92 Egypt. J. Chem. Vol. 62, No. 7, pp. 1185 - 1195 (2019)

Egyptian Journal of Chemistry
http://ejchem.journals.ekb.eg/

# Recent Developments on Wettability Treatment of Wool and Polyester Textiles

**Omaima Gaber Allam**

*Proteinic & Synthetic Fibers Department, Textile Industries Research Division, National Research Center, 33 El Buhouth St., Dokki, Cairo,*
Code 12311, Affiliation ID 60014618

THE PRESENT abstract is an overview of the advancements methods on wettability treatment of wool and polyester textiles. Article will emphasize the potential advantage of the use of these cutting edge strategies to reach for ideal treatment conditions and the best outcomes, particularly hydrophilicity, dampness substance and increment coloring handling while at the same time keeping up the physical and concoction properties of every material. Treatments divided into: chemical treatment, enzymatic treatment and physical treatment such as: alkoxides, plasma technology and microwave irradiation.

## Introduction

Wetting is the capacity of a fluid to continue reaching with a strong surface, coming about because of intermolecular associations when the two are united. The level of wet (wettability) is controlled by a force balance among adherent and coherent powers [1]. Adherent powers between a fluid and strong reason a fluid drop to spread over the surface. Coherent powers inside the fluid reason the drop to roll together and evade contact with the surface. The contact point (θ), as set in Fig., 1 and Table 1, is the edge at which the liquid– vapor interface meets the solid– fluid interface. The contact edge is dictated by the outcome among Adherent and Coherent powers. As the inclination of a drop to spread out over a level, strong surface expands, the contact point diminishes. In this way, the contact angle gives a converse proportion of wettability [2, 3].

*Wool*

*Morphological structure of wool*

Wool has two sorts of cells: *cuticle cell and cortex* cells as shown in Fig. 2.

*Cuticle cell (*scales): This surface of fleece filaments is comprised of the epicuticle, exocuticle and endocuticle. Scales go about as an obstruction for water and synthetic compounds retention.

*Cortex cells:* The cortex is the main part of the fiber. Cortical cells are caught both by the cell layer combined (CMC). It is a continuous region, containing slightly crosslinked proteins that extend throughout the whole fibre. It is known to have a large impact on the mechanical and chemical properties of the fibre. Being the only uninterrupted stage in the fibre, it so feeding a channel by which dyes and chemicals can diffuse in and out of wool [4].

*Chemical structure of wool*

Wool is an individual from a gathering of proteins known as keratin. The basic building blocks of all proteins are amino acids which are linked together by the peptide bond to form polypeptide chains. Complete hydrolysis of wool contains from 18- 22 different amino acids. They typically have a high content of either cysteine, or glycine and tyrosine [5, 6].

*Corresponding author E-mail: omaimaalaam@yahoo.com
Received 19/12/2018; Accepted 23/1/2019
DOI: 10.21608/ejchem.2019.6591.1564

*The advantage and disadvantage of wool*

*The advantages of wool*

The external scales of wool acquire an anhydrous property. Moreover wool fibers naturally pull moisture away from the body and it can absorb up to 30% of its weight. Wool is generally utilized in attire, inside materials, and modern applications, particularly in warm defensive dress for guys working in risky occupations, for example, oil taking care and firefighting [7].

*The disadvantages of wool*

Two main shortage of wool are shrinkage and pilling. Wool is sensitive to and easy to staining. However, there are many manner is obtainable to defeat the disadvantages of textiles and develop their wettability. These methods divide into chemical modification or physical modification [7].

*Chemical treatments of wool*

Chemical treatments such as oxidation and reduction are the commonly used methods in the industry. These techniques were applied to increase hydrophilic wool fibre [8]. For instance wool was incorporated with a biocidal compound in particular 2-(4, 6-dichloro-1, 3, 5-triazin-2-yloxy) – N-phenylbenzamide (receptive salicylanilide) to enhance their antimicrobial properties just as insects. The reaction mechanism was proposed as follow in Fig. 3 [9]. Also, the colouring of wool fabrics at low temperature was achieved by pre-swollen the fabrics with the two chose ionic fluids; 1-ethyl 3-methyl imidazolium acetic acid derivation (EMIA), and 1-butyl 3-methyl imidazolium chloride (BMIC) [10].

*Bleaching*

Bleaching impacts the outside of fiber and excess the whiteness of wool [11, 12]. Materials

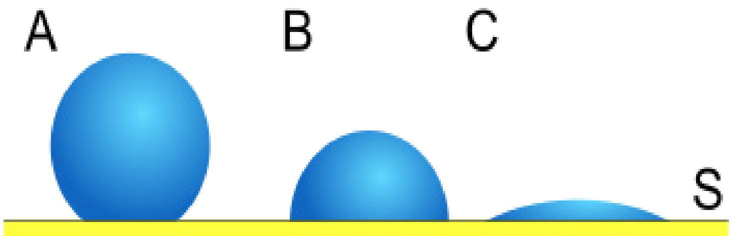


**Fig. 1. A has an expansive contact edge, and C has a little contact edge.**

**TABLE 1. The relation between contact angle and degree of wetting.**

| Contact angle | Degree of wetting | Strength of: Solid/liquid interactions | Liquid/liquid interactions |
|---|---|---|---|
| θ = 0 | Perfect wetting | strong | weak |
| 0 < θ < 90° | high wettability | strong | strong |
| | | weak | weak |
| 90° ≤ θ < 180° | low wettability | weak | strong |
| θ = 180° | perfectly non-wetting | weak | strong |

