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Nanotechnology and its application in textiles

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Abstract

Nanotechnology is the science of small things particularly that are less than 100 nano meters in size. Small particles can have significantly different properties than the same materials at larger scale. Therefore, numerous improved devices and materials can be manufactured if their differences and control can be explored. There is a great commercial possibility in the textile industry for Nanotechnology because of the non-permanency and less durability of the finishes applied by conventional methods. This technique can provide high durability for fabrics, Nano-particles have a large surface area-to-volume ratio and high surface energy, and therefore the particles possess better affinity for fabrics. The different range of technical textile applications such as protective clothing, medical textiles, sportswear, automotive textiles etc. can have the benefit of nanotechnology in the form of various Nano finishes like stain resistance, antimicrobial, controlled hydrophilicity / hydrophobicity, antistatic, UV protective, wrinkle resistant and shrink proof abilities.

Keywords: Nanotechnology, Nano finishes, UV Protective clothing, Wrinkle resistance, Anti-static fabrics, Hydrophobic textile surface

Introduction

Nano technology is the science of small things particularly that are less than 100 nano meters in size. In this discovery of science, it was found that materials at small dimensions—small particles, thin films, etc—can have significantly different properties than the same materials at larger scale. Therefore, numerous improved devices and materialscan be manufactured if their differences and control can be explored (www.nnin.org).

Nobel Laureate Physicist Richard Feynman first gave the concept of Nano technology in 1959. It is defined as the understanding, manipulation, and control of matter at the length scale on nanometer, such that the physical, chemical, and biological properties of materials (individual atoms, molecules and bulk matter) can be engineered, synthesized or altered to develop the next generations of improved materials, devices, structures, and systems (Feynman, 1959; Taniguchi, 1974).The early 2000's marked the beginnings of commercial application of nanotechnology and was limited to the bulk production of Nano materials.

Nanotechnology is also defined as the understanding, manipulation, and control of matter at the length scale on nanometer, such that the physical, chemical, and biological properties of materials (individual atoms, molecules and bulk matter) can be engineered, synthesized or altered to develop the next generations of improved materials, devices, structures, and systems.

NASA has defined Nanotechnology as creation of functional materials, devices and systems through control of matter on the Nano meter length scale (1-100 nanometers), and exploitation of novel phenomena and properties (physical, chemical, biological, mechanical and electrical) at that length scale.

Nanostructures are not man-madematerials; instead the evolution of plants and animals gives many examples of Nano structures in nature. Similarly there are many natural Nanoscale materials, such as catalysts, porous materials, certain minerals, soot particles, etc., that have unique properties particularly because of the nanoscale features. In the past decade, innovations in our understanding of nanotechnology have enabled us to begin to understand and control these structures and properties in order to make new functional materials and devices. We have entered the era of engineered nanomaterials and devices.

There is a great commercial possibility in the textile industry for Nanotechnology because of the non-permanency and less durability of the finishes applied by conventional methods. Nanotechnology can provide highdurability for fabrics, Nano-particles have a large surface area-to-volume ratio and highsurface energy, and therefore the particles possess better affinity for fabrics. This feature results in a high durability for fabrics as well as finishes. The basic properties of a nanoparticle are mainly determined by size, shape, composition, crystallinity and morphology (Wang, Dickson et al 2000).

Need of nanotechnology

The Conventional methods used to impart different properties to fabrics have many drawbacks including Lower Sustainability, reduced Breathability and Less comfortability. On the other hand, the use of Nanotechnology has provided high durability for the fabrics because of the smaller size of Nano particles, large surface area and a High surface energy without even affecting their breathability or hand feel.

