66 *Egypt. J. Chem.* **59**, No.6, pp. 1095- 1111 (2016)

Evaluation of Functional and Comfort Properties of SA/TDI/PEG1000 Adduct Treated Cotton/ Polyester Blended Fabric

H.M. Fahmy, A.A. Aly , A. Amr, Sh.M. Sayed and A.M. Rabie*

*Textile Research Division, National Research Centre, 33 Bohouth St.(former El Tahrir St.) Dokki , Giza , P.O. 12622, Scopus affiliation ID 60014618 and *Faculty of Science, Ain Shams University, Cairo, Egypt.*

THE SA/TDI/PEG1000 adduct was synthesized by reacting a mixture of stearyl alcohol (SA) and polyethylene glycol (PEG) of molecular weight 400, 1000, 2000, or 6000 Dalton with 2,4-toluene diisocyanate (TDI). The prepared adduct emulsion was incorporated in different easy care finishing formulations to illustrate the impact of that adduct emulsion on the performance, functional and comfort properties of treated cotton/polyester fabric. Among five salts namely ammonium sulphate, magnesium chloride, zinc sulphate, copper sulphate and ammonium chloride examined as catalysts for the aforementioned finishing formulations, ammonium sulphate with a concentration of 6 g/l was the unique catalyst that imparts treated fabric with significant durable functional properties. Furthermore, increasing of the adduct concentration in the finishing bath results in an increase in fabric weight, tensile strength, softness, stiffness, water repellency, antibacterial, water vapor resistance and thermal resistance properties of treated fabric along with a reduction in resiliency and air permeability properties of that fabric. On the other hand, inclusion Ag or TiO_2 nano-particles (NPs) in easy care finishing baths containing the SA/TDI/PEG1000 adduct emulsion effectively upgrades the antibacterial properties along with a slight reduction in the water repellency of treated fabric. Furthermore, the morphology of prepared Ag- or TiO_2-NPs was characterized via their TEM images. Meanwhile, fabric samples treated with SA/TDI/PEG1000 composites containing such NPs were characterized via their SEM and EDX images as well as TGA analysis.

Finishing is the final step in the fabric manufacturing process, the last chance to improve its functional and comfort properties[1] . Some of the functional finishes gaining popularity are wrinkle resistant finish, water and oil repellent finish, hydrophillic finish, antimicrobial finish, fragrant finish, flame retardant finish, sun protective finish and soft-finishes[2-17]. Coating as a finishing process can impart a textile with new properties textile to become multifunctional textile.

Water repellent fabric is obtained by coating it with a hydrophobic finish such as paraffin repellents, stearic acid‑melamine repellents, silicone repellents and fluorocarbon-based repellents[1,3]. Water repellent fabrics having comfort properties are coated with water repellent finishes that have hydrophilic and hydrophobic segments. The hydrophobic segments impart water resistance and facilitate adhesion of the coating film to the substrate, while the hydrophilic segments provide water vapor permeability[18-20]. Polyurethanes are one of the most frequently polymers coatings that are used over other polymeric coatings to enhance the hydrophobic properties of fabrics because of their advantages such as the good adhesion on textile surface, high gloss, water and solvent resistance, high moisture permeable properties, good abrasion resistance and strength, high flexibility, dry-cleanability, softer handle, low add-on required and cheapness [21-23]. Polyurethanes are made by reacting diisocyanates with one or more of polyols compounds.

On the other hand, cellulosic textiles are well known as convenient media for the microorganism' s growth such as bacteria, fungi, etc. The bacterial growth causes an unpleasant odor, stains, discoloration, and deterioration in the mechanical strength of textiles along with cross infections for the wearers themselves[5,6,8]. Many bioactive agents can effectively kill and/or control such bacterial growth such as metal salts, triclosan, chitosan, antibiotics, etc. Recently with the generation of nanotechnology, the textile finishing research has been developed and by means of nano-size substances, *e.g.* Ag, ZnO, and Tio_2 nano-particles, antibacterial textiles were obtained[5,6,8].

In our previous work, the SA/TDI/PEG1000 adduct was synthesized, characterized and its emulsion was utilized as a water repellent finish for cotton/polyester blended fabric[24]. As an extension, the present work aims at utilization of such adduct emulsion to impart cotton/polyester blended fabric with additional functional properties via incorporating it in different easy care finishing formulations. Moreover, the impact of these finishing treatments on comfort properties of treated fabric was also studied as follows.

Experimental

Materials

Mill-scoured and bleached cotton/polyester (50/50) blended fabric of plain weave structure, weight of 125g/m^2 and count (Ne) of 30/1 and thickness of 0.31 mm was supplied by Misr Spinning and Weaving Co., Mehalla EL-Kobra, Egypt, was used. Durapret LF conc. 70%, low formaldehyde resin for easy care finishes, Biotex, was used. Egyptol® (a nonionic detergent, based on ethylene oxide condensates provided by the Egyptian Company for Starch, Yeast and Detergents, Alexandria, Egypt, was used. 2,4-toluene diisocyanate (TDI), stearyl alcohol (SA) of purity 95% and polyethylene glycol of molecular weight 1000 Dalton (PEG1000) were used. Ammonium sulphate, ammonium chloride, copper sulphate, zinc sulphate, magnesium chloride and isopropyl alcohol were all of laboratory grade chemicals.

Methods

Synthesis of SA/TDI/PEG1000 adduct

The SA/TDI/PEG1000 adduct was prepared with total conversion of 99.2% as follows: a thermostated mixture of 5 g of SA and 1 g of PEG 1000 was melted at 70 ^{O}C in 100 ml stoppered glass bottle under dry nitrogen in an air circulated oven. To that melt, TDI (dried on molecular sieves at 30 ^{O}C) of molar ratio 20 % to SA was added and mixed well with the above other reactants. The reaction was then left to proceed for 90 min at 100 ^{O}C.

Emulsification of the prepared SA/TDI/PEG1000 adduct

At the end of the reaction, hot distilled water at 70 ° C of calculated volume according to the desired concentration was added to the reaction products followed by stirring the mixture for 3 min using a strong homogenizer and then the formed emulsion was cooled to the room temperature to form homogeneous oil in water emulsion.

