Recent techniques of surface modification for textile fabrics

D.M. Essa
Material Testing and Chemical Surface Analysis Lab., National Institute of Standards (NIS), Egypt.
Corresponding author's email: dalia.essa@nis.sci.eg

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Abstract

Textiles are considered one of the important industries for any country, but they produces many industrial wastes that affect the environment and health, as well as consume a lot of water and energy, which costs the country a lot of money. Recent trends in the textile industry aim to direct the researches to develop new ways to reduce the time, water and energy consumed by treating textile surfaces, either by chemical or physical surface treatment. The types of textile surface modifications summarized in this paper were discussed by chemical treatments such as surface grafting, enzymatic modification, ozonation and nano-treatments, and some of physical treatments such as plasma, gamma rays, microwave, ozone and /or UV. It has been shown the many properties acquired by these fabrics after treatment that make them more comfortable to use such as increased wettability, shrinking resistance, twisting and desizing of fibers, dyeing, printing and new functional advances including bacterial resistance, UV protection, self-cleaning, softness, easy care and stiffness. Also surface modification used to clean the fiber surface, deposit protective coatings on fibers or increase the strength of fibers.

Keywords: Surface modification, textile, eco-friendly, nano-treatment, grafting.

1 Introduction

1.1 Textile fabric classification

The fibrous materials from which textile goods are manufactured may be either of natural or man- made origin, thus, a general classification of textile fabrics according to their nature classified them into;

I) Natural fibers involve three types:

a) Mineral (e.g. asbestos),

b) Animal (e.g. wool, silk, mohair), and,

c) Vegetables, of three types; such as flax and Jute, seed and leaf, such as sisal, and seed, e.g. cotton,

II) Man -made fibers involve:

a) Regenerated e.g. viscose, rayon, acetate, triacetate and rubber,

b) Synthetic e.g. polyamide, polyester, polyacrylonitrile, polyolefin, glass fibers and other types.

c) Man-made fibers combined with natural or other synthetic to create blended fibers. They primarily combine natural and synthetic fibers.

1.2 Types of surface modification

The wet processing of textile materials consumes much of electricity, fuel, and water. Therefore, greenhouse gas emissions and contaminated effluent are environmental problem. Environmental pollution in textile wet processes can be reduced in four main ways. They are process optimization chemical energy consumption, in reduction in water and time loss, use of ecofriendly chemicals, reuse of water, and new technologies like ozone and plasma technologies, transfer printing, enzymatic processes, etc.

Surface modification is effective for improving in functionality without changing the bulk characteristics of fibers. Modifying of the surface energy of textile fibers is pursued with the aim to enhance their own hydrophilicity, wettability, and dyeability or of conferring functional properties such as water and oil repellency, adhesion improvement soil release and antistatic performances. [1] Also, the choice of surface modification depends on the end-uses of the products.

Surface modification divided into two type: I) chemical modification which involves a change in fiber composition as surface grafting or an, enzymatic modification method with different reagents and II) physical modification which includes such as plasma, ozone-gas treatment, microwave, ultrasound, gamma radiation, and neutron and electron beam irradiations. [2] Figure (1) illustrates different Sustainable pretreatment techniques [3].

Figure (1): Sustainable pretreatment techniques [3].

2 Chemical surface modification of fabrics

2.1 Surface Grafting

It is method of chemical modification by graft copolymerization to give fabric comfort properties such as water absorption, moisture regain and thermal properties. [4]

When cotton fabric that had been phosphorylated through in-situ chemical solution polymerization, it was discovered that the cotton became conductive and had a surface electrical resistivity of 9.02 k Ω, which was significantly lower than that of cotton fabrics without treatment, which had a resistivity of more than 1000 M Ω. The modified phosphorylated cotton fabric had a higher adsorption capacity (250 mg g-1) than the unmodified cotton fabric (54 mg g-1) and the polyaniline-modified cotton fabric (113.7 mg g-1). [5]

Eman et al studied the graft copolymerization of Hydroxyethyl cellulose (HEC) by acrylic acid (AA) or by acrylic acid and acrylamide (AM) mixture with different composition ratio AA/AM (70/30 & 30/70) then the produced copolymer utilized to remove the ion Ni from aqueous solutions the result show that at optimum conditions of metal removal the removal efficiency of Ni ion follows the sequence: HEC-g-AA (I) >HEC-g-AA-Am (II) > HEC-g-AA-Am (III) with value of removal efficiency 94.6%, 91.2%and 86.1% respectively. [6]

Wool fabrics were modified with chitosan and chitosan nanoparticles (1%, 2%, 3%) with synthesized direct dye to enhance the exhaustion of dye, fastness properties, and antimicrobial activity of dyed fabrics. Also, we use the ultrasonic technique for wool dyeing to reduce the temperature and time of dyeing. The results assessed for dyeing and antimicrobial activity indicate high-quality dyeing properties, Also, these direct dyes have higher antibacterial activity toward Gram-positive and Gram-negative bacteria therefore they can be used in biomedical applications [7]