Current applications of nanotechnology have its presence in areas such as:

Electronics/semiconductor industry	**Medical fields**	**Automobile industry**
Pharmaceuticals including drug delivery, cosmetics, among others	Materials science including textiles, polymers, packaging, among other	Environmental monitoring and control
Biotechnology	Sports equipment	Optoelectronics
Forensics	Food science: quality / packaging	Aerospace industry
Military	National security	University and federal lab research

Nano materials and environment

Everything produced on earth has some kind of impact on the environment and so does Nano materials. The major aspects to be focused under environment compatibility of Nano materials used depends on the kind of raw material used and the release of Nano materials in to the environment in the whole life cycle of the textile material. Although, the studies published does not reveal anything on energy consumption and raw material quantities used.

According to a study performed by Walser et. al. in 2011, a significant contribution can be made in energy saving in the use phase of the textile just by adjusting the laundry behavior. The textiles having active biocidal ingredients need fewer washing cycles, which saves power and laundry detergents.

Some nanotechnology techniques like Self-cleaning and improved dyeability can also result in saving laundry cycles, detergents and energy consumption. However, the processes involved in the finishing and manufacturing of textiles including laundry and disposal are major source for introduction of Nano materials in the environment.

Some of the commonly used Nano materials in the production of Nano textiles are Silver, Silicon dioxide, Titanium dioxide, Zinc oxide, Aluminum (hydro)oxides, Nano clay (primarily montmorillo-nite), Carbon nanotubes, Carbon black, Copper, Gold, Iron (hydro)oxides, Polypyrrol and Poly ani-line among others.

How are nano materials formed?

There is a possibility to impart desired function to the textiles by introducing synthetic nanomaterials or by nanostructuring. The nanomaterials, if used in the manufacturing and finishing process, are either integrated into the fiber volume or applied as a coating onto the textile (Som et al., 2009).Textiles consisting of nanostructures maybe fibers with a diameter in the Nano scale range or fibers and coatings with Nano pores.

Nanotechnology in textiles

Like other fields, Nanotechnology has given a major contribution in textile industry also. This technique has its presence in various fields of textiles like Finishing, Nano composite fibers, high performance polymeric Nano coatings. Nanoparticles are also successfully being used in conventionaltextiles to impart new functionality and improved performance(Joshi 2008).These materials have their application in the field of medical, defence, aerospace and other technical textile applications include filtration, protective clothing and also in smart and intelligent textiles (Joshi et al 2008).

New coating techniques like sol-gel, layer-by-layer,plasma polymerization, etc. can develop multi-functionality,intelligence, excellent durability and weather resistance to fabrics.A more promising route to develop multifunctional and intelligent high performance textiles is polymeric Nanocomposite coatings wherenanoparticles are dispersed in polymeric media and used forcoating applications. Nanofibers are sub-micron size in diameter because of which they are gainingpopularity in some specialized technical applications such as filterfabric, antibacterial patches, tissue engineering and chemicalprotective suits. They have multifunctional properties like high surface area, a small fibre diameter, good filtration properties, thin layers and high permeability (Casey &Turney, 2006; Nyati, 2005).

The Nano materials that are already being used in Textiles and also have a future in textile industry are Silver, Silicon dioxide, Titanium dioxide Zinc oxide, Aluminium hydroxides, Nano clay, carbon nanotubes and Carbon black. The other materials used in secondary terms are Copper, Gold, Iron hydroxides, Polypyrrol and Polyaniline (Som et. al 2010)

What are nano fibres?

According to the National Science Foundation, India, fibres that has a diameter of 100 nanometers (nm) or less are termed as Nano fibers. In textile industry, the definition of Nano fibers extends up to the size of 1000 nanometers. The non-woven industry defined Nano fiber, as any fiber that has a diameter of less than 1 micron (<1000nm) (Hedge et al, 2005). The major characteristics of Nano fibres that make them incredibly useful are – increased surface area, increased porosity and increased flexibility and rigidity (Venkatesh 2015).

Production technique of nano fibers

Among the other techniques of Nano fiber production, the most commonly used is "Electro spinning". Electro spinning is a technique that uses electrostatic forces to produce fine fibers, having small pore size and high surface area. This process facilitates a polymer solution or melts to be spun into smaller diameter fibers using a high potential electric field. Reportedly, the average diameter of electro spun fibers ranges from 100 nm–500 nm. The process of electro spinning is technically simple and easy to adapt. The key elements requires – Power Supply, Reservoir containing the polymeric solution and a Grounded collector.

