

## Innovative Application of Nanotechnology

**Manoj Kumar Gupta**

Mechanical Engineering Deptt.  
H.N.B. Garhwal University  
Srinagar (Uttarakhand) India

### ABSTRACT

*The fundamental of nanotechnology is that the properties of substance drastically change when their size reduced to the nanometer range. Nanotechnology is emerging interdisciplinary technology that has been blooming in many area during the recent decade including, material science, mechanics, optics, medicine, plastic, electronics and aerospace. The textile industry has already impacted by this technology. This paper summarizes the application of nanotechnology in different areas of textiles like manufacturing nanofibres, nanotubes, finishing textiles, medical textiles, protective textiles and others scope of nanotechnology in textiles are analyzed.*

**Keywords:** Textile ,Nanotechnology Nanofibers, Nanotubes.

### I. INTRODUCTION

The "Nano" in nanotechnology comes from Greek world "Nanos" which means dwarf. Scientists use this prefix to indicate one billionth meter or nanometer ( $10^{-9}$ ). Thus, nanotechnology according to National Nanotechnology Initiative (NNI) is defined as utilization of structures with at least one dimension of nanometer size. Nanotechnology is also known as "bottom up" technology in which bulk material can be made precisely from tiny blocks, apart from "top down" traditional technology. This results in material with less defects and better quality [20]. The nanotechnology was first discussed by Richard Feynman in his famous 1959 lecture "There's Plenty of Room at the Bottom" in which he proposed that the properties of materials and devices at the nanometer range would present future opportunities. Rarely has a technology attracted as much publicity in a short period of time as nanotechnology. It has been hailed as biggest innovation since computer chips. The fundamentals of nanotechnology lie in the fact that properties of material changes drastically when either of its dimensions is reduced to nanometer range e.g. gold changes its color to red and its melting point decreases whereas copper reduces its conductivity in the presence of magnetic field when reduces to nanometer size [19]. There is also an increase in reactivity due to increase in surface to volume ratio. Properties at this stage are described by quantum mechanics rather than classical mechanics. Nanotechnology is increasingly attracting worldwide attention, federal funding and research activity due to its wide range of uses. Moreover, a small amount of nanosize particle can interfere with matrix polymer, bringing up the resultant material to unprecedented level.

The textile industry has already impacted by nanotechnology. Research involving nanotechnology to improve performances is flourishing. There are two concepts in molecular nanotechnology:

#### (a) Positional assembly:

Positional assembly is a technique that has been suggested as a means to build objects, devices, and systems on a molecular scale using automated processes. It is frequently used in normal macroscopic manufacturing [21, 19].

#### (b) Massive parallelism (self replication):

Self-replication is a process in which devices whose diameters are of atomic scale, on the order of nanometers, create copies of themselves [21, 19].

### II. NANOTECHNOLOGY IN MANUFACTURING TEXTILES

Large changes can be made in properties of fabric by making a small change in its constituent material. Here comes nanotechnology in manufacturing textiles. Fabric using nanofibres, nanocomposites etc. are getting appreciation from whole world. There demand has increased by many folds due to their unique properties.

#### (a) Nanofibres

Nanofibers are defined as fibers having diameter in range of nanometers. They can be produced by interfacial polymerization and electro spinning. Some nano fibers are given below:

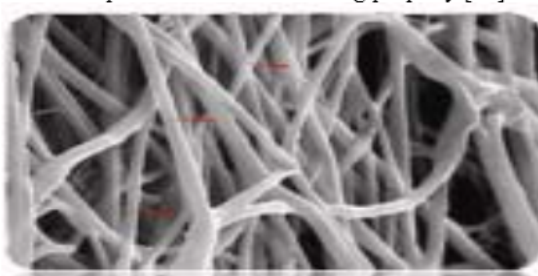
- (i) Electro spun cellulose- It is a high performance material obtained from reclaimed cellulose by using elctrospinning method.
- (ii) Luminescent Polyester -The polyester core is covered with approximately 60 layers of nylon and polyester. This creates a mystical hue that changes according to (i) how light strikes the fabric and (ii) The angle from which the fabric is viewed. Only reflecting light of a specific wavelength, this structure effectively brings out color.

#### (b) Carbon Nanofibres

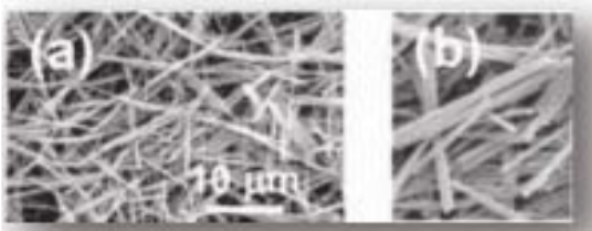
These are the ordered array of carbon atoms that have high tensile strength due to high aspect ratio. They also have high chemical resistance and electrical conductivity [19].