F. Aubert-Viard, et al. designed a wound dressing that release chlorhexidine (CHX) as an antiseptic agent, used ensuring long-lasting antibacterial efficacy during the healing. The textile nonwoven (polyethylene terephthalate) (PET) of the dressing was first modified by chitosan (CHT) cross linked with genipin (Gpn). Parameters such as the concentration of reagents (Gpn and CHT) crosslinking time and working temperature were optimized to reach the maximal positive charges surface density. This support was then treated by the layer-by-layer (LbL) deposition of a multilayer system composed of methyl-beta-cyclodextrin polymer (PCD) (anionic) and CHT (cationic). After a thermal treatment to stabilize the LbL film, the textiles were loaded with CHX as an antiseptic agent. [8]

2.2 Enzymatic modification

Enzymes are large-molecular-size proteins whose active groups react with substrates to produce products by lowering the reaction's activation energy. Enzymes are biocatalysts consisting of metabolites derived from bacterial derivatives of living organisms. The substances that participate in chemical or biochemical reactions and remain unchanged at the end of the reaction are called catalysts [9].

Enzymatic surface modification of textiles is a process that involves treating fibers or attaching functional groups to the surface to change their physical and chemical surface properties [10]. Also this treatment is cost reduction, energy and water saving, improved product quality and potential process integration [11].

Stanescu M.D. also suggested a classification of enzymes reaction and in table 1 provides Classification of enzyme according to its application [12].

Table (1): *Classification of enzyme according to its application* [12].

Group of enzymes	**Reaction catalyzed**	**Example**
Oxidoreductases	Transfer of hydrogen and oxygen atoms or electron from one substrate to another	Dehydrogenases Oxidases.
Transferases	Transfer of a specific group (a phosphate or methyl, etc) from one substrate to another	Transaminase Kinases
Hydrolases	Hydrolysis of a substrate	Esterase Digestive enzymes
Isomerases	Change of the molecular form of the substrate P	Phosphor hexo isomerase Fumarase
Lyases	Non-hydrolytic removal or addition of a group to the substrate	Decarboxylases Aldolases
Ligases (synthetases)	Joining of two molecules by the formation of new bonds	Citric acid synthetase

All catalytic enzyme reactions include at least three passages as follows as in figure (3)

1) The substrate (S) combines with the enzyme (E) into a complex substrate enzyme (ES).

2) The complex enzyme-substrate (ES) converts into an enzyme-product (EP)

3) (P) Releases from (EP), and releases (P) so that (E) is able to start a new cycle of catalysis

After pre -treatments using lipase enzyme and potassium permanganate as an oxidizing agent, the Wool/PET fabric was loaded with titanium dioxide nanoparticles [13].

Polyester fibres were modified by Cutinase and the large amount of carboxyl and hydroxyl groups were generated on the surface of fibres because of the hydrolysis of ester bonds which leads to increase the wettability of the fabric significantly with a better capillary effect, a shorter wicking time, a smaller contact angle and a higher moisture regain. Also, the oily stain removal index was greatly improved due to the better fabric hydrophilicity and wettability. The cutinase pre-treatment technology provides a hydrophilic polyester fabric with improved wear comfort, better stain removal, but without significant damages to the mechanical performance of fabrics [14].