Electro spinning is a technique that uses high voltage to draw very fine fibres from a liquid (solution or melt). The use of high voltage produces an electrically charged jet of polymer solution or melt, which dries or solidifies resulting in a polymer fibre (Formhals 1934).

Fabric finishing by using nanotechnology

Finishing of textile fabrics is a process in which various procedures are done on the surface of the fabrics to impart different kinds of aesthetic and functional properties. There have been major developments and innovations in the field of textile Nanotechnology in the last few years (David, 2002). There are many ways of imparting enhanced surface properties to the fabrics like surface finishing, coating, and/or altering techniques, using nanotechnology. Coating is a common technique used to apply Nano-particles onto textiles. The coating compositions that can modify the surface of textiles are usually composed of nanoparticles, a surfactant, ingredients and a carrier medium (Cramer et al 2003).

The Conventional methods used to impart different properties to fabrics have some kind of drawbacks that includes Lower Sustainability of the materials and reduced breathability of the fabrics. It also makes the fabric less comfortable to wear. Nanotechnology on the other hand, has high advantages and can provide high durability for fabrics. This has become possible because of the keys characteristics of the Nano materials that includes -

- Smaller size
- Large surface area
- High surface energy

The different range of technical textile applications such as protective clothing, medical textiles, sportswear, automotive textiles etc. can have the benefit of nanotechnology in the form of various Nano finishes like stain resistance, antimicrobial, controlled hydrophilicity / hydrophobicity, antistatic, UV protective, wrinkle resistant and shrink proof abilities(Joshi M. 2011). The most desirable functional textiles among the consumer group are bioactive, antimicrobial and UV-protecting textiles (Purwar et al 2004).

Water and/or stain- resistant fabrics can be produced by making some alterations in the fabric's surface properties. One of the examples of such property is the "Lotus-

Effect," which demonstrates the natural hydrophobic behavior of a leaf surface. This sort of surface engineering, which is capable of replicating hydrophobic behavior, can be utilized in developing special chemical finishes like water and stain resistance (Song et al., 2001; Russell, 2002). Many researches have been performed with a view to use this concept of surface engineered nanotechnology to develop high performance and smart textiles. These textiles possess hydrophobic surfaces that are capable of repelling liquids and resisting stains, while complementing the other desirable fabric attributes, such as breathability, softness, and comfort (Anonymous, 2003; Chen, 2002; Song et al, 2001; Russell, 2002).

In a research performed by Beringer and Hofer 2004, the Nanoparticles of hydroxylapatite, TiO_2, ZnO and Fe_2O_3 were combined with other organic and inorganic substances. It was found out that the surfaces of the textile fabrics can be enhanced with properties like greater abrasion resistance, water repellency, ultraviolet (UV) resistance, and electromagnetic- and infrared-protection. In another technique of Nanotechnology called Microencapsulation, extensively used in pharmaceutical industry, several liquid or solid agents (fragrant, flame-retardant agents, etc.) encapsulated in phase-changing materials acting as binders (e.g. wax) are used. The process of microencapsulation can be used to develop odor-eliminating finish, fire retardant finish and anti-microbial finishing for fabrics (Erkan et al 2004, Buschmannet al 2003).

Structures of nano particles

Basically there are three kinds of Nano particles – Whiskers, Nano Nets and Nano Wraps. The most common ways to use Nanotechnology on fabrics is to make them water repellant and stain resistant. This property is achieved by the use of Nano whiskers. The fabrics are embedded with billions of tiny fibers, called "Nano whiskers" (think of the fuzz on a peach), which are waterproof and increase the density of the fabric. The use of Nano whiskers makes a fabric water and oil repellant, wrinkle resistant, increases durability and breathability without affecting its texture and hand feel (Abate 2015).

