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THE SHORT REVIEW: REVOLUTION IN NANOTEXTILES

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ABSTRACT

Implementation of nanotechnology in various fields is drastically increasing day-by-day for gaining better and multi fuctionalized properties. The first part gives introduction of nanotechnology and related textile properties achieved by applied nanofabrication methods. The study presents overview of recent development of nanotechnology in textile areas, including the properties of nano-sized entities and using these nano-sized materials in fabrication of smart nanotextiles and about their resultant performance. Emerging fabrication methods and novel properties of Nanoparticles will have built up intelligent fabrics in surrounding such as self-cleaning, sensing, anti-static, flame retardant and UV protective fabric. Therefore, the article shows an overview of nanotechnology research and development in nanotextiles

***Index Terms*: Nanotechnology, Nanotextiles, Electrospinning, Anti-microbial textiles, Anti-static, Nanofinishing.**

INTRODUCTION

The prefix ‘Nano’ is referred to a Greek prefix meaning ‘dwarf’ or something very small and depicts one thousand millionth of a meter (10^{9}m). The study of a matters and molecules on the scale of nanometer ranging between 1 to100nm.Nanoscience breakthrough in almost every field of science and nanotechnologies make life easier in this Era.(Samer Bayda, 2020)Nanotechnology has multipurpose functions, the stain and wrinkles defiance, flame retardant, antimicrobial and autistic properties, moisture control, ultraviolet protection and release features. The nanomaterials inside the fabric could influence numerous qualities comprising reductions, electrical conductivity, flammability and strength.(Haque, 2019)Nanoscience and nanotechnology represent an expanding research area, which involves structures, devices, and systems with novel properties and functions due to the arrangement of their atoms on the 1-100nm scale.(Samer Bayda, 2020)Nanotechnology based coatings are widely considered to be a new insight into finishing procedures for textiles. Nano treated materials are introduced for the purposes of surface and smart functionalization of textiles. The use of nanotechnology in modification of conventional textiles is rapidly growing in the world and covers a wide range of applications such as industrial, apparel and technical textiles. Nanoparticles show many properties like antibacterial, super hydrophobic, fire retardant, self – cleaning, super hydrophilic, moth proofing, electromagnetic shielding and electrical conductivity which give site for textile to work with it.(M. Parvinzadeh Gashti, 2016,)

Changes in application and use of materials increase gradually, this important role of nano fiber in nanotechnology. The earliest textile developments involved the use of natural materials and synthetic fiber also such as lycre, a segmented polyurethane urea, and Kevlar, poly-para-phenyleneterephthalamide, has ultra-high strength properties and is used in bullet proof vests.(Shirley Coyle, 2007)Today needs for personal mobility, healthcare, or rehabilitation requires that novel function sin sensing and actuating be integrated into textiles. Which is need of present world, and nanotextile is providing a great solution to upcoming domestic problems.

DISCOVERY

Nanotechnology is defined by the extents of engineering and science where incidents happen at the size in the nanometer scale and are exploited in plan, categorization, fabrication, material functions, and structures, systems and device.(Haque, 2019) Because, of its wide variety Nanoparticles structures have been used by human in fourth century AD, first time by the Roman, which demonstrated one of the most interesting examples of nanotechnology in the ancient world. The Lycurgus cup from the British Museum collection represents one of the most outstanding achievements in ancient glass industry. In1990, the scientist analyzed the cup using a transmission electron microscopy (TEM) to explain the phenomena of dichroism. This dichroism is because of Nanoparticles with 50-100nm in diameter. Dichroism is also seen in late medieval church windows, shining a luminous red and yellow color due to the fusion of Au and Ag Nanoparticles into the glass.(Samer Bayda, 2020)

In 1857, Michael Faraday studied how gold Nanoparticles produce different color solution under creating lighting conditions. The American physicist and Nobel Prize laureate Richard Feynman introduce the concept of nanotechnology in 1959. During the annual meeting of the American Physical Society, Feynman presented a lecture entitled "There's Plenty of Room at the Bottom" at the California Institute of Technology (Caltech).(Toumey, 2008,) This new idea demonstrated that Feynman's hypothesis has been proven correct, and for these reasons, he is considered the father of modern nanotechnology. After fifteen years, Norio Taniguchi, a Japanese scientist was the first to use and define the term "nanotechnology" in 1974 as: "nanotechnology mainly consists of the processing of separation, consolidation, and deformation of materials by one atom or one molecule."(Samer Bayda, 2020)

English physicist William Gilbert (1544-2012) is the first scientist who produced Nanofibers via electro spinning, more than four centuries ago.(Marcio L.F.Nascimento, 2015)Beginning with the development of the electrospinning method. In 1600, the first record of the electrostatic attraction of a liquid was observed by William Gilbert.(Nick Tucker, 2012)Christian Friedrich Schonbein produced highly nitrated cellulose in 1846.(Nick Tucker, 2012)In (1855-1944) Charles Vernon Boys described the process in a paper on nanofiber manufacture.(Boys, 489-499)John Francis Cooley filed the first, electro spinning patent in(Marcio L.F.Nascimento, 2015), (Boys, 489-499) 1900In 1914 John Zeleny published work on the behavior of fluid droplets at the end of metal capillaries. His effort began the attempt to mathematically model the behavior of fluids under electrostatic forces.(Nick Tucker, 2012)

Nanofinishing

Finishing of fabrics made of natural and synthetic fibers to achieve desirable hand, surface texture, color and other special aesthetic and functional properties, has been a primary focus in textile manufacturing. In the last decade, the advent of Nanoparticles has spurred significant developments and innovations in the field of textile technology. Fabric finishing has taken new routes and demonstrated a great potential for significant improvements in the properties of textiles by applications of Nanoparticles. A few representative applications of fabric finishing using Nanoparticles are schematically displayed in the figure.(A. P. Sawhney, 2008)

Table (1) : Nanomaterials practiced in textile finishing(HassanBS, 2019)

Finishing	Nano materials used
Protection from UV	ZnO, TiO_2
Improved staining and fade reduction	Nanoporous hydrocarbon, carbon black, SiO_2, matrix
Moisture absorbency	TiO_2
Self-cleaning properties and water repellency	TiO_2, Fluoroacrylate, CNT, SiO_2 matrix
medicinal products or fragrances	Montmorillonite (nano clay), SiO_2 (as matrix)
Antistatic and conductive	Carbon nanotubes (CNT), Carbon black, Copper, Polypyrrole, Polyaniline
Durability	Metal oxides Al_2O_3, SiO_2 matrix, ZnO, CNT, Polybutylacrylate
Antibacterial	Chitosan, Ag, SiO_2 matrix, ZnO and TiO_2,
Fire proofing	Boroxosiloxane, CNT, Montmorillonite (nano clay), Sb_3O_2