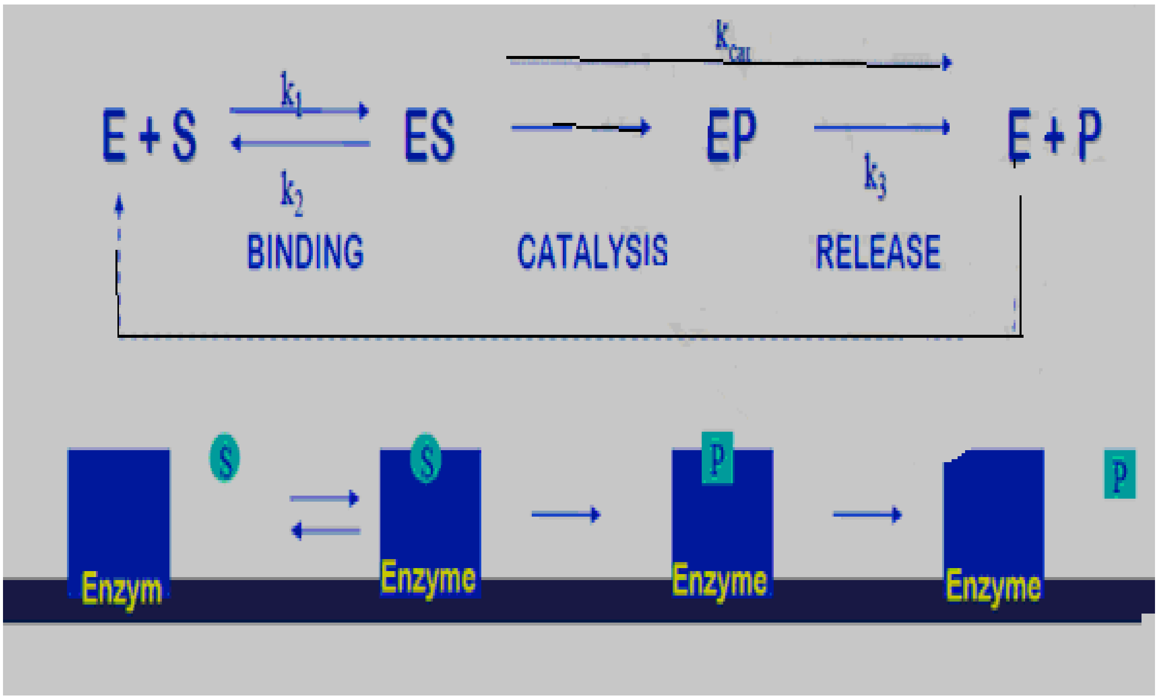

Figure (2): Schematic presentation of catalytic enzyme reactions.

Cotton fabrics were pre-treated with three enzymes: acid cellulase, neutral cellulase, and xylanase, then dyed with catechin. The pre-treatment with these enzymes improved the dyeing efficiency of fabrics with better color fastness properties and enhanced dyeing rates as comparison to the conventional dyeing processes. Also enzymes treatment significantly improved ultraviolet protection and antibacterial properties of the dyed fabrics. xylanase outperforms the other enzymes [15].

2.3 Nano-treatment

Nanotechnology in textiles can improve properties including wrinkle resistance, water and soil resistance, antistatic, antimicrobial, and UV protection with relation to chemical processing.
The cotton/wool and viscose/wool blended fabrics were finished with silver and/or zinc oxide nanoparticles in finishing bath along citric acid or succinic acid as ester-crosslinking and sodium hypophosphite catalyst using the padding technique. The obtained finished fabrics have multi-functionalization expressed as antibacterial activity, UV blocking functionality and wrinkle recovery ability. Also have durable multi-functional properties even after 10 washing cycles. [16]

To achieve the materials' UV protection factor UPF values and antibacterial activity against both positive and negative bacteria, numerous types of fabrics, including wool, polyester, and wool/polyester blends, were treated with nano- titanium oxide. The treated fabrics also have electrical characteristics. [17]

Figure (4) shows all the properties acquired by the textiles modified with nanoparticles, also table (2) gives a brief overview of the NP or nanostructures employed in the functional fabrics.

Table 2: *Overview of the usage of NP or nanostructures in functional fabrics [18].*

Functional fabrics	NP / nanostructure
Conductive / Antistatic fabrics	Cu, Polypyrrole , Polyaniline
Reinforced textiles / tear and wear resistant fabrics	Al_2O_3, CNT, polybutylacrylate SiO_2, ZnO
Antibacterial	Ag , chitosan ,SiO_2 ,TiO_2 ZnO
Self-cleaning fabrics / fabrics with antiadhesive properties	CNT, fluoroacrylate , SiO_2 TiO_2
UV-blocking textiles	TiO_2, ZnO
Flame retardant textiles	CNT, boroxosiloxane, montmorillonite , Sb_3O_2

Figure (3): Nanotechnology in textile finishing. [18]

3 Physical surface modification of fabrics

Presently, the most common methods used to physically alter fabric include low-temperature plasma technology, gamma radiation, UV radiation, microwave treatment, and ultrasonic technology. Without affecting the fiber's performance, these physical modifications can be applied. The techniques reduce the use of chemical reagents, and the fabric modification is fast, clean, efficient in terms of water and energy use, and it won't create any pollutants. Therefore, these physical modifications serve the dyeing industry as successful alteration techniques. [19, 20]

3.1 Plasma modifications

The fourth state of matter is called plasma, and it is described as an ionised gas with a neutral overall charge that contains electrons, ions, gas atoms, and molecules in either the ground or excited state.

This surface-specific procedure uses the smallest amount of working gas possible (or vaporized liquid). Cleaning, activation, grafting, etching, and polymerization are some of the plasma treatment's effects on the substrate's surface. The nature of the gas and process parameters such as pressure, flow rate, strength, frequency, and duration decide the form and extent of the effect. [21]

Compared to other methods, plasma surface treatment has advantages for changing the functional characteristics of fibers. The plasma treatment has the following advantages comparing with traditional techniques: Because plasma is a dry modification method, it is dependable and safer; it uses very little chemical; it can quickly change materials that are difficult to modify; it takes little time to process; and there is no waste. [22]
Plasma uses less water and energy and causes very little fiber damage, which makes the procedure very appealing. It will be utilized to improve the quality of textile products through fabric preparation, dyeing, and finishing techniques. Cleaning, activation, grafting, and deposition are the four processes that plasma processes can conveniently be divided into, as shown in figure (5). [23] The protective coatings applied on to the textiles through plasma technology make the textiles more durable. [24]

Plasma classified into two groups the first is thermal or equilibrium hot plasma, and the second is non-thermal or non-equilibrium plasma, or cold plasma which is used for improving the physical and chemical properties of textiles. [25]

