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Multi-functionalization of cellulosic fabrics using Nanotechnology

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Abstract : The primary assignment of the present article is to give the best possible completing definition and in addition treatment conditions for accomplishing creative multi-functional properties, i.e. antibacterial, UV-protection, superhydrophobic and photocatalytic properties of cellulosic fabrics. Also enhance the fire resistant and conductive properties of fabrics without unfavorably influencing the physico-mechanical execution properties of the treated substrates fundamental for the industrial needs.
The present article is providing review of the recent projects of nanotechnology and their applications in textile finishing processes. This review highlights the known advantages of utilizing nanotechnology in textile finishing which can be summarized in: (i) more effective, i.e. having large surface areas per unit weight, (ii) fewer impacts on physical and chemical characteristics, i.e. durability, handle and air permeability, (iii) less consumption of chemical and energy; (iv) low coast and achieving of high coloring power, (v) minimal impacts on environment.
Keywords : fabrics- Nanotechnology-Textile – functionalization – nano size.

Introduction

Textile manufacture is considered to be one of the most important and basic industries of the world. Always there is an urgent need to replace conventional production process with novel techniques to achieve eco-friendly production processes and products, as well as enhancement of lifetime. Better properties and quality is actually a fundamental necessity. Nanotechnology takes a top position among advanced technologies that meets this needs.

Nanotechnology is defined as the science of forming and creating of new nano-scale particles from 1-nm to 100-nm with different properties such as great quality, unique performance and minimal defects on comparing with the original size of bulk materials properties.

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Nanotechnology is applicable in various fields like textile manufacture, pharmaceutical industries, laser novel generation, chemical and biodetector, synthesis of inks and supported materials as well as information recording disks. Nanotechnology has numerous facilities in application fields of textile sector to enhance and modify existing properties of materials and/or to add novel and desirable functions to textile fabrics. R & D activities in the field of nanotechnology applications of textile industry focus on creating textile fibers including nano-size materials during forming and finishing processes.

1. Chemical Finishing

It is notable that conventional textile wet processes namely: pretreatments, chemical finishes and coloration, are costly, environmentally unfriendly and adversely affect the overall performance properties of the treated materials [1].

As of late, there has been expanding interest for investigating new eco- friendly material handling procedures e.g. nano-, bio-, plasma technologies, which could cut the materials/water/vitality utilizations, bring down the cost, overhaul the execution and the practical properties, enhance life time, adapt to the expanding attention to natural security and fulfill the buyer requests [2].

Accordingly with a specific end goal to accomplish enhanced fabric functionalities and execution properties, e.g. antimicrobial activity, UV-protection, flame retardant, anti-odour and easy-clean ect. Nanotechnology applications have turned into a vital strategy in material industry particularly in textile finishing [2].

Figure 1 shows textile functionalization based on nanosol [3].

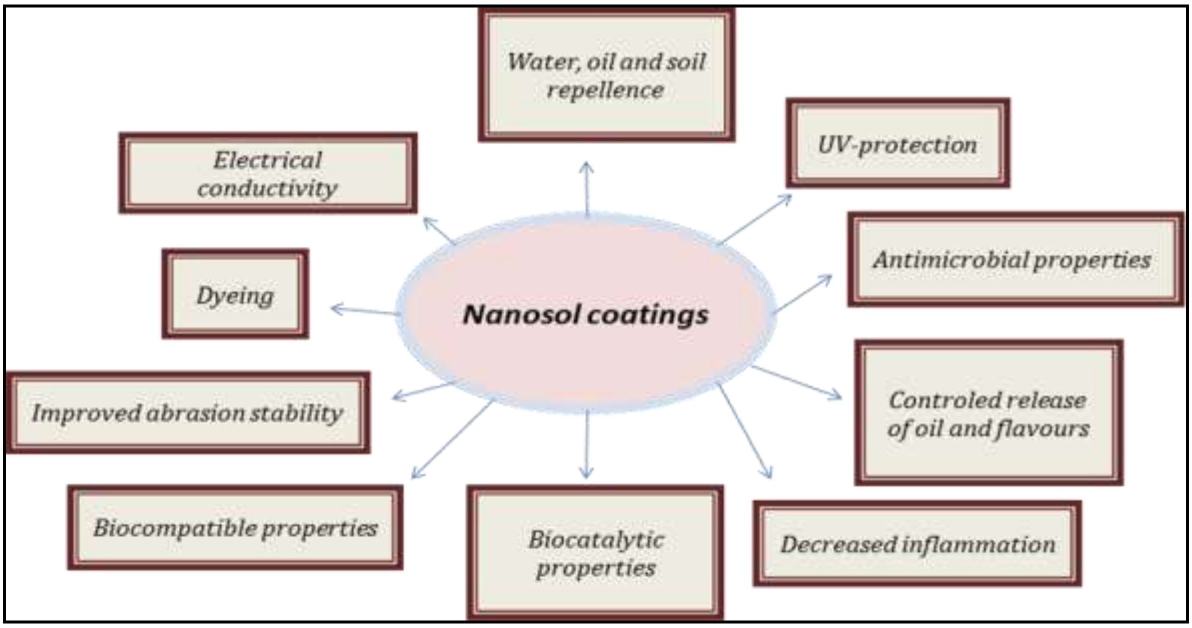

Figure1: textile functionalization possibilities using modified nanosol

2. Evolution of Nanotechnology

In the world nanotechnology now is one of the most advanced and essential frontiers sciences and technologies [2,4]. In various industrial sections nanotechnology can be applied as a creation operator. Utilization of nanotechnology in products manufactures includes the converting of the bulk material particles from the original size into nano-particle size which ranges from 0.1 to 100 nm (10-9 meters). The Greek term of "nano" characterizes a locative dimension, actually one nanometer equals billions of meter or in other words, it's approximately the length of one row contains 5 to 10 atoms. The proportion of manometer to a meter is the same as the proportion of a football to the whole earth. Converting the particle size of materials to nano size is accompanied with novel and desirable properties of the final products.

The scientific term of nanotechnology includes the characterization of creating small particle size (less than one hundred manometer) via employing mechanical or chemical means like ultrasonication, wet milling, various technologies as supercritical fluid and using of compressed fluid anti solvent for precipitation [2].