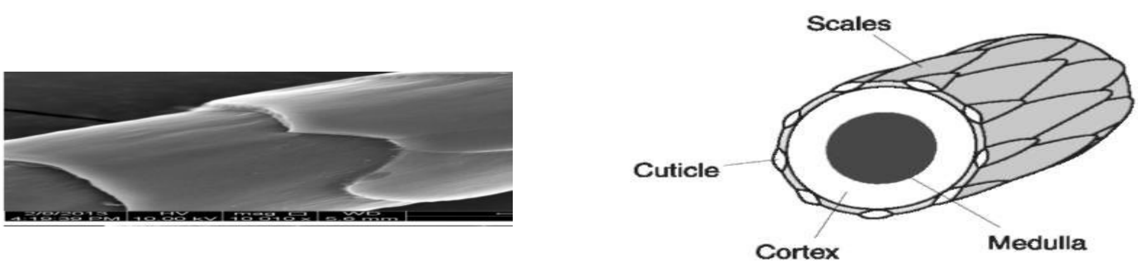


**Fig. 2. Morphological structure of wool.**

used in protein-fabrics bleaching have hydrogen peroxide, sodium borohydride, thiourea and oxalic acid [13,14]. Past examination has proved that hydrogen peroxide using corona discharge treatment could afford the treated wool fabric with excellent hydrophilic properties [15].

*Chlorination*

Chlorination oxidizes cysteine in the A-layer of the exocuticle of fleece to cysteic corrosive and expels around 60% of the surface lipids from the epicuticle. This change which makes the fiber progressively hydrophilic and raises it's the coloration rate [16].

*Nano treatments*

Nanoparticles own small sizes and high surface ratio. Treatment of wool fabric using nano titanium dioxide ($TiO_2$) and Butane tetracarboxylic acid to achieve higher absorption of acid dye and ultraviolet defense [17, 18]. Silver nano colloids have been synthesized by chemical reduction of silver salt solution. These nanoparticles have been applied to wool by padding technique to improve the colour strength of wool fabrics dyed with direct dyes [19,20].

*Enzymatic treatments*

Enzymes can be applied to lessening the using of water and Harmful substances. An enzyme has an imperative impact on changes in the surface structure of wool without any estimated damage to the fibre (21-24). Bleaching, shrinkage prevention and biopolishing of wool fabrics were studied to get on the wool with excellent whiteness and a soft handle. Excellent whiteness, shrinkage prevention and soft handle of wool have been getting on by treatment with enzyme. It has been noted that enzyme focus and response time have a worthy impact on enzymatic modification at a given pH [25].

Keratinase was prepared from leather wastes at Egyptian tanneries to improve felting, whiteness and dyeability of wool fabric under certain condition [26].

*Physical treatments of wool*

These days, the customary wet strategy utilized in pre-treatment can make a lot of waste water so it is smarter to utilize physical techniques to overcome them.

*Plasma technology*

Stabilized hydrophilic molecules on the fiber surface act as a wetting property. Thus, the reaction process and results on the textile surface treated by plasma needs to be studied to optimize the parameters of the irradiating time and the voltage of the plasma jet [27-29]. Enzymatic treatments have been estimated in tandem with plasma surface treatments. Wool fabrics were treated with low temperature oxygen plasma with and without proteolytic enzymes and examined for their physico-mechanical and dyeing properties. The results display that dyeing rate increase with plasma pre-treatment followed by protease treatment. The results suggest that plasma-induced modification on surface of fabrics assist to penetration of the enzyme into the wool. Moreover the strength and the elongation did not change [30-32]. Recently, after woven wool fabric was treated by atmospheric pressure plasma jet (APPJ). The wettability improvement and its uniformity of the treated wool fabric were closely related to treatment time, oxygen flow rate, and jet to- substrate distance as shown in Fig. 4 - 6 [33, 34].