PROPERTIES OF NANOFABRICS

1. Super-hydrophobic

Lotus plants have super hydrophobic surfaces. When water drops cascade on lotus leaves, water drops slopes the surface a little & rolls off keeping the surfaces dry in the substantial rain. The droplets collect small dirt particles while rolling & the lotus leaves stay spotless yet in the drizzle.(Haque, 2019)The surfaces which possess angle more than 150 angle with water which is as known artificial lotus effect. If the same contact angle obtains with oil, then that is known as super oleo phobic.(Pedro J.Rivero, 2015)Hydrophobicity is mainly achieved by nano whiskers where the fabrics are embedded with billions of tiny fiber called nano whiskers (think of the fuzz on the peach), which are waterproof & increase density. Whiskers are very-very small in fact no more than 1/1000th size of cotton fiber which because liquid roll off i.e. no staining. Since the attached whiskers are at nanoscale, they do not affect the hand, breathability of fabric & can withstand many launderings.(Dedhia, 2017)Super hydrophobicity was obtained due to roughness of the fabric surface, without affecting the softness & abrasion resistance of cotton fabric.(Subrata Chandra das, 2014)

2. Antibacterial

Many antimicrobial agents are already in used for textile; the major classes of antimicrobial for textile include organo-silicones, organo-metallic, phenols and quaternary ammonium salts. The bis-phenolic compounds exhibit a broad spectrum of antimicrobial activity. For imparting antibacterial properties, nano-sized silver, titanium dioxide, zinc oxide, triclosan and chitosan are used (Gouda, 2013)the part of the oxygen in the air or water is turned into active oxygen by means of catalysis with the metallic ion, thereby dissolving the organic substance to create a sterilizing effect. With the use of nano-sized particles, the number of particles per unit area is increased, and thus anti-bacterial effects can be maximized. Nano-silver particles have an extremely large relative surface area, thus increasing their contact with bacteria or fungi, and vastly improving their bactericidal and fungicidal effectiveness.(Subrata Chandra das, 2014)It is highly reactive with protein and shows antimicrobial properties at concentrations as low as 0.0003 to 0.0005%. The Nano silver particle when comes in contact with bacteria and fungi brings about important changes in the cell mechanism. They inhibit their cell growth by affecting the cellular metabolism, suppresses respiration, the basal metabolism of the electron transfer system, and transport of the substrate into the microbial cell membrane. This technique also hinders the multiplication and growth process of the bacteria and fungi which cause infection, odor, itchiness and sores.(Dedhia, 2017)

3. UV protective

The Inorganic UV blockers are more preferable because of their non-toxic and chemically stable nature when exposed to high temperatures and UV rays. These materials work by absorbing UV radiation thus blocking its transmission through the fabric to the skin.(Dedhia, 2017)Among these semiconductor oxides, titanium dioxide (TiO_2) and zinc oxide (ZnO) are commonly used. It was determined that nano-sized titanium dioxide and zinc oxide are more efficient at absorbing and scattering UV radiation than the conventional size, and are thus better to provide protection against UV rays. This is due to the fact that nano-particles have a larger surface area per unit mass and volume than the conventional materials, leading to the increase of the effectiveness of blocking UV radiation. A thin layer of titanium dioxide is formed on the surface of the treated cotton fabric which provides excellent UV protection; the effect can be maintained after 50 home launderings.(Gouda, 2013) According to the study of the UV-blocking effect, the fabric treated with zinc oxide nano-rods demonstrated an excellent UV protective factor (UPF) rating.(Subrata Chandra das, 2014)When the process of padding is used for applying the Nanoparticles on to the fabric, the nano particles get applied not only on the surface alone but also penetrates into the interstices of the yarns and the fabric, i.e. some portion of the Nanoparticles get penetrate into the fabric structure. Such Nano particles which do not stay on the surface may not be very effective in shielding the UV rays. UV blocking treatment for cotton fabrics are developed using the sol-gel method. Spraying (using compressed air and spray gun) the fabric surface with the Nanoparticles can be an alternate method of applying the Nanoparticles.(Gouda, 2013)

4. Anti-static

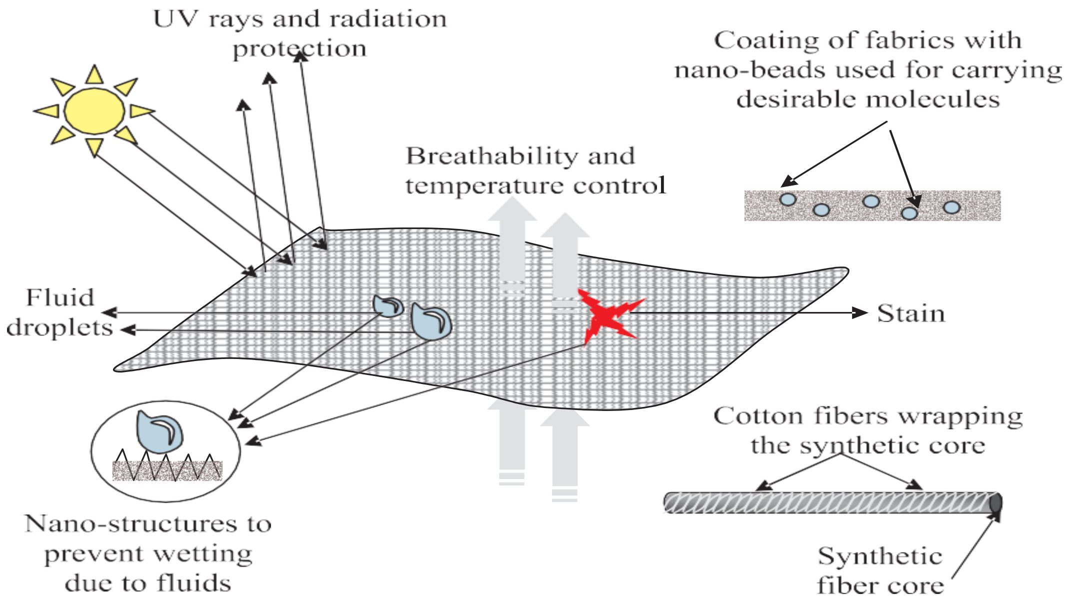
An antistatic agent is a compound used for treatment of materials or their surfaces in order to reduce or eliminate buildup of static electricity generally caused by the tribo-electric effect. The molecules of an antistatic agent often have both hydrophilic and hydrophobic areas, similar to those of a surfactant; the hydrophobic side interacts with the surface of the material, while the hydrophilic side interacts with the air moisture and binds the water molecules.(Gouda, 2013)Similar to those of a surfactant, the hydrophobic side interacts with the surface of the material, while the hydrophilic side interacts with the air moisture and binds the water molecules. Nanotechnology can offer anti-static properties to even synthetic fibers which usually exhibits poor anti-static properties. In a research done on anti-static finishing, it was reported that Nano-sized particles like titanium dioxide, zinc oxide whiskers, Nano antimony-doped tin oxide (ATO) and silanenanosol could impart anti-static properties to synthetic fibers. These materials help to remove the static charge formation on the fabric. When the anti-static finish is applied on to the fabric, the Nano particles get durably attached to the fibrils to create an electronically conductive network. This conductive network prohibits the formation of isolated chargeable areas and voltage peaks usually found in anti-static materials.(Dedhia, 2017)This method can overcome the limitation of conventional methods, which is that the anti-static agent is easily washed off after a few laundry cycles.(Y.W.H. Wong, 2006)