Preparation of TiO_2 nanoparticles

Titanium dioxide nano-particles (TiO_2-NPs) were prepared as previously reported using titanium tetraisopropoxide precursor with 2-propanol and nitric acid[25].

Silver nano-particles preparation

Silver nano-particles (Ag-NPs) were prepared using trisodium-citrate as a reductant as reported elsewhere [26].

Fabric treatment

Fabric samples of 30X30 cm^2 were padded to a wet pick up of ca 100 % in finishing baths containing 60 g/l DMDHEU as crosslinker, 6 g/l of different salts as catalysts and different concentrations of the adduct emulsion (0 - 50 g/l). The padded samples were dried at 100 ^{O}C for 3 min in Wenner Mathis AGCH-8155 oven and then cured at 160 ^{O}C for 3 min. The finished fabrics were washed at 50 ^{O}C for 15 min, thoroughly rinsed, and finally dried for testing.

Testing and analysis

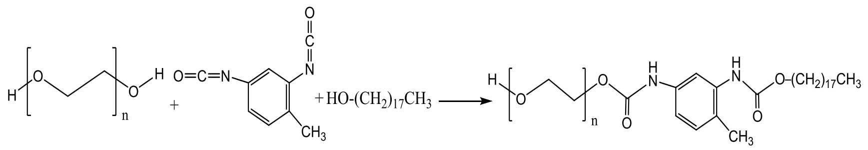
- Fabric weight (W) was determined according to ATSM D 3776 – 79.
- The percent total conversion was determined according to ASTM procedure D 1638–T59.
- Dry wrinkle recovery angle (WRA) was determined according to ASTM D-1296-98.
- The tensile strength (TS) of the finished fabric sample was tested in the warp direction according to ASTM D-2256-98.
- Water repellency rating (WRR) was performed using the spray test as described by AATCC Test Method 22-1989.

- Stiffness (S) was determined in the warp direction according to ASTM Test Method D 1388-96 using Jika (Toyaseiki) apparatus.
- Surface roughness (SR) was measured using a Surfacoder 1700a.
- Antimicrobial activity of control and finished viscose fabrics were tested, expressed in the inhibition zone (IZ) per millimeters, according to the disc diffusion method, AATCC Test Method 147-2004. The antibacterial activities of the untreated blank as well as finished fabrics were tested against the following bacteria:
  Gram-positive bacteria: Staphylococcus aureus (SA).
  Gram-negative bacteria: Escherichia coli (EC).
- Air permeability (AP) was evaluated according to ATSM (D 737-96). The air permeability of a fabric is the air flow passing through that fabric under a given air pressure.
- Water vapor resistance (WVR) was measured by Permetest instrument working on similar skin model principle as given by the ISO 11092.
- Thermal resistance (TR) was determined according to ASTM D 1518-85.
- Durability to wash was assessed by subjecting the fabric to 5, 10 and 15 laundering cycles. Each laundering cycle consists of washing for 10 min at 50 ^{O}C using 2 g/l nonionic surfactant followed by rinsing and air drying at ambient conditions.
- The morphology and particles size of the Hybrid emulsion was obtained by transmission electron microscope (TEM) using a JEOL, JEM 2100 F electron microscope at 200 kV.
- Scanning electron microscope (SEM) images of the treated and untreated fabric samples were obtained using SEM Model Quanta 250 FEG (Field Emission Gun) attached with EDX Unit (Energy Dispersive X-ray Analyses), with accelerating voltage 30 kV, magnification 14× up to 1,000,000 and resolution for Gun, FEI company, Netherlands.
- Thermogravimetric analysis (TGA) was performed at a temperature starting from 25 °C to 600 °C under inert nitrogen atmosphere with heating rate of 10 °C min^{-1} using the instrument: SDT Q600 V20.9 Build 20, USA.

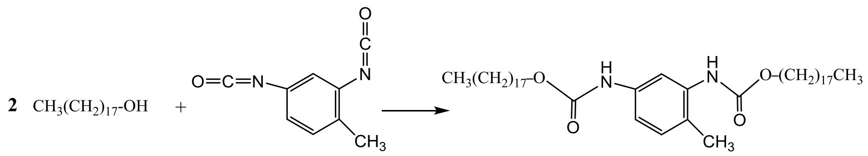
Results and Discussion

Factors affecting functional and comfort properties of SA/TDI/PEG1000 adduct emulsion treated fabric

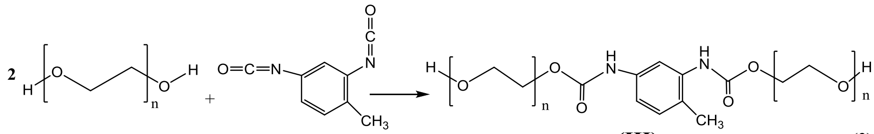
The SA/TDI/PEG1000 adduct was prepared by reacting of a mixture of PEG 1000 and SA with TDI as represented by the following equations[3, 9]:



(I) .... (1)



(II) .... (2)



(III) .... (3)

Thus, the above reaction yields a mixture of compounds I, II, III as well as un-reacted starting materials. For simplicity the reaction product will be referred for as SA/TDI/PEG1000 adduct. The prepared adduct emulsion was incorporated in different easy care finishing formulations and the impact of such finishing treatments on some performance, functional as well as comfort properties of treated fabric was studied as follows along with an appropriate discussion.

Catalyst type

TABLE 1. Effect of catalyst type on the functional properties of treated fabric.

Catalyst type	WRR	ZI (mm)	
		G +ve	G -ve
Magnesium chloride	50	5	3
Zinc sulphate	70	7	5
Ammonium sulphate	80	9	7
Copper sulphate	70	8	5
Ammonium chloride	50	12	10

Fabric finishing conditions: The fabric is padded in finishing bath containing 60 g/l of DMDHEU, 6 g/l of any of the used catalysts as well as 40 g/l of adduct emulsion to a wet pick up of 100 %; drying at 100 ^{O}C/3 min; curing, 160 ^{O}C/3 min. WRR: water repellency rating; ZI: zone of inhibition; G+ve: St. aurous; G-ve: E. coli.