Feyman has created a series of machine tools called one-tenth-scale, utilizing of these small tools would give a chance to create a novel generation of one-hundredth scale machine tools. It's a must to design different tools as all the parameters will change according to the change in size which becomes smaller, gravity would be of no importance but surface tension and van der Walls forces would be essential. Professor Norio Taniguuchi at Tokyo Science University has originated the scientific term of nanotechnology in 1974 to characterize the concept of converting original particles of bulk materials into nanoparticles. K Eric Drexler in 1986 defined the term of nanotechnology in his book entitled "Engines of Creation", after that he studied the field of nanotechnology in his MIT doctoral dissertation deeply with details to clarify nano-systems: production, counting methods and molecular mechanization.

The users of nanotechnology concern with the computational means as they can control them to innovate and create broad areas of molecular systems with unique structure, properties and also the capability of manufacture low price products [5]. Nano-devices self-combine are one of the basic features of nanotechnology as they construct themselves from the bottom up. The technique of scanning probe microscopy is essential for characterization and forming of nanoparticles. The surfaces and the areas around the atoms can be detected by scanning tunnel microscope and atomic force microscope, various designs of microscope can be useful in creating novel structure on surfaces. The properties of materials in original state are completely different from their properties in the nano-form. If we take gold as an example, we will find that in original particle scale gold is considered to be chemically inert but in nano size it can be used as strong chemical catalyst.

The form of nano-size powder plays a very important role in many fields of applications like ceramics, uniform nano-porosity performance and comparable applications. The ability of nanoparticles to aggregate and forming agglomerates is considered to be a serious problem in the manufacture processes. However, addition of different dispersing agents is recommended to prevent the occurring of agglomeration. A small piece of material with thickness equals one atom was constructed by researchers of Manchester University in October 2004 [6].

2.1. Manufacturing Techniques for Synthesis of Nanoparticles

The fundamental classes of nanoscale structures are: nanoparticles, e.g. nano metal oxides, nano wire or tubes e.g. carbon nano tubes, nano layers, and nanopores, e.g. aerogel **.**

Both top-down and base up procedures can be utilized for assembling nanostructures, as appeared in figure 2.

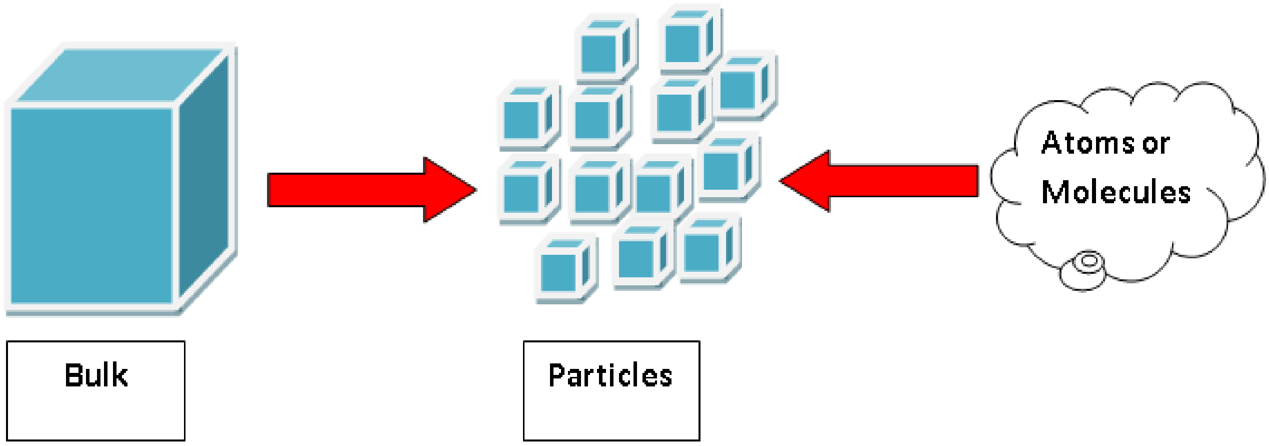

Figure 2: production of nanoparticles: top-down (lifte), and bottom-up (right) [7]

2.1.1. The Top –Down Method

The rule of the top –down methodology is to alter a mass bit of the material into the needed nanostructure and then the resulting metal-nanoparticles will be stabilized by the expansion of colloidal as protecting operator. Cutting, grinding and etching are typical fabrication techniques, which have been enhanced to work on the nano scale. The range sizes of the resulting nanostructures lies between 10-100 nm.

The major challenge for top-down approach is increasingly formation of small structure with adequate accuracy. Also, top-down approach is unsuccessful for few reasons. One of the issues with the top –down methodology is the surface structure defect. Such deformity in the surface structure could bring about a noteworthy impact on the physical properties of the nanostructure and surface science also because of the high surface to volume ratio [8,9].

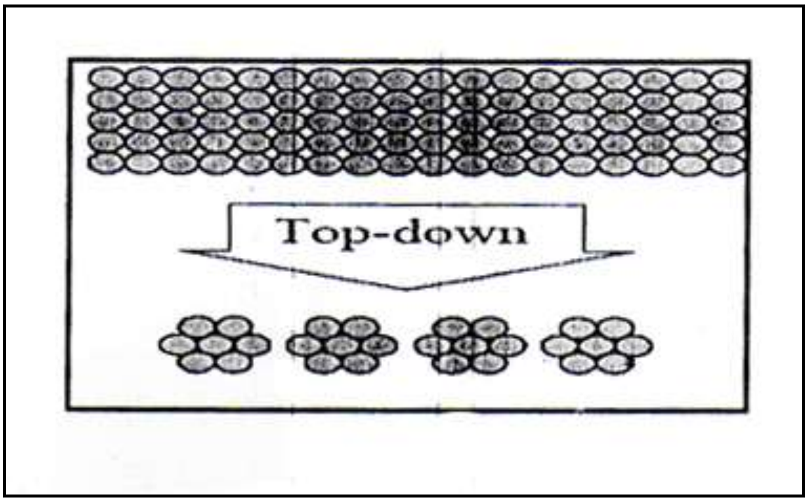

Figure 3: Top down Method for Nanofabrication

2.1.2. The Bottom – Up Method

Bottom-up, or self-assembly, alludes to development of a structure atom by- atom, molecule –by-molecule or cluster-by-cluster. An example of this approach is to use a colloidal dispersion in the nanoparticles synthesis. The nanostructures size which could be acquired with a bottom-up way covers the full nano scale. A vital preferred standpoint of the bottom-up approach is the higher conceivable outcomes to create nanostructures with more homogeneous synthetic structures and less imperfection. The mechanisms utilized in the synthesis of nanostructures plays an important role to reduce the Gibbs free energy, hence; the created nanostructures are in a state close to a thermodynamic harmony [10].