5. Wrinkle defiance

To impart wrinkle resistance to fabric, resin is commonly used in conventional methods. However, there are limitations to applying resin, including a decrease in the tensile strength of fiber, abrasion resistance, water absorbency and dye-ability, as well as breathability.(Gouda, 2013) To overcome the limitations of using resin, multiple researchers have used nano TiO2 and nano silica for recovering the crinkle defiance of silk also cotton. The outcome showed that when nano silica used as a catalyst with maleic anhydride can effectively recover the wrinkle resistance of silk.(Haque, 2019) Nano-titanium dioxide employed with carboxylic acid as a catalyst under UV irradiation to catalysis the cross-linking reaction between the cellulose molecule and the acid. On the other hand, nano-silica when applied with maleic anhydride as a catalyst could successfully improve the wrinkle resistance of silk. More over the wrinkle recovery of the fabrics can also be improved to a great extent by imparting techniques like padding and exhaustion beside the use of nano-materials to the fabrics. Studies also have suggested that treatment of fabrics with microwaves are more wrinkle resistant as comparable to oven curing, because it generates higher frequency and volumetric heating which minimizes the damage from over drying.(Gouda, 2013)

6. Flame retardant

Synthetic fibers such as polyamide or polyester are highly inflammable, and continuous investigations are carried out in the development of flame retardant products because the legislation requires the use of low flammability products in the industry. A pad-dry-cure method was selected to incorporate the ZnO nano particles onto the fabrics, it has been demonstrated that an increase of the curing temperature from 160 to 180 °C. As far as globular nano particles are concerned, the use of silicon based structure soluble in water as octalpropylammonium shows promising results as flame retardant with an important decrease of CO2 and CO production. More specifically, polyester fabrics were not burnt when a methane flame was applied.(Pedro J.Rivero, 2015)



Figure(1): Fabric finishing for enhanced properties and performance(A.P. Sawhney B. Condon, 2008)

FABRICATION TECHNIQUE

Nanoparticle based coating is a widely used technique and considered as efficient and new insight for finishing procedures for textiles. Fabrication or incorporation of Nanoparticles on textile include in situ synthesis immobilization and cross linking of Nanoparticles on textile surface. Since nano treated textiles are covering wide range of applications for having multi functionality, several methods have been developed such as spraying, transfer printing, immersion, rolling, padding, and simultaneous exhaust dyeing. Considering rinsing and pad dry cure methods, some issues are concerned with these methods like shape of nanoparticle and purity, dispersibility in colloids, durability in textiles.

1. ELECTROSPINNING

Electrospinning has its own versatility and potential for application in diverse fields. It is a spinning technique working with the help of electrostatic force to produce fibers with larger surface area which lacked by conventional electrospinning.(Carosio F, 2011) This process is mainly based on the principle of strong mutual electrical repulsive forces overcoming weaker force of surface tension in charged polymer liquid.(Sing Yian Chew, 2005) The process is carried out at room temperature with atmospheric conditions. Electrospinning setup include three main components, high voltage supply, a spinner and a grounded collecting plate and also need a high voltage source to inject charge of polarity into a polymer solution or melt, which is further accelerated towards collector of opposite charge(Nandana Bhardwaj, 2010).

Process of electrospinning

Polymers are dissolved in solvents before electrospinning, which forms polymer solution. This polymer solution is then introduced into the capillary tube for electrospinning. In this process, a polymer solution is held by surface tension and electric charges are induced on liquid surface due to electric field. As electric field applied reaches a critical value, repulsive electrical forces overcome the surface tension forces. Simultaneously charged jet of solution is ejected from the tip of the Taylor cone and an unstable and rapid whipping of jet occur in space between the capillary tip and collector which leads to evaporation of the solvent, leaving a polymer behind. Solution and processing parameters.

Such as concentration of polymer, viscosity, molecular weight, applied voltage, tip to collector distance, conductivity can affect the aspects of fiber. (Nandana Bhardwaj, 2010)Therefore, by changing these parameters desired properties for particular application can be gained.