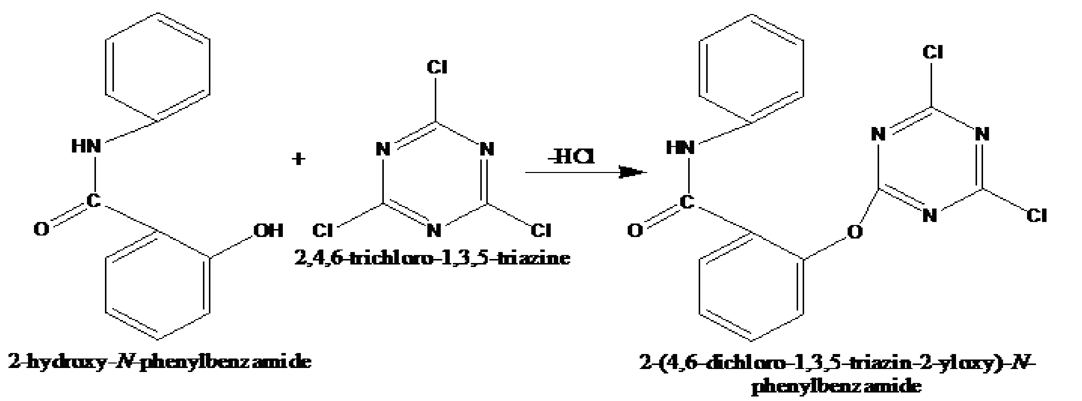


**Fig. 3. The mechanism of reaction.**

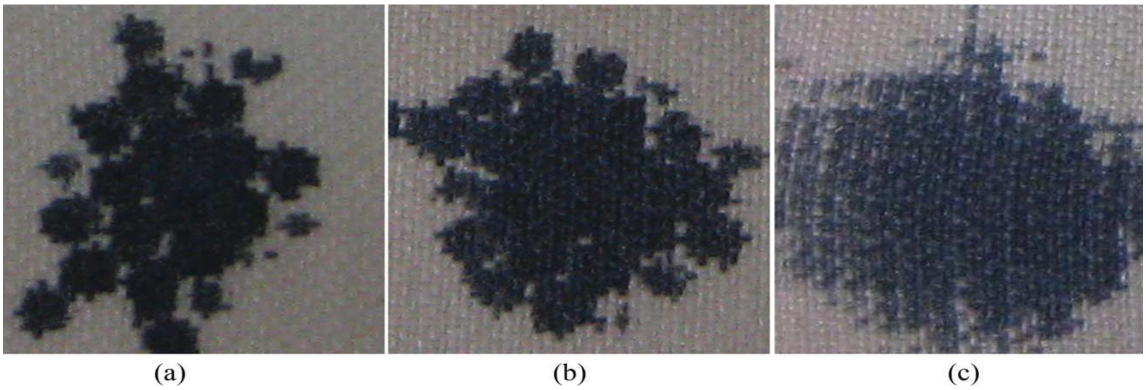


**Fig. 4. Influence of treatment time on diffusion of water droplet on the treated wool fabric surface: (a) 20 s, (b) 30 s, and (c) 40 s.**

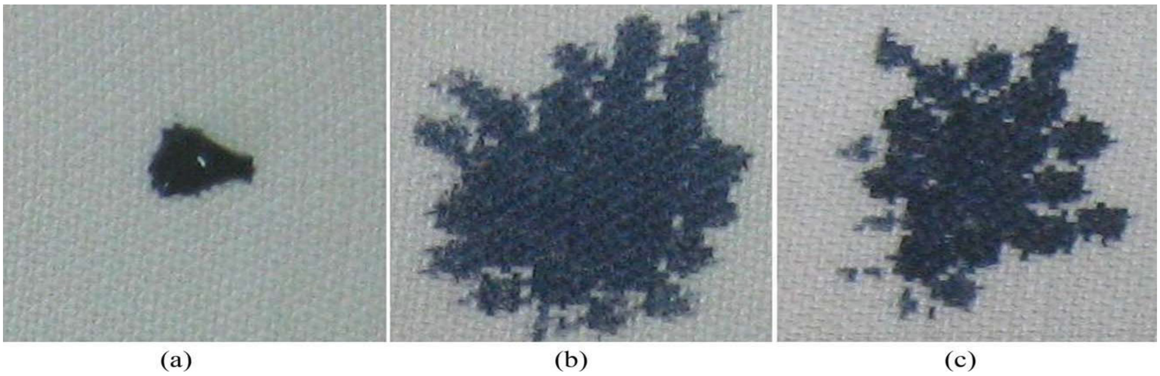


**Fig. 5. Influence of oxygen flow rate on diffusion of water droplet on the treated wool fabric surface: (a) 0 L/min, (b) 0.2 L/min, and (c) 0.3 L/min.**

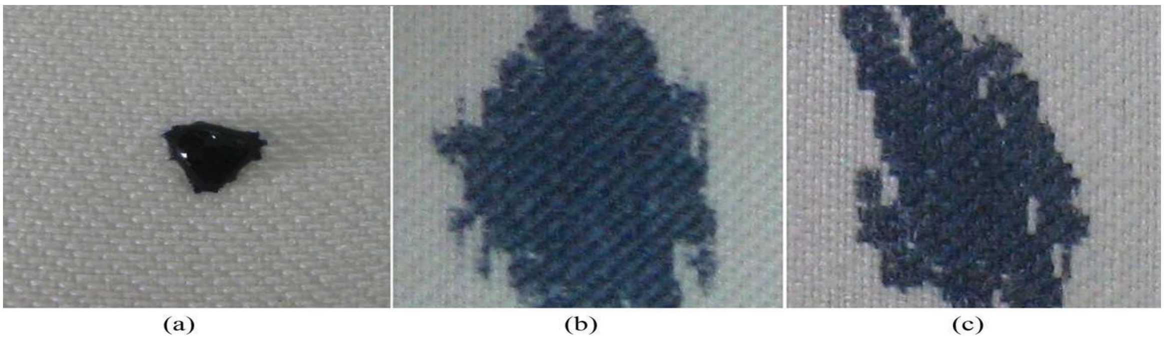


**Fig. 6. Influence of jet-to-substrate distance on diffusion of water droplet on the treated wool fabric surface: (a) 0.5 mm, (b) 1 mm, and (c) 1.5 mm.**

*Microwave irradiation*

The use of microwave heating method in textile dyeing and finishing has been the subject of considerable importance because of various advantages such as uniformity, flexibility, less energy and high efficiency. The advantages of wool have a relatively higher dielectric constant and so microwave irradiation can generate heat on wool fibre through non-contact heating. The use of high efficient microwave heating method in wool dyeing and finishing achieving energy saving and high efficiently has been investigated. Although the breaking strength of the treated wool fabrics also was improved with microwave irradiation, the chemical structure and crystallinity did not show any significant change [35, 36].

The effect of microwave irradiation on the physical property, chemical structure, surface morphological structure, and fine structure of wool fabric was investigated. The results showed that the physical properties of the treated wool fabrics as well as the surface morphological structure in term of concentration of cystine S- S bonds and crystallinity were affected with microwave irradiation conditions. However, the chemical structures are not significantly changed. Wool has a relatively higher dielectric constant so that the use of high efficient microwave heating method in wool dyeing and finishing achieving energy saving and high efficiency has been the subject of considerable interest .The main disadvantage of a wide application of microwave energy in textile finishing is the negative influence of electromagnetic irradiation on the environment [37]. The separate of the Peanut red skin can be considered as a natural dye of worthy quickness properties together with super antibacterial for woolen fabrics [38].