The reaction of N-methylol compounds with cellulose is acid catalyzed. Selecting the proper catalyst is needed to maximize the extent of crosslinking of a fabric that indeed governs the significance of functional properties of that fabric[1] . Table 1 shows the effect of the catalyst type on the functional properties of cotton/polyester fabric treated with different easy care finishing formulations. It is clear that: i) treating fabric samples with finishing baths containing 40 g/l of the adduct emulsion in presence of the aforementioned catalysts imparted antibacterial as well as water repelling properties to treated fabric, ii) the fabric sample treated in presence of ammonium sulphate as a latent catalyst has the highest hydrophobic as well as antibacterial properties, and iii) according to the catalyst type, the antibacterial properties of treated fabric can be arranged in the following order: ammonium chloride > ammonium sulphate > copper sulphate > zinc sulphate > magnesium chloride, whereas the water repellency rating of these treated samples can be arranged as follows: ammonium sulphate > copper sulphate = zinc sulphate > ammonium chloride = magnesium chloride. The enhancement in antibacterial properties of the above mentioned catalysts treated fabric may be explained in terms of: i) the antibacterial properties of the long-chain fatty alcohols that can penetrate and disrupt the cell membranes of the bacterial cell[27-29] and ii) the antibacterial properties of polyethylene glycol 1000[30].

However, the alteration in extents of the aforementioned functional properties, *i.e.* water repellency rating and antibacterial properties, of treated fabric could be related to the differences between these catalysts with respect to rate of dissociation and/or decomposition, extent of crosslinking reactions and/or interactions, metal type and size, nature of anion, as well as location and distribution of crosslinks[31-36].

Catalyst concentration

TABLE 2. Effect of catalyst concentration on the functional properties of treated fabric.

Ammonium sulphate concentration (g/l)	WRR	ZI (mm)	
		G +ve	G -ve
2	0(0)	13(4)	11(3)
4	50(0)	11(5)	10(4)
5	70(50)	10(5)	8(3)
6	80(70)	9(6)	7(4)
7	80(70)	7(5)	6(5)

Fabric finishing conditions: The fabric is padded in finishing bath containing 60 g/l of DMDHEU, 40 g/l of adduct emulsion as well as different concentrations of ammonium sulphate to a wet pick up of 100 %; drying at 100 ^{O}C/3 min; curing, 160 ^{O}C/3 min. WRR: water repellency rating; ZI: zone of inhibition; G+ve: St. aurous; G-ve: E. coli. Values in parentheses indicate retained water repellency rating and antibacterial properties after 5 laundering cycles.

Table 2 shows the functional properties of cotton/polyester fabric treated with different easy care finishing bathes containing different concentrations of ammonium sulphate as a catalyst. It is clear that increasing the concentration of that catalyst in the finishing bath is accompanied by a significant improvement in the water repellency rating along with a reduction in the antibacterial properties

of treated fabric. Furthermore, the results shown in Table 2 also reveal that, laundering of the aforementioned finished fabric samples for 5washing cycles has a negative impact on the retained water repellency as well as antibacterial activity of treated fabric. The variation in extents of such functional properties of treated fabric may be explained on the basis that the reaction of N-methylol compounds, *i.e.* DMDHEU, with fabric cellulose is acid catalyzed[(1)]. The lower the pH, the higher the extent of crosslinking of that fabric is, and consequently the higher the water repellency as well as the lower the antibacterial properties of treated fabric. However, a concentration of 6 g/l of ammonium sulphate seems to be the proper concentration that effectively enhances the functional properties of treated fabric as well as the durability of such properties for washing.

Emulsion concentration

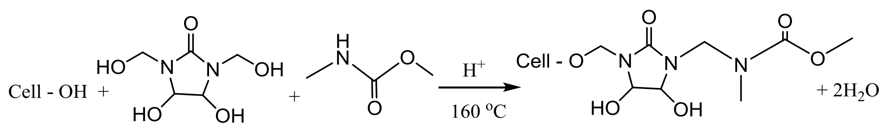
TABLE 3. Effect of emulsion concentration on some performance, functional and comfort properties of treated fabric.

Emulsion conc. (g/l)	**W (g/m^2)**	**WRA $(W+F)^O$**	**TS (Kg)**	**WR R**	**Inhibition zone (mm)**		**SR (μ m)**	**S (mg)**	**AP ($cm^3/cm^2.s$)**	**WVR (m^2PaW^{-1})**	**TR (Clo)**
					G +ve	**G -ve**					
Untreated	125.01	187	49.1	0	0	0	17.65	498	47.34	3.6	1.436
5	129.85	249	2	0	4	2	16.62	570	35.85	4.6	1.447
15	133.03	243	44.2	50	5	4	16.29	640	32.45	5.1	1.456
30	134.16	238	44.7	70	8	5	16.01	676	30.22	5.4	1.468
40	135.85	235	45.1	80	9	7	15.77	712	29.39	5.7	1.475
50	138.21	231	45.5	80	11	9	15.58	784	28.56	5.8	1.481
			46.1								

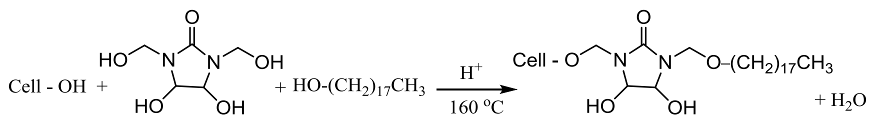
Synthesis reaction conditions: PEG MW, 1000 Dalton; PEG/SA weight ratio, 20 %; TDI/SA molar ratio, 20%; reaction time, 90 min; reaction temp., 100 ^{O}C.