The main benefit of using cold plasma, which is classified into atmospheric pressure plasma and low- pressure plasmas, is that it can significantly modify the chemical and morphological composition of a textile's surface without changing the fabric's bulk qualities. [26]

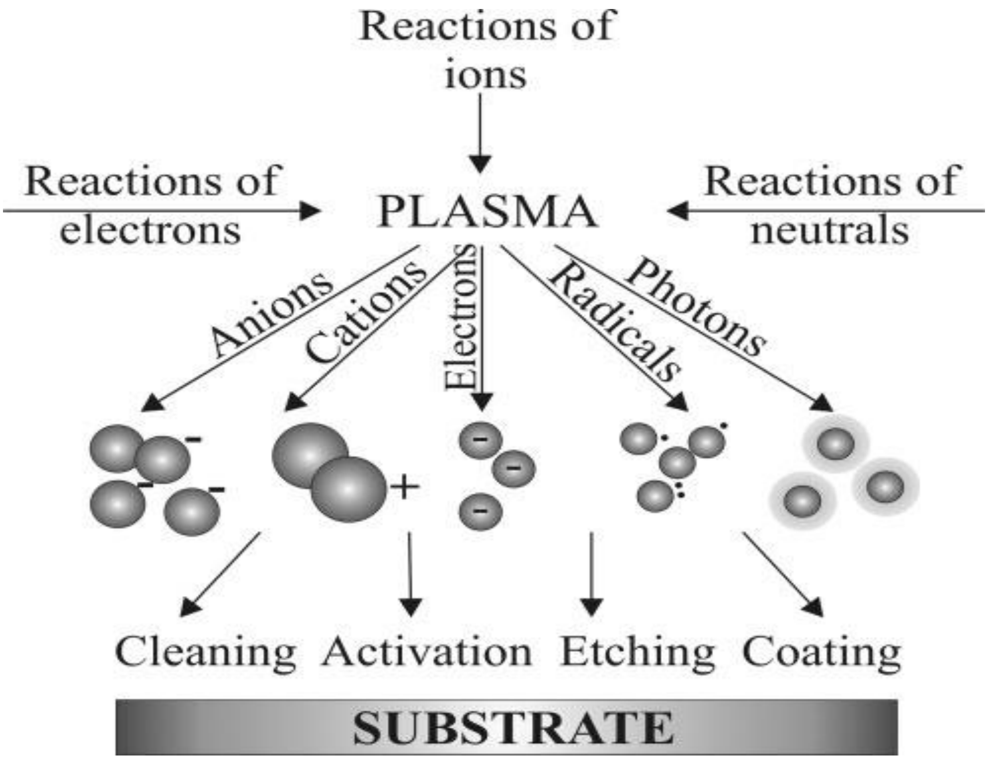

Figure (5): Plasma–substrate interactions. [23]

The most common forms of atmospheric pressure plasma are:
1-Glow discharge: plasma produced by passing Radio frequency, microwave, and direct current at low frequency voltage through a pair or group of electrodes.
2- Corona discharge: plasma produce using atmospheric pressure by putting it through a pair of different size electrodes at a low frequency or high voltage flow,
3-Dielectric-barrier discharge (DPD): It is produced using a pulse voltage flow on a pair of electrodes, one of them is covered in dielectric material. [27]

To improve the dyeability, printability, wettability, soil resistance, flame, water, and oil repellence, antimicrobial effectiveness, antibacterial and antifungal properties, and physical properties of natural textile materials like cotton and silk, plasma treatment has been applied on textiles. [28]

The effects of plasma treatment with corona glow discharge plasma on the changes in wetting characteristics of polyester and cotton fabrics were investigated. The findings indicate that as the treatment period increase the wetting properties increase. Multiple factors, including changes in surface morphology, the creation of active chemical functional groups on the fabric surface, the presence of free radicals on treated fabrics, and changes in their physical properties, all affect how fabrics are treated with plasma. [29]
Plasma discharge is widely used to improve the wettability and/or hydrophilicity of numerous textile materials. [30] The increase in hydrophilicity in several fibres such as polyester (PET), polyethylene (PE) [31], polypropylene (PP, polytetrafluoroethylene (PTFE), silk. [32]

It was also observed that of when wool fabric treatment with Corona discharge the possibility to be worn next to skin increases due to high absorbency. [33]

Plasma treatment significantly improved the mechanical characteristics of natural fibres. [34] Additionally, this process can add different functional groups to the surface of natural fibers, which can create strong covalent connections with the matrix and a strong fibre/matrix contact. The polyester fabric was treated using an effective plasma technique prior to cationization treatment to activate the surface and improve the efficiency for dyeing with nature dye (madder dye). It was found that exposure to nitrogen plasma treatment for 10 min at a discharge power level of 12 W under atmospheric pressure produced reactive groups and free radicals on the fabric surface and improve dyeing. Also the treated samples' fastness characteristics against washing, sweat, crocking, and light were very good to excellent. [35]

