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A Review on the Development of Innovative Capabilities in The Textile Finishing of Natural Fibers

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HERE in focus on the nano technology and biotechnology as new technique knock for textile multifunctional finishing process with highly effective and recent research concentrate and restrict on using this promising technology concomitant also advanced highly effective tools namely sonication, plasma, microwave for finding out how to reduce conventional techniques utilities.

Nanotechnology is revolutionizing the way in which the functional properties are imparted to the textile materials. Cotton, the king of natural fibers, requires nanotechnological interventions to achieve the functionalities like antibacterial, UV protecting, super hydrophobic and flame retardancy. Nano-finishing also helps to impart these properties without affecting the inherent comfort nature of cotton. In addition, the amount of material required to impart the functional property is relatively less due to its nano-size range. Enzymes have become an indispensable part of textile processing and are utilized for a wide variety of applications in the modern textile industry. Various established enzyme-based processes that are currently used in the textile industry demonstrate the potential of industrial biotechnology to successfully provide 'greener' alternatives

Keywords: Cotton, Wet processing, Nanotechnology, Biotechnology, Smart textiles, Advanced tool, Finishing

Introduction

Development of innovative capabilities in the textile manufactures international production and consumption especially of natural fibers need excessive role of Research and Development (R&D) in upgrading the output of finishing processes. In recent statistics for production and consumption of cotton fibers, Consumption of natural fibers totaled 31 million tons in 2017, and cotton accounted for 25 million tons. Natural fibers account for 35% of total fiber use, and cotton alone accounted for 27% [1].

A great deal towards development of sustainable finishing processes of cotton fabric for the sake of high quality plus preserving the good original physical and mechanical properties and improvement of undesired unflavored properties taken into consideration environmental prospects as green tools, low cost, low energy consumption, decreasing time and water factors become a must to cope the annual consumption of natural fabrics cotton specifically.

Developments include techniques as well as syntheses with a view to reduce energy, water, chemicals, labour, time and cost in cotton finishing processes. In addition efforts to form the basis of potential means for environmentally sustainable industrial technologies. For convenience, these

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combination activities may be classified into two main categories. The first Nanotechnology effect in all finishing process of cotton fabric and its benefit after combined with new tools like plasma, sonication, microwave to enhance cotton properties to befitting for final use and for production on industrial scale and commercial products. The second covers those concerned with **Biotechnology** for the same parameters. Does Use Matter? Comparison of Environmental.

The main target of this review is focus on the nano technology and biotechnology as new technique knock for textile multifunctional finishing process with highly effective. Recent research concentrate and restrict on using this promising technology concomitant also advanced highly effective tools namely sonication, plasma, microwave for finding out how to reduce conventional techniques utilities. Furthermore, we will focus on the future trend of cotton finishing process.

Nanotechnology

Nanotechnology is developing technology which still growing in many parameters recently. Nanotechnology common power considered as the giant force to customer in a second industrial revolution.

Nanoparticles (NPs) have a much larger surface compared to bulk materials generally, for the same nanoparticles material have higher reactivity and variable chemical properties and wavelength is similar to light wavelength. Ingredients in nano scale commandeer different properties compared with macro scale, performing valuable applications [2].

Nanotechnology finishing in cellulosic based fibers

Nanotechnology deals with functional systems based on the use of sub-units with specific size. At present, nanotechnology based research program, aims to the multi-functionalization of cotton Nano/smart. Emerging technologies open the way to: a) success in saving resources and energy consumption, b) decline pollutants emission c) develop innovative textile products with great value added and functional performance properties and d) fulfil the unlimited demand and requirements of textile consumer as well as to enhance the appeal, the market and the textile products [3].

Nanotechnology usage in textile industry augmented rapidly for many reasons for its unique and valuable properties. There is a considerable prospective for gainful applications of nanotechnology in cotton and other textile industries. Nanotechnology application can economically cover the properties and values of textile processing and products. The use of nanotechnology allows textiles come to be multifunctional and crop fabrics with special functions, including antibacterial, [4-19] animal retardant, [20] UV protection, [21-23] dyeing and printing, [24, 25] easy-clean, [26-31] water and stain repellent, [32-35] flame retardant, [36, 37] thermo-regulating, [38-43] odor and gloss properties, [44-46] adsorption of metals and air pollutions, [47-51] and dual responsive pH and temperature [52, 53] which in turn, adds greater values to the textile products and makes the dyeing, printing and finishing more competent. The upcoming feat of nanotechnology in textile applications lies in areas where new philosophies will be combined into durable, multifunctional textile systems without compromising the intrinsic textile properties, including process ability, ;manipulability etc.

The concept of nanotechnology started last half century ago but recently become familiar in the textile applications. The use of nanotechnology in textile industry has increased speedily due to its unique properties of applications. Thanks to huge economical potentiality and solo properties of nanomaterials, nanotechnology as attracted both the economical and scientists concern [54].

Nanotechnology attracting worldwide attention, because it is widely seems as offering huge potential in wide range of end users. Applications of nanomaterials in textile are expected to increase by a trillion dollar in industry sector by the next decade for their wonderful technological, economic and ecologic benefits. Research involving nanotechnology to improve performances or achieve successful health impact of cotton fiber. Here in the applications of nanosized substances to generate advanced quality during the manufacturing and finishing processes in cellulosic-based fibers. Unique and valuable properties are obtained when nanotechnology is used in cotton finishing process [55].

The future of nanotechnology in textile applications achieved successfully via gathering durable and multifunctional textile systems without harming the internal textile features. Advances within the technical and functional properties of textile products, particularly in finishing processes become now accessible due to low energy use, water and chemicals vis-a-vis the conventional techniques and this is done via sustainable applications of nanotechnology. Figure 1 defines Np, properties, features [56, 57].

Methods of preparation of nanoparticles

Preparations of nanoparticles involve three focal methodologies for the metallic NP production: biological, chemical, physical. Meanwhile, methods of NPs preparation are described as "bottom-up" and top-down as shown in Fig. 2 and 3. First method produces NPs without structural defects and with homogenous chemical configuration, while the second method leads to structure which often have defaults [3].

Chemical reduction method

For preparation of nanoparticles by chemical ways takes place via reducing and stabilizing agents. Example of some *Reducing agents*: Sodium borohydride, Hydrazine, Dimethylformamide, Ascorbic acid. *Stabilizing agents*: Polymers: Polystyrene, Polyvinylpyrrolidone (PVP) Co-Polymers: Poly(ethylene oxide)-block-poly-2-vinylpyridine, Polystyrene-block-Poly-4-vinyl pyridine, Dendrimer: Polyamidoamine, glucose and dextrose, Polyaniline, and some organic reducing agents as soluble starch [58] used in synthesis of silver nanoparticles by chemical reduction method, **[59]** Tragacanth gum used in insitu synthesis of nano silver on cotton using as natural source with hydrogel properties, modified poly(vinyl alcohol) thiol (PVA-SH) [60, 61].