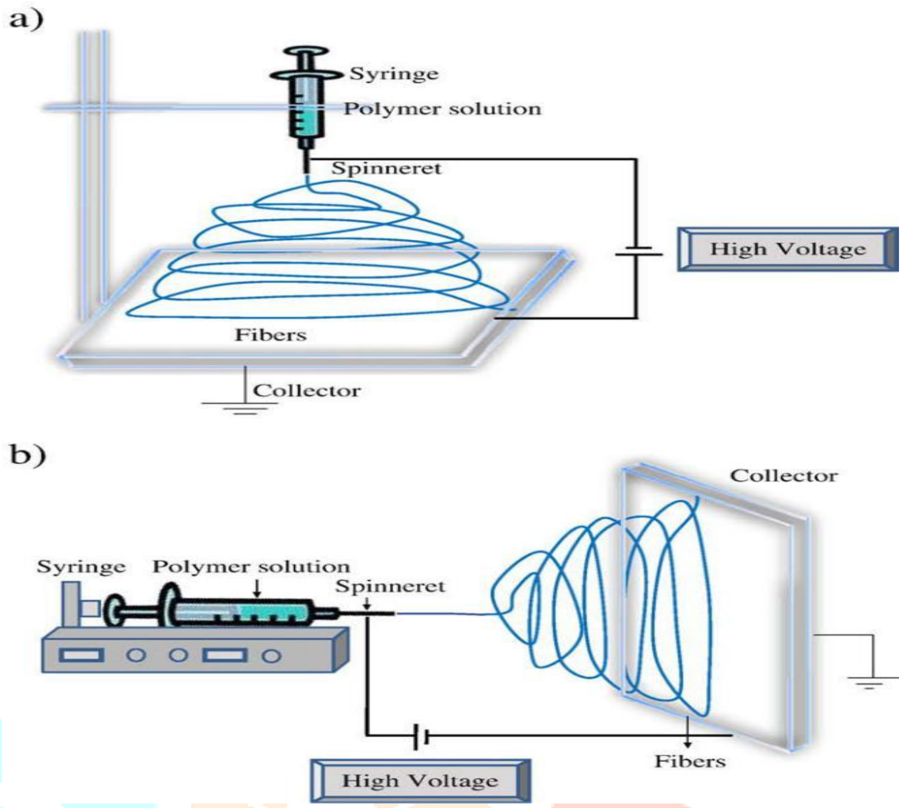


Figure (2): Schematic diagram of set up of electrospinning apparatus
a) Typical vertical set up and
b) Horizontal set up of electrospinning apparatus
(Nandana Bhardwaj, 2010)

2. SOL-GEL METHOD

One of the most important approaches to coating fabrics in the sol-gel method involves synthesis metal oxide Nanoparticles such as SiO_2 and TiO_2 from the molecules of precursors. The fabricated colloidal sols are able to produce a continuous network of Nanoparticles creating a thin film on polymeric substrates, metal alkoxides such as titanium tetraisopropoxide (TTIP), tetrabutyltitanate and tetraethyl orthosilicate(TEOS) among others have mainly been used to synthesis Nanoparticles results in the homogeneous of Nanoparticles. Main mechanisms associated in this method are hydrolysis under controlled pH, time and temperature. All of these factors contribute to the ultimate characteristics and stability of the synthesized sols.(M. Parvinzadeh Gashti, 2016,)
Sol-gel is a wet treatment process and for sol-gel synthesis, a homogeneous solution is formed by dissolving the precursor in a solvent reaction (water or an organic solvent) which is the foremost step, irrespective of whether the raw material is either an inorganic salt or metal alkoxides. Sol-gel processes can be divided into five stages called hydrolysis, condensation (gelation),gel aging, application and curing.(Aravin Prince Periyasamy, 2020)
The sol-gel formed by hydrolyzing or alcoholizing the solute or solvent whereby the resultant product is divided into little nanometer-sized particles. The 'sol-gel' originated from the hydrolysis and condensation of metal alkoxides. The first metal alkoxides was prepares from silicon tetrachloride($SiCl_4$) to the atmosphere. Inorganic gels from aqueous salts solution have been studied for a long time. Graham demonstrated that water is silica gel could be exchanged with organic solvents, which supported the theory that the gel is made of solids network with continuous porosity.(Esposito, 2019)

a. Preparation of the solution of precursors

- Preparation of the solution of precursors.
- Hydrolysis and partial condensation of alkoxides from a "sol".
- Formation of the gel via polycondensation of hydrolyzed precursors.
- Drying. The gel forms a dense "xerogel" via collapse of the porous network caused by the evaporation of the solvents (or an aerogel for example through supercritical drying).
- Calcination to obtain mechanically stable materials.(Esposito, 2019)

b. Chemical reaction

Chemical reactions continue for long after the gel formation, structure, and properties of the gel and aging step may be added. In multicomponent systems (mixed oxide preparation) the different of hydrolysis of the precursors can cause the gelation on the take place at different times, through homo-condensation, which leads to phase separation phenomena.
1. To study the flame retardancy properties of cotton fabric by using diethylphosphatoethyltriethoxysilane(DPTES)as a sol-gel precursor together with Monoethanolamide (MEA)as a neutralizer for acidic conditions of DPTES with or without the addition of tetraethoxysilane(TEOS)and 3-glycidoxypropyltriethoxysilane(GPTES)to increase the durability of finishing process.
Their results showed that the cotton sample were in self-extinguished classification and had the LOI (limited oxygen index)value of 29.It was observed that the amount of residue of treated fabrics at Tmax, compared with that of untreated fabric increased from 37.5 to 60% and the total heat release (THR)of treated fabric decreased from 12to 4.2Kg/g. Thermal shielding effect of silica phases and character-forming

by synergistic effect of phosphorous and nitrogen were attributed to be the causes of flame retardancy and thermal behavior of cotton sample reduced from 29 to 21 after one washing process.(Arik, 2017)

2. Investigated the flame retardancy and water repellency properties of cotton fabric treated with sols-
Containing 1-methylimidazolium chloride propyltriethoxysilane (MCPTS)salts synthesized. The results indicated that their flame retardancy and water repellency properties improved. Water uptake values with dip test with regard to untreated fabric decreased from 340 to 0%. The weight of residue of treated fabric increased from 1to93%which is higher than the test results (48%). The fabric sample lost their flame retardancy properties after three washing process and entirely burnt.(Arik, 2017)

3. CROSS- LINKING METHOD

Fibers when self-polymerizing cross-linking are used. Three dimensional polymers are formed by condensation of small molecules into macromolecules inside the fibers when self-polymerizing cross-linkers are used. Reactant cross-linkers agents can form covalent bonds by reacting with the cellulose hydroxyl groups.
N-methylol cross-linker agents have been used for long by the textile industry as durable press finishes producing wrinkle-resistant cotton fabrics. However, they release formaldehyde either from threaded fabrics or during finishing processes. Polycarboxylic acids have been confirmed as the most promising formaldehyde-free cross-linking agents for cotton cellulose among the various new reagents investigated. Among the various effective polycarboxylic acids,1,2,3,4-butanetetracaroxylic acid (BTCA)is the most effective cross-linking agent for cotton fabric.(Genc, functionlization of cotton fabrics by esterificatin cross-linking with 1,2,3,4-butanetracarboxylic acid (BTCA), 2015)

a. Experimental Process

Investigated the effect of cross-linking with BTCA on the pilling behavior of fabrics. (Focused on improving anti-pilling, wrinkle resistant and flame retardant properties of cotton fabrics cross-linked with BTCA).

Material

Undyed plan knitted 100% cotton fabric was desi zed, scoured, and bleached by the supplier. The cross-linking agent used was 1,2,3,4-butanetetracarboxylic acid (BTCA). The catalyst used was analytical grade sodium hypophosphite(SHP).