For the reason PP is hydrophobic in nature, inactive synthetic fabric because the absence of reactive functional groups in the molecular structure so PP fibers are modified by irradiation argon plasma irradiation to form free radical centers onto the surface and graft copolymerization in presence of styrene was used. Excellent regeneration ability of PP modified >90% were showed and which were effective in cleaning hydrocarbon pollutants from the air. [36]

Nonwoven polypropylene fabrics were modified with oxygenated DBD plasma and then grafted with 2% nano ZnO, TiO_2 and Ag to acquire pp fabric uv- blocking by using nano ZnO, TiO_2 and a high antibacterial activity by using nano- Ag. [37,38]
Polyester and silk fabrics were treated with cold plasma using O_2 gas or O_2/Ar mixed gas as working gas then treated fabrics modified by nano-silver. Results showed that treated fabrics had significantly improved antibacterial activity and increased UV protection factor (UPF). From the mechanical properties the physical properties of the fabrics not affected by plasma treatment. The treated silk samples with oxygen and oxygen/argon mixed gas plasma and/or nano-silver treated silk samples dyed with natural Red Lac dye that gave high color intensity and high fastness properties for light and washing for treated fabrics. [32,39]

The color strength and color fastness properties of dyed cotton treated by Low-temperature plasma samples with madder and weld natural dyes under various conditions were improved. [40]

Pre-surface modification of cotton, linen and viscose with N_2-plasma improved the antibacterial functionalization with enhanced durability due to formation of new active binding sites such as $-NH_2$ groups which loaded by nano– silver to acquire a fabrics antibacterial properties. [41]

3.2 Gamma irradiation

Gamma rays are rays emitted by radioactive isotopes (Cs-137 or Co- 60) when the atomic energy level jumps. When modified, gamma rays produce ionizing radiation that acts on the

fabric's surface, causing the surface groups to ionize and excite to form free radicals, thereby changing the physical properties and chemical composition of the fabric surface. [19]
I.A. Bhatti *et al.* established that the optimal dose of gamma radiation for improving the dyeing ability of cellulosic fabric is 6 kGy given by a Cs-137 gamma irradiator. Also, There was a significant improvement in the fastness properties of light, washing, and rubbing. [42]
Mechanical properties of cotton fabric modified by subject to gamma radiation which was prepared by using solution of chitosan were investigated. Gamma radiation increases the cross-linking and FTIR analysis verified intermolecular interactions between cotton and chitosan. The gamma radiation chitosan cotton fabric not only shows a noticeable change in tensile strength, but it also has remarkable elongation properties. [43]

Gamma radiation has been used to improve the mechanical properties of the pineapple fabric reinforced polyester resin and the jute fabric reinforced polyester resin. The results show that as the gamma radiation dose is increased, all mechanical properties significantly improve. The study showed that gamma radiation significantly enhances all mechanical properties. [44]

The gamma radiation effect on the mechanical properties and surface structure of cotton, flax, and silk fabrics was investigated. Gamma radiation in doses not exceeding 15 kGy does not cause significant deterioration in the mechanical properties. A dose of 100 kGy leads to a clear weakening of these fabrics; the greatest destructive effect is observed in linen fabric. Also The previous irradiation of cotton and linen fabrics does not increase their susceptibility to biodegradation during fungal growth. Silk fabric samples irradiated with a dose of 100 kGy show a clearly higher susceptibility to bacterial biodegradation than unirradiated samples. [45]
Enhancing the binding of the ZnO nanoparticles with cotton fabrics can be achieved after irradiation by gamma ray of 9 kGy. This suggests that there is an increased level of binding between the functional nanoparticles which have been coated on cotton fabrics after gamma ray irradiation, which can be useful for the textile industries. [46]

Cellulose substrates modified by chitosan and gamma irradiations with doses (2, 4, and 6 kGy) then natural dyes extracted from floral stems of banana was applied on the modified fabric. The results illustrate improvement of color strength and UV protection ability. [47]

3.3 Ozone treatment

Ozone is excellent oxidizing agent and is used for fibre modification. In this treatment hydrophilic groups are incorporated on fibre surface which results in change in fibre surface chemistry. Ozonation of textile has many advantages [48-50]

- reduce water and chemical consumption and time save of ozonation process than conventional wet processes,
- No chemicals needed compared to the other conventional methods, no waste
- Combination with novel technologies like UV, plasma, and ultrasound,
- improving dyeability of fabrics

Aramid fibres treated with ozone to improve its surface property. The result indicated that the hydrophilic property improved with increasing ozone exposure periods, and that ozone treatment also caused a slight increase in ball bursting load and penetration displaced. [51]
Treated wool by ozone cause oxidation of fabric leads to increase in polymer adsorption by increasing the polarity. [52] Whereas fabric made from Nylon 6 and polyester fiber treated by ozone showed improvement in surface tension of fibers which further increased its moisture regain, water absorption, and dyeing. [53]