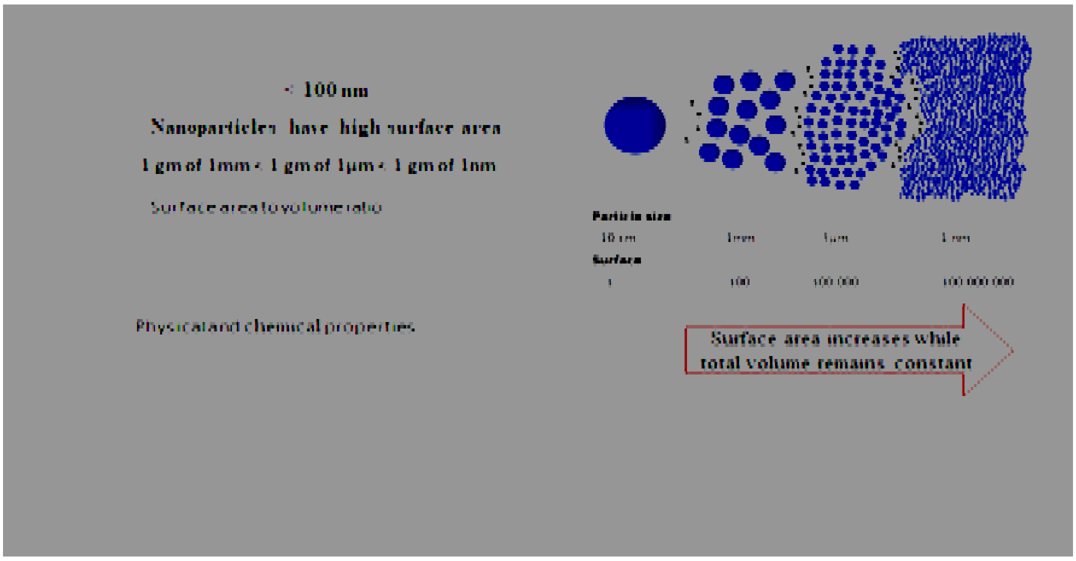


Fig.1. General definition and features of nanotechnology.

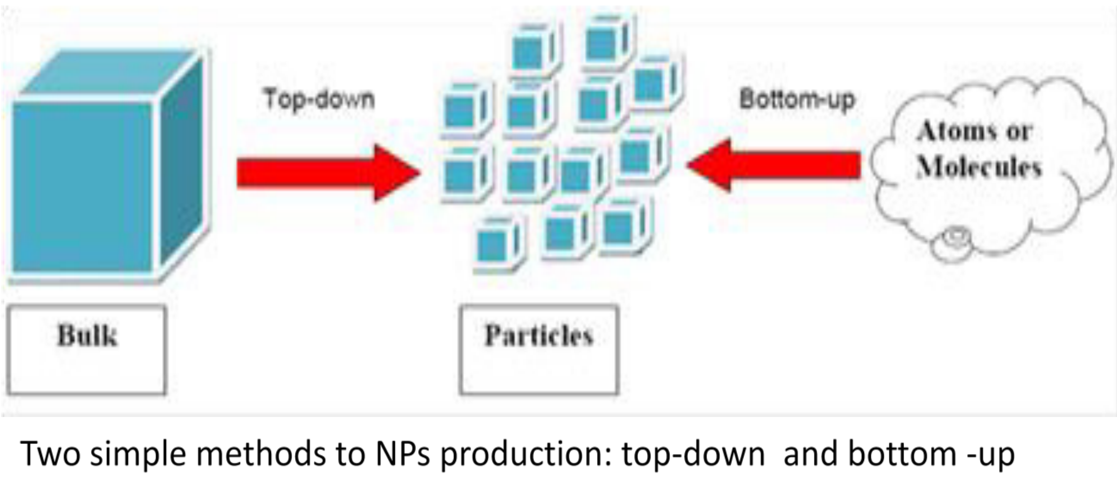


Fig. 2. Top-down and bottom -up methods to produce the nanoparticles

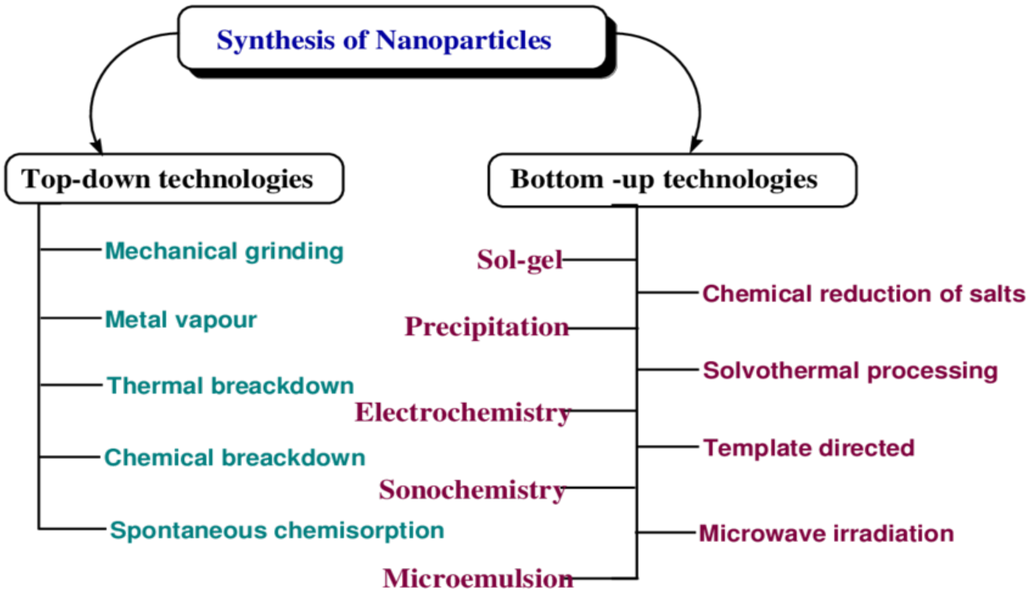


Fig. 3. Methods of synthesis nanoparticles [3].

Reduction via sodium borohydride: The synthesis of silver nanoparticles by sodium borohydride ($NaBH_4$) reduction occurs by the following reaction [62].

$$Ag^+ + BH_4^- + 3\ H_2O \rightarrow Ag^0 + B(OH)_3 + 3.5\ H_2 \quad \text{(Eq. 1)}$$

Advancement of fabric finishes using nanoparticles

Because of the development of nanotechnology in the assembling of both fibers and yarns to improve the fabric finishes, the applications and potential outcomes are outstanding in the area of textiles for the last years. blending of nanoparticles and the organic/inorganic compounds, there are several properties of treated fabrics surfaces were enhanced such as abrasion resistant, water repellent, ultraviolet (UV), electromagnetic and infrared protection [55]. This was realized with easy-fast technique takes place based on nano-bio-plasma technologies. The achievement takes place at low cost and eco-friendly manner. Nanotechnology applications become a very important technique [55]. Wong and others reviewed that the application of nanotechnology in textile industry as illustrated in Fig. 4 prolonged durable properties for fabrics, as it has large surface area-to-volume ratio and high surface energy NPs, preserving the texture of fabrics [63].

Application Protocols

Nanoparticles alone do not have good affinity towards textile materials unless using binder or make surface modification to impart this affinity [64]. The incorporation of nanoparticles on textile surface affected by variable parameter [65, 66]. Figure 5 shows many different applications of nanoparticles on textile surface as pad-dry-cure method using binder, electrospraying, surface modification linking, surface etching, etc.