Procedure:

BTCA and SHP concentration were equivalent to the weight of agent in the 100ml.water solution. The fabric was treated in the solution composing different concentration of BTCA and SHP, the fabric was then passed through squeeze rolls at a pressure of 2bar and speed of 2m/min.by using foulard. The fabric was pre-dried at 80º**C** for 3 minutes and cured for 2 minutes at 170ºC.The added on value (%)was calculated dividing the weight of the cured fabrics to the weight of untreated dry fabric.(Genc, functionlization of cotton fabrics by esterificatin cross-linking with 1,2,3,4-butanetracarboxylic acid (BTCA), 2015)

Chemical analysis of fabric by FT-IR spectroscopy

To investigate the chemical structure of cotton fabrics cross-linked with BTCA, the FT-IR spectra of untreated cotton fabric and treated ones were examined.

Testing of the fabrics

Tests of the treated and untreated fabrics were performed on the conditioned fabric samples under standard atmospheric conditions (20±2ºC temperature and 65±2 relative humidity)
The pilling resistance test of treated and untreated fabrics was performed on a Nu-Martindale Abrasion tester according to TS EN ISO 12945-2 anti-pilling effect of the BTCA on the fabric, pilling tests were repeated after 1,10 and 20 washing cycles. Therefore, the durability of BTCA cross-linking on the cellulose backbone was also investigated.
The wrinkled recovery angle (WRA) was tested according to the TS 390 EN 22313April 1906 in order to evaluate the wrinkle –resistant performance of the specimens.
Flame retardant properties of the fabrics were determined according to ASTM 01230-94 by using a 45º flammability tester BV AFC Auto test instrument. Untreated and treated fabric samples mounted in a specimen holder were brushed, dried at 105ºC for 3o minutes, coiled down in a desiccator containing a drying agent for 90min, and then moved to the 45º flammability tester with the specimen positioning at an angle of 45º.The specimen was exposed to a standard butane flame for 3s to cause ignition and combustion, then the burning time and burning characteristics were recorded. The arithmetic mean burning time of 5 specimens and the burning characteristics were used as the basis to determine the flammability classifications.
The samples, untreated and treated with BTCA, were also tested according to AATCC Test Method 39-1980 to investigate the water absorbance time of the fabrics(Genc, functionlization of cotton fabrics by esterificatin cross-linking with 1,2,3,4-butanetracarboxylic acid (BTCA), 2015)

Result

In this study cotton fabric was functionalized by cross-linking of polycarboxylic acid (BTCA). The effect of BTCA cross-linking on the pilling, crease resistance and flame retardant properties of the fabrics were evaluated. The changes in chemical structures, water absorption, air permeability, bursting strength and whiteness and yellowness of the cotton fabric after BTCA treatment in the presence of SHP were also examined. It was found that the fabrics treated with BTCA had anti-pilling properties, event after 20 washing cycles there was no pilling on the fabrics. It was concluded that 6% concentration of BTCA was enough to obtain durable pilling resistance. Water absorption of the fabrics decreased significantly at higher concentration of BTCA (15%), while there was no significant effect of the 6% BTCA treatment on water absorption.12
Attachment of TiO_2Nanoparticles on the cotton fabric surface by using some carboxylic acids as the linking spacers. They used succinic acid, 1,2,3-propanetricarboxylic acid and 1,2,3,4-butanetetrecarboxylic acid (BTCA) and stabilized stable linkage between the particles and substrate. The coating process consisted of two main steps-including fabrics pretreatment with the chemical spacers and coating with TiO_2 Nanoparticles. The fabrics pretreatment with the chemical spacers and coating with TiO_2nanoparticles.The fabrics were treated with the aqueous solution of spacers in the presence of NaH_2PO_2 for 1 hour followed by a curing step. In the next step, the pretreated sample were soaked in the finishing bath containing 5g/L. TiO_2(P25) Nanoparticles and dried at 100ºC for 1hour.(M. Parvinzadeh Gashti, 2016,)

4. THIN FILM DEPOSITION

The thin film can be labeled as thin materials layers ranging from a fraction of nanometers to one micron (10^{-6} meters) in thickness. The paramount distinction between thin film and thick coating depositions is the thickness of the layers deposited. Thin film deposition involves deposition of individual atoms or molecules on the surface while thick coating deals with deposition of particles. It is being used to modify the physical and chemical properties and surface morphology of materials without altering the properties of the bulk material. A thin film can be personalized as one homogeneous composition, single layer, crystalline phase composition and microstructure, or have an inhomogeneous multilayer or composite structure depending on the envisaged properties and area of applications. The structure of the multilayer can be periodic, have a set pattern or be entirely random. Almost all thin films deposition techniques have four or five basic chronological steps. The steps are unique to the overall properties of the thin film and are listed below:

1. The source of the pure material to be deposited is selected. This source of material will act as a target during the deposition process,
2. The target is transported through a medium to the prepared substrate. This medium can either be a fluid or vacuum, depending on the materials and the deposition technique used,
3. The target is deposited onto the substrate, forming a thin film on the substrate surface,
4. The thin film may be subjected to an annealing or other heat treatment processes, depending on whether or not this is necessary to achieve the desired film properties,
5. The film properties are analyzed. If necessary, the analysis results can be incorporated to modify the deposition process.(Olayinka Oluwatosin Abegunde, 2019)

- **Vapor deposition**

One method to produce thin film on textiles is vapor deposition. There are mainly two types of methods i.e. physical vapor deposition (PVD) and chemical vapor deposition (CVD). Some parameters like substrate type, thickness of film and uniformity determine the selection of method.(M. Parvinzadeh Gashti, 2016,)

1. Physical vapor deposition

There are three stages in the formation of coating in the process of PVD i.e. obtaining vapors of the applied material, transporting ionized or neutral material to the basic material and condensation of the vapors of the applied material on a specific substrate and an increase of coating thickness. There are many advantages of PVD like high in purity, efficiency and eco-friendly nature of the process. There are many applications of PVD process like electrical, antibacterial & thermal.(Pamela Miskiewicz, 2020)

2. Chemical vapor deposition

CVD is a generic term for deposition of the thin film via series chemical reaction. The process of material synthesis occurs when the constituent of the target in the vapor phase reacts via a chemical process near the surface or onto the surface of the substrate, leading to the growth of the thin film. CVD is a thermodynamically complex process involving chemical reactions under specific conditions such as temperature, pressure, reaction rates, and momentum, mass, and energy transport. Several process factors and chemical reaction between the reactant and substrate are responsible for the quality of films produced during CVD and the quality of the film can be controlled and modified by using the appropriate combination of process parameter like flow rates, pressure, temperature, concentration of chemical species, reactor geometry, etc. (Olayinka Oluwatosin Abegunde, 2019)