Fabric finishing conditions: the fabric is padded in finishing bath containing 60 g/l of DMDHEU, different concentrations of adduct emulsion and 6 g/l of AS to a wet pick up of 100 %; drying at 100 ^{O}C for 3 min; curing, 160 ^{O}C/3 min. WRA: wrinkle recovery; TS, tensile strength; WRR: water repellency rating; ZI: zone of inhibition; G+ve: St. aurous; G−ve: E. coli; SR, surface roughness; S, stiffness; AP: air permeability; WVR, water vapor resistance; TR, thermal resistance.

Table 3 shows the extents of some physico-mechanical and comfort properties of SA/TDI/PEG1000 adduct emulsion treated fabric as functions in SA/TDI/PEG1000 adduct concentration. It is obvious that increasing the adduct concentration in the finishing bath is accompanied by: i) an increasing in fabric weight, tensile strength, stiffness, water vapor resistance and thermal resistance of treated fabric, ii) a reduction in resiliency, surface roughness and air permeability of treated fabric, and iii) an enhancement in the water repellency and antibacterial properties of treated fabric. The variation in extents of such properties is related to the formation of a hydrophobic film onto fabric structure that: i) lowers the surface energy and consequently the tendency of treated fabric to be wetted(2,33), ii) increases the smoothness of treated fabric as a result of the inclusion of SA as well as PEG 1000 onto the fabric structure that impart lubrication to fibers and yarns of treated fabric(32) , iii) forms a barrier against the bacterial growth, and iv) resists air penetration as well as water vapor transmission through the fabric structure and thereby enhances the thermal insulation of treated fabric(2); the higher the adduct concentration, the higher the deposition and fixation of its ingredients onto the fabric structure and consequently the more is the alteration in extents of such properties of treated fabric. Furthermore, the enhancement in tensile strength along with the reduction in resiliency of finished fabric may be explained by the progressive consumption of some DMDHEU in binding the adduct ingredients to the cellulosic regions of treated fabric through the labile hydrogen of terminal hydroxyl groups or urethane groups as represented from the following equations(2,7,8,10):



(DMDHEU) (Urethane group) **.............. (4)**



(DMDHEU) **.............. (5)**

Nano particle type

TABLE 4. Effect of nano-particle type on the water repellency rating and antibacterial properties of treated fabric.

Nano-particle type	WRR	ZI (mm)	
		G +ve	**G -ve**
Without	80 (70)(50)(0)	9 (6)	7 (4)
Ag	70(50)(0)	12 (7)	10 (5)
TiO_2	70(50)(0)	14 (10)	13 (8)

Fabric finishing conditions: The fabric is padded in finishing bath containing 60 g/l of DMDHEU, 6 g/l of ammonium sulphate, 40 g/l of adduct emulsion and 30 g/l of the nano particles stock solutions to a wet pick up of 100 %; drying temperature, 100 ^{O}C/3 min; curing temperature, 160 ^{O}C/3 min. WRR: water repellency rating; ZI: zone of inhibition; G+ve: S. aurous; G−ve: E. coli. Values in parentheses indicate retained water repellency rating and antibacterial properties after 5 laundering cycles.

Table 4 shows the effect of inclusion of Ag-NPs or TiO_2-NPs in different easy care finishing formulations containing SA/TDI/PEG1000 adduct emulsion on some functional properties of treated cotton/polyester fabric. For a given set of

finishing conditions, the data in Table 2 signify that fixation of such nano particles through the nominated adduct onto/within the finish/fabric matrix, regardless of its type, brings about an upgrading in the antibacterial activities of treated fabric against G−ve (E. coli) and G+ve (S. auereus) bacteria. Furthermore, Table 2 reveals also that the aforementioned nano-particle impair the water repellency rating of their treated water repellent fabric samples lowering it to the value of 70.

The additional improvement in the antibacterial properties of TiO_2-NPs/ adduct treated fabric is related to the formation of high oxidative radicals on the TiO_2-NPs loaded fabric surface, e.g. $HO\cdot$ and $HO_2\cdot$ that attack the bacterial cell membrane and destroy it[(5,8)]. On the other hand, the improvement in the antibacterial properties of Ag-NPs/adduct treated fabric is a result of generation of Ag-ions, in the presence of moisture, that joins to the bacterial DNA leading to its inactivation according to equation 1[(5,8)]:

$$O_{2\,(aq)} + 4H_3O^+ + 4Ag_{(s)} \rightarrow 4Ag^+_{(aq)} + 6H_2O \quad \text{-----} (1)$$

and/or producing of oxygen radicals that oxidize the molecular structure of bacteria according to equation 1[(5,8)]:

$$H_2O + (1/2)\,O_2 \xrightarrow{Ag^+} H_2O_2 \rightarrow H_2O + (O) \quad \text{------} (2)$$

Moreover, while washing the treated fabric for 10 cycles preserve the antibacterial properties of treated fabric, despite of the reduction in their extents, it impairs the water repellency rating of that fabric and lowers it to zero.

Characterization of the prepared nano-particles and their SA/TDI/PEG1000 composite treated fabric

The particle size of freshly prepared Ag-NPs and TiO_2-NPs are characterized via investigating their TEM images. Moreover, fabric samples treated with easy care finishing bathes containing SA/TDI/PEG1000 composites, *i.e.* containing Ag-NPs or TiO_2-NPs, were characterized via investigating their SEM and EDX images. Furthermore, a fabric treated with easy care finishing bath containing 40 g/l of the SA/TDI/PEG1000 adduct emulsion was characterized, compared with an untreated sample, using the TGA analysis. Given below is the discussion.

TEM, SEM and EDX images

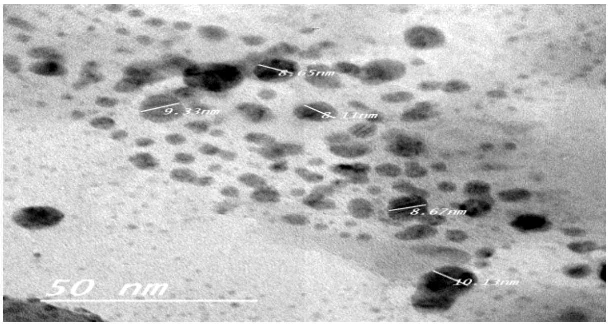


Fig. 1. TEM image of Ag-NPs.