Nano whiskers form a cushion of air around each cotton fiber and when something is spilled on the surface of the fabric, the miniature whiskers actually cohesively prop up the liquid drops, allowing the liquid drops to roll off and this is how they can repel stains. This treatment lasts for about 50 home wash cycles before its effectiveness is lost. A corollary finish is that of using Nano particles to provide a "lotus plant" effect which causes dirt to rinse off easily, such as in the rain. (https://oecotextiles.wordpress.com/2012/08/01/nanotechnology-in-the-textile-industry/)

Another structure of Nano particles is Nano Net that has the capability of injecting linen like properties into a synthetic fiber. Nano Net can be used on synthetic fibre like polyester to alter its properties to give it a feel like that of cotton and linen along with increasing its absorbency. It wicks body moisture very fast and dries quickly giving a cooling effect (Aabate2015).

The third structure of Nano materials are Nano Wraps. Nano wraps are just like a coating on synthetic fibres that wraps the fibre to alter its properties. This structure is basically used to provide wrinkle resiliency and strength to the fibre. It enhances the durability of the fabric and improved color fastness of the fabric too. Along with making the fabric anti-static, it also imparts the property of good crease retention making the fabric more wrinkle resilient (Abate 2015).

Properties of nano textile fibers
UV-protection

Numerous researches have been performed in the field of imparting UV finish to the fabrics as it has now become one of the important features of a textile material. UV blocking treatment for cotton fabrics are developed using the sol-gel method. Mainly, there are two kinds of UV blockers - Inorganic UV blockers and Organic UV blockers. The Inorganic UV blockers are more preferablebecause of their non-toxic and chemically stable nature when exposed to high temperatures and UV (Yang et al., 2004; El-Molla et al., 2011). The UV-blocking property of a fabric can be enhanced by using a dye, pigment, delustrant, or UV absorber finish. These materials work by absorbing UV radiation thus blocking its transmission through the fabric to the skin (Hustvedt and Crews 2005).

Whenever a radiation strikes a fibre surface, it can be REFLECTED, ABSORBED, or TRANSMITTED through the fibers or pass between the fibers. Cotton and Silk provides little protection to UV radiation whereas Wool and Polyester gives higher protection as the fibers absorb the UV radiation.Tight micro-fibre fabrics provide a better UV protection when compared to fabrics made from normal sized fibres or fibres having same specific weight (Tanveer 2012).

The most commonly used Inorganic UV blockers are titanium dioxide (TiO_2) and zinc oxide (ZnO) among other semiconductor oxides such as TiO_2, ZnO, SiO_2 and Al_2O_3. The Nano-sized titanium dioxide and zinc oxide provides comparatively better protection against UV rays because of their function of absorbing and scattering UV radiation. In this procedure, a thin layer of titanium dioxide is formed on the surface of the treated cotton fabric. This finish provides an excellent UV protection and the effect can be maintained after 50 home launderings (El-Molla et al., 2011). In a research done on UV protection of fabrics it was found that the Nano rods of titanium dioxide on cloth achieved a promising photo-catalytic bactericidal activity along with excellent protection against UV radiation (Feiet al2006).

When the finishing is done with zinc oxide, the Nano rods made up of zinc oxide generally 10-50nm in length are applied on the cotton fabric. In a research on Nano finishes, it was reported that the fabric treated with zinc oxide Nano rods were found to have demonstrated an excellent UV protective factor (UPF) rating (Wong et al., 2006). The larger surface area of the Nano-particles makes it possible to increase the effectiveness of UV blocking property (Kathiervelu, 2003; Yang et al., 2003).

In another procedure to enhance the finish, the process of padding is used to apply the finish. Through this process, the Nano particles besides getting applied to the surface, penetrates into the interior of the yarns and the fabric. But a drawback of this finish is that the Nano particles which do not stay on the fabric might not prove very effective in shielding the UV rays.Therefore, it is better to apply the finish on the right (face) side of the fabric as this surface gets exposed to the rays and can be covered with the nanoparticles for better UV protection. Spraying (using compressed air and spray gun) the fabric surface with the nanoparticles can be an alternate method of applying the nanoparticles (Patra& Gouda S. 2013).