5. Ion implantation

The ion implantation technique includes bombarding the surface of a solid material with known metallic ions to implant them into the near surface of substrates such as textiles, polymers and ceramics, among others to modify characteristics.(M. Parvinzadeh Gashti, 2016,)There are mainly three types of ion implantation techniques can be used in textile industry i.e. Mass-analyzed ion implantation (MAII), direct ion implantation (DII), and plasma source ion implantation (PSII).One of the most recent ion implantation technique is metal vapor vacuum arc (MEVVA) which is a type of direct ion implantation (DII) ion source implantation. The MEVVA source works on principle of vacuum arc discharge between the cathode and the anode to create dense plasma from which an intense beam of metal ion of cathode material is extracted. This metal ion operates in a pulse mode. This method gives many properties to textile like breathability, windproof & water resistivity.(T.Oktem, 2006) The degree of surface modification of the materials depends on individual chemical and structural properties, and also on variation of implantation parameters such as type of implant, energy of implant, current density in ion beam, substrate temperature etc. And the most important parameter is ion dose $F_{0,}$ which determines the implant amount. Ion implantation can be conventionally distributed into low dose and high dose processes. The range of low dose is ($\sim F_0 < 5.0\times10^{14}$ ion/cm^2). The high dose implantation is divided into two characteristic dose sub- ranges, first sub -range is ($10^{15} \leq \sim F_0 \leq 10^{17}$ ion/cm^2). The next sub-range of high dose implantation is ($\sim F_0 \leq 10^{17}$ ion/cm^2). (A.L.Stepanov, 2012)

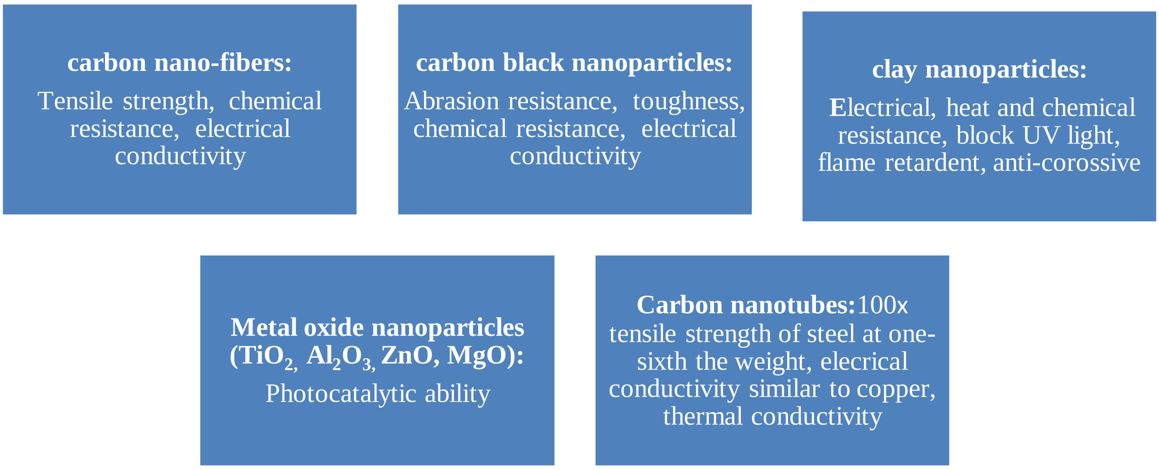


Figure (3): Properties and Applications of Nanoscale Materials Used to Improve Textile Performance(Shirley Coyle, 2007)

APPLICATION

Nanotechnology is improving day by day with advanced techniques and exploration; there is tremendous growth in fabrication of nanotextiles in last 10-20 years. Nano-Tex is a company originated in California which is a pioneer of nano-cures particularly for fabrics. The first product was introduced in December 2000.Nano-Tex (http://www.nano-tex.com) is a leading producer of nano coated textile finishes for increasing durability, water and oil repellency, and stain resistance. Their chemical formulation and application technology is easily adopted by existing textile mills and embeds textiles with "Nano whiskers" that make the fabric dense, increasing the surface tension so drops of liquid can't soak through. Nano treatments are long-lasting with greater efficiency. Nano treated fabrics can be resistant to stain, spill, static, heat/thermal resistant.(Haque, 2019)

- Resist Spills: This can be used in (Glashauser A, 2011) cotton, silk, polyester, rayon, or wool, by using this treatment fabric turns out to be stain resistant and liquid repellent.
- Coolest comfort: This is introduced in December 2000, particularly intended for synthetics. The fabric treated with Nanoparticles absorbs the sweat from body permitting person remain sweat-less.
- Repels Static: This is first static-less cure used in artificial fibers. This treatment further prevents the statically attracted material such as lint, dust, and dog hair.
- Resists and reliefs spots: This is applicable to cotton, and cotton and polyester mixes. In this treatment fabric is coated with super hydrophobic material which prevents fabric from wetness and keeps intact and spot-free.(Haque, 2019)

Smart nanotextiles are also given a distinctive place in the fashion world as light emitting textiles are finding their way onto fashion house catwalks. Furthermore, this technology is integrated in invisible coatings and advanced fibers, which can dramatically change the appearance of the textile, giving it a new effect.(Shirley Coyle, 2007)

Intelligent Knee Sleeve is a developed for sports, where knee injuries are often possible. Intelligent knee sleeve uses Polypyrrole(PPY) sensor to monitor the wearer's knee joint motion during sports practice. The Polypyrrole (PPY) is coated on fabric which works as strain gauge and is connected to microcontroller that triggers alarm tone when knee bends beyond a pre-set angle. This is a result of joint effort of Intelligent Polymer Research Institute and Biomedical Science at the University of Wollongong.(E. Jebamalar Leavline, 2015)

Anti-bacterial textiles (E. Jebamalar Leavline, 2015)are used to sanitize clothing. Puck skin is double layer fabric made up of microfiber charcoal Bamboo yarn and embedded silver nano silver ceramic ions. Charcoal Bamboo yarn absorbs sweat and increases wicking, whereas silver Nanoparticles kill bacteria that cause irritation and odor issues. Puck skin fabric is especially designed for hockey players; it shows superior moisture wicking property at inner layer and honey comb pattern at exterior, which creates air pockets for evaporation and blood heat regulation. **(Puck Skin)**

Traditional synthetic fibers as polyamide or poly ester are considered to be highly inflammable; hence continuous research is carried out for development of flame retardant fabric. Recent studies in this sector were presented by Alongi et.al (Alongi J, 2014) which implied emerging techniques and fabrication methods of Nanoparticles on synthetic fabric such as polyester or cotton/polyester blends.