(c) **Composite fibers**

Fibers which are employed by filler materials such as nanoparticles to get desired properties are called composite fibers. Carbon nano particles are added to fiber to enhance their tensile strength, resistivity to chemicals and electrical conductivity. Composite fibers are also employed by clay nano particles for flame retardant, anti-UV and anti corrosive behavior e.g. nano particles of Montmorillonite have been applied as UV-blocker in nylon composite fibers. The mechanical properties with clay mass fraction of 5% exhibits a 40% higher tensile strength, 68% greater tensile modulus, 60% higher flexural strength and a 126% increased flexural modulus. Also heat distortion temperature raised from 65°C to 152°C. Clay nano particles are also used to introduce dye attracting sites and creating dye holding space in polypropylene fibers. Some metal oxide nanoparticles are also used to impart unique properties in fabric such as ZnO nanoparticles are used for UV shielding function and reduction in static electricity in synthetic fibers, TiO<sub>2</sub>/MgO nanoparticle for self sterilizing property [20].



**Fig. 1 Nano fibres**

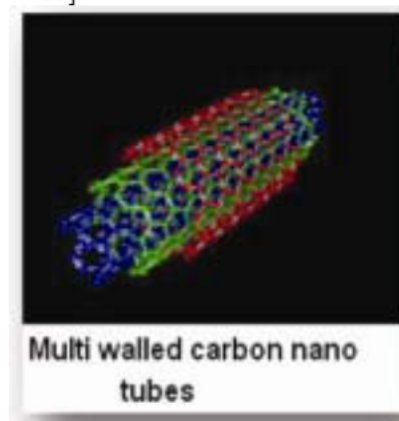


**Fig. 2 Composite fibres**

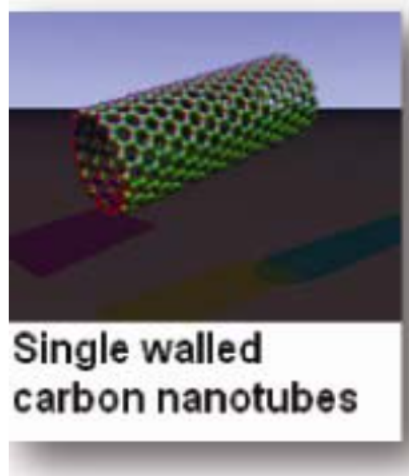
(d) **Carbon Nanotubes**

Carbon nanotubes are allotropes of carbon with a cylindrical nanostructure. Nanotubes are members of the fullerene structural family, which also nanotube may be capped with a hemisphere of the buckyball structure. CNT has tensile strength 100 times that of steel at 1/6<sup>th</sup> weight. Generally, CNT are classified into single walled carbon nanotube (SWNTs) and multi walled carbon nanotube (MWNTs). One of the best examples of the CNT composite fiber is

SWCT-polyvinyl alcohol fiber with fiber diameters in macro meter range produced by using a coagulation based spinning process. The fiber exhibits high stiffness and strength, moreover, toughness 20 times higher than steel wire of same length and mass. Therefore this type of fibers has potential applications in safety harnesses, explosion proof blankets and electromagnetic shielding [23, 25].



**Fig.3 Carbon nanotubes**



**Fig.3 Carbon nanotubes**

### III. NANOTECHNOLOGY IN FINISHING TEXTILES

Nanoparticles when employed in a fabric impart their properties to the fabric. Here comes nanotechnology in finishing textiles. In this field particular attention has been paid to make chemical finishing more controllable and thorough. Ideally discrete molecules or

nanoparticles of finishes can be brought individually to designated sites on textile materials in a specific orientation and trajectory through thermodynamic, electrostatic or other technical approaches. The nanotechnology finishes creates carefree fabrics that minimize stains, offer superior liquid repellency and provide additional wrinkle resistance.

(a) **Water Repellent Finish**

There is a great demand of water repellent garments in this new emerging world e.g. dresses for divers, swimmers, water proof coverings for tents, water proof bags, shoes, rain coats etc. Wetting of fabric depends upon difference in surface tension of solid fabric and liquid. If critical surface tension of solid fabric is greater or equal than surface tension of liquid then liquid will wet the fabric. Thus, water repellency can be attained when critical surface tension of solid is smaller than surface tension of liquid [8]. This is done by using fluorocarbons, which are organic compounds consisting per fluorinated carbon chain. Fluorocarbons generally lower the surface tensions by forming a thin film of coating around the fiber. Some useful fluorocarbons are perfluoroalkyl acrylate polymers. Fluorocarbons can be added in number of ways like by spraying, foam or exhaust. Researchers at Clemson University developed a highly water repellent coating made of silver nanoparticles. The patented coating-a polymer film (polyglycidyl methacrylate) mixed with silver nanoparticles can be permanently integrated into any common fabric like cotton, polyester, silk etc.