Antimicrobial

The anti-microbial finish in Nanotechnology is imparted by the use of Nano-sized silver, titanium dioxide,zinc oxide, triclosan and chitosan (Burniston et al., 2004). Apart from this, the other anti-microbial agents already having their presence in textile finishing industry are organo-silicones, organo-metallics, phenols and quaternary ammonium salts. The Nano-silver particles enhance the bactericidal and fungicidal effectiveness as they have an extremely large relative surface area which increases their contact with bacteria or fungi. 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 inhibits 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 (Wong et al., 2006). This technique also hinders the multiplication and growth process of the bacteria and fungi which cause infection, odor, itchiness and sores (Yang et al., 2003).

Some of the synthetic antimicrobial Nano particles extensivelyused in textiles are (Patra& Gouda 2013)–

Triclosan is a chlorinated bio- phenol. It is a synthetic, non-ionic and broad spectrum antimicrobial agent. It possesses antibacterial, antifungal and antiviral properties.

Chitosan is a natural biopolymer. It is effectively used as antibacterial, antifungal, antiviral, non-allergic and biocompatible agent.

ZnO nanoparticles have been extensively used for their antibacterial and UV-blocking properties. When compared to other inorganic forms of Zinc, ZnO is more preferable as it has lower toxicity and higher efficiency in preventing infection (Huang et al 1999).

Water repellence

Nanotechnology can offer a water repellent finish to the textile materials with the help of Nano whiskers that are hydrocarbons and 1/1000 of the size of a typical cotton fiber. These whiskers when added to the fabric create a peach fuzz effect without lowering the strength of cotton. The working principle of this technique is that the spaces between the whiskers on the fabric are smaller than the typical drop of water, but still larger than water molecules, therefore the water remains on the top of the whiskers and above the surface of the fabric. However, liquid can still pass through the fabric, if pressure is applied to it (Wong et al., 2006; Russell, 2002).

Hydrophobic or water repellant textiles can be developed either by - i. creating a rough structure on a hydrophobic surface or,

ii. by modifying a rough surface using material with low surface free energy.

Nano sphere impregnation involving a three-dimensional surface structure with gel forming additives which repel water and prevent dirt particles from attaching themselves are also used. This finish can sustain heavy showers also because it beads up the water droplet on the surface rolls of easily when the fabric slopes. It has been linked to the lotus leaf effect because the leaves of the lotus plant keep clean even during light rain. By altering the micro and Nano-scale surface features on a fabric surface, a new kind of material can be developed which is capable of replicating hydrophobic behavior and can be utilized in developing special chemical finishes for producing water-and/or stain- resistant fabrics. This also results in enhanced fabric attributes like breathability, softness and comfort. The surfaces of the textile fabrics can be modified to achieve desired effects and considerably greater abrasion resistance, ultraviolet (UV) resistance, electromagnetic and infrared protection properties.

Self-cleaning textiles (the lotus effect)

If we observe the leaves of the lotus plant, we see that the leaf despite of being fully in

water does not allow water to stay on it. This is because the leaves of the Lotus plant are super-hydrophobic. The surface of a lotus leaf appears very even, but it is actually not. When we see the leaf surface under a microscope, we observe that it contains systematically arranged, water repellent, Nano size wax crystals. These form three dimensional small nipple like structures which are of the size of a few Nano meters. These structures combine with the water repellent chemical properties of the leaf wax and make the leaf extremely non-wettable; also exhibiting Self-cleaning properties.
(http://www.nanowerk.com/spotlight/spotid=19644.php)

Wrinkle resistance

Nano titanium dioxide and Nano-silica are used to enhance the wrinkle resistance property in cotton and silk fabrics respectively (Wong et al., 2006). However, in conventional methods resin is most commonly used to impart this finish to the fabrics. But because of the limitations of applying resin like decrease in the tensile strength of fiber, abrasion resistance, water absorbency and dye-ability, as well as breathability, new areas of nanotechnology were explored. Nano-titanium dioxide when used with carboxylic acid act as a catalyst under UV irradiation to catalyse the cross-linking reaction between the cellulose molecule and the acid. On the other hand, wrinkle resistance of silk can be improved by Nano-silica when applied with maleic anhydride (Song et al., 2001; Zhou et al., 2003).