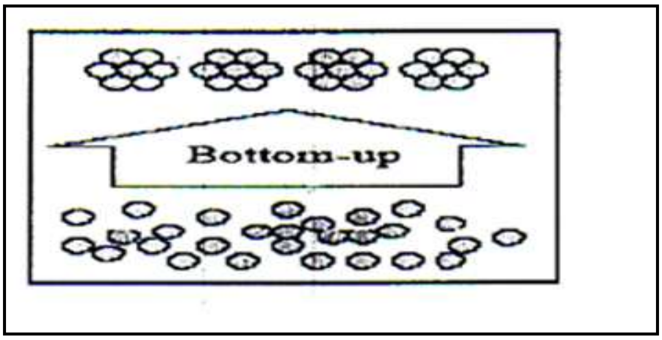

Figure 4: Bottom - up Method for Nanofabrication

3. Nanotechnology for Innovative Textiles

- Nanotechnology can be employed to manufacture anti-static agents for preventive clothes versus electrostatic charges and bad condition of climate [11].

- Nanotechnology can be used to impart the ultraviolet protection and Flame retardant properties of cotton fabrics by using ZnO nanoparticles and polycarboxylic acids [12].
- Multifunctional cationized cotton fabric can be prepared by using TiO2 nanomaterials [13].
- Utilization of chitosan nanoparticles as a green finish in multi-functionalization of cotton textile [14].
- Sol-gel hybrid nanomaterials based on TiO_2/SiO_2 was used to prepared multifunctional cotton fabric [15].
- Novel conductive textile fabric can be obtained using polyaniline and CuO nanoparticles [16].
- $ZnTiO_3$ nanoparticles were used as novel multifunctional finish of cotton fabric [17].
- Utilization of nanoparticles gives the ability of controlling the emission of perfumes, biocides and antifungal on textiles.
- The fibers which were modified by Ciba Specialty Chemicals via using the technique of nano-container microcapsule have the ability to absorb undesirable odors and inhibit the growth of bacteria by anti-microbiotics emission [11].
- A polyester yarn of huge ability to absorb moisture were manufactured by Kenebo Spiming Crop of Japan, the ability of the produced polyester yarn equals thirty times the ability of traditional polyester. Also, a fabric with pack of fine nanometer nylon filaments which has huge moisture absorption ability has been manufactured.
- Bright polyester fabrics have been manufactured and the produced fabrics have been coated with sixty films of nylon and polyester which differs in light refractive indicators. A variant hue was obtained by changing the angle of light refraction and the observer view point [11].
- Improving trials of nanofibers could achieve the production of light and durable composites of fiber- based polymer. The spinning of nanofibers was carried out by the Swiss Fedral Institution of technology. Fibers of Carbon nanotube composite were produced by Irelands Trinty College and Taxes with seventeen times more tough than Kevlar. A Belgian Company called nanocyl is commercializing the technology of carbon nanotube which was manufactured by it.
- Chemielectronic military clothes are produced via utilization of nanotechnology. The produced uniforms are considered to be protective against dangerous injuries, chemical and shots, help in wounds healing and keep life support system of the soldiers. It can be defined as a Woven textile which has distinctive capabilities in one piece. The developed uniforms can be protective against shells and chemicals, also it could be provided with sensors and have the ability to be varied from soft to hard [18].
- According to surrounding circumstances the smart electronic clothes could be changed automatically. For example, control unit and desk player were sewed in a jacket to provide it with heat and light in coldness and darkness [19,20].

4. Environmental Benefits of Nanotechnology

Nanotechnology plays an essential role in environmental pollution prevention and remediation including finding and elimination of pollutants from air, water and soil and creating novel eco-friendly industrial processes.

- Pollutants and oil splotch could be easily removed from water sources.
- The corrosive ozone layer could be rebuilt by Airborne nanorobots.
- Bottom-up method produces nano-material by ecofriendly ways unlike traditional industrial process. Conventional manufacturing technique relay on using large quantities of chemicals, dyes and energy but industrial processes which based on nanotechnology can reduce the consumption of used materials and power up to 99%. Also pollutants would be minimized, as the concept of nanotechnology concerns with the recycling of any unused or unwanted atom [21].

Our need for non-renewable energy will be reduced by employing of nanotechnology and nanomachines in different fields. The importance of traditional sources of energy like mining cool, digging for oil and trees cutting will be minimized. Quick development of clean energy is required by Global Industrialization to protect air, water an environment from pollution.

4.1. Safety Concept

The fears of the novel term "nanoparticles" and its impact on environment are considered to be main issues in the headlines. Actually submicron sized particles are existing everywhere around us but we have not enough information about the toxicity of these particles. For example, few people know that blue asbestos is the only dangerous type of asbestos material and not used in a household environment. Realizing the true and specific concept of material toxicity would save a lot of money spent on un-required cost. Safety issues of nanoparticles should be understood well to avoid the drop in the same problem, and the precautions of handling them must be clarified [22].

5. Nanotechnology and Textile Finishing

As the utilization of high performance textiles and the increasing concern over environmental and ecological issues have grown, the pressing requirement for creative finishing technologies, e.g. nanotechnology, to give the requested useful properties and to adapt to the requirement for progressive material items to confront the immense difficulties in the worldwide business sector without unfavorably influencing the earth has become in like manner.

The granted functional properties of textile products are dictated by: sort of substrate, finishing method, finishing formulation, equipment, and execution necessities as well as economical and ecological aspects.

The flood of nanotechnology has demonstrated an incredible potential in material completing the process of enhancing existing material exhibitions and to create and grant uncommon capacities, for example, such as antimicrobial, ultraviolet protection properties, oil and water-repellency, maintaining fabric breathability, flam-retardant functionality, conductivity and self- cleaning properties [1].

5.1. UV Protective Finish

Over presentation to UV radiation (Table 1), particularly UV-B (280-320 nm) can bring about untimely maturing and sunburn of the skin and additionally debasement of textile materials [7].

Along these lines there is an incredible interest for the UV-protection materials. The upgrade in UV-protection functionality relies on upon nature of material filaments, fabric development, coloring and finishing conditions, utilizing of specific added substances, for example, UV-absorber and lighting up operators, and additionally laundering conditions of clothing [23]. Reducing the presentation time to UV-radiation alongside utilizing defensive garments with high UPF (ultraviolet protection factor) values in addition to sunscreens are the principle choices of security [24].

Nano-structured materials in view of ZnO-nanoparticles (having a few favorable circumstances, for example, lower cost, white appearance, UV-blocking property and not hurtful) can be utilized to grant remarkable UV-blocking property to the finished textiles.