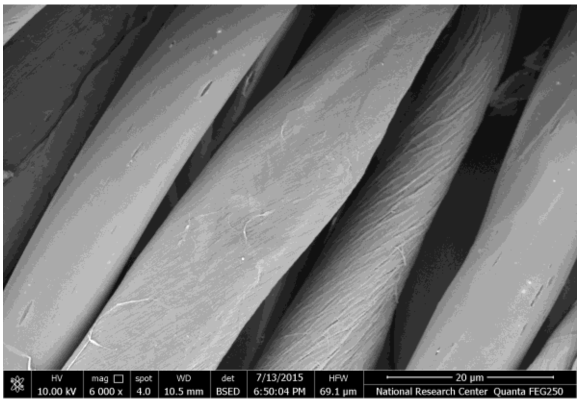


Fig. 2(a). SEM of untreated fabric.

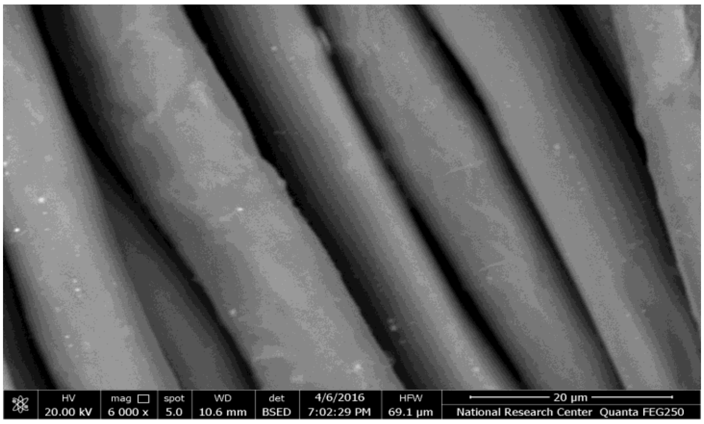
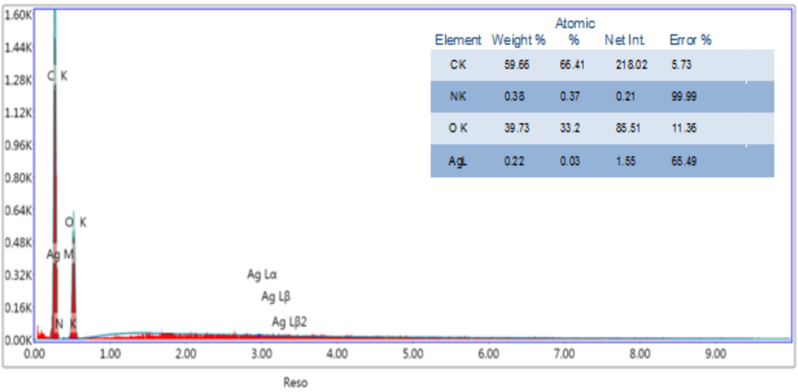


Fig. 2(b). SEM of water repellent fabric loaded with Ag-NPs.



Element	Weight %	Atomic %	Net Int.	Error %
CK	59.66	66.41	218.02	5.73
NK	0.38	0.37	0.21	99.99
O K	39.73	33.2	85.51	11.36
AgL	0.22	0.03	1.55	65.49

Fig. 3. EDX image of water repellent fabric loaded with Ag-NPs.

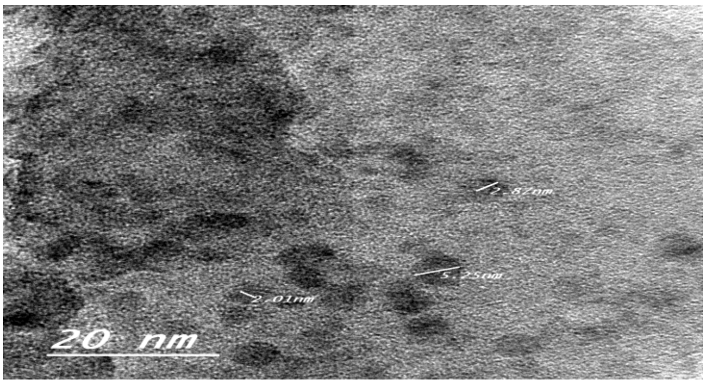


Fig. 4. TEM image of TiO_2-NPs.

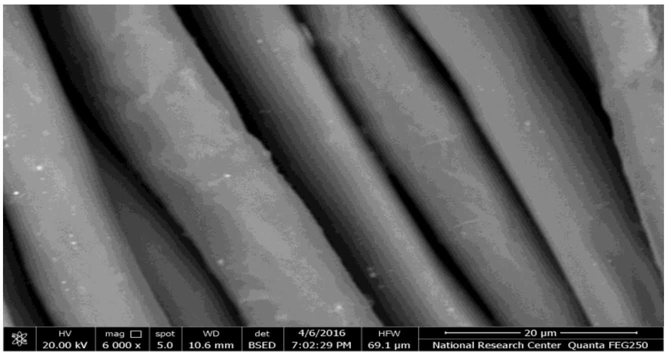


Fig. 5. SEM of water repellent fabric loaded with TiO_2-NPs.

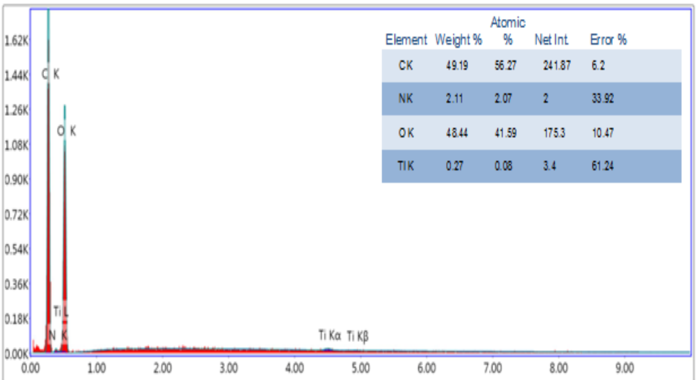


Fig. 6. EDX image of water repellent fabric loaded with TiO_2-NPs.