For *in-situ* processing using cellulosic textile materials, the basic substrate is swollen by chemical treatment and the pores opened, in so doing, the substrate became ready for holding the nanoparticles inside the system. On the other hand, the simplest way is *ex-situ* processing is done by pad-dry-cure method, wherein, a polymeric binder is applied together with the nanoparticles treatment to the textile materials [67]. Alternatively, modification of the surface of the nanoparticles is done in such a way that they can chemically link to the surface of the textile materials. In recent developments, Nano finishes are induced to textile surface by using electro-spraying technique wherein, with the help of very high voltage (up to 80kV), polymeric solution is converted to nanoparticles nanofibers and deposited on the surface of textile materials [68].

Functional properties cotton using Nanoparticles

Nano-finishing refers to harnessing of nanotechnology to textile products in order to impart functional properties. It is concerned with both the external application of nanomaterials on the surface and in-situ formation in the textile materials.

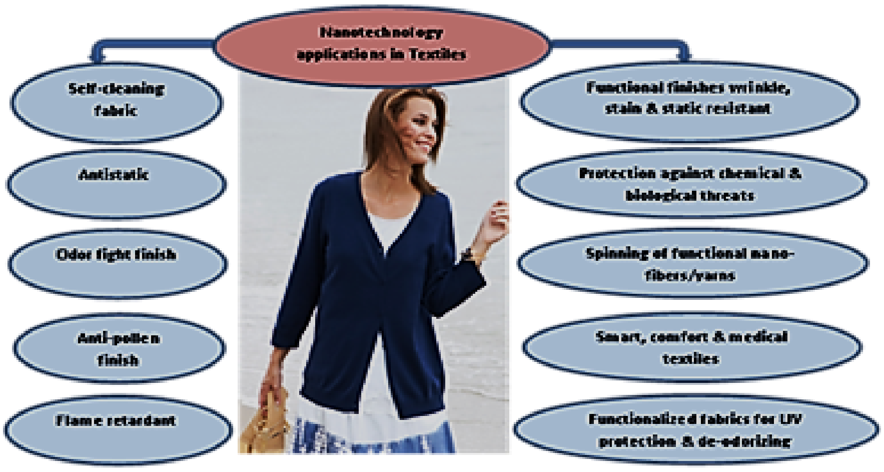


Fig. 4. Presenting the use of nanomaterials on textile substrates for functionalization possibilities [55]

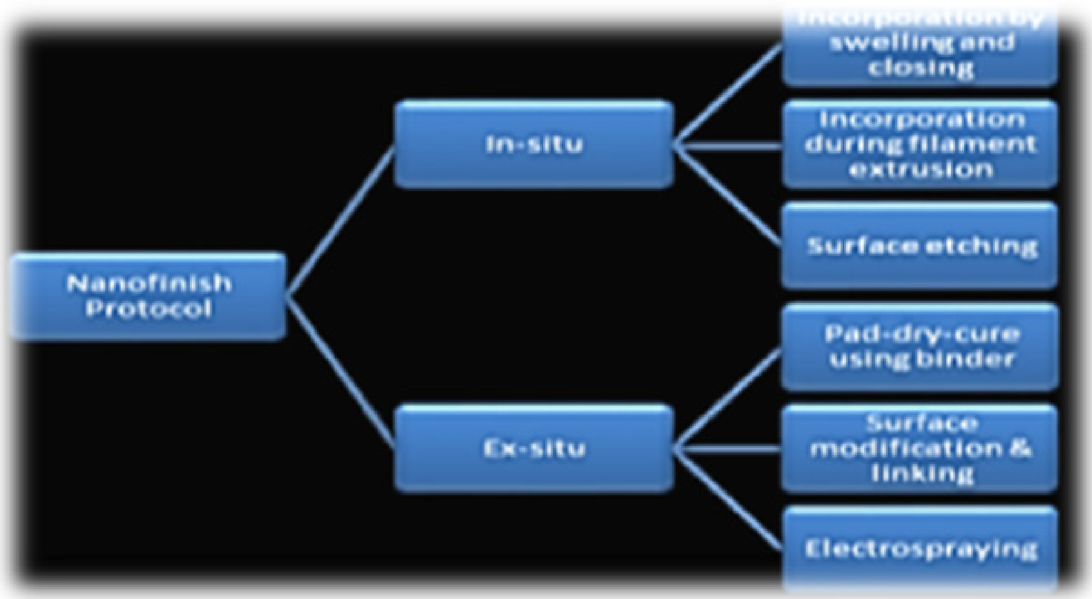


Fig. 5. Different applications of nanoparticles to textile surface [67]

Antimicrobial finishing

Antimicrobial finished textiles [69-73] occupy a very important position among the finished textile products they are required not only in medical field, but also for use in hotels, hostels, railways, home furnishings and other public places. The antimicrobial activity of a textile product is attributed to the incorporation of Nps in or on fabrics like ZnO, TiO_2, Ag which preform antimicrobial activity to modified fabrics, when Ag NPs applied to the fabrics. The release of silver ions when conventional silver treatment or AgNPs treatment are used reduce antimicrobial properties of textile. Hence, the antimicrobial efficacy of the treated textile is a manifestation of the capability of antimicrobial agents to release silver ions [74].

The intermolecular interactions with the cell membrane takes place via Ag ions and AgNPs. Some of the previous reports indicate that the AgNPs smaller than 10nm diffuse into the microbial cell and fix to the thiol groups of enzymes and nucleic acids. Alternatively, the AgNPs in the presence of oxygen may catalytically speed the formation of reactive oxygen species (ROS) that are highly toxic to the microbial cells [75].

TABLE 1. Nanoparticles commercially used for functional textile production [68]

SN	Nanoparticles	Properties
1	Ag-Nano particles	Anti-bacterial finishing
2	Nano-TiO_2	Self-cleaning, antibacterial, enhancement of UV protection, air permeability and hydrophobicity
3	Nano ZnO and TiO2	Photo-catalytic and protect from sunlight damaging
4	ZnO and TiO_2	UV-protection, fiber protection ,oxidative catalysis
5	Nano-ZnO	Antibacterial, UV-protection
6	NanoTiO_2 and MgO	Chemical and biological protective performance, provide self-sterilizing function.
7	Nano-ZnO/nano-SiO_2	Durable antibacterial, UV-protection
8	Nano-ZnO/silica	Super-hydrophobic, flame retardant
9	Nano-SiO_2	Super-hydrophobic, antibacterial, UV protection, flame retardant, water and stain repellent
10	NanoSiO_2/AgNPs	Antibacterial, water repellent, good thermal properties
11	Ag/TiO_2 nano composite	Durable antibacterial, self-cleaning, stain photodegradable, UV-protective, air permeable
12	Clay nanoparticles	High electrical, heat and chemical resistance.

In some cases, the nanoparticles interrupt the process of DNA replication and causes cell mortality. In other cases cotton fibers treated with CtsNPs/PLA the positively charged CtsNPs diffuse into the cell wall and cause leakage of cytoplasmic components from the cell membrane as the cell wall is negatively charged [76]. The metal ions catalyze the production of oxygen radicals that oxidize molecular structure of bacteria [77].

$$H_2O + 1/2O_2 \quad \text{metal ion} \quad H_2O_2 \qquad H_2O + (\cdot O) \qquad \text{Eq.(2)}$$

$$O_2(aq) + 4H_3O^{+} + 4Ag(s) \quad 4Ag^{+}(aq) + 6H_2O \qquad \text{Eq.(3)}$$

$$H_2O + {}_{1/2}O_2 \quad {}^{Ag+} \quad H_2O_2 + H_2O + (\cdot O) \qquad \text{Eq.(4)}$$

Figure 6 shows collection mechanisms of antimicrobial effect by nanomaterials as DNA damage, destruction of cell membrane, inactivation of cell enzyme, metal ion toxicity, interruption of electron transfer [79].