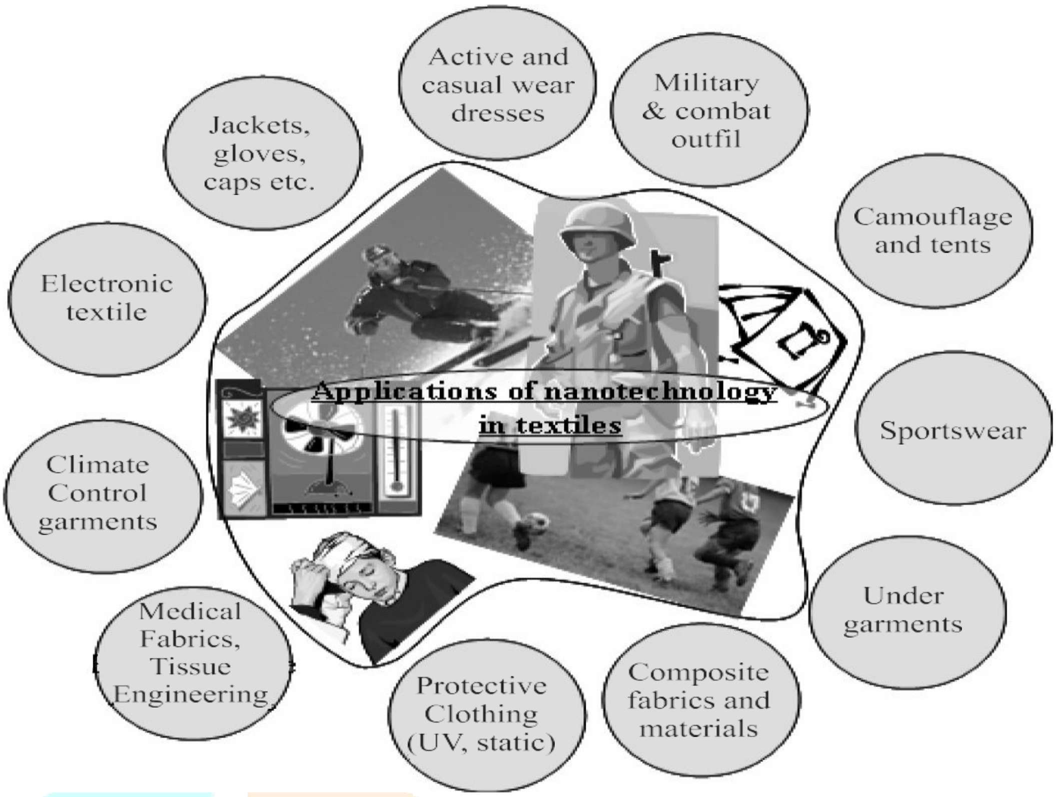


Figure (4): Representation application of nanotechnology in textile
(A.P. Sawhney B. Condon, 2008)

DRAWBACKS

1. In case of textile containing nano silver, there are several studies concerning the release of silver nanoparticles during washing. Some investigations that showed that some products can lose up to 30%of the silver in the washing water after only one wash; nevertheless, some suppliers of the silver-based antibacterial finishes claim that there is practical no release during washing and that the finish remains effective after more than 50 washes.(L Almeida and D Ramos, 2017)
2. The nanoparticles interact with the body in following ways- Inhalation, Ingestion and skin contact. These all three pathways are related to textiles; skin contact is of course the most relevant.(L Almeida and D Ramos, 2017)
3. ZnO nanoparticles showed more antibacterial activity against S.aureus and Pneumonia bacteria.TiO_2nanoparticles had no antibacterial effect against both types of bacteria, while Al_2O_3 had only slight effect against K.pneumonia bacteria.(Tarek Mohamed Abou Elmaatyand Basant Awad Mandour, 2018)
4. Nano waste can be an arising issue in this technological development due to mass use of textiles coated with nanoparticles, hence recycling balance should be maintained while upgrading these technologies.
5. Taking into consideration safety of personnel involved in production, conversion and even use of nano fibers and their products, we still do not know the short term or long term health risks, especially the probable risks of pulmonary (lung) disease due to nano-size of particles.

QUALITY LABEL FOR NANOTECHNOLOGY

Nanotechnology quality control checking consists of:(a) Category of nano-technological completion, (b)Graphic scrutiny of nanotech completion products utilizing a(SEM) scanning electron microscope, (c) measure the outcome of the final product, (d) measure the mechanical fitness, (e) cleaning durability, (f)measure of breathability and biocompatibility. These verification aspects are considered while checking quality control of fabrics and usage. The challenges of the nano-varnish to the outcomes of deterioration and maintenance are verified, as well as durability is assured for distinct least quality of wash and dry rounds for care handlings. The supplementary factors are discussed on the HohensteinQuality Label(www.hohenstein.de)

CONCLUSION

Nanotechnology holds an enormously bright future for textiles. We provided a brief review on present status and emerging development in nanotextile world, researchers are being conducted globally for improvement in the field. We also presented the novel fabrication techniques and commercial realization of nanotextile products in market. There is considerable potential for profitable applications of nanotechnology in cotton and other textile industries.