Table 1 indicates the solar radiation characteristics, striking the earth's surface.

Table 1: Sun light spectrum

Sunlight spectrum	wave length range [nm]	fraction of the total energy [%]	energy [W/m^2]
UV-C UV-B UV-A	200-285 285-320 320-400	0 0.4 3.9	- 4 44
visible light	400-800	51.8	580
Infrared	800-3000	43.9	492

At the point when straight light falls onto a textile, part of the radiation is absorbed; the material reflected another part and the rest of through it, as appeared in figure 5.

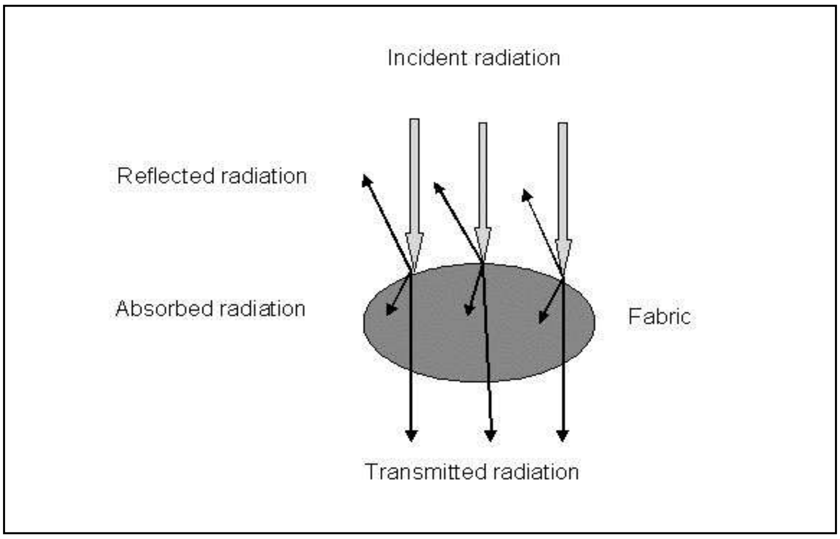

Figure 5: Radiation irradiating a textile surface

5.1.1. Evaluation of UV Protection Finishes –

UPF is the contraction of the ultraviolet protection factor. It demonstrates how much more a man wearing the material can stay in the sun before the begin of skin blushing happens contrasted with an unprotected individual [25-27]. UPF has been received to make mindfulness among the end clients of the negative effects and impacts of UV-radiation. The UV protection factor is controlled by utilizing the accompanying condition [25, 26].

$$\mathrm{UPF} = \frac{\int_{\lambda = 280\,nm}^{400\,nm} E_\lambda \, S_\lambda \, \Delta\lambda}{\int_{\lambda = 280\,nm}^{400\,nm} E_\lambda \, S_\lambda \, T_\lambda \, \Delta\lambda}$$

where:

T(λ) = the spectral transmittance through specimen at wavelength λ,

E(λ) = the solar irradiance [W m^{-2} nm^{-1}],

Δλ = the wavelength interval of the measurements [nm],

S(λ) = the erythema action spectrum,describing the harmfulness of the different wavelengths.

As depicted the UPF of a material is controlled by the transmission of the UV radiation through the material. Transmission of a given material is relying upon [14]: Moisture content, the specific fiber material, structural characteristics of the fabric, specific finishing products, e.g. UV absorbers, presence of optical brightening agents, the color and dyeing intensity, and washing conditions of the fabrics.

5.2. Antibacterial Finish

5.2.1. Necessity Of Antibacterial Finish

The development of microorganisms on textiles, particularly natural fibers-based textiles, could be talked about as far as huge responsive surface area alongside accessibility of appropriate conditions for developing i.e. moisture, oxygen, temperature and nutrients [29]. The development of microorganism has negative impacts on textiles as well as on the wearer (in case of clothes), since it brings about biodegradation of textile materials alongside their scattering health risk.

5.2.2. Requirements of Antibacterial Finishes

A viable antimicrobial finish should be: brisk acting to be compelling, ready to murder or stop the development of microorganisms, it must be durable to wash or dry cleaning, compatible with other ingredients in the finishing formulation, has minimal impacts on both the environment and the product quality, simple to apply for ease and low poisonous quality criteria.

5.2.3. Nano- Structured Antimicrobial Agents

Inorganic nanostructured active materials have great antimicrobial property on textile fabrics; it can be classified into two basic groups (figure 6). The classification of the most efficient nano-structured agents can be as next: metallic and non-metallic nanocomposites of TiO2, silver nanostructured compounds, Cu-ZnO-gold nano scale particles, Gallium antibacterial agents, nanoclay and hybrid nano-clay containing silver-chitosan/day, polyvinyl pyridinium –clay and hybrid of montomorillonites containing silver.

Figure 6: order of inorganic anti-microbial agents based on nano-structured.

5.2.3.1. Silver Nanoparticles (AgNPs)

Silver nanoparticles have distinctive properties which enable them to be applicable in broad areas of industrial applications as medical fields, biochemistry, textile manufacture and electrochemistry 30,31. Previously, silver was used for curing burns, wound and various bacterial infections in many forms like metallic silver, silver nitrate and silver sulfadiazine. Conventional uses of silver have been reduced because of distinctive silver nano-sized particles antibiotic property as well as catalytic materials relay on size, distribution, structure and chemical-physical conditions; numerous researches have studied the effect of size and shape on the forming and efficiency of formed nano-sized silver particles 32,33. Visible light enable Ag nano-sized particles to show more efficient interaction than any other organic or inorganic chromospheres and this is related to the huge density of conducting electrons 34.

5.2.4. Mechanism of Antibacterial Finishes

Antimicrobial items can be characterized into: i) bacteriostats, i.e. that stop the development and spread of microorganisms, and ii) bacteriocides, i.e. that really slaughter organisms. A compelling biocide must reach and communicate with its microbial target locales. The bacteriostatic systems of activity of antimicrobial finishes are including avoiding cell creation, hindering of compounds, harming cell layer, and/or devastation of the cell wall and poising of the cell from inside.

The antimicrobial proficiency of biocide definitions shifts extraordinarily between various sorts of microorganisms. Resistance to disinfection takes after the decreasing order: Mycobacterium > Gram -ve bacteria > Gram +ve bacteria.