UV protection finishing

Untimely ageing and sunburn effect of the skin and degradation of fabrics are usually related to in excess exposure to UV radiation specifically UV-B (280-320 nm). UPF refers to the ultraviolet protection factor. The main options of protection are decrease the exposure time to UV-radiation and wearing protective clothes having high UPF values. Inorganic UV blockers are more preferred than organic UV blockers because UV blockers are safe and chemically stable towards high temperatures and UV [80].

Necessary attention should be paid while engineering the basic design and structure of the material for the latter to provide protection against harmful effects of UV radiation. Metal oxides such as ZnO and TiO_2 in nano form absorb UV light and act as a UV protecting agents for textile material. The band gap energy should be in range of 3-3.5/eV to act as good UV absorption material. The required band gap can be achieved simply by reducing the size of a particle as given in Fig. 7. The band gap increases from 3.19eV in case of micro-ZnO to 3.32eV in Nano ZnO. Doping of metal oxides [82] and synthesis of hybrid nanomaterials are the methods to produce tailor-made material for specific end use.

Sol-gel method of production of nano-titania and in situ generation of nano-ZnO on cotton fabric [83] result in durable UV protective materials. In sol-gel method, the metal sign experiences quick hydrolysis to produce the metal hydroxide, followed by immediate condensation resulting in three-dimensional gels. During drying, it forms the crystalline metal oxide nanoparticles. In case of in situ process, the metal precursors

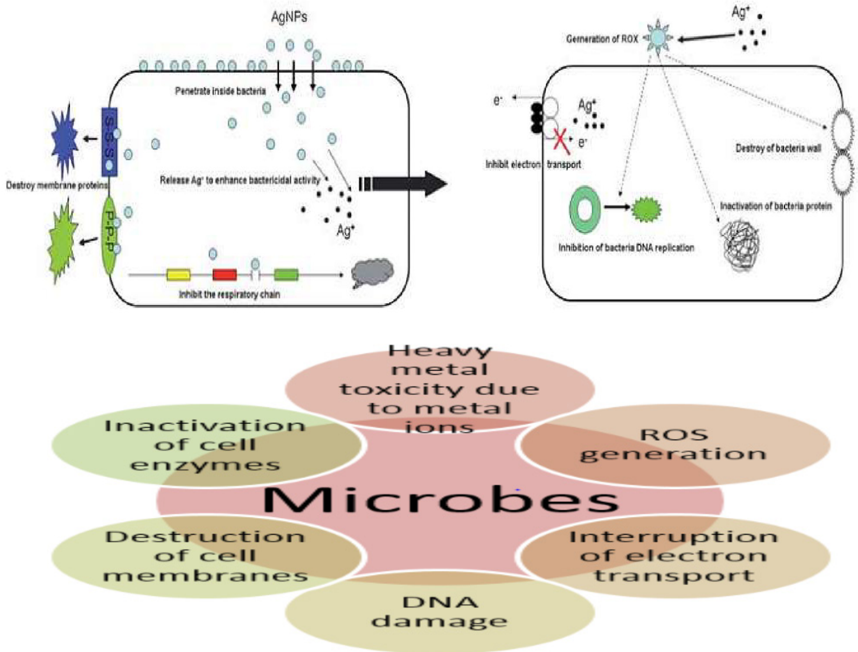


Fig. 6. The various mechanisms of antibacterial activity by nanomaterials [78]

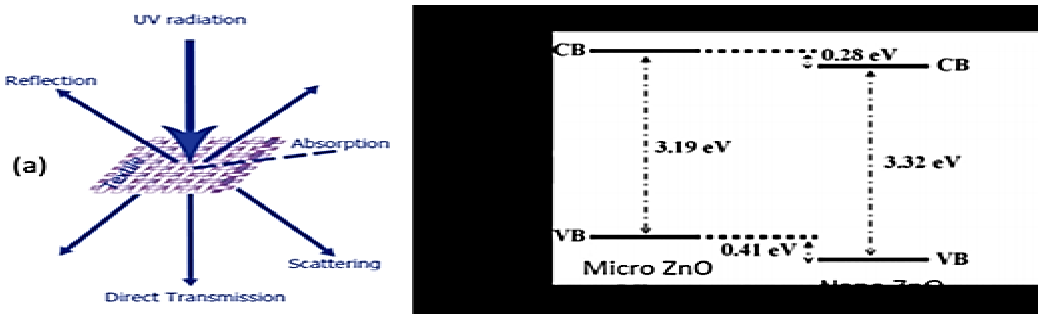


Fig. 7. Transmission of the absorbed light through clothes [81]

enter the swollen cotton fibers and is subjected to double decomposition and hydrolysis resulting in nanoparticles formation inside the pores.

Nanosized TiO_2 and ZnO particles absorbing and scattering UV radiation better than the conventional size. Hence, those nanoparticles capable to chunk UV emission because they acquire much larger surface area per unit mass and volume. Formation of thin layer of titanium dioxide or Zinc oxide nanorods using sol-gel method on cotton fabric provides excellent UV protection as these nanoparticles cover the surface and penetrate into the fabric structure. Spraying nanoparticles using compressed air and spray gun is another method for applying nanoparticles to cotton fabrics [84].

Seeking novel route to produce modified viscose fabrics with at least maintained mechanical properties and improved properties in UV-protection and antimicrobial activities was the approach using TiO_2 nano particles gives improvement results for UV protection express as UPF and jumping data for viscose up to 290 using NPs to improve the UV-protection characteristics. [84-86].

Transmission of nano materials depend on a few variables including the specific fiber material, fabric structural, moisture, the color intensity, presence of optical brightening agents, laundering conditions and finishing agents, such as UV absorbers. TiO_2 nanoparticles impregnation onto cotton fabrics by using titanium sulphate /

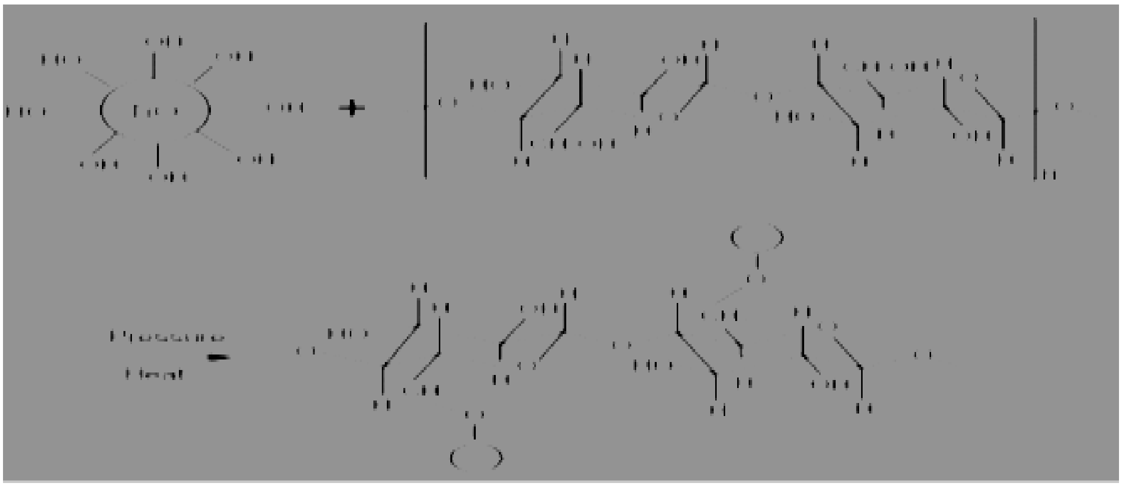
urea/ hexadecyltrimethyl ammonium bromide led to that, the particle size of as synthesized TiO_2 was controlled below 10 nm [77, 84, 87].