Nano-tex enhances the water repellent property by creating nano-whiskers, which are made of hydrocarbons and are  $1/1000^{\text{th}}$  size of typical cotton fiber. They are added to create peach fuzz effect without lowering the strength of cotton. They create a surface through which water molecules can pass while water droplets cannot, thus maintaining breathability. Schoeller improves water repellence by nanospheres. Nanosphere impregnation involves a 3-D surface structure with gel forming additives which repel water and prevent dirt particles from attaching themselves. The mechanism is similar to lotus effect occurring in nature [6, 8, 11].



**Fig.4. Water Repellent Finish.**



(b) **Self Cleaning Effect**

With the help of nanotechnology self-cleaning fabric surface are produced by the following methods. In the first place, create extremely water repellent microscopically rough surfaces on which dirt particles can hardly get a hold and therefore, can be simply rinsed off water. The second example is given by photocatalytic layers. When layer of nanocrystalline titanium oxide is exposed to sunlight, it can remove dust, dirt and bacteria by itself [6]. Coating of mixture of polyglycidyl methacrylate and silver nano particles is also used due to their resistance to dirt and water.

(c) **Anti-Microbial Finish**

Self Cleaning Effect Nano-sized silver coating is used to provide anti microbial properties. Metallic ions convert free oxygen into active oxygen, which destroys the organic substance to create the sterilizing effect. Nano silver is also very reactive with proteins. When contacting bacteria and fungi, it will adversely effect cellular metabolism and inhibit cell growth. Photocatalytic effect of  $\text{TiO}_2$  and  $\text{ZnO}$  are also used for anti microbial finish.



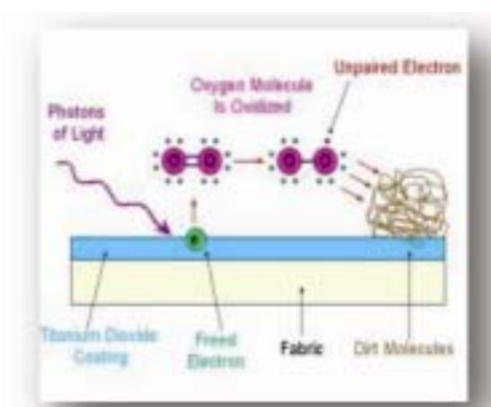


Fig.5.Self Cleaning

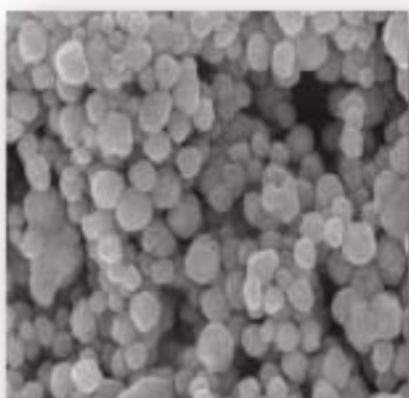


Fig.6.Silver nano particles.

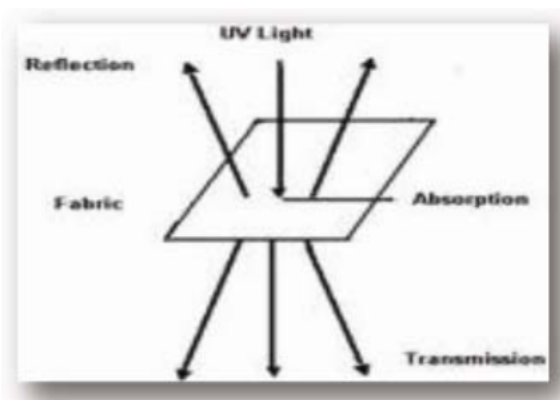


Fig.7.UV Protection.

(d) **Wrinkle Resistance**

To improve wrinkle resistance of cotton and silk, fabrics are employed with nano-titanium dioxide and nano silica. Nano-titanium dioxide was employed with carboxylic acid as a catalyst under UV radiation to catalyse the cross linking reaction between the cellulose

molecules and the acid. On the other hand, nano-silica was applied with maleic anhydride as a catalyst. This process improved the wrinkle resistance of silk [6, 11].

(e) **Flame Retardant Finish**

For flame retardant finish in garments is achieved by using colloidal antimony pentoxide which is supplied by Nycol nano Technologies, Inc. Nano antimony pentoxide used with Halogenated flame retardants for a flame retardant finishes. The ratio of halogen to antimony is 5:1 to 2:1.