*Ultrasonic energy*

Ultrasonic energy offers many potential advantages such as energy savings and reduced processing times, environmental improvements, process enhancements and lower overall processing costs. In literature it has been reported that ultrasonic energy can be successfully applied to the textile wet processes without inducing cracking or etching of the fabric surface for example laundering, scouring, bleaching and dyeing [39]. The possibility of reducing the temperature of conventional wool dyeing using ultrasound was further investigated, in order to reach exhaustion values comparable to those of the standard procedure [40,41] . The use of ultrasonic energy for wool scouring could result in clear and white fabric with better removal of grease and lower damage to the wool surface [42] . Wool was treated with chitosan and dyed with rhubarb as natural dye. The results showed an increase in color intensity while reducing the temperature for treated dyed wool using ultrasonic mode as compared with conventional mode [43] .

*Ultraviolet radiation*

Because of increasing environmental legislation relating to adsorbable organohalogens (AOX), recent work has focused on the development of dry treatments, for the modification of surface fabric to achieve good dyeability and excellent fastness properties. Thus, the application of ultraviolet (UV) / Ozone treatments for cleaning surfaces of wool was investigated. Then the wettability of surface wool treatment is increased, which improved dyeing and printing properties, even at low temperature [44]. The influence of solo and united UV\Ozone and chitosan was investigated on wool fabrics to improve their dyeability. It is found that, there is increase in colour strength fabric [45].

*Polyester*

Polyester is a class of polymers that include the ester functional group in their fundamental chain. It is prefer to spun polyester with natural fibres .fibers to produce a cloth with mixed properties [46].

*World fibre production*

Figure 7 shows the relation between the world fibre production and year. It is expected that the production of polyester fiber will increase compared to both cotton fiber and woolen [47] .

*Chemical structure of polyester*

Polyester fibers are more distinguished among polymers currently used. Polyester is prepared by the polycondensation response of a glycol (or alcohol) with a difunctional carboxylic acid. Hundreds of polyesters exist because of the horde of blends of alcohols and acids, albeit just around twelve are of important as illustrated in Fig. 8 [48].

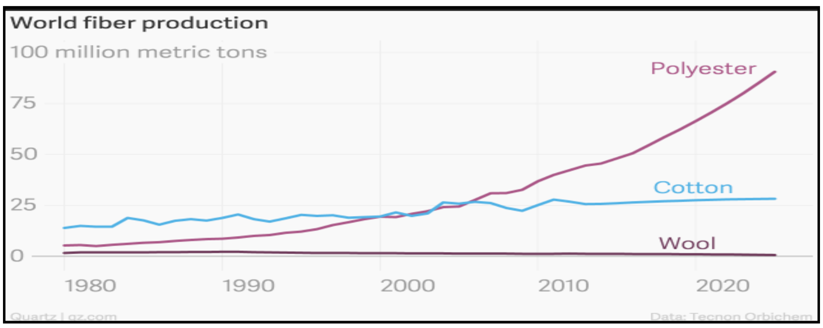


**Fig. 7. The production of polyester compared to cotton & wool fibre.**

*The Advantage and disadvantage of polyester*

*Advantages of polyester*

Polyester incorporate focal points as wrinkle obstruction, sturdiness, flexibility, quicker drying and simplicity of care [49] .

*Disadvantages of polyester*

The polyester fabric has hydrophobic properties, they do not swell in aqueous media and this has undesirable effect on the dyeability of this fabrics.Polyester has low moisture regain which keep the perspiration trapped inside the body. Polyester is also more electrostatic compared to the natural fabrics [49] .

*Chemical treatments of polyester*

Chemical treatment and various techniques have been emphasized to increases the dyeability and develop better moisture regain of polyester and capillary wicking of liquid water [50].

*Alkali treatments*

It is notable that the basic hydrolysis of polyester strands utilizing fluid sodium hydroxide and cationic surfactant done the polymer surface to improve the hydrophilicity of fabrics [51] .

*Microcrystalline cellulose treatment*

Fabrics made of modified polyester can give better moisture regain, especially if using fine filament yarn or blend. Two techniques were suggested in order to study the effect of applying microcrystalline cellulose (MCC) particles as coating materials on polyester fabric and its blend with cotton to improve the wettability. Figure 9, illustrates the wicking height in warp and weft directions for different types of coated material. It is clear that the increase in the weight of coating layer will increase the wickability of the fabric in all state of affairs [52].

*Polyvinyl alcohol treatment*

Absorption of polyvinyl alcohol (PVA) onto polyester (PET) fabric was carried out to modify surface properties. The polyester was treated by sodium hydroxide solution containing PVA. Otherwise polyester fabric was treated with sodium hydroxide without PVA as a control sample.

The wetting conduct of polyvinyl alcohol (PVA) treated (PET) fabric increase impressively because of the great linkage among (PET) and PVA. The nearness of PVA in the treated (PFT) fabric after ten washes is affirmed by spot test (drop of water onto the surface) as shown in Fig. 10. The water contact angle of PVA treated (PET)