Rafaela *et al* modified polyester to enhance the method which of finishing agents and dyes interact with the surface of the modified fabrics. Modified polyester dyed with C.I. Disperse Yellow 211 dye Results show that increasing dyeing efficiency allows for better colour solidity and a reduction in the amount of dye needed. [54]

3.4 UV- treatment

Ultraviolet light oxidation of fabric surface, lead to forming carboxyl, aldehyde, hydroxyl, carbonyl and other reactive groups, which helps to increase the affinity of dyes and fabrics, thus improving the dyeing performance of natural dye. [55]
Wool fabrics modified by UV radiation, which cause oxidation of wool surface and more functional groups introduced and the rate of dyeing and fastness properties increase. **[56]** To improve the performance of oil absorption, the surface of polypropylene modified UV radiation-induced graft polymerization of butyl acrylate. [57]

The greatest and most durable wettability results were obtained after 40 min of UV irradiation in combination with 30 g/L nano-TiO2, 50 g/L H_2O_2, and 30 g/L NaOH treatment. The hydrophilicity of treated polyester fabrics by UV irradiation and treatment with nano-TiO2, H_2O_2, and NaOH will increase with an irradiation time of 30 min, making the fabric nearly wettable. The treated fabric had excellent mechanical and physical properties modification. Due to the chemical modification of the polyester fabric's surface with the addition of hydrophilic groups, the hydrophilicity of the treated fabric can be considered as permanent. [58]

Rehman *et al* modified cotton fabrics by UV irradiation to improve dye exhaustion of lutein colorant extracted from marigold flowers using different dye conditions. They found that the exposure to UV radiations for 90 min delivered better dye uptakes, For the best color strength and fastness properties, the optimum dyeing conditions were 40^{o} C for 70 min with a salt concentration of 4 g/L. [59]
Ibrahim et al studied the physical surface modification of pure cotton, pure polyester and blend (cotton/ polyester) by UV/Ozone for different period of time and the result showed the (K/S) values and light fastness grades of the treated fabrics using direct and disperse dyes are greatly improved for blend sample than cotton than polyester. [60]

3.5 Microwave treatment

Microwave radiation is a clean, environmentally friendly and efficient heating technology and is understood as converting energy from microwave to heat in the form of dielectric materials. [61] Materials with a high dielectric coefficient (e.g., water, salt and ethanol) can heat themselves by dipole oscillations during microwave irradiation. [62] At the same time, in most microwave dyeing methods, microwave radiation increases the dyeing rate and improves the absorption of dyestuff. In addition, microwave irradiation causes a mass transfer effect from the substrate to the solvent, which causes the cell wall to rupture. [63] Also, the reduction in time of dyeing proves that it is cost and time effective tool and makes the process eco-friendly. So this radiation technique can be applied onto modification of different application methods of dyeing using natural and synthetic fabrics

Researchers have compared microwave dyeing tests with conventional dyeing tests and found that with microwave irradiation, dyes and compounds can penetrate the fabric in a short time and obtain an excellent dyeing rate. [64] The irradiated fabric is heated by the dielectric heating of the electromagnetic field, which saves energy; after the microwave radiation treatment of fabrics, the physical properties of the radiation time and power-related. [65]
When using microwave irradiation is easy to adjust the heating state by adjusting the heating power and time to control. Microwaves for polar water, dyes and additives molecules also have a role to play. It can accelerate the vibration of molecules to promote the dissolution of dyes and the diffusion of internal fibers. [66] At the same time, microwaves can make some reactions to reduce the activation energy, compared with traditional heating methods, heating the required reaction time to shorten. [67]

Studying the effects of microwave irradiation on cotton fabric and Reactive Violet H3R dye solution at different periods of time and at different powers showed that 8 minutes of high power microwave irradiation enhanced color strength. Additionally, color fastness as evaluated by ISO standards confirmed that microwave treatment did not affect the results. [68]
Reactive Blue 21 dye was used to dye cotton fabric, and the influence of microwave irradiation on the dyeing process was investigated. The results suggest that microwave treatment of the dye solution for 3 min. produced the maximum color strength onto the irradiated fabrics at 60^oC for 30 min. The treated samples have improved light, washing, and rubbing fastness properties. That mean microwave treatment, cotton fabrics have good color fastness properties in addition to better dyeing behaviour. [69]

The polyester fabric was treated with microwave and plasma treatment increases the fastness properties of fabrics and improves dyeability while reducing or eliminating the usage of chemicals (carrier). Also, treated fabrics were interacted with silver nanoparticles to acquire antibacterial activity in the fabric. [70]

Grey cotton fabrics were desized, scoured, and bleached using microwave heating. Result indicated that applying a microwave in the pre-treatment process allowed for a complete fabric preparation in just 5 minutes as opposed to the traditional pre-treatment technique, which

requires 2.5 to 3 hours to complete. This means that microwave treatment saves time, chemicals, and water. [71]
Niyaz *et al* used microwave to degum the silk fabrics as an eco-friendly method of surface modification irradiation. [72]
The enhancement in wettability was greater when used microwave technique. On the other hand, zinc oxide particles deposit on polyester fabric's surface have an effect on bacterial growth, ultra-violet protection factor UPF value, and dyeing process. Microwave irradiation energy is more efficient than the heating energy obtained by conventional techniques. To some extent, the use of microwave technology in the textile industry will minimize effort, time, energy, and production cost. [73]

