6	4-5	5
150 PPm	4	4	4	4	4-5	6	5-6	5-6

8.2 Evaluation of antibacterial activity of nylon fabric

The quantitative results for the evaluation of antibacterial activity of nylon fabric samples are shown in Figure 15 . It is easily noticed that the untreated nylon sample shows clear growth of bacteria, which reflects that almost all the bacteria were alive after 24 hours with zero R %. On the other side, the dyed untreated nylon sample exhibits slightly higher antibacterial activity scoring 45.60 % and 48.70 % R % values against the Gram- negative and Gram-positive bacteria, respectively. This may be attributed to the presence of various functional groups in AB 172 dye which can act as bacterium cells [37].The experimental results reveal that the R% values of pre-treated nylon fabric towards Gram-positive bacteria and Gram-negative bacteria are 96.18% and 94.08% respectively. The pre-treated nylon dyed fabric , higher values of antibacterial activity scoring 97.80 % and 99.33 % *against E. Coli and S. Aureus* . When compared to untreated fabric samples, aureus were found. This could be owing to the fact that metallic ions and metallic compounds have certain sterilizing properties. It is thought that a portion of the oxygen in the air or water is converted to active oxygen by catalysis with a metallic ion, causing the organic substance to dissolve and creating a sterilizing effect [38,39]. Green synthesized AgNps reacts strongly with proteins. It has a negative impact on cellular metabolism and inhibits cell growth when it comes into touch with bacteria. Furthermore, it prevents infection, odour, itching, and sores by inhibiting the multiplication and proliferation of bacteria that cause infection, odour, and sores.

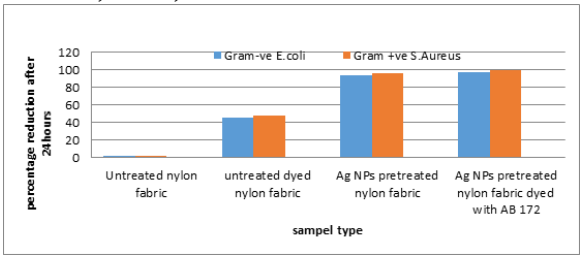

Fig.15 : Antibacterial activity of nylon fabrics towards *E.Coli and S. Aureus*

9.Conclusion

In this work, green synthesized AgNPs treatment generates a nylon fabric with advanced color fastness and antibacterial qualities, allowing them to improve human health care while lowering temperature, minimizing environmental impacts, fabric damage, dyestuff usage, and conserving energy. Monodisperse of green synthesized AgNps was synthesized using white sugar as both a reducing and stabilizing agent, as well as NaOH as a reaction accelerator. For the synthesis of stable, monodispersed of green synthesized AgNps, our technique is a fast, cost-effective, environmentally benign, and evergreen methodology. The protocol's high cost viability and simplicity can be explained by the fact that it requires a very low concentration of all reagents. It's the first time green synthesized AgNps have been synthesized in sunlight using a typical white sugar. Through a hydrolysis process leads to structures able of reducing silver salts to its metal states by oxidizing it to salts of carboxylic acid, where these behaviors were evaluated using SEM, TEM, EDS , XRD and FTIR spectroscopy. Nano Ag treatment enhances the E% nylon fabrics dyes with acid dye and also improves the fastness towards light , washing and perspiration . AgNps treatment to nylon also improved the resistance to microbial attack.

Conflicts of interest

"There are no conflicts to declare".

Formatting of funding sources

No funding sources

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