Figure 1shows the TEM image of Ag-NPs where these particles are well distributed and less than 10 nm in size. Moreover, Fig. 2(a) and (b) show SEM of the untreated and Ag-NPs loaded water repellent fabric images, respectively where a smooth deposited film of the SA/TDI/PEG1000 composite loaded with Ag-NPS can be seen on the surface of treated fabric. Furthermore, Fig. 3 shows EDX spectrum of Ag-NPs loaded water repellent fabric which confirms the presence of Ag-NPs with a content of 0.22% (w/w).

On the other hand, Fig. 4 shows the TEM image of TiO_2-NPs where these particles are not aggregated and of size less than 10 nm. Additionally, Fig. 5 shows SEM of the image of TiO_2-NPs loaded water repellent fabric. It is clearly seen from Figure 5 that the surface of fabric is coated with a smooth homogeneous film of the SA/TDI/PEG1000 composite. Moreover, loading the coated fabric with TiO_2-NPs of a content 0.27% (w/w) is confirmed by EDX spectrum represented by Fig. 6.

The TGA curves of untreated and water repellent fabric samples were shown in Fig. 7. It is clear that the thermograms of these samples consist of three parts. The first part represents a dehydration stage[37,38] which starts from about 25 to 110 ^{O}C with a weight loss of 3.26 and 2.714% for untreated and water repellent fabric samples respectively. The second part represents the first stage of the thermal degradation[37,38]. This stage is in the region of about 328 to 389 ^{O}C and accompanied with a weight loss of 44.55 and 41.55% for the above mentioned samples respectively. The third part corresponds to the conversion of the remaining materials to carbon residues. In the part, the weight loss was about 31.48 and 28.38 % in the range of about 398 to 500 ^{O}C for the above fabric samples respectively.

Thermal gravimetric analysis (TGA)

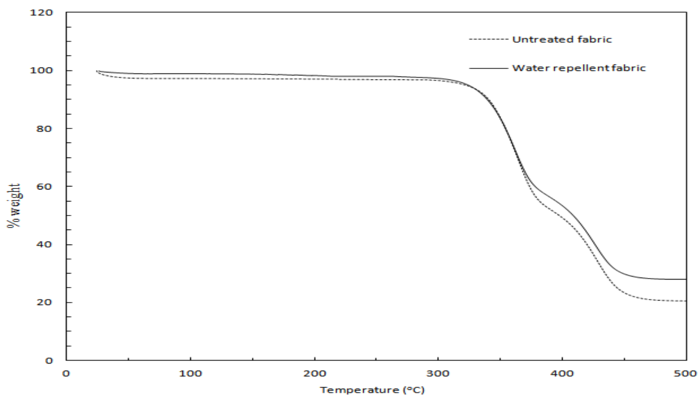


Fig. 7. TGA of untreated and water repellent fabric.

Conclusions

1. The adduct SA/TDI/PEG1000 was prepared and its emulsion was incorporated in different easy care finishing formulations to impart cotton/polyester blended fabric with water repelling as well as antibacterial properties.
2. Ammonium sulphate with a concentration of 6 g/l was the unique catalyst that imparts treated fabric with significant durable functional properties.
3. Increasing the adduct concentration in the finishing bath was accompanied by: i) an increase in weight, tensile strength, stiffness, water vapor resistance and thermal resistance of treated fabric, ii) a reduction in resiliency, surface

roughness and air permeability of treated fabric, and iii) an enhancement in the water repellency and antibacterial properties of treated fabric.

4. Inclusion of 30 g/l of Ag or TiO_2 nano-particles of stock solutions in easy care finishing baths containing 40 g/l of the adduct emulsion, 60 g/l of DMDHEU and 6 g/l AS effectively upgrades the antibacterial properties along with a slight reduction in the water repellency of treated fabric.
5. The TEM images of the prepared Ag or TiO_2 nano-particles show that the particle size of these nano particles is less than 10 nm.
6. The SA/TDI/PEG1000 composites containing Ag-NPs or TiO_2-NPs treated fabric samples were characterized via investigating their SEM and EDX images as well as TGA analysis.

References

1. **Schindler, W.D. and Hauser, P.J.,** *Chemical Finishing of Textiles*, Woodhead Publishing Ltd and CRC Press LLC, Cambridge, England, Chap 6, 74 (2004).

2. **Ibrahim, N.A., Khalifa, T.F., El-Hossamy, M.B. and Tawfik, T.M.,** Factors affecting the functional and comfort related properties of reactive dyed cotton knits. *Journal of Industrial Textiles*, **40** (1), 41-56 (2011).

3. **Abo-Shosha, M.H., El-Sayed, Z., Fahmy, H.M. and Ibrahim, N.A.,** Synthesis of PEG/TDI/F6 adducts and utilization as water/oil repellents and oily stain release finishes for cotton fabric. *Polym. Plastic Technol. Eng.*, **44** (6), 1189-1201 (2005).

4. **Ibrahim, N.A., El-Sayed, Z., Fahmy, H.M., Hasabo, A.G.A. and Abo-Shosha, M.H.,** Perfume finishing of cotton/polyester fabric crosslinked with DMDHEU in presence of softeners. *RJTA*, **17** (4), 58-63 (2013).

5. **Ibrahim, N.A., Amr, A., Eid, B.M., Mohamed, Z.E. and Fahmy, H.M.,** Poly (acrylic acid)/ poly(ethylene glycol) adduct for attaining multifunctional cellulosic fabrics. *Carbohydrate Polymers*, **89**, 648‑660 (2012).

6. **Ibrahim, N.A., Fahmy, H.M., Abdel Rehim, M., Sharaf, S.S. and Abo-Shosha, M.H.,** Finishing of cotton fabrics with hyperbranched poly (ester-amine) to enhance their antibacterial properties and UV protection. *Polymer-Plastics Technology and Engineering*, **49** (13), 1297‑1304 (2010).

7. **Fouda, M.M.G. and Fahmy, H.M.,** Multifunctional finish & cotton cellulose fabric. *Carbohydrate Polymers*, **86,** 625-629 (2011).