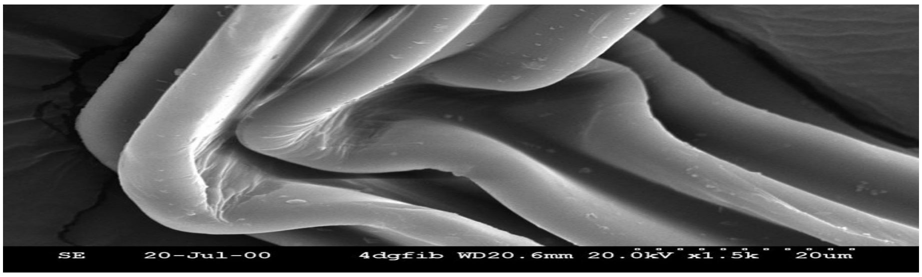


**Fig. 8. SEM: Surface area of polyester fabric.**

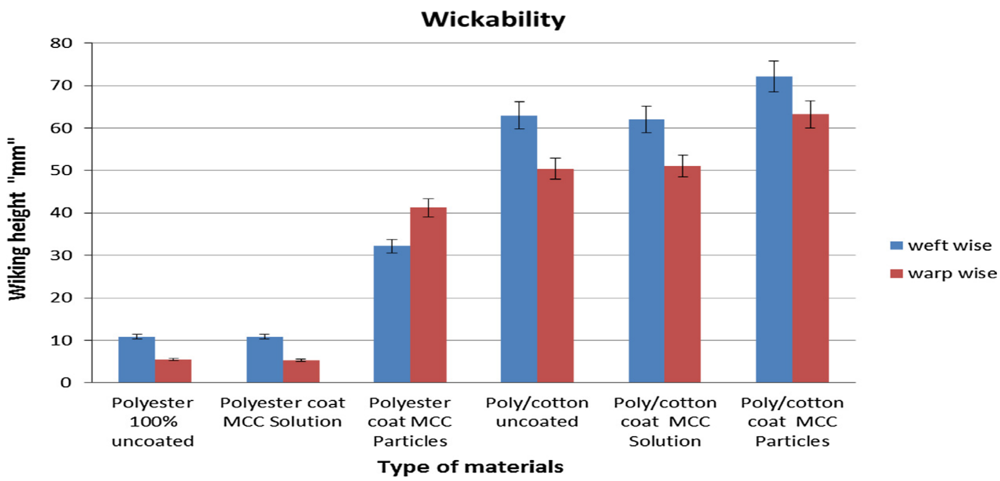


**Fig. 9. Wicking height in warp and weft directions versus the type of material coating.**

fabric is found to be much less than untreated and control (PET) fabrics, which reveals its hydrophilic character [53,54].

*Nano treatments*

The effect of nano titanium di oxide ($TiO_2$) on the dyeing behavior of polyester fabric is investigated. The polyester fabric was first thermally treated with nano $TiO_2$ and then dyed with two different disperse dyes at the boil without a carrier. The dyeing adsorption of polyester fabrics was positively affected by nano $TiO_2$ pre-treatment and an increase in nano $TiO_2$ content led to higher color strength. This method is also free from some of the disadvantages involved in carrier dyeing such as toxicity [55]. The treatment of polyester with $SiO_2$ nanoparticle in nearness of binder granted high level of surface functionalization to the fabrics. The nearness of binder quicken the coloring properties of $SiO_2$ nanoparticles pretreated polyester with disperse dye by diminishing the temperature of coloring from 130 ◦C to 90 ◦C without the use of carrier as well as rising the color yield, compared with the control sample (56). Polyester texture was changed by applying a hydrophilic surface completing specialist that contains nanocrystalline cellulose (NCC). To bestow unrivaled hydrophilicity, NCC was further cationically changed through quaternization by uniting with glycidyl tri-methyl ammonium chloride (GTMAC). The surface completion was connected on the texture utilizing a rolling– drying– relieving process. The surface properties of the texture changed from hydrophobic to hydrophilic after warmth treatment with the NCC-containing surface completing specialist [57].

*Enzymatic treatments*

Enzyme treatments can be chosen as a green surface modification as it offers many advantages than chemical and physical methods. Many investigations have indicated that lipases enzyme degrade polyester (PET) in a two-step reaction: adsorption onto the (PET) surface followed by hydrolysis of the PET ester bonds. Hydrolysis of the ester linkage in polyesters should produce polar hydroxyl and carboxylic groups. Enzymatic treatment with different lipases causes adequate effects, especially, referring to water penetration, absorption and the mechanical parameters of the processed fabric (strength, elongation, wear resistance) [58-60].

*Physical treatments of polyester*

*Plasma technology*

Plasma treatment; it has been studied at both vacuum and atmospheric pressures. The various gases employed include oxygen, nitrogen, ammonia and ...etc.,The hydrophobicity of polyethylene terephthalate (PET) was greatly improved with the plasma method. The surface wettability enhancements were due to two reactions; 1: direct reaction (*i.e.* oxidation) of reactive gases (oxygen plasma) and 2: free radical formation and their subsequent reactions such as degradation and crosslinking [61-63].

*Plasma- ultraviolet*

The effect of lamp irradiation on polyester (PET) surfaces was carried out. Two sort of techniques were utilized: vacuum ultraviolet (VUV) light irradiation and VUV irradiation in the being of oxygen gas (VUV/ $O_3$ ). Results showed that wettability of polyester was amended because a great increase in the surface free energy after treatment and elemental ratio of oxygen on surface increased, whereas that of carbon decreased [64].

*Microwave irradiation*

The use of recent developments, mainly microwave for improvement functionalization of textile fibers especially dyeability .These recent technologies are economically feasible, secure, and acquire superiority over other traditional methods such as, reduce chemicals and auxiliaries need for dyeing polyester fabrics (65-67). Over all, utilizing microwave radiation to help the coloring of polyester with C.I. Disperse Red 60, gives imperative vitality investment funds since coloring temperature is diminished from 130 °C to 80 °C and furthermore the new procedure gives better color take-up [68] .


**Fig.10. Spot test on ( a) untreated (PET) fabric , (b) control (PET)fabric , and PVAtreated fabric.**

## Conclusion

The present review discusses recent development on wettability treatment of wool and polyester textiles. The methods divide into two groups depending on whether they involve changes in composition and fabric structure. The bleaching of wool is carried out by hydrogen peroxide ($H_2O_2$). Also chlorination of wool is improved by combination of hypochlorite with sulfuric acid and resins such as Hercosett. Chlorination removes scales out of wool. This lead to improvement of dyeing process. Aalkaline hydrolysis has been utilized since quite a long while to change the physical properties of polyester especially hydrophilicity and other comfort-related properties of fabrics. Enzymatic treatments have been utilized to improve physical properties of wool such as smoothness, drapeability, dyeing affinity, shrink resistance and water absorbency.