5.2.5. Antibacterial Finishes and Their Efeect-

Science of some antimicrobial finishes and also their method of activity could be abridged as takes after [35]:

- Oxidizing agents for example halogens, aldehydes, and peroxy compounds, these compounds can assault the cell layer, arrive the cytoplasm and change/inactivate the microorganism's chemicals.
- isothiazones, halogens, and peroxo compounds which are radical formers; these are source dangers to nucleic acids, since they are exceptionally receptive (likewise at low fixation level) because of the nearness of free electrons.
- Quaternary ammonium compounds which have polycationic properties; Fabrics finished with these compounds cause breakingdown to the cell.
- Chitosan is a powerful natural antimicrobial agent got from Chitin, a vital segment in shellfish shells.
- Natural herbal products can be utilized for antimicrobial finishes.
- Complexing metallic compounds cause inhibition of the metabolism, like copper, cadmium, silver and mercury.
- Phenol products such as Triclosan 5-chloro-2-(2,4-dichloro phenoxyl), since Triclosan represses development of microorganisms by entering and aggravating the cell.

5.2.6. Evaluation of Antibacterial Activity

Different tests have been utilized to decide the adequacy of the antibacterial activity of textiles. Some of these tests are [36]:

- AATTC Test Method 100-2004: It is quantitative technique for deciding the level of antibacterial action of treated materials.

The bacterial development amount in inoculated and incubated textiles is dictated by utilizing serial dilutions which took after by inoculations in sterile agar plate.

- Zone of inhibition test: Quick qualitative strategy for deciding antibacterial movement of treated material against both Gram-positive and Gram-negative bacteria. In this test, by demonstrating the inhibition zone around the tried specimen, it can be appeared if a tried finishing agent is shielding the material from microorganisms or not.

- Tetrazolium/formazan test (TTC): TTC-test strategy is viewed as a fast technique for assessing the antibacterial movement of the finished fabrics. The red formazan got demonstrates the action and suitability of the cells. Since, within the sight of microorganisms, tetrazolium salts (TTC) is diminished to red formazan.

5.3. Water Repellent Finishes

Water-repellent completion ought to in the best case shield material fabrics from wetting, without unfavorably influencing the air penetrability of the finished fabrics, through decreasing the free energy on the fibre surface. A surface tension of fabric surface is lower than that of the fluid is important to active repellent surfaces [1].

5.3.1. Mechanisms of Repellancy

By lessening the free energy at textile fabric surfaces, repellent finishes accomplish their properties. Surfaces that show low cooperations with fluids are alluded to as low energy surfaces; i.e. if the bonding forces between the fabric surface and the liquid, are less than the internal cohesive interactions within the liquid, the drop will not spread [37]. Low energy surfaces can be connected to textiles through the chemical reaction of the repellent material with the fabric surface. Cases of these are waxes, fatty acid resins, and fluorinated.

5.3.2. Evaluation of textiles treated with water repellent finishes

Water repellency can be assessed utilizing the water drop test (technique institutionalized by TEGEWA) [13], spray test and the contact angles (CA).

5.4. Super- Hydrophobic Coatings

A superhydrophobic surfaces preparation is an imperative subject as of late for both technological and logical concern. Lotus leaf is the best case for a self-cleaning superhydrophobic surface, since water drops dot up and move off the surface of the leaf without wetting it. The paired micro–nanoscale surface roughnesses together with the nearness of hydrophobic epicuticular wax gems cause the superhydrophobicity of the lotus leaf surface [38]. Wenzel [39] and Cassie–Baxter models [40] are two hypothetical models for the investigation of superhydrophobic surface. Wenzel model expresses that water bead infiltrates an unpleasant surface while the water drop suspends on the highest point of it for Cassie–Baxter model. Hydrophobic surfaces can be obtained by using a mixture of silane hydrophobes such as long-chain alkyltrialkoxysilanes and silane crosslinkers as a non-fluorine silane [41]. Daoud et al. [42] obtained a water contact angle of 141° by using a mixture of silanes for cotton surface treatment. For superhydrophobic surfaces planning, a great deal of work was done [43], and distinctive methodologies have been done to get superhydrophobic materials [44]. Wang et al [45] consolidate particles of gold into cotton substrate and initiate a double size surface topology.

Michielsen and Lee [46] make mechanical and chemical surface modifications to get artificial superhydrophobic surfaces through the grafting of octadecylamine or 1H,1H-perfluorooctylamine to poly(acrylic acid) chains, which was previously grafted onto a Nylon 6,6 woven fabric surface.

Li et al. [44] uses water glass and nonfluorinated alkylsilane to prepare cotton with superhydrophobic surfaces. A few procedures, including the most essential sol–gel forms have been utilized for superhydrophobic surfaces preparation. textile fabrics with silica nanosols coating, containing perfluoroalkyl compounds has been utilized to accomplish oleophobic, ultra-hydrophobic, as well as soil repellent functional properties [47,48]. Besides, numerous endeavors have attempted to expand the hydrophobic properties of materials by utilizing inorganic sols in view of silica or titanium dioxide alongside other hydrophobic added substances, e.g. polysiloxanes. Non-fluorinated hydrophobic nanosols in view of long chain alkylsilane added substances have been utilized to stay away from the negative ecological effects of fluorinated mixes and also to accomplish covered fabrics with ultra-hydrophobic properties.

5.5. Photocatalytic Activity

A combined word Photocatalysis is alluded to two sections, "photograph" and "catalysis". Photocatalysis is a response which utilizes light (photo) to actuate a substance which alters the rate of a compound response without being incorporated itself (catalysis) [49]. As an appealing multi-functional material, nanosized TiO_2 or ZnO have been pulled in consideration for their photocatalytic exercises in this way improving the degree of debasement of natural contaminations, i.e. self - cleaning and natural decontamination under UV-illumination from daylight or lit up light sources [50].

5.5.1. TiO2 Nanoparticles (TiO2NPs)

New approaches for producing extraordinary multi-functional materials using TiO_2 nano-particles have been created [51-53] (TiO_2NPs) have novel characteristics as huger stability, long lifetime, wide-spectrum antibiosis and special photocatalytic properties [54-56]. The previous findings enable nanoparticle of TiO_2 to be applicable in various fields like UV protection pollution prevention of environment [57], antibacterial and self-cleaning finishing, purification of water and air, [58] solar cell of high efficiency and gas sensors [59,60]. TiO_2 photo-activity property relay on structure, micro-structure and purification degree of the powder.