8. **Fahmy, H.M., Eid, R.A.A., Hashem, S.S. and Amr, A.,** Enhancing some functional properties of viscose fabric. *Carbohydrate Polymers*, **92**, 1539‑1545 (2013).

9. **Abo-Shosha, M.H., Ibrahim, N.A., Fahmy, H.M. and Hebeish, A.,** Polyethylene glycol / toluene diisocyanate / dodecanol adducts as softeners for cotton fabric, *2nd International Conference of Textile Research Division (Textile Processing: State of the Art & Future Developments), NRC, Cairo, April 11-13* (2005).

10. **Abdel-Wahab, B.F., Gaffer, H.E., Fouda, M.M.G., Osman, E.M. and Fahmy, H.M.,** Synthesis of some new 2-(2,3-dihydroinden-1-ylidene) hydrazinyl)-4-methylthiazole derivatives for simultaneous dyeing and finishing for UV protective cotton fabrics. *Journal of Applied Polymer Science,* **112**, 2221-2227 (2009).

11. **Fahmy, H.M., Aly, A.A., and Sayed,** Sh.M., Graft copolymerization of N-vinylpyrrolidone onto stearyl alcohol to impart water repellency and antibacterial properties for cotton/polyester fabric. *Progress in Organic Coatings*, **105**, 176-182 (2017).

12. **Fahmy, H.M., Abo-Shosha, M.H., and Ibrahim, N.A.**, Crosslinking of cotton fabrics thermally with PVP to improve their performance and antibacterial properties. *Carbohydrate Polymers,* **77**, 845–850 (2009).

13. **Ibrahim, N.A., Abo-Shosha, M.H., Fahmy, H.M., El-sayed, Z.M., and Hebeish, A.A.**, Hybrids for finishing cotton fabric with durable handle performance. *J. Materials Processing Technology*, **200**, 385-389 (2008).

14. **Fahmy, H.M., Samaha, S.H., Abo-Shosha, M.H., and Ibrahim, N.A.,** Effect of Inclusion of Cationized starch Derivatives in Finishing Bath on Ester – Crosslinking of Cotton Fabric. *Tinctoria,* **10**, 22-27 (2004).

15. **Fahmy, H.M.,** Enhancing Some Performance Properties of Ester Crosslinked Cotton Fabric by Pre-Quaternization. *Egypt. J. Chem.*, **47** (6), 627-640 (2004).

16. **Gaffer, H.E., Fouda, M.M.G., and Fahmy, H.M.,** Enhancing Functional Properties of Viscose Fabric by Using Novel Aryl-Azo Sulfonamide Derivatives. *Journal of Applied Sciences Research*, **9** (6), 4059-4067 (2013).

17. **Fahmy, H.M., and Abdel-Halim, E.S.,** Utilization of Poly (N-vinyl-2-pyrrolidone) to enhance UV protection and antibacterial properties of ester crosslinked cotton fabrics. *Journal of Industerial Textiles,* **40** (2), 109-122 (2010).

18. **Holmes, D.A.,** *Handbook of Technical Textiles,* Woodhead Publishing Ltd and CRC Press LLC, Cambridge, England, Chap 12, p. 282 (2000).

19. **Abo-Shosha, M.H., El-Hilw, Z.H., Aly, A.A., Amr, A. and El-Nagdy, A.S.I.,** Paraffin wax emulsion as water repellent for cotton/polyester blended fabric. *Journal of Industrial Textiles,* **37** (4), 315–325 (2008).

20. **Save, N.S., Jassal, M. and Agrawal, A.,** Smart breathable fabric. *Journal of Industrial Textiles,* **34** (3), 139-155 (2005).

21. **Abo-Shosha, M.H., El-Hilw, Z.H., Aly, A.A., Amr, A. and Rabie, A.M.,** New textile water repellent based on reaction of toluene 2,4-diisocyanate with stearyl alcohol. *AATCC Review,* **9** (7), 38–42 (2009) .

22. **Hu, J.,** *Shape Memory Polymers and Textiles*, 1st ed., Woodhead Publishing Limited. Cambridge, England, chap. 5, p. 160 (2007).

23. **Sen, A.K.,** *Coated Textiles: Principles and Applications*, 2nd ed., Taylor & Francis Group, LLC, chap. 1, p. 22, 2008.

24. **Fahmy, H.M., Aly, A.A., Amr, A., Sayed, Sh.M. and Rabie, A.M.,** SA/TDI/PEG adducts as water repellent finishes for cotton / polyester blended fabric. *Progress in Organic Coatings,* **99,** 166-172 (2016).

25. **Boz, A., Yuranova, T. and Kiwi, J.,** Self-cleaning of wool-polyamide and polyester textiles by TiO_2-rutile modification under daylight irradiation at ambient temperature. *Journal of Photochemistry and Photobiology A: Chemistry*, **172** (2), 27–34 (2005).

26. **Sileikaite, A., Prosycevas, I., Puiso, J., Juraitis, A. and Guobiene, A.,** Analysis of silver nano-particles produced by chemical reduction of silver salt solution. *Material Science,* **12**, 287–289 (2006).

27. **Togashi, N., Shiraishi, A., Nishizaka, M., Matsuoka, K., Endo, K., Hamashima, H. and Inoue, Y.,** Antibacterial activity of long-chain fatty alcohols against *Staphylococcus aureus*. *Molecules,* **12,** 139-148 (2007).

28. **Kubo, I., Muroi, H., Himejima, H. and Kubo, A.,** Antibacterial activity of long-chain alcohols: the role of hydrophobic alkyl groups. *Bioorg. Med. Chem. Lett.,* **3**, 1305-1308 (1993).

29. **Arora, S., Yadav, V., Kumar, P., Gupta, R. and Kumar, D.,** Polymer based antimicrobial coatings as potential biomaterial: A Review. *Int. J. Pharm. Sci. Rev. Res.,* **23**(2), 279-290 (2013).