The photodecomposition efficiency can be enhancing under various illumination conditions (Fig. 8). The photocatalytic activities of TiO_2 are frequently reliant upon the crystallite size, morphology, phase, crystallinity and the porosity [88-92].

Water repellence finishing

Cotton, the king of fibers, is the best suitable substrate for making fabrics of necessary comfort. Nevertheless, the hydrophilicity of the cotton fibers detract from their utilization for water repellency. In this regards, researchers are trying to mimic the hydrophobic surface structure of the lotus leaf by modifying the surface of cotton in the nano-scale.

The main function of water-repellent finish is to protect textile fabrics from wetting, without adversely harming the other properties such as air permeability of finished fabrics. This target is attained via reducing the free energy of the textile surface. The amount of water attached to a surface is determined by the surface free energy. Surface with lower surface energy could not be dampened with water [93]. Surface tension of textile must be decreases to achieve active repellent surface. Surfaces that display low interactions with liquids are commonly known as low energy surfaces.



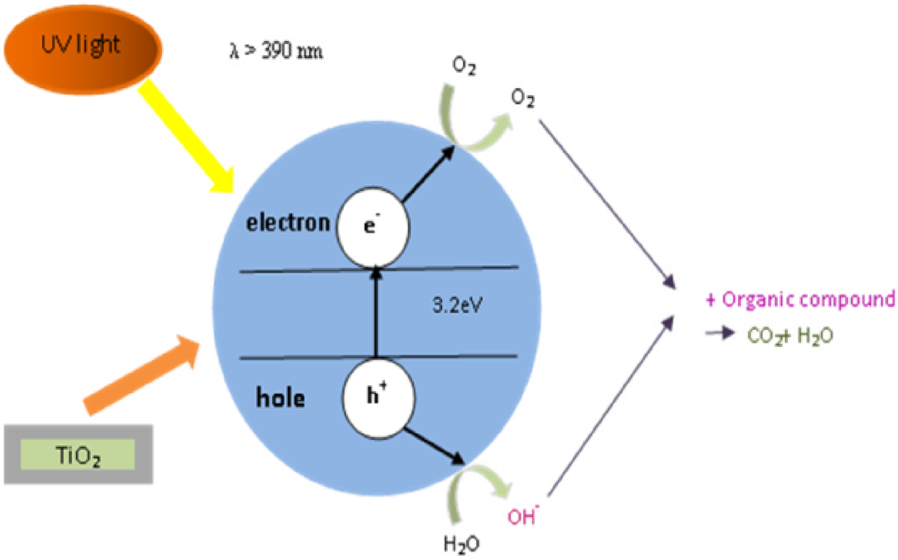


Fig. 8. Two-reaction direction of TiO_2-coated cotton fibers as UV protection [85]

Super hydrophobic surfaces are extremely difficult to wet because the contact angles of a water droplet is normally more than 150° which can be referred to as the Lotus effect **[94]** Another nouvelle super hydrophobic surface is cotton fabric treated with silica modified by 3-aminonopropyltriethoxysiloxane and 3-glycidoxypropyl trimethoxysilane in two steps and subsequently treated with perfluoro decyltrichlorosilane for hydrophobicity (Fig. 9. [95].

One of the approaches for developing a super hydrophobic surface consists of a two-step process: producing nanostructure surface followed by a treatment with a fluorocarbon-containing polymer or silane compounds. Unconventional new approaches for the design of super hydrophobic surfaces are focused on the surface functionalization of silica nanoparticles with non-fluorinated alkylsilanes or fluorosilanes [96]. Cotton fabrics treated with silica nanoparticles (synthesized via sol-gel process) in combination with very low amount of water-repellent agent exhibits super-hydrophobicity with a contact angle above 130 degree.

Flame retardant finishing

During any fire accident, the fibers that trapped fire after initial ignition were cotton followed by polyamide, filament acetate, viscose and others. Thus, the cellulosic garments were reported to be the most flammable. Cellulose undergoes thermal decomposition at temperatures above 300°C. Thermal decomposition forms not only water and carbon dioxide, but also carbon monoxide, methanol, ethanol, acetone, formic acid, acetic acid, and other products, which will ignite and burn with an adequate supply of air. Largely assumed that an effective flame-retardant finish controls pyrolysis by designing the cellulose to carbonization through dehydration at temperatures below 300°C. The limiting oxygen index (LOI) technique offers a quantitative measure of reduced fabric flammability over broad ranges of chemical treatment.

Recent research focuses on the use of nanoparticles to impart flame-retardant properties. Nano zinc oxide was applied on bleached jute fabric to impart fire retardant property. Nano zinc oxide was prepared from aqueous Zinc acetate by co-precipitation method in the presence of NaOH followed by calcinations at 600°C. It was then applied on the jute fabric using an aqueous solution of potassium methyl siliconate as dispersing media by pad-dry method. Application of 0.01% of nano ZnO on jute fabric imparts good fire retardant performance [97-99].

In addition, it was reported to impart multifunctional properties by using hybrid nanoparticles. Cotton fabrics with good water–oil-repellence and flame-retardant properties with relatively durable properties could be produced using nanosols containing guanidine dihydrogen phosphate, urea, tetraethylortho-silicate and hexadecyltrimethoxysilane as precursors, along with lower concentrations of Guard as commercial water–oil-repellent agent [100, 101].

Self-cleaning

The realization of self-cleaning properties on textile surfaces by using the nanotechnology includes a vast potential for the development of new materials or new products and applications for known materials. Self-cleaning garments have been developed, keeping nature as a role model considering self-cleaning property of plant leaves and insects (Fig. 10).