REFERENCE

1. Samer Bayda, Muhammad Adeel, TizianoTuccinardi, Marco Cordani and Flavio Rizzolio, The History of Nanoscience and Nanotechnology: From Chemical–Physical Applications to Nanomedicine, Molecules. January 2020, 1-16, DOI: 10.3390/molecules25010112
2. Munima Haque,Nano Fabrics in the 21st Century: A Review, Asian Journal of Nanoscience and Materials, 2019, 2(2), 131-148., DOI: 10.26655/ajnanomat.2019.3.2
3. M. Parvinzadeh Gashti, E. Pakdel, F. Alimohammadi, Nanotechnology-based coatingtechniques for smart textiles, Active Coatings for Smart Textiles, 2016, 243-268, DOI: 10.1016/B978-0-08-100263-6.00011-3
4. Shirley Coyle, Yanzhe Wu, King- Tong Lau, Danilo De Rossi, et. al., Smart Nanotextiles: A Review of Materials and Applications, Material Research Society, 2007, 434-441, DOI: 10.1557/mrs2007.67
5. Christopher P. Toumey, Reading Feynman into Nanotechnology, Society for Philosophy and Technology Quarterly Electronic Journal 12(3): 133-168, 2008, DOI: 10.5840/techne20081231
6. Marcio L. F. Nascimento, Evando S. Araujo, Erlon R. Cordeiro, Ariadne H.P.de Oliveira, Helinando P.de Oliveira, A Liturature Investigation about Electrospinning and Nanofibers: Historical Trends, Current Status and Future Challenges, Recent Patents on Nanotechnology, volume 9, 2015,1-10, DOI: 10.2174/187221050902150819151532.
7. Nick Tucker, Jonathan J. Stanger, Mark P. Staiger, Hussam Razzaq, Kathleen Hofman, The History of the Science and Technology of Electrospinning from 1600 to 1995, Journal of Engineered Fibers and Fabrics,2012 ,63-73.
8. C. V. Boys, Production, Properties, and Uses of the Finest Threads, The London, Edinburgh and Dublin Philosophical magazine and Journal of Science, Volume 23, 2009, 489-499, DOI: 10.1080/14786448708628043
9. A.P. Sawhney, B. Condon, K.V. Singh, S.S. Pang, G. Li and David Hui, Modern Application of Nanotechnology in Textiles, Textile Research Journal Vol 78, 2008,731-739, DOI:10.1177/0040517508091066.
10. Hassan BS, Islam GMN and Haque ANMA, Applications of Nanotechnology in Textiles: A Review, Advanced Research in Textile Engineering, 2019; 4(2): 1038.
11. Pedro J. Rivero, Aitor Urrutia, Javier Goicoechea and Francisco J. Arregui, Nanometerials for functional textiles and fibers, Nanoscale Research Letters (2015)10:501,1-22, DOI 10.1186/s11671-015-1195-6
12. Khushboo Shrimali and Ela Manoj Dedhia, Nanotechnology and its application in textiles, International Journal of Sciences and Applied Research4(6) 2017;20-31
13. Subrata Chandra Das, Debasree Paul, Sk. Md. Mahammudul Hassan, Nasifchowdhary, Sudipta Bain, Applications of Nanotechnology in Textiles: A Review, International Conference on mechanical engineering and renewable energy 2013(icmere2013)1-3 may 2014,
14. J. K. Patra and S. Gouda, Application of nanotechnology in textile engineering: An overview, Journal of Engineering and Technology Research, Vol,5(5), p.p.104-111, June2013,10.5897/JETR2013-0309
15. Y.W.H. Wong, C. W. M. Yuen, M. Y. S. Leung, S. K. A. Ku, and H.L.I. Lam, SELECTED APPLICATIONS OF NANOTECHNOLOGY IN TEXTILES, AUTEX Research Journal, vol.6, No 1, March 2006
16. Carosio F, Laufer G, Alongi J, Camino G, Grunlan JC, Layer-by-layer assembly of silica based flame retardant thin film on PET fabric, Polymer Degradation and Stability, Vol 96, Issue 5, 2011, 745-750, DOI:10.9790/019X-04010106
17. Sing Yian Chew, Jie Wen, Evelyn K. F. Yim, and Kam W. Leong, Biomacromolecules 2005;6: 2017-2024
18. Nandana Bhardwaj, Subhas C. Kundu, Electrospinning: A fascinating fiber fabrication technique, Biotechnology Advances 28, 2010, 325-347, DOI: 10.1016/j.biotechadv.2010.01.004.
19. Aravin Prince Periyasamy, Mohanapriya Venkataraman, Dana Kremenakova, Jiri Militky and Yan Zhou, Progress in Sol-Gel Technology for the Coatings of Fabrics, Materials, 2020,13, 1838; doi:10.3390/ma13081838,1-34.
20. Serena Esposito, Traditional" Sol-Gel Chemistry as a Powerful Tool for the Preparation of Supported Metal and Metal Oxide Catalysts, Materials,2019,12, 668; doi:10.3390/ma12040668, 1-25.
21. Nurhan Onar Camlibel and Bucket Arik, Sol-Gel Applications in Textile Finishing Processes, Recent Application in Sol-Gel Synthesis, 2017, 254-281, DOI: 10.5772/67686.
22. Sennur Alay and Ebru Genc, functionalization of cotton fabrics by esterification cross-linking with 1,2,3,4-butanetracarboxylic acid (BTCA), Cellulose chemistry and technology, 2015, 405-413.
23. Olayinka Oluwatosin Abegunde, Esther Titilayo Akinlabi, OluseyiPhilip Oladijo, Stephen Akinlabi and Albert UchennaUde, Overview of thin film deposition techniques, AIMS Materials Science, 6(2): 174-199, DOI: 10.3934/mastersci.2019.2.174
24. Pamela Miskiewicz, Iwona Frydrych, Agnieszka Cichocka, Application of physical vapor deposition in textile industry, Autex Research Journal,1-13, 2020, DOI;10.2478/aut-2020-0004
25. T. Oktem, E. Ozdogan and S.E. Namligoz, A. Oztarhan, Z. Tek, I. Trakcioglu and A. Karaaslan, Investigating the applicability of metal ion implantation technique (MEVVA)to textile surfaces, Textile Research Journal, Vol76(1):32-40,2006, DOI: 10.1177/0040517506059708
26. A.L. Stepanov, Application of ion implantation for modification of TiO2: A review, Reviews on advanced materials science30:150-165, June2012
27. Glashauser A, denk L, minuth WW (2011) J Tissue Sci Eng. 2: 105
28. E. Jebamalar Leavline, D. Asir Antony Gnana Singh, S. Prasannanayagi and R. Kiruthika, 2015. A Compendium of Nano Materials and their Applications in Smart Nano Textiles. Research Journal of Nanoscience and Nanotechnology, 5: 44-59. DOI:10.3923/rjnn.2015.44.59
29. Puck skin 2013. Sport Safety hockyunderware. Nanotechnology Silver Anti-microbial textured Micro- Fiber, maximum moisture wicking, Anti-Static Labeling Eliminates Order: http://www.puckskin.com
30. Alongi J, Carosio F, Malucelli G, Current emerging techniques to impart flame retardancy to fabrics: an overview, Polymer Degradation and Stability 106, 2014, 138-149, DOI:10.1186/s11671-015-1195-6.
31. Carosio F, Alongi J, Frache A, Influence of surface activation by plasma and nanoparticle adsorption on the morphology, thermal stability and combustion behavior of P31ET fabrics, EuropeanPolymerJournalVol47, Issue5,2011,893-902, DOI: 10.1016/j.eurpolymj.2011.01.009.
32. L Almeida and D Ramos, Health and safety concerns of textiles with nanomaterials, IOP Conference Series: Materials Science and Engineering,2017, 1-6, DOI: 10.1088/1757-899X/254/10/102002.

33. Tarek Mohamed Abou Elmaaty and Basant Awad Mandour, ZnO and TiO2 Nanoparticles as Textile ProtectingAgents against UV Radiation: A Review, Asian Journal of Chemical Sciences, 4(1): 1-14, 2018; Article no. AJOCS.40329, DOI: 10.9734/AJOCS/2018/40329.
34. Hohenstein Institute (2014) www.hohenstein.deAccessed 25 Aug 2020