On the other hand keratinase improve physical and chemical properties of wool fabric. Lipases are an excellent alternative to classical organic technique. Treatment of polyester with different lipases causes adequate effects, especially, referring to wear penetration, absorption and the mechanical properties parameters of the processed fabric. There are a lot of investigations on plasma treatment of some textile fabric for changing their wettability properties. For examples, wool and polyester in plasma treatment can improve the ability of these fabrics to retain moisture or water droplets on their surface. Moreover, the use of high efficient microwave heating method in wool dyeing and finishing achieve energy saving and high efficiency especially in dyeing wool/ polyester blend textile.

## Future outlook

Surface modification of natural protein fabric to provide functional and durable properties will continue to be a growing and exciting area in the global fabrics and textile industries. On the other hand, despite the fact that polyester fabric is very waterproof, it has a bright future, especially in the fashion industry, where consumers are increasingly attracted by its ease of care. In the future, the main objective, combined with low operating cost, improved durability, overcoming wool and polyester defects, and development of new textile features, will be the use of environmentally friendly processors such as enzymes and plasma applications.

## References

1. Rafiee, J., Mi, X., Gullapalli, H., Thomas, A. V., Yavari, F., Shi, Y. and Koratkar, N. A., Wetting transparency of grapheme, *Nature Materials*, **11** (3), 217-222 (2012).
2. Eustathopoulos, N., Nicholas, M. G. and Drevet, B., *Wettability at High Temperatures,* Oxford, UK: Pergamon (1999).
3. Dezellus, O., and Eustathopoulos, N., Fundamental issues of reactive wetting by liquid Metals, *Journal of Materials Science*, **45** (16), 4256 - 4264 (2010).
4. Lewis, D. M. and Rippon, J. A., *The Coloration of Wool and Other Keratin Fibres,* John Wiley & Sons. (2013).
5. Bragulla, H. H. and Homberger, D. G., Structure and functions of keratin proteins in simple, stratified, keratinized and cornified epithelia, *Journal of Anatomy*, **214** (4), 516-559 (2009)
6. Gong, H., Zhou, H., Dyer, J. M. and Hickford, J. G., The sheep KAP8-2 gene, a new KAP8 family member that is absent in humans , *Springer Plus Journal*, **3** (1), 528 (2014).
7. Kan, C. W.; Yuen, C. W. M.; Chan, C. K.; Lau, M. P., Effect of Surface Treatment on the Properties of Wool Fabric, *Surface Review and Letters*, **14** (04) ,559-563 (2007).
8. Li, Y., The science of clothing comfort, *Textile Progress*. **31**(1), 125 (2001).
9. Abou El-Kheir, A., Mowafi, S., Salama, M., El-Sayed, A. A. and Kantouch, A., Imparting biocidal properties to wool fabrics using salicylanilide derivatives, *Egyptian Journal of Chemistry,* **56** (5, 6) 435- 447 (2013)
10. Kantouch, A., Khalil, E.M., Mowafi, S., Allam, O.G. and El-Sayed, H., Utilization of ionic liquids for low temperature dyeing of proteinic fabrics, *Egyptian Journal of Chemistry,* **54**, (2) 189 – 203 (2011).
11. Millington, K. R., Continuous photo bleaching of wool , In Proceeding 11th International Wool Textile Research Conference (2005).
12. Yilmazer, D. and Kanik, M., Bleaching of wool with sodium borohydride, *Journal of Engineered Fabrics & Fibers*. **4** (3), 45-50 (2009).
13. Chen, W., Chen, D. and Wang, X., Surface modification and bleaching of pigmented wool, *Textile Research Journal*, **71** (5), 441-445 (2001).
14. Wang, X., Shen, X and Xu, W., Effect of hydrogen

peroxide treatment on the properties of wool fabric, *Applied Surface Science*, **258**, 10012– 10016 (2012).

15. Wang, X Cao, G., and Xu, W., Improving the hydrophilic properties of wool fabrics via corona discharge and hydrogen peroxide treatment, *Journal of Applied Polymer Science*, **112**, 1959- 1966 (2009)

16. Meade, S.J., Dyer, J.M., Caldwell, J.P. and Bryson, W.G., Covalent modification of the wool fiber surface: Removal of the outer lipid layer, *Textile Research Journal*, **78** (11) 943- 957 (2008).

17. Chattopadhyay, D.P., Nanotechnology-the emerging trends, *Textiles,* **33**, 21-24 (2006).

18. Q1a, A. N., Mirjalili, M., Nasirizadeh, N. and Torabian, S. , Optimization of nano $TiO_2$ pretreatment on free acid dyeing of wool using central composite design, *Journal of Industrial and Engineering Chemistry*, **21**, 1068-1076 (2015).

19. Chattopadhyay, D.P. and Patel, B .H. Improvement in physical dyeing properties of natural fibres through pre-treatment with silver nanoparticles, *Indian Journal of Fibre and Textile Research*, **34**, 368-373 (2009).

20. Barani, H., Montazer, M., Calvimontes, A. and Dutschk, V., Surface roughness and wettability of wool fabrics loaded with silver nanoparticles: Influence of synthesis and application methods, *Textile Research Journal*, **83** (12) 1310-1318 (2013).

21. Kotlińska, A. and Symonowicz, B. L., Research on the enzymatic treatment of wool fibres and changes in selected properties of wool, *Fibres and Textiles in Eastern Europe*, **19**, 3 (86) 88-93 (2011).