Besides the use Nano materials, techniques like padding and exhaustion can also improve the wrinkle resistance of fabric. According to studies, fabrics treated with microwaves show more wrinkle resistance as compared to the method of oven curing. The reason behind this is that it generates higher frequency and volumetric heating which minimizes the damage from over drying.

Antistatic

We often observe that there is a buildup of static electricity caused by the triboelectric effect on the fabric. Therefore an anti-static agent is used to treat the fabric surfaces in order to reduce or eliminate the buildup of static charge on the fabrics. When an anti-static finish is applied to the fabric, the molecules of the antistatic agent possess 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 (Dong and Huang, 2002).

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 thatNano-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 (Wong et al., 2006).

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.(http://www.fibre2fashion.com/industry-article/7187/nano-finishing-in-textiles?page=2)

In case of silanenanosol, the silica gel particles when applied on the fiber absorbs water and moisture in the air by amino and hydroxyl groups and bound water. Electrically conductive Nano-particles are durably anchored in the fibrils of the membrane of Teflon. This in turn creates an electrically conductive network that prevents the formation of isolated chargeable areas and voltage peaks commonly found in conventional anti-static materials. The advantage of this method is that it gives durability to the finish does not allow the anti-static agent to get easily washed off after a few laundry cycles (Anonymous, 2003).

Nanotechnology in apparel industry
(http://textilelearner.blogspot.in/2012/12/application-of-nanotechnology-in.html)

Nanotechnology has marked its presence in almost every possible field including Apparels and smart textiles. The non-permanency and less durability of the functional finishes imparted through conventional methods leads to the emergence of the use of Nanotechnology. Innovative functionalities like energy storage and communications can also be added through this technique. In the Nano improved textiles available in the market,stain repellent and wrinkle-resistant threads arewoven in textiles. Body warmers has also been developed that uses Phase Change Materials that responds to changes in the body temperatures and Nano socks treated with silver nanoparticles has also been created to protect against infection and odor caused due to certain bacteria on the skin.

The other applications of Nanotechnology treated apparels are:

Swim suits
The most known application of Nanotechnology in swim suits is the shark-skin suit worn during world-record breaking Olympic swimming championship. It repels water molecules by a plasma layer enhanced by nanotechnology. It is designed in such a way that it helps the swimmer to glide through the water easily.

Sporting goods
Nanotechnology has facilitated the development of textile-based Nano sensors that can sense their surroundings and interact with the wearer. These sensors can monitor our vital signs when the body is active and also responds to the change in weather.Running shoes, tennis racquets, golf balls, skin creams are some examples among sporting goods that have been enhanced by nanotechnology.

Flexible electronic circuits:
Among the electronic circuits, Nano ribbons are the widely used ones. These are tiny electronic sheets that are highly flexible in nature. These ribbons form the basis for the chips that have high level of flexibility and stretchability. The researchers are focusing development and use of these ribbons to line the brain to monitor activity in patients at risk of epilepsy or be integrated into surgical gloves to monitor a patient’s vital signs during surgery.

Lifestyle applications:
Lifestyle products like textile and cosmetics are among the first ones to use Nano materials.
Bullet proof vests are one such example of Lifestyle application of nanotechnology. This uses Nanotube fibers that make a material seventeen times tougher. Scientists are focusing for future developments to use nanotechnology to create Smart and Interactive Textiles (SMIT) that can sense electrical, thermal, chemical, magnetic, or other stimuli.