(f) **Odour Fights Finish**

Odours are formed as a result of bacterial growth. Thus these can be prevented by antimicrobial finish. Cyclodextrins can be incorporated into a fabric finish to prevent odour. Greensheild, a nanotech firm in Taiwan, has applied nanotechnology to create underwear's that can fight odour [6]. The underwear fiber release undetectable negative ions and infrared rays that destroy odour causing bacteria. Similarly, microcapsules containing fragrances can also be implanted in fabric for slow release overtime to neutralise foul order.

(g) **UV Protection**

For protecting material from UV radiation, we add semiconductor oxides of  $\text{TiO}_2$ ,  $\text{ZnO}$ ,  $\text{SiO}_2$ , and  $\text{Al}_2\text{O}_3$ . Among these  $\text{TiO}_2$  and  $\text{ZnO}$  are commonly used. The nano particles have large surface area per unit mass and volume, thus more effective in scattering and absorbing UV radiation. Apart from  $\text{TiO}_2$ ,  $\text{ZnO}$  nanorods of 10 to 50 nm length also show excellent results in blocking UV rays [6].

## IV. NANOTECHNOLOGY IN PROTECTIVE TEXTILES

Protective textiles demand the balance of very different properties of drape, thermal resistance, barrier to liquids, water permeability, reduction in weight and cost, antistatic and stretch properties etc. with conflicting requirements against heat, cold, chemical and bacteria. Nanotechnology with its latest developments is helping in providing these properties to protective textiles. Electro-spun nanofibre-based membrane are used for making the material light weight. Nanomaterials such as nanotubes developed either from silicon or carbon would be very useful for producing highly functional protective clothing. Carbon nanotubes provides fibres of ultra high strength and performance. Further enhancement of fibre strength and conductivity is achieved by heat treatment. Electrospun polypropylene nanofibre and polyurethane nanofibres are used as barrier to liquid penetration in protective clothing. Polymer clay nanocomposites have emerged as a new class of materials that have superior properties

such as higher tensile strength, heat resistance, and less permeability to gas compared with traditional composites. Thus it is conceivable that nanotechnology developments in long term will play a key role in protective systems.

## V. NANOTECHNOLOGY IN MEDICAL TEXTILES

Nanotechnology also have widespread applications in medical textiles such as imparting antimicrobial properties to clothing, development of wound closing nanofibre systems, in drug delivery systems, in blood filtration etc. A new medical technology to clean blood affected by radiological, chemical and biological attacks is being developed jointly by Argonne National Laboratory and The University of Chicago Hospitals. In addition to cleaning biological and radiological toxins from blood, the technology shows promise for delivering therapeutic drugs to targeted cells and organs. This technology uses a novel approach to magnetic filtration. The key is biodegradable polyanospheres 100 to 5000 nm in diameter, which are injected into the patients blood stream and are small enough to pass through the smallest blood vessels, yet too large to be filtered from the blood stream into the kidneys.

Textile fibers on the nano order level produced by ultrafine processing nanotechnology can be used to enhance drug delivery in biomedical applications. The objective of drug delivery system is to deliver a defined amount of drug efficiently, precisely and for a defined period of time. Drug delivery for polymer nanofibres is based on the principle that dissolution rate of a drug particulate increases with increased surface area of both the drug and corresponding carrier [7].

## VI. CONCLUSION

Nanotechnology has an enormously promising future for textiles. The recent developments in finishing and manufacturing textiles based on nanotechnology have endless possibilities and at present the application of nanotechnology in textile merely reached a straight line. These nano finished textiles have a wider applications in protecting material, drug delivery in medicines, space suit designs etc. Our surrounded world is full of textile applications which can be innovated by using nanotechnology. It has also opened new opportunities for research and development work. Though there are some security concerns regarding use of nanotechnology but we hope that it will make our future better and bring hundreds of billion dollars to textile industry.

## REFERENCES

- [1] Rathinamoorthy R. and Senthil Kumar P., "Synthesis of nanoparticles and their applications in textiles." *Milliand International*, 2009, may, 110-111.
- [2] Nivedita S. and Roy S., "Nanotechnology and its potentials in sericulture", *Indian Silk*, 2011, March, 21-33.
- [3] Moghe A.K. and Gupta B.S., "Hybrid nanofibre structures for tissue engineering", *AATCC Review*, 2009, October, 43-47.
- [4] Wilson A., "Advanced nonwoven media for liquid filtration: A Growth Area", *Technical Textiles International*, 2010, December, 11-16.
- [5] Viswanath C. S. and Ramachandran T., "Comfort characteristics of cotton fabrics finished with fluoro-alkyl nano lotus