22. Bishop, D.P. Shen, J. Heine, E. and Hollfelder, B., The use of proteolytic enzymes to reduce wool fibre stiffness and prickle, *Journal of Textile Institute*, **89** (3) 546–553 (1998).

23. Schumacher, K. Heine, E. and Höcker, H., Extremozymes for improving wool properties, *Journal Biotechnology*, **89**, 281- 288 (2001).

24. Kholiya ,R. Khambra,K. Rose, N. and Sangwan,N., Optimization of process conditions for cellulase enzyme treatment of woolen fabric, *Colourage,* **55** (1) 65 – 68 (2008).

25. Cardamone, J.M. Yao, J. and Philips, J.G.,Combined bleaching, shrinkage prevention and biopolishing of wool fabrics, *Textile Research Journal*, **75** (2), 169 – 176 (2005).

26. Allam, O. G. Mowafi S., Abou El –kheir, Azza M. Abdel-Fattah, A., and Bendak, A. Effect of extracted Egyptian keratinase on the properties of native coarse wool, International *Journal of Advanced Research,* **3** (3), 994-1003 (2015).

27. Ceria, A. Rovero, G. Sicardi S. and Ferrero, F. Atmospheric continuous cold plasma treatment: thermal and hydrodynamical diagnostics of a plasma jet pilot unit, Chemical Engineering and Processing: Process Intensification, **49** (1), 65-69. (2010).

28. Shah, J.N. and Shah, S.R. Innovative plasma technology in textile processing: A step towards green environment, *Research Journal of Engineering Sciences*, **2** (4), 34-39, (2013).

29. Demir, A. Atmospheric plasma advantages for mohair fibers in textile applications, *Fibers and Polymers,* **11** (4), 580-585. (2010).

30. Yoon, N.S. Lim, Y.J. Tahara M. and Takagishi, T., Mechanical and dyeing properties of wool and cotton fabrics treated with low temperature plasma and enzymes, *Textile Research Journal,* **66** (5), 329-336 (1996).

31. Kan, C.W. Yuen, M. Tsoi W .Y. I. and Tang, T. B. Plasma pretreatment for polymer deposition-improving antifelting properties of wool, Plasma Sciences, *IEEE Transactions,* **38** (6), 1505-1511 (2010).

32. Kutlu, B. Aksit, A. and Mutlu, M. Surface modification of textiles by glow discharge technique: Part II: Low frequency plasma treatment of wool fabrics with acrylic acid, *Journal of Applied Polymer Science*, **116** (3), 1545-1551 (2010).

33. Yu, W. and Shouguo, W. The research about the time-effect of the wettability on the wool surface treated by the Ar plasma jet in the atmospheric pressure, *Nuclear Instruments and Methods in Physics Research* , **267**, 3137–3139(2009).

34. Wang, C. and Qiu, Y. Study on wettability improvement and its uniformity of wool fabric treated by atmospheric pressure plasma jet", *Journal of Applied Polymer Science*, **123**, 1000–1006 (2012).

35. Ahmed, N.S.E. and El-Shishtawy, R.M. The use of new technologies in coloration of textile fibers, *Journal of Material Science*, **45** (5), 1143-1153 (2010)

36. Zhao, X. and He, J. X. Improvement in dyeability of wool fabric by microwave treatment, *Indian*

*Journal of Fiber and Textile Research*, **36** (1), 58-62 (2011).

37. Xue, Z. and Xin,H. J. Effect of microwave irradiation on the physical properties and structures of wool fabric, *Journal of Applied Polymer Science*, **119**, 944- 952 (2011).

38. Helmy, H. M., Kamel, M. M., Hagag, K., El-Hawary, N. and El-Shemy, N. S., Antimicrobial activity of dyed wool fabrics with peanut red skin extract using different heating techniques, *Egyptian Journal of Chemistry; the 8th International Conference,* 103 - 116 (2017).

39. Hurren, C. Cookson, P. and Wang, X., The effects of agitation in laundering on the properties of wool fabrics, *Ultrasonic Sonochemistry*, **15**, 1069–1074 (2008)

40. McNeil, S.J. and McCall, R.A., Ultrasound for wool dyeing and finishing, *Ultrasonic Sonochemistry,* **18**, 401–406 (2011).

41. Ferrero, F. and Periolatto, M. Ultrasound for low temperature dyeing of wool with acid dye, *Ultrasonic Sonochemistry*, **19**, 601- 606 (2012).

42. Kadam, V. V. Goud, V. and Shakyawar, D.B. Ultrasound scouring of wool and its effects on fibre quality, *Indian Journal of Fibre and Textile Research*, **38**, 410-414 (2013).

43. Ali, N.F., El- Khatib, E.M., El- Mohamedy, R.S.R., Nassar, S.H., El-Shemy, N.S., Dyeing properties of wool fibers dyed with rhubarb as natural dye via ultrasonic and conventional methods, *Egyptian Journal of Chemistry.* **62**(1) 119 - 130 (2019).

44. Micheal M.N. and EL- Zaher, N. A. Efficiency of ultraviolet / ozone treatment in the improvement of the dyeability and light fastness of wool , *Applied Polymer Science*. **90**, 3668- 3675 (2003).

45. Gohar, H., The effect of both ultraviolet \ ozone and chitosan on natural fabrics, *International Journal of Chemistry*, **2** (2) 28- 39 (2010).

46. Scheirs J. and Long, T.E., Modern polyesters: chemistry and technology of polyesters and copolyesters, John Wiley and Sons, Hoboken, NJ (2003).

47. Pastore C.M. and Kiekens, P. Surface characteristics of fibres and textiles, 94, Surfactant Science Series, Marcel Dekker, New York (2000).