Coating techniques used for fabric finishing through nanotechnology
The sol gel technique
The sol-gel technique is based on the hydrolysis of liquid precursors and formation of colloidal sols, which can be easily coated on textiles.The wet gel thus formed, when dries, yields porous xerogels

(dry gels).Xerogels are stable, transparent and insoluble in water and most of organic solvents and porous solid materials.Nano Sol-gel method is used to impart self cleaning, antibacterial and water repellent finishes on fabrics.

The preparatory material (or precursor) used to produce the "sol" usually consists of inorganic metal salts or metal organic components, such as metal alkoxides. These precursors are submitted to a series of hydrolyse and polymerisation reactions to create a colloidal suspension (or "sol").Further this sol is transformed into a ceramic material in different forms for different applications:

- Thin layers (films) are applied by spin-coating or dip-coating
- By moulding the "sol" we obtain a wet gel that forms a dense ceramic structure after evaporation and heat treatment. Under super critical conditions, this gel forms a very porous material with an extremely low density (aerogel). It is possible to manufacture ceramic fibres by adjusting the sol’s viscosity.

Magnetron splutter coating

Splutter coating is one of the physical vapor deposition (PVD) methods and is used to deposit various materials on the textile fabrics.A quadruple magnetic field is known to increase the deposition rate, so magnetron sputter systems are widely used for thin film deposition. It is a vacuum process that applies a high voltage across a low-pressure gas to create reactive gas molecules. During sputter coating, reactive gas molecules strike a target and cause atoms from the target to travel to the substrate.

Plasma technique

Plasma technique can be termed as a mix of ions, electrons, neutrons, photons, free radicals, Meta stable excited species and molecular and polymer fragments (Shishoo 2007). It can be achieved in different atmospheric conditions, either low pressure or atmospheric pressure, and can also be achieved in different types of power including low-frequency, radio-frequency, or Microwave (Shishoo R. 2007). In textiles, plasma technology is widely used for a range of applications such as shrink-resistance, anti-scratch, superhydrophobic, superhydrophilic, and flash-fire resistance. It is a suitable technique for modifying the structure and topography of the surface as well as deposing of nanocomposites into the surfaces (Hocker 2002; Manolache 2010; Horrockset al 2011).

The plasma is an ionized gas that consists of free electrons, ions, radicals, UV-radiation and other particles. The conversion of gas to plasma takes place when the kinetic energy of the gas particles rises to equal the ionization energy of the gas. When this level is reached, collisions of the gas particles cause a rapid cascading ionization resulting in plasma.It has a reactive nature and can be used to bring desired modifications to the surface of certain substrates. This technology works by depositing or removing chemical materials on the surface of substrates to impart desired properties ((Kan 1999; 2001, Ganpathy 2000, Allan et al 2002).

Layer by layer technique

Layer-by-layer (LBL) technique is used for fabricating a thin layer film and is based on the concept of self-assembled Nano layers. It involves the polyelectrolytes with opposite charge to deposit alternately on the fabric surface with wash steps in between(Ugur et al 2010).It involves a sequential adsorption of oppositely charged polycations and polyanions to build a series of polyelectrolyte multilayer film on the substrate.In this process, the substrate is charged appropriately and then immersed in an oppositely charged polyelectrolyte solution and then rinsed (Ou R. et al 2007).

The charged surface attracts the oppositely charged polyelectrolyte and binds it with strong electrostatic bonds.After rinsing, the substrate coated with a mono layer is treated with the solution of oppositely charged electrolyte solution. This cycle can be repeated to deposit up to 20 ultra-thin layers.A wide range of charged Nano particles, dyes and enzymes can be incorporated in the layers in a controlled manner.Layer by Layer method provides a chemically mild alternative to the conventional processes of finishing for producing ultra-thin, transmissive and stable coatings.

Conclusion

The new concepts employed for the nano finishes can further open up opportunities in the field of research and development. Nanotechnology has the potential for development and evolution of a new range of improved materials including polymers and textiles. However, there are some limitations regarding cost and production of materials treated with Nano finishes. On the other hand, the release of Nano particles in the environment and their effect on human health should also be studies further.

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