5.5.2. Mechanism of Photocatalysis

At the point when photocatalyst e.g. semiconductor ZnO or TiO_2 was illuminated with UV-light, electron (e-) from the valence band was excited to the conduction band bringing about the arrangement of holes (h+) in the valence band. Both energized state electrons (in conduction band) and holes (in valence band) can recombine, yet in the event that appropriate scrounger for electrons or gaps is accessible, recombination is prevented [49]. Example, in an air domain, the photogenerated gaps and electrons can respond with water atom which adsorbed at first glance or respond with oxygen particle to shape hydroxyl and superoxide radicals as appeared in the accompanying conditions:

$$\mathbf{ZnO + h\nu \rightarrow ZnO\ (e+h)}$$

h^+ + $H_2O \rightarrow$ $OH^\cdot$ + H^+
e^- + $O_2 \rightarrow$ O_2^-
[$OH^\cdot$ + dye $\rightarrow$ degradation the of dye]

These radicals can oxidize most natural compound because of their high reactivity. Photocatalyst of ZnO as example for the photocatalysis component was delineated in Figure 7.

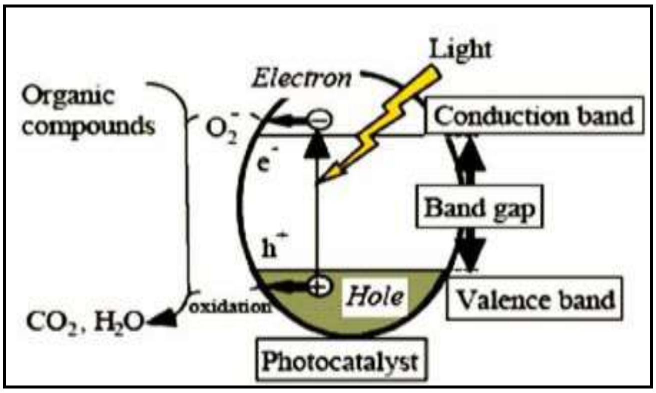

Figure 7: mechanism of photocatalysis [49]

5.6. Flame Retardancy

Fire resistant materials are vital in numerous applications for the aversion of flame and for insurance of human life, due to the way that flame or fire is frequently begun from the smoldering of the material materials which along these lines brings about blazes and even loss of human life, making harm properties, structures, and so forth.

The combustibility of fabrics changes significantly between filaments, running from a high combustibility of cellulosic strands to the innate fire resistant (FR) nature of synthetic filaments. As a rule, fabrics produced using untreated regular filaments, for example, cotton, material, and silk, will blaze effectively with a high fire speed. In addition to fibres, the fire spread rate of fabrics is likewise reliant on the fabric thickness and structure; lightweight and free fabrics are more inclined to bursting into flames rapidly [61]. Blended fabrics are thought to be less ignitable with moderate fire spread as most synthetic filaments, for example, nylon, acrylic, and polyester, oppose start. In any case, once lighted, synthetic fabrics melt, and their danger may increment on the grounds that the high rate of blazing, consolidated with the melting of the fabric, can bring about considerably more genuine smoldering. The flame peril connected with blended fabrics might be more noteworthy than that of fabrics made of just synthetic or just cellulosic filaments. Diminishing combustibility of cellulosic fabrics has then been one of the real difficulties confronting the textiles industry [12].

Cotton is the broadly utilized material fiber with high combustibility. Utilization of fire resistant items on cotton is an imperative material issue particularly for insurance of customers in military and the aircraft business. For quite a while, phosphorous compounds including tetrakis hydroxymethyl phosphonium chloride (THPC) and N-methylol dimethylphosphono propionamide (MDPA) with the exchange names of "Pyrovatex CP" or "Pyrovatex CP New" have been the most helpful way to deal with get sturdy fire resistant finishes for cotton. They can respond with the fiber or structure cross-linked structures on the fiber [62]. These compounds impact the pyrolysis reaction, keep the development of levoglucosan and combustible volatiles, increment the arrangement of char and go about as fire resistant for cellulose [63]. It is demonstrated that the measure of phosphorus substance on the treated cellulose is an imperative component in fire resistant effectiveness. As such, a lot of fire resistant prompted more adequacy in diminishing combustibility of cellulose fiber [64]. The significant disadvantage of these mixes is the capability of formaldehyde discharge amid curing and utilization of items by buyers. Formaldehyde is known as a cancer-causing agent compound by World Health Organization in this way development of free- formaldehyde durable fire retardants ought to be considered [64].

In the most recent a quarter century, nanotechnology has pulled in an awesome enthusiasm from both academic and industerial exploration, as an outcome of the empowering and amazing results accomplished in numerous fields by utilizing nano-sized items. Alluding to fabrics, yarns and filaments, distinctive methodologies have been outlined and abused with a specific end goal to upgrade their last properties [65]. Specifically, in the field of fire retardancy, three methodologies have demonstrated the most intriguing results: i) the deposition of (nano) coatings, ii) the presentation of nanoparticles in the customary back-coating and iii) the nanostructuring of the synthetic fibres [66].

5.6.1. Technology of Coating

Coating is a procedure in which a polymeric layer is connected specifically to one or both surfaces of the fabric. The polymer coating must stick to the textile and a sharp edge or comparative opening controls the thickness of the viscus polymer. Thick coating is needed, this might be developed by applying progressive covering layers, layer on layer, Inter layer attachment should consequently be high [67]. At long last, a slender top layer might be connected for tasteful or specialized improvement of the coating [67].As one of the least demanding and most effective ways, fire resistant coatings have been utilized generally to secure a substrate against flame. Undoubtedly, it introduces a few favorable circumstances: it doesn't change the characteristic properties of the material (e.g. the mechanical properties), it is effectively handled, and it might likewise be utilized on numerous substrates, for example, metallic materials, textiles, polymers, and wood [68]. Nano coating was a novel solution recently achieved recently in the textile field from the flammability and combustion point of view which result from the introduction of nanoparticles either into the component fibres themselves or on to their surfaces, including those of derived yarns and fabrics. It has been established that during combustion, these nano-objects can migrate to the fibre surface, acting as a ‘thermal shield’ that has a protective role on the polymer [69]. The first is based on the possibility of introducing finely dispersed nanoparticles of various types within thermoplastic fibres during melt spinning. This aspect can be referred to as the ‘nanostructuring’ Alternatively, it is possible to directly deposit novel and smart coatings conferring flame-retardant features to the fabric surfaces, including those of the component yarns and fibres (i.e., ceramic protective layers or flame retardant species alone or coupled to ceramic protective layers) figure 8. To this aim, sol-gel processes, nanoparticle adsorption, dual-cure processes, layer by- layer assembly and plasma deposition are novel approaches.