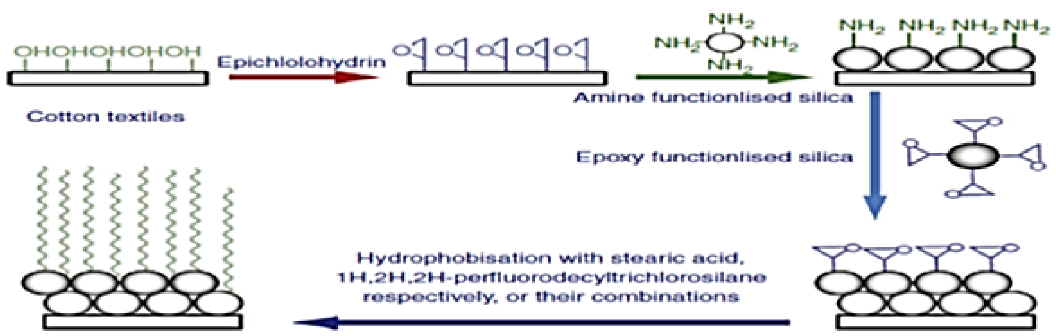


Fig. 9. Deposition of silica NPS on cotton fabric to develop a complex arrangement

Nano TiO_2 was synthesized via sol-gel method to be applied on preprinted viscose yarns in presence of binder for enhancement of self-cleaning properties, through coating with SiO_2/TiO_2 nanoparticles [86, 102, 103]. Majority of wet-table leaves and insects are naturally more or less smooth without any prominent changing of surface morphology. In contrast water repellant leaves and insects exhibit, various surface sculptures mainly wax crystal in combination with epidermal cell. The opening of new application fields for textiles will lead to a new growth stage.

For the growing market of technical textiles, successful transfer of the self-cleaning effect on textile materials can expect a further increase in production volume, sales and application fields. Structure based soil and water-repellent properties lead to an efficient use of materials and are therefore in agreement with the principles of sustainable development.

The use of a self-cleaning coating is attractive as well as are labor saving and effectively improve the appearance of the environment. On the long run, it can save time and money by reducing expensive dry cleaning bills. It could take several years for the retail market of self-cleaning clothes and linens to launch, as the technology still needs modification.

Safety and ecotoxicology

Submitting nano-Ag treated textiles to washing potentially releases both dissolved and particulate silver, and, few of the Ag released refer to particles having size larger than 450 nm. [104]. Hence, life cycle assessment is necessary to know the fate and movement of nanomaterials once out of control into the environment. Consumer behavior considerably affects the environmental impacts during the use phase. Lower washing frequencies compensated for the increased climate footprint of nano-silver T-shirt production.

The toxic releases from washing and disposal in the life cycle of T-shirts appear to be of minor relevance [105]. Safety issues need to be addressed in laboratories, industries and in their site of use. The awareness need to be created among the customers for their safe handling and disposal. In addition, a crucial point of future developments in nanotechnology is the consideration of the ethical, legal, and societal implications of this technology. The means of introducing nanotechnology based products into the society, and their relevant policies are to be discussed with various stakeholders. The means of address in ethical, legal, and social issues will determine the trust by the public and the future of nanotechnology based innovation.

Recapping of Nanotechnology in textile industry

Nanotechnology is opening up a demand for higher precision, greater density and lightning speed combined with the intellectualization and miniaturization to progress into the next generation of apparels. The commercial application of nanotechnology has already been introduced in many prospect of textile arena. To create, alter and improve textiles at the molecular level and increase durability and performance beyond that of normal textiles are possible now. To continue this favorable trend, the textile industry should contribute more to research in nanotechnology and intensify its collaboration with other disciplines. With the changing trends and demands of the customer, it is the need of the age to make use of the technology available today. These applications and developments show that nanotechnology will emerge to dominate the textile field in future. Nanotechnology will also allow the textile industry to make products at lower energy thresholds, which helps to sustain the environment [106].

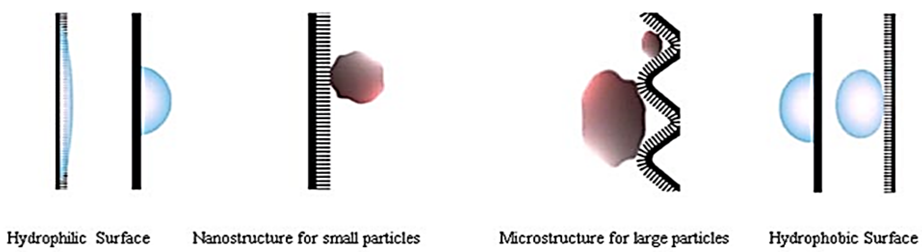


Fig. 10. Self-cleaning mechanism using nanoparticles in fabric finishing [87].

Nanotechnology is revolutionizing the way in which the functional properties are imparted to the textile materials. Cotton, the king of natural fibers, requires nanotechnological interventions to achieve the functionalities like antibacterial, UV protecting, super hydrophobic and flame retardancy. Nano-finishing also helps to impart these properties without affecting the inherent comfort nature of cotton. In addition, the amount of material required to impart the functional property is relatively less due to its nano-size range. However, caution needs to be exercised to avoid excess and improper usage of the nanomaterials and to restrict the entry of waste nanoparticles into the environment.

Biotechnology

Basic and practical aspect of biotechnology

Biotechnology is defined as an application of scientific and engineering principles and methods together in material processing via using bio materials for obtaining industrial products and services. It is not considered as an absolute industry but it is a technology that has many applications in many industrial sectors. Biotechnology speaks of technological application that employs biological systems to fabrication products projected to improve the requirements of human life friendly [107-109].

Biotechnology applications in textile industry

Biotechnology approved huge latitude of other condition pleasant procedures. In material handling, the biotechnology can be effectively utilized for fundamental process like desizing, scouring and bleaching [110, 111]. Finally, we can state biotechnology is the best approach to improvement of the material industry.

Of equivalent significance is the use of catalysts in completing procedure of cotton texture as it contributes the decoupling of economic development and the utilization of common properties. Chemicals are organic with high stimulant selectivity. Right now, catalysts advocate incredible significance in reasonable innovation and green science. Compounds replace risky synthetic mixtures in present wet processes for some reasons. Catalyst are more suitable effective and eco-accommodating decrease synthetic compounds water consume energy [112].

Composition of enzyme

Enzymes considered proteins of large numbers of amino acids for producing a three-dimensional product. The sequence of amino acids produces defined structure and characteristics [113].

Activity of enzymes

Enzymes exerts its catalytic activity only in the presence of cofactors. The dimension structure determines the enzyme activity. Enzymes Denaturation cause protein three-dimensional structure disrupts. Enzymes undergoes two proposed models. Enzymes show its catalytic assets in the presence of co-factors [113].

Theory of action of enzymes & method of preparation

Lock-and-key Model or Template

The main recommended model for enzyme complex formation is lock & key [113]. These active sites are specific so that there is no need to any further modification after substrate enzyme binding.

Factors affecting enzyme activity

Several factors affect the enzyme efficiency as per its concentration, substrate concentration, pH, temperature, inhibitors and activators [114]. Several factors influence the degree of preserving enzymatic response.

Classification of enzymes

The International Union of Biochemistry (I.U.B.) makes guidelines of naming compound. The compound names demonstrate both the controlling material and the sort of response catalyzed. Catalyst (enzyme) names end in “ase”. The sort of synthetic response catalyzed can order compounds.

Departure of water-Hydrolases, Transfer of electrons – Oxidases changing structure of particle – Isomerases. At present, over and above 2000 compounds have been isolated and described. Among them around 50 microbial proteins, have up-to-date applications. There is a substantial number of microorganisms, which create variety of chemicals. Microorganisms delivering chemicals of material are recorded (Table 2) [112].

Pretreatment process using biotechnology

Crude cotton submitted to different procedures, for example, scouring, cleaning and coloring before it is changed into end-use garments. These procedures disburse high score of vitality, water and chemicals, which mainly cause pollution to environment. Cleaner production based on cleaner processes become necessary [108]. A wide scope of trade enzyme is accessible for usage in textile industry to achieve ultimately sustainable textile performance without harm to the environment.