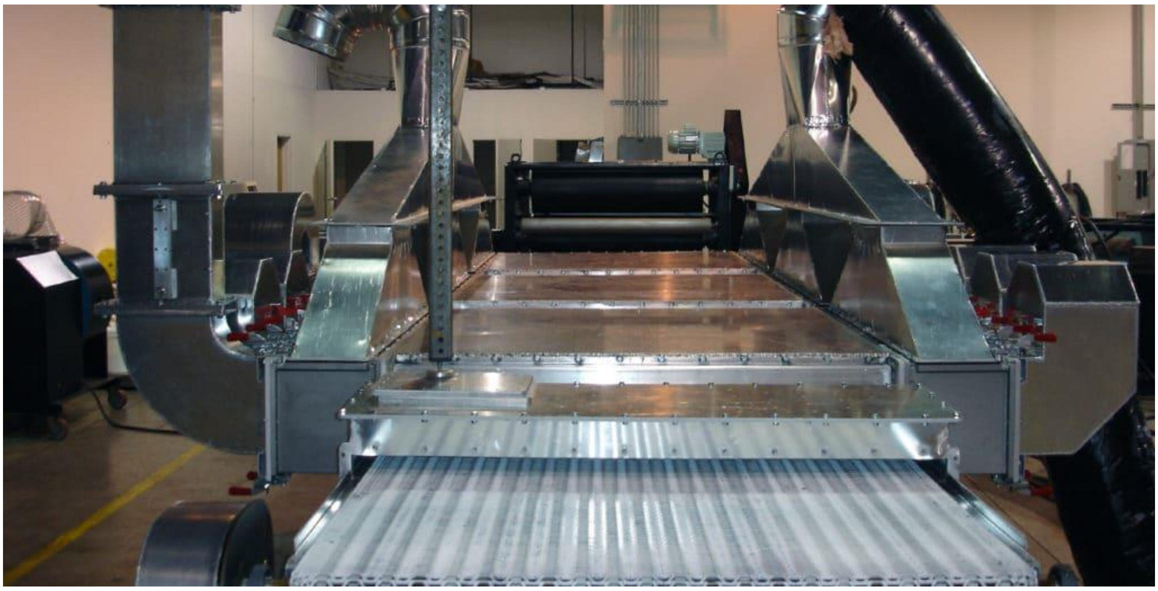

Figure (6): Textile & Fabrics drying microwave system. [73]

3.6 Ultrasonic modification

Using ultrasound modification on fabrics enhanced the dyeing rate of the dyestuff, saving ad energy, chemicals and time consuming and resulting in minor fabric damage. [74]
Applying of ultrasonic waves, cavitation process occurs leading to tiny bubbles' formation, growth, and explosive rupture. Cavitation bubbles oscillate and implode, enhancing the molecular motion and agitation in the dye bath as in figure (7). [75]

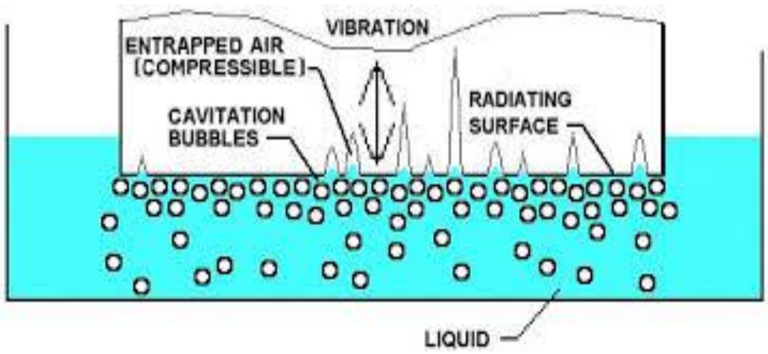

Figure (7): Cavitation or bubbles formed in liquid by ultrasonic waves. [75]

Khaled et al using ultrasound to treated cotton fabric dyed with direct dye to improve the fastness to washing, rubbing and light as well as the colour components expressed as well as 'a' red-green, 'b' yellow-blue, and 'L' brightness components. [76]

When cotton fabric was dyed using ultrasonic waves with natural pigment curcumin, there are significant increase in the dyeing percentage by 49.62% compared with conventional dyeing method, also its wash and light fastness has been improved. [77]

Ultrasonic energy be used for wool scouring a clear and white fabric was obtained with better removal of grease and lower damage to the wool surface. [78] Chitosan was used to treat the modified wool with ultrasound, and rhubarb was used as a natural dye. The results showed that color intensity increased with reducing the temperature for treated dyed wool mode as compared with conventional mode. [79]

It has been observed that the microwave energy and ultrasonic energy methods used less energy in less time than the conventional method when used to modify the surface of hemp fibers. Additionally, it was observed that the microwave energy technique required less time and energy than the ultrasonic energy method when the two eco- friendly methods were compared. [80]