48. Gharagheizi, F. Sattari, M. and Angaj, M. T. Effect of calculation method on values of solubility parameters of polymers, *Polymer Bulletin*, **57** (3), 377-384, 377 (2006).

49. https://en.wikipedia.org/wiki/Polyester (2015).

50. Niu S. and Wakida, T. Effect of heat setting temperature on alkali hydrolysis of poly (ethylene terephthalate) fibres, *Textile Research Journal*, **63**, 346-350 (1993).

51. Raslan,W. M. and Bendak, A. Changes induced in silk-like polyester properties by alkoxides treatment, *Journal of Applied Polymer Science,* **98** (4) 1829 - 1837 (2005).

52. Messiry M. El. Ouffy, A. El. and Issa, M. Microcellulose particles for surface modification to enhance moisture management properties of polyester, and polyester/cotton blend fabrics, Alexandria Engineering Journal, 54, 127–140 (2015).

53. Joseph, R. Shelma, R. Rajeev, A. and Muraleedhran,C.V. Characterization of surface modified polyester fabric, Journal of Materials Science : Material, 20, 153- 159 (2009).

54. Natarajan, S. and Moses, J.J. Surface modification of polyester fabric using polyvinyl alcohol in alkaline medium, *Indian Journal of Fibre and Textile Research*, **37**, 287- 291(2012).

55. Harifi, T. and Montazer , M. Free carrier dyeing of polyester fabric using nano $TiO_2$, *Dyes and Pigments* , **97** (3) 440 - 445 (2013).

56. Gabry, L.K. El- Allam O.G. and Hakeim, O.A. Surface functionalization of viscose and polyester fabrics toward antibacterial and coloration properties, *Carbohydrate Polymers*, **92**, 353– 359 (2013)

57. Zaman, M. Liu, H. Xiao, H. Chibante, F. and Ni, Y. Hydrophilic modification of polyester fabric by applying nanocrystalline cellulose containing surface finish, *Carbohydrate Polymers*, **91**(2), 560–567 (2013).

58. Đorđević Dragan, M. Petronijević Živomir, B. and Cvetković Dragan, M., Polyester fabric modification by some lipases, *Chemical Industry and Chemical Engineering Quarterly ,* **4**, 183 -188 (2005).

59. El-Bendary, M. A. Abo El-Ola, S. M. and Moharam, M. E. Enzymatic surface hydrolysis of Polyester (ethylene terephthalate) by lipasezyme and its production, *Canadian Journal of Pure and Applied Science,* **4** (2), 1207-1216 (2010).

60. Wavhal, S. D. and Balasubramanya, R. H. Role of Biotechnology in the treatment of polyester fabric, *Indian Journal Microbial*, **51**(2), 117–123 (2011).

61. Narushima , K. Yamashita, N. Isono, Y. Islam,M. R. and Takeuchi, M. Effect of irradiation power on surface modification of polyester by ammonia plasma treatment, *Japanese Journal of Applied Physics* ,**47**, 3603-3605 (2008).

62. Narushima,K. Yamashita,N. Fukoka, M. Inagaki,N. Isono,Y. and Islam,M. R. Surface modifications of polyester films by ammonia plasma, *Japanese Journal of Applied Physics* **46** (7A) 4238-4245 (2007).

63. Vesel, A. Junkar, I. Kovac, J. and Mozetic, M. Surface modification of polyester by oxygen- and nitrogen-plasma treatment, *Surface and Interface Analysis*, **40**, 1444 - 1453(2008).

64. Kasahara, T. Shoji, S. and Mizuno, J. Surface modification of polyethylene terephthalate (PET) by 172- nm excimer lamp, Transactions of the Japan: Institute of Electronics Packaging, **5** (1), 47-54 (2012).

65. Bhat, N. V. Kale, M. J. and Gore, A., Microwave radiation for heat – setting of polyester fibres, *Journal of Engineered Fibers and Fabrics*, **4** (4), 1-6 (2009).

66. Manik, J.K. and V.B. Narendra, Effect of microwave pretreatment on the dyeing behavior of polyester fabric, *Coloration Technology,* **127** (6), 365– 371 (2011).

67. Hebeish, A. ELmaaty, T. A. Ramadan, M., and Magdy, H., Microwave and Plasma Treatments for functionalization of polyester fabrics, *International Journal of Current Microbiology and Applied Sciences.* **4** (7), 703-715 (2015).

68. El-Apasery, M. A., Abdelghaffar, R.A., Kamel, M.M., Kamel, M.M., Youssef, B.M. and Haggag, K.M., Microwave, Ultrasound assisted dyeing-part I: dyeing characteristics of C.I. Disperse Red 60 on polyester fabric, *Egyptian Journal of Chemistry, The 8th International Conference*, 143 - 151 (2017).

## التطورات الحديثة لمعالجة الابتلال لمنسوجات الصوف والبوليستر

**اميمة جابر علام**
شعبة بحوث الصناعات النسجية - قسم الالياف البروتينية والصناعية - المركز القومي للبحوث٣٣ - البحوث - الدقى - الجيزة - مصر
Affiliation ID: 60014618

هذه الدراسة هى نظرة عامة لطرق معالجات الابتلال المتقدمة لمنسوجات الصوف والبوليستر. وسوف تستعرض اهمية استخدام المعالجات الاستراتيجية المتطورة للوصول إلى ظروف معالجة مثالية وأفضل النتائج ، خاصة القابلية للماء و الرطوبة وزيادة معدل الصباغة مع الحفاظ في نفس الوقت على الخصائص الفيزيائية والطبيعية لكل مادة. تنقسم المعالجات إلى: المعالجة الكيميائية والمعالجة الأنزيمية و االمعالجة الفيزيقية مثل: الاوكسيدات الكحولية وتكنولوجيا البلازما وأشعة الميكروويف.