TABLE 2. Microorganisms producing enzymes of textile concern

3.3	Composition of Enzyme	19
3.3.1.	Activity of Enzymes	19
3.4.	Theory of action of enzymes & method of preparation	19

Enzyme Name	Application
Amylase	Starch desizing
Pectinase	Bioscouring instead caustic
Xylanase	Bleaching
Catalase	Bleach Clean up
Oxide-reductase	Dyeing
Cellulase	Finishing
Laccase	Denim finishing
Hemicellulase	Hydrolysis of hemicelluloses

Desizing process

The current process concerned with elimination of sizing from fabrics. It is usually done to prepare the fabric for further processing without complications as it becomes free from unfavoured matters [115]. α-amylase enzyme are protein especially utilized in the desizing of cotton textures measured with non-dissolvable starches or its subordinates by virtue of their speed, selectivity, specificity and natural benefits. [116-118]. It does not because critical changes in elasticity and strain diminish the release of waste synthetic compounds to the earth [119].

Recently a mix of glucoamylase and α-amylase can be utilized for synchronize desizing and corrosive demineralization for cotton textures therefore giving an elective course to ejecting soluble earth and cationic metal particles from cotton texture not in progress successful desizing implementation which isn't conceivable by ordinary washing or treatment. One included preferred standpoint this procedure could offer is diminishing the oxidative degradation of cellulose caused by the closeness of metal particles.

The utilization of immobilized catalysts in the desizing procedure takes into consideration their simple discharge from the stream, reuse, and brings down the cost. The desizing skill of amylases can be additionally upgraded by substrate initiation utilizing ultrasound technique, [120]**,** the presonicated amylase indicated higher desizing effectiveness regarding the un-sonicated compound at the equivalent temperature [107].

On sonication, the higher adsorption capacity of sonicated amylase protein enhances its availability to starch-sized cotton substrate and increment its reactant movement toward insoluble starch-measure fascinatingly. Enzyme activity unaltered after sonication because sonication procedure is moderately weak so the general desizing productivity is enhanced for the sonicated catalyst.

Bio scouring

Bio scouring is the way toward evacuating the waxes (a blend of unsaturated fats and high atomic weight alcohols and esters) contained in the thin external covering of the skin of a cotton fiber is of extraordinary significance to deliver very absorbent strands that can be colored and wrapped up. Currently. The synergistic utilization of pectinase and cellulase blend usage of consolidated treatment as (chemical/ultrasound)

Usage of chemical/ultrasound [121] and (catalyst/DC air plasma).

A very dynamic alkalothermophilic cellulase free xylanase created recently from separated strain of Bacillus stearothermophilus in-press of sturdy state maturation utilizing corn seed having steadiness above an expansive scope of pH from 6 to 12 and temp. From 37 to 85°C. This treatment consider more successful scouring of both the speed and the uniformity of the treatment.

One-advance merged desizing, scouring and fading process [122] has been created for polyester/cotton sheet utilizing a novel desizer perfect with sodium hydroxide as a scouring and hydrogen peroxide as a blanching professional.

Bleaching

Bleaching is one of the essential wet preparing course. The goal of cotton blanching is to decolorize normal colors and offer pure white appearance. The synchronization of enzymatic handling in cotton fading is lucrative alternative. This is done with a view to overcome problems of using chemical bleaching agents and reduces processing costs. A few creators have effectively shown the utilization of laccases in cotton blanching dependent on the possibility that these compounds could likewise decolorize or eliminate flavonoids of cotton by striking phenolic hydroxyl groups [123, 124].

A research facility scale test [125] demonstrated that the combination of a hydrogen peroxide fading procedure joined with a laccase-intervened framework pre-treatment is advantageous as far as (I) bleaching with a lower amount of hydrogen peroxide; (ii) fading temperature diminished; (iii) decrement of bleaching time. In a pilot scale think about on the joined laccase– hydrogen peroxide cotton fading with ultrasound energy, [126] the nature of the items was amazingly enhanced by the assessment of whiteness levels over the qualities gotten by current techniques (Fig. 11).

The combined laccase–hydrogen peroxide cotton bleaching with ultrasound energy in a pilot scale study. The quality of the products was remarkably improved according to whiteness levels evaluation presented in Fig. 12 [127].

Bleach clean up

Dye clear up is the strategy for prolonged peroxide evacuation in the cotton fading process happens by broad washing that creates a lot of acidic wastewater or treatment with synthetic compounds, for example, sodium bisulphite or hydrosulphite minimizes hydrogen peroxide with increment in high salt level during process stream, Catalase can change over hydrogen peroxide to water and oxygen (Fig. 12) Enzymatic peroxide catalases have been considered for the expulsion hydrogen peroxide from texture following fading. For the discharge of hydrogen peroxide from fiber material, extensive volume of water consumed in washing to avoid coloring troubles. The catalase with less water murders these remaining hydrogen peroxides [129].

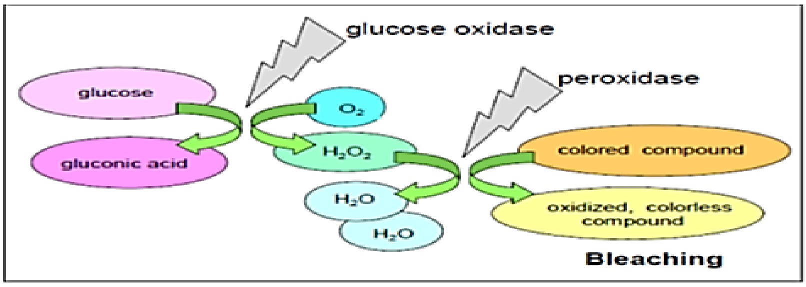


Fig. 11. Use of oxidoreductases in bleaching processes [126]

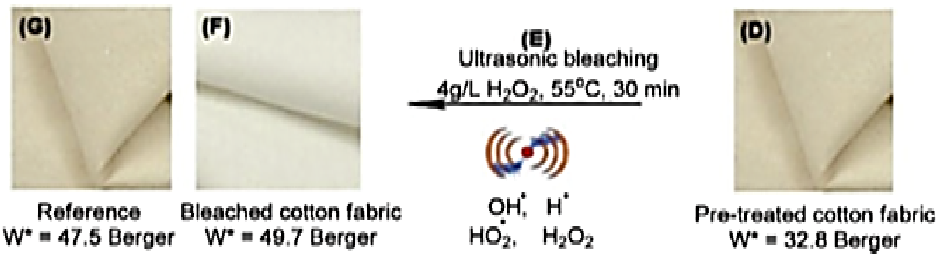


Fig. 12. combined laccase-hydrogen peroxide cotton bleaching [128]

Biostoning

Biostoning is an environment-friendly process, designated as it uses enzymes to wash/ bio-stone denim thereby, producing distressed appearance without harming the machinery or the environment plus saving cost. Furthermore, biostoning is accompanied by improved quality in addition to being used by many denim manufacturers. Various methods including mechanical, chemical, physical and enzymatic treatment used for biostoning treatment of the denim garment [130].