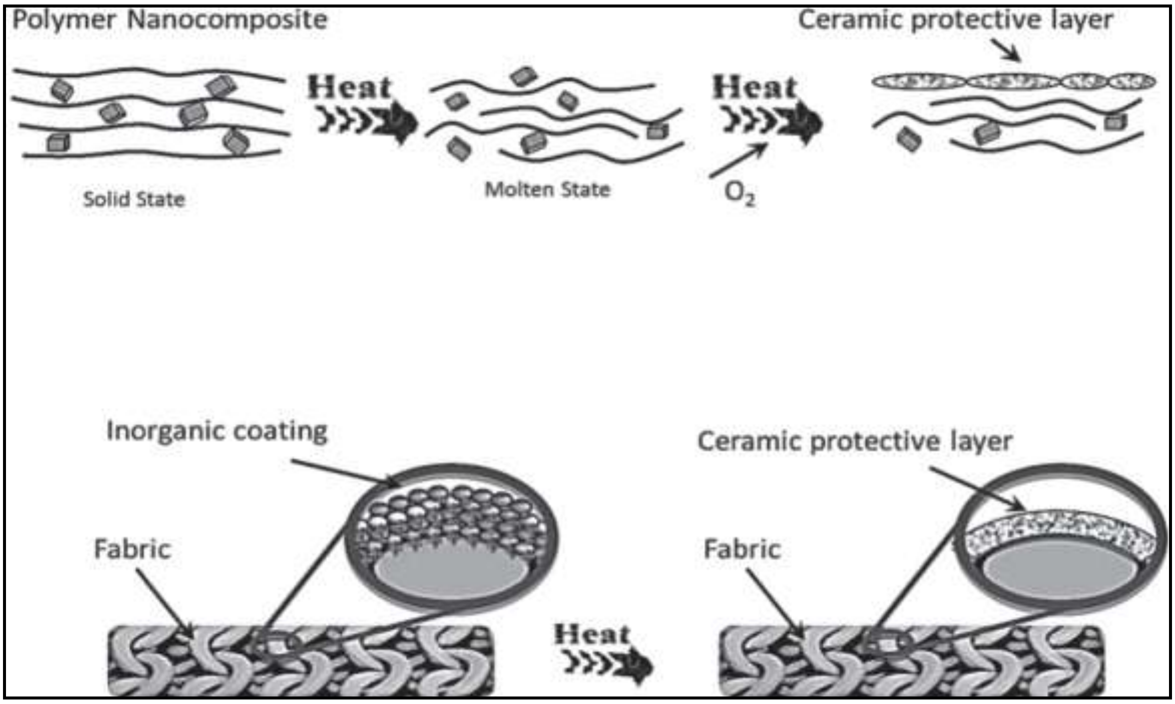

Figure 8: flame-retardancy properties of fibers and fabrics

Based on the flame retarding mechanism, “flame-safe” coatings are classified as either intumescent or non-intumescent types. Intumescent coating can be described as a mixture that has capability to swell and form a three dimensional char layer on top of the substrate when exposed to fire. Traditional intumescent systems consist of a carbon source that acts as a char former (e.g. pentaerythritol), an acid source that acts as a dehydrating catalyst (e.g. polyphosphate) and a blowing agent that helps form the porous barrier (e.g.

melamine, guanidine) [70]. This carbonaceous cellular/porous-like residue acts as a barrier to heat, air and pyrolysis products, and finally shields the underlying substrate from fire spread [71]. Bourbigot's group [72] has extensively investigated such kind of systems, while a state of the art review on this topic has been recently reported by Weil [73]. In contrast to that, there is a lack of comprehensive reviews of non-intumescent flame coating systems published in the last 10 years. Unlike intumescent system such coating exhibits a different mode of action on exposure to heat, where it may release active species acting in gas phase for flame inhibition, catalyze decomposition of the surface of the material to form non-voluminous glassy/char layers, or act as insulative mirror for protection against radiation from heat source. Conventional non-intumescent coatings contain flame retardant additives hinder flame spread, however, are in absence of providing a significant voluminous protection to the substrate like intumescent one. Therefore the efficiency of the solely use FR (flame retardant) compound in non-intumescent system is insufficient for certain applications and currently experiencing wide revolutions in terms of FR (flame retardant) chemistry.

5.6.2. Coatings from Nanoparticles Adsorption

Nanoparticle adsorption speaks to the most straightforward route for seeking after a surface change utilizing nanoparticles; it just comprises in the immersion of the fabric into a fluid suspension of nanoparticles so as to advance their adsorption on the fiber surface with respect to a typical finishing treatment. It has as of late exhibited that it is conceivable to present upgraded fire retardancy properties to both synthetic (i.e. polyester) or natural (i.e. cotton) fabrics and their blends through the arrangement of a nanosized coating. By this highway, an inorganic shield, possibly able to shield the fundamental polymer from oxygen, heat and fire, is kept on the fiber surface. To be sure, the nanocoating can go about as a thermal insulator retaining the heat and oxygen from the air and hindering their exchange to the surrounding polymer. In the meantime, the coating can capture the volatile species delivered by the substrate that can assist fuel the burning. Henceforth, the substrate is secured and tends to pyrolyse as opposed to blazing. Nanoparticle adsorption has been misused likewise to functionalize cotton fabrics with carbon nanotubes [74]. The treated fabrics show upgraded mechanical properties, exceptional fire retardancy, enhanced UV-blocking and super water repellent properties.

5.6.3. Mechanism of Flame Retardant

To render fabrics defensive against flame, Flame retardants are utilized to repress or even stifle the ignition procedure, by meddling with one or all the more smoldering stages, e.g. heating, decay, ignition, or fire spread. Specifically, contingent upon the nature, material Flame retardants can act physically and/or chemically in the solid, fluid, or gas stage [75, 76].

5.7. Electerical Conductivity

Recently the improvement of fabrics with new properties and applications has become extraordinary thought; the electrical conductivity is considered as one of these properties. Different techniques have been utilized to create leading fabrics, such as treatment of fabrics with conducting polymers [77].

Smart textiles speak to the up and coming era of fibres, fabrics and articles delivered from them. They can be depicted as textile materials that think for themselves, for instance through the incorporation of electronic devices or smart materials. Various smart textiles as of now highlight in cutting edge of garments, primarily for protection and safety and for included fashion or convenience.One of the primary reasons for the rapid development of smart textiles is the vital venture make by the military industry. Distinctive works have been concerned with the generation of polypyrrole (PPy) or polyaniline (PAN) treated fabrics to deliver conductive fabrics [78-80]. The utilizations of polyaniline coated fabrics are for instance as: ammonia sensors, electromagnetic static, charge dissipation, electromechanical devices or precious metals recovery.