30. **Nalawade, T.M., Bhat, K. and Sogi, S.H.P.,** Bactericidal activity of propylene glycol, glycerine, polyethylene glycol 400, and polyethylene glycol 1000 against selected microorganisms. *Journal of International Society of Preventive and Community Dentistry*, **5** (2), 114-119 (2015).

31. **Ibrahim, N.A., Abo-Shosha, M.H., Gaffar, M.A., Elshafei, A.M. and Abdel-Fatah, O.M.,** Antibacterial properties of ester—cross-linked cellulose–containing fabrics post-treated with metal salts. *Polymer-Plastics Technology and Engineering*, **45,** 719–727 (2006).

32**.** **Abo-Shosha, M.H., Ibrahim, N.A., Fahmy, M.H. and Hebeish, A.,** Utilization of water soluble size additives in easy care finishing. *American Dyestuffnnual Reporter,* **84** (7), 44-51 (1995).

33. **Fahmy, H.M., Aly, A.A., Amr, A., Sayed, Sh.M. and Rabie, A.M.,** An innovative SA/PVP hybrid for attaining water repellent cotton/polyester blended fabric. *International Journal of Chem. Tech. Research*, **9** (3), 215-227 (2016).

34. **Fahmy, H.M., Aly, A.A. and Mohamed, Z.E.,** Synthesis of poly (N-vinyl-2-pyrrolidone)/pyrodextrins adducts and their utilization in functionalization of cotton fabric. *International Journal of Chem Tech Research*, **9** (9), 96-109 (2016).

35. **Fahmy, H.M., Eid, R.A.A., Nada, D.E. and Abd El-Aziz, S.M.,** Functionalizaton of Linen Fabric using Poly (N-vinyl-2-pyrrolidone). *Egyptian Journal of Chemistry,* **58**(4), 447-458 (2015).

36. **Fahmy, H.M.,** Utilization of Poly (N-vinyl-2- pyrrolidone) in easycare finishing of cotton fabrics to improve their performance properties and antibacterial activities. *Journal of Industerial Textiles*, **39**, 2, 109-122 (2009).

37. **Hashem, M., Elshakankery, M.H., Abd El-Aziz, S.M., Fouda, Moustafa M.G. and Fahmy, H.M.,** Improving easy care properties of cotton fabric via dual effect of ester and ionic crosslinking. *Carbohydrate Polymers,* **86,** 1692–1698 (2011).

38. **Fahmy, H.M., Mohamed, Z.E., Abo-Shosha, M.H., and Ibrahim, N.A.,** Thermosole Cross-Linking of Chitosan and Utilization in the Removal of Some Dyes from Aqueous Solution. *Polym-Plastic Technol. Eng.,* **43**(2)**,** 445-462 (2004).

(*Received* 27/11/ 2016;
accepted 13/12 /2016)

تقييم تأثير استخدام متراكبات الكحول الستيريلى / تولوين ثنائى الأيزوسيانات / عديد ايثيلين الجليكول 1000 على الخواص الوظيفيه و خواص الراحه الملبسيه لأقمشه القطن/ بوليستر

هشام مصطفي فهمي، آمال أحمد علي ، أحمد السيد عمرو، شيماء محمود سيد و عبد الجواد محمد ربيع*
شعبة بحوث الصناعات النسجية – المركز القومي للبحوث – الجيزة و
*قسم الكيمياء – كلية العلوم – جامعة عين شمس – القاهرة – مصر.

تم فى هذه الدراسة إدخال مستحلب متراكب الكحول الستيريلى / تولوين ثنائى الأيزوسيانات / عديد ايثيلين الجليكول 1000 ضمن خلطات تجهيز الرعاية السهلة لأقمشة القطن / بوليستر لبيان تأثير هذا المتراكب على الخواص الأدائية و الوظيفية و خصائص الراحة الملبسيه للقماش المعالج. و قد أكدت النتائج أن: أ) من بين خمسة أملاح مستخدمه كمواد حفازه فى حمام تجهيز العنايه السهله لأقمشه مخلوطه من القطن/بوليستر و هى أملاح كلوريد الماغنسيوم و كلوريد الأمونيوم و كبريتات الأمونيوم و كبريتات النحاس و كبريتات الزنك كان ملح كبريتات الأمونيوم هو أحسن هذه الأملاح من حيث اكساب الأقمشه المعالجه لخواص مقاومة الماء و مقاومة البكتريا، ب) استخدام ملح كبريتات الأمونيوم بتركيز 6 جرام/لتر قد أدى الى اكساب الأقمشه المجهزه لخواص و ظيفيه جيده مع مقاومة هذه الخواص للغسيل المتكرر، ج) معالجة عينات أقمشه القطن / بوليستر في حمامات تجهيز تحتوي على تركيزات مختلفة من مستحلب المتراكب يؤدى الى زياده فى خواص مقاومة الماء و قوة الشد و تصلب و مقاومة البكتريا ومقاومة نفاذية بخار الماء و الحراره مع انخفاض في مرونة و خشونة سطح و نفاذية الهواء لعينات الأقمشه المعالجة.، د) أدى معالجة عينات الأقمشه في حمامات تجهيز تحتوي على 40 جرام / لتر من مستحلب متراكب الكحول الستيريلى / تولوين ثنائى الأيزوسيانات / عديد ايثيلين الجليكول 1000 و 60 جرام / لتر من الرابط العرضى و 6 جرام/لتر من كبريتات الأمونيوم و 30 جرام/لتر من جزيئات الفضه أو ثانى أكسيد التيتانيوم النانومتريه الى زياده فى خواص مقاومة القماش للبكتريا مع نقص بسيط فى خواصه المقاومة الماء. و قد تم تحديد حجم جزيئات الفضه أو ثانى أكسيد التيتانيوم النانومتريه المحضره و المستخدمه فى تجهيز الأقمشه السابقه باستخدام محلل حجم الجزيئات كما تم اثبات وجود هذه الجزيئات النانومتريه داخل تركيب الأقمشه المعالجه بها باستخدام المسح بالمجهر الالكترونى عالى النفاذيه كما تم أيضا توصيف الأقمشه المعالجه بهذا المستحلب باستخدام التحليل الحرارى.