To obtain denim garment with a new look and clear effluent recently nanoclay co-applied with cellulase in biostone washing of denim [131]. Based on the results of this study, nanoclay as a new tool along with cellulase enhances the lightness, decreases the boost polluted, creates a new charm and eliminate go-on colour in the sewage. The clay particles act as effective absorber for the navy dyes released from this fabric into the washing sewage. Meanwhile the nanoclay-cellulase system significantly reduce the effluent colour and boost polluted [132].

Research is concerned with combination of laccase with Au nanoparticles to formulate laccase-Au hybrids. This leads to dramatic increase in the activity of laccase [133]. Progress in enzyme immobilization technology, like crosslinked enzyme aggregates and adsorption of enzyme onto multi-walled carbon nanotubes [109, 134], Offer increased enzyme operational and storage stabilities. Enzyme immobilization technology provide also a facile means to separate and reuse the enzyme [135, 136], It is further reported that combination of laccase with sono-chemistry reduces the consumption of chemicals and energy, thereby providing a cost effective means to upscale laccase-catalyzed processes to an industrial scale [137], These examples present a few of the many ways scientists and engineers are working to establish laccase biotechnology on industrial scale.

Amazingly, such an extensive array of applications can be achieved with a single class of molecules: delignification and biobleaching of pulps, lignocellulosic fiber modification, bioremediation of industrial effluents, biosensors, synthesis of fine chemicals and active pharmaceutical ingredients, and applications in the food, cosmetic, and textile industries. The full potential of laccases is yet to be reached as the novel applications continue to flow [138]. Laccases are true enzymes that keep giving. It is happy to learn the state-of-the-art in which laccases can continue to advocate sustainability in the chemical industry and further.

Bio-polishing

The bio-polishing finishing process involves the treatment of most cotton or cotton blend with cellulase enzymes to remove protruding ends from fiber surface. Thus biopolishing purposes are 1) removal of protruding slubs, fibres, spoils pills and hairiness, 2) prevents sticking, clear structural appearance with improved luster to achievement of surface smoothness and softens fabric hand , 3) increases flexibility and material relaxation To convert Poor quality fabrics, uneven, bumpy, rough, material surface to lustrous, soft, elegant, top quality with a fine, high quality surface appearance, hairiness or fuzz of the fabrics should be reduced. For all this reasons it can be accomplished independently throughout wet processing but for convenience it can be performed after bleaching [139].

The development of processes based on one-bath for effecting desizing–bleaching–dyeing [140] and rapid enzymatic single-bath treatment for desizing–scouring–bleaching–dyeing show a case of inherent potential of intelligent bio-catalytic technology. It is as well to emphasize that the potentiality of combined physico-chemical and biotechnological methods such as substrate activation by plasma, ultrasound etc., followed by enzymatic treatments provide novel implements for combined pre-treatments, functionalization, and improved dye ability.

Obviously, enzymatic technology for cotton processing is in preceding step of development. However, cooperative work should be carefully planned by the collaboration of enzyme bioengineering consultants, textile technologists and sponsors in textile industries to consider the sustainability productions, economic characteristics and environmental controls of modified processes vis-a-vis existing technologies in practice.

Advantages of using enzyme in textile wet processing

Charity Biotechnology for future development of Finishing processes of cotton fabrics with imaginable substitution of harsh chemicals by enzymes as well as to encompass the enzymatic treatment in multi-functionalization of cotton fabric. Utilization of enzymes in textile wet processing is advantageous in terms of minimum fiber Damage, less water; mild condition; ecological; biodegradability; highly specific action; very fast reaction rate; safe and easy to control. Enzymes are catalysts and act as a catalyst. After reaction, it will be obtained and reused again. It is absolute safe and permanent.

Recently, development of new enzymes was made for application in various wet processing of different fibers; Enzymatic scouring of cotton fabric can be performed using different enzymes alone or in combination. Pectinase, cellulase, protease, lipase and others exemplify enzymes. It is worthy nothing that many enzyme-manufacturing companies have commercialized the scouring enzymes. That fruitful improvement of industrial enzymes and enzyme-based processes needs the commitment of key public and private sponsors in order to take the responsibility of investments to reduce the technical risks and overcome the tasks associated with currently used enzymes in the textile industry [140].

In recent times, there has been an unlimited attention in modifying the mechanical, surface, materials, bio-nano-composites, green composites as well as functionalized textile materials.

Recapping of biotechnology in textile industry

The progress of the enzymatic technologies in textile processing is attracting worldwide attention. Enzymes have become an indispensable part of textile processing and are utilized for a wide variety of applications in the modern textile industry. Various established enzyme-based processes that are currently used in the textile industry demonstrate the potential of industrial biotechnology to successfully provide 'greener' alternatives.

1. Desizing process by combination of enzymes leads to synergetic effect desizing and demineralization in one step without degradation of cellulose plus ease removal from the stream and reuse.
2. On Sonication and/or plasma technique, the higher adsorption ability of the enzyme increase.
3. Synergistic advantage of using pectinase and celluloase
4. The integration of laccase –hydrogen peroxide, sonication improved product quality.
5. Catalase enzyme (bleach clean up) reduce water amount to eliminate residual hydrogen peroxide
6. Cellulase in presence of nanoclay co-applied in biostone washing of denim with new look, clear effluent.
7. Combination of laccase and Au NPs increase its activity dramatically leads to established laccase biotechnology on industrial scale in addition to advance sustainability in chemical industry.
8. Activation of substrate by plasma, ultrasound followed by enzymatic treatment provide new tool
9. Development of single-bath treatment for desizing-scouring-bleaching-dyeing show a promising product
10. Ultrasonic energy significantly intensified enzymatic activity on various types of cotton fabrics, but it did not contribute to a decrease in tensile strength. The combined enzyme/ sonication treatment of cellulosic textiles offers significant advantages such as less consumption of expensive enzymes, shorter processing time, less fiber damage and better uniformity of treatment

Conclusion

The application of industrial biotechnologies in the textile industry is anticipated to make significant contributions to the enhanced eco-efficiency of textile processing sectors and improve the quality of human life in the coming decades. The development of innovative strategies and advanced tools is crucial to move toward a greener and sustainable textile production in the future. Technology development may lead to new means to freshen clothes without washing, efficient sorting of used clothing, new fiber recycling technology and new low temperature detergents.

- Enable textile production via photoacoustic imagine application, which means Photons plus Ultrasound: Imaging and Sensing have not been assessed yet.
- Saving the water and energy consumption using new technologies such as plasma, microwaves and electromagnetic waves, super-critical carbon dioxide

- Nanobionic technology can be treated on any kind of fabric, including leather and foam products. When Nanobionic technology comes in close contact with the human body, it stimulates local blood flow, increases strength and endurance, thermo-regulates body temperature, boosts energy, reduces free radicals and speeds up the recovery process will offer great benefits to the consumers
- Chemical routs were established for environmental protection through energy, water, and materials conservation. they include:

1. combined wet processes
2. enhancement of cotton reactivity towards dyeing and finishing
3. synthesis of reactive carbohydrates as permanent finishes to substitute the convential ones
4. recycling of the water soluble starch sizes as per ultrafilteration technology

- Synthesis of silver NPs large enough to treat tons of textile fabrics, submitted to the necessary testing and analysis and exported.
- Coupling frontier sciences such as nanotechnology and biotechnology for producing smart apparel, domestic and technical (medical) textile products.

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