Polyaniline (PANI) and polypyrrole as conducting polymers are turning out to be progressively vital for their innovative significance due to their optical, electrical properties and their high air, electrical and chemical stability at ambient conditions [80]. Another approach to manage enhance process ability is the usage of PANI colloidal dispersion [81]. polarons and bipolarons are considered the charge carriers of the PANI, stabilized by counter ions incorporated into the polymer during synthesis. Therefore, the choice of counter ion which called dopent affected to great extent on physical and conducting properties of PANI. In the recent years, polyaniline nanocomposite materials containing inorganic nanoparticles has pulled in much intrigue overall due to the enhanced dependability, conductivity and one of a kind optical properties [82,83]. Copper oxide (CuO) is considered as a versatile semiconductor materials and it is pulling in account as a result of the business interest for optoelectronic gadgets working at ultraviolet and blue regions [84]. CuO is a monoclinic n-type semiconductor with narrow band gap energy of 1.5–1.8 eV, furthermore it has very large excitation binding energy (60 meV) at room temperature [85]. Recently CuO has wide applications because of its exotic properties [86]. It has reach application in various areas, such as electromagnetic anticorrosion coatings, shielding device, photodetectros, lightweight battery electrode, sensors and solar cells [87, 88]. Because it has environmental stability and good mechanical flexibility, and it's controlled resistivity with acid/base (doping/undoping).

5.7.1. Evaluation of Electerical Conductivity

The electrical conductivity of the dried fabrics composite were resolved at surrounding room temperature (250C) utilizing a Digital Multi-meter. Electrical estimations were recorded by method for an electrical circuit formed by a Hewlett Packard 6634B System DC Power Supply and an advanced Hewlett Packard 34401A Multimeter. Conductivity = 1/ R_s ;

Where, R_s is the surface resistance. Surface resistance was measured according to the American Association of Textile Chemists and Colourists Test Method 76-1995 [89]. Two rectangular copper electrodes (20 X 30 mm2) separated by 20 mm were placed on the fabric sample (30 X 60 mm2) by a 1-kg mass. Surface resistance (R_s) is given by:

$$R_S(\Omega/square) = \frac{W}{D}R;$$

where R is the resistance measured by the multimeter, and W and D are the width of the sample and the distance between the two electrodes, respectively.

6. Methods of characterization metal nanoparticles

The description of nanoparticles can be carried out via general techniques like (TEM, SEM and WAXS) which are successfully employed in the field of nano-material characterization. Also molecular chemistry techniques can be used for characterization of nano-materials; these techniques set the structure, size and distribution of formed nanoparticles.

6.1. Transmission Electron Microscopy (TEM)

High resolution TEM is the most effective and common technique utilized for giving visual characterization of metal nanoparticles, including the morphological structure, size and distribution shape. The obtained TEM micrographs gives complete information and total vision about different nano-material phases (cylindrical, cupic, pentagon or hexagonal). Also TEM micrographs help in characterization of nano-material structure [90].

6.2. Scanning Electron Microscopy (SEM)

Nanostructure and nano-materials can be described via utilization of scanning electron microscopy technique. SEM resolution reach a group of nanoparticles, then the device can carry out the adjusted magnification which ranges from 10 to more than 300000. The utilized technique gives the surface chemical component and topographical information. The electron beam which was generated from scanning electron microscope can scan back and upwards a sold specimen. Various signals are produced from the interaction between the specimen and the generated beam, these resulted signals are the source of obtained data of the measured specimen [91].

6.3. X-Ray Diffraction

For determination of crystal structure of solids X-ray diffraction is mainly used, including geometry and lactic constant. Also X-ray diffraction is utilized to characterize defects, obscure materials and single crystal orientation, etc. Crystalline phase of the sample causes the diffraction of X-ray beam and by measuring the diffraction angle the pattern is acquired. Various informations can be obtained via diffraction patterns as shape of nano-crystal structure, nano-crystal purity, unit cell parameters and crystallinity degree of the measured nano-crystalline substrate [92].

6.4. Wide Angle X-Ray Scattering

The Type of X-Ray Diffraction which is usually employed in characterization of crystalline structure is Wide Angle X-ray Scattering (WAXS). The analyzing of the specimen occurs in closed 1-mm Lindeman glass capillaries and the specimen must be in a solid state. Various factors control the diffused correct intensity (A) Nanoparticle chemical components, (B) Structure of nano sized particles, (C) Nanomaterial interactions [93].

6.5. Infrared Spectroscopy (IR)

Molecules adsorption on the nanoparticle surfaces is determined via using Infrared Spectroscopy (IR). Carbon monoxide is found to be very beneficial liganed as it is absorbed easily on surfaces of metals. Also has a vibrational frequencies range from 1800-2100 cm^{-1} [94].

6.6. UV-Vis Spectroscopy

U.V. Spectroscopy has been used for investigation of transitions of electrons between atomic orbital's or bans, ions or molecules in different states of matter. Various distinctive colors are showed by metallic nanoparticles, the theory of color was clarified by Mie in 1908 Via Maxwell's equation solving for spreading and absorption of electromagnetic radiation via small metallic particles [95].

The ability of metallic small particles to absorb electromagnetic radiation is due to the cohesive vibration of the valence band electron motivated via interaction with the electromagnetic field. These reverberations take place in nanoparticle case and not in original particle size, the occurred reverberation called surface Plasmon. Hence, optical characteristics can be studied by using UV-Vis Spectroscopy [96].

6.7. Dynamic light scattering (DLS)

The size of the nanoparticles was measured by dynamic light scattering (DLS), using Zetasizer, Nano-S, produced by Malvern [12].

7. Future out look

Nanotechnology as a frontier science and technology overcomes the boundaries of applying traditional techniques in textile finishing field. There will be a Continuous research to create novel textiles technically and environmentally applicable. It can empower flexible coating architecture and microstructural configuration to satisfy flexible requirements, e.g. precise-characteristic control (physical, chemical and mechanical properties), and multifunctional assemblies.

The researchers of finishing technology using Nano finishes will continue to fulfill the following aspects:

1. Employing of novel techniques.
2. Desirable functional properties and high durability.
3. Minimal consumption of energy, chemicals and water.

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