Studying the modifications of poly (ethylene-terephthalate) fabric by ultrasound and nanoparticles of natural zeolite change the fabric surface properties. The change in chemical composition did not occur but it led to functionalization PET fabric. The implementation of zeolite to polyester fabric increase by increasing ultrasound power. The fabric optical brightener is significantly higher which improves fabric aesthetic appearance yielding a better absorption of the surfaces in wet finishing and making these fabrics more comfortable and UV protection. [81]

3.7 Laser treatment

The use of Laser to modify the polymers surface has no any changes in its bulk properties. It changes morphological of the smooth surface of synthetic fibers make it (roughness) and further changes in chemical properties (water absorption, dyeing. Advantage of laser treatment is that the small area can be treated and depending on the level of power chosen. [4]
Research shows that Pulsed CO_2 laser of polyamide and polyester fabrics will improve dye adsorption property and antibacterial properties of cotton fabric. [82]
Table (3) summarized and comparing the advantages and disadvantages of some of the aforementioned pre-treatment methods.

Table (3): *Advantages and disadvantages of some of the aforementioned pre-treatment methods. [84]*

Method	Types	Effects	Advantages	Disadvantages
Chemical treatment	Mercerization, acetylation, peroxide treatment, polymer grafting permanganate treatment, isocyanate treatment, benzoylation, silanization, etc.	Cleaned fiber surface, chemically modify the surface, stop the moisture absorption process, , good interfacial adhesion, improved fiber strength, increased surface roughness	Easy processability, useful and acceptable in diversified applications, implemented at industrial scale, most commonly used methods	Use of hazardous chemicals, solvent waste disposal, proper handling, , increased cost of final product
Plasma	low-pressure plasma, Atmospheric pressure plasma, corona etc.	Removal of weakly attached surface layers, formation of new functional groups, positive impact on the mechanical properties, enhanced hydrophobicity, improved interfacial adhesion	No need of hazardous chemicals or solvents, minimized environmental impact, short treatment time low operating cost, greater flexibility	Low-pressure plasma required a well-designed plasma reactor system along with expensive vacuum systems, only batch process is possible
Enzymes	Hemicellulase, laccase, pectinase, xylanase, cellulase etc.	Separation of fibers from non-fiber components, Improved interfacial adhesion, cleaned fiber surface, improved appearance and color brightness	Environment friendly, high quality fibers, low fermentation waste well-controlled environment treatment,	Expensive and limited to pilot scale

4 Different types of surface characterization technique

The surface characterization technique is a most powerful means to quantify surfaces under investigation several surface analysis techniques are used, the usage of this techniques is possible to obtain accurate information regarding to chemical, morphological, and electrical properties. The chemical characterizations included infrared (IR), Raman, and X-ray photoelectron spectroscopy (XPS), which provides information regarding to the chemical composition, crystalline structure, and chemical bonding between the atoms that built up the material. On the other hand, the morphological characterizations provide information related to the surface shape, size, aspect ratio, and topography using techniques such as Scanning Probe Microscopy, Scanning Tunneling Microscopy, and Scanning Electron Microscopy-Energy Disperse Spectroscopy. [85]

5 Future trends

The 2030 strategic plan aims to pay attention to sectors such as energy, water, environment and strategic industry, under which the textile industry fall. The textile industry is considered one of the basic industries, which result in many pollutants that affect the environment, and both water and energy are used up in significant volumes. Therefore, researchers were interested with modifying fabrics in environmentally eco- friendly techniques to save time, energy, and water, and to reduce the use of chemicals and detergents. To obtain a safe clothing product that does not affect human health and does not cause him any harm. Therefore, the research focused on treating the surfaces of fabrics in the previously mentioned ways in this review.
Using the aforementioned modification methods to achieve the 2030 Strategic Plan in several sectors as follows:

5.1- Energy

Introducing ways to use clean energy sources in the textile industries with new techniques that help in rationalizing energy by treating fabrics with plasma to improve the coloration, as well as blocking ultraviolet rays and producing anti-bacterial and anti-viral fabrics.
You can use ultrasonic waves to prepare the surfaces of the fabrics for different treatments according to the end use of the treated fabric.

5.2 Water

Development of polymeric membranes using new technologies for use in the purification of industrial and sanitary wastewater by chemical or/and physical modification.

5.3 Environment

It is possible to use physical modification to activate the surface of the fabrics without using chemicals and reduce the use of water significantly, which preserves the environment and the production of fabrics that have the ability to absorb oils to purify waste water and you to absorb heavy metals from industrial wastewater that are produced from different industries.

5.4 Health and Population

Fabric treatments can be used in the health field to produce anti-bacterial and anti-viral fabrics. It is also possible to produce dressings for wounds and surgeries loaded with antibiotics, as well as hospital supplies, such as clothes for medical staff, bed covers and curtains used in rooms. Production of anti-ultraviolet rays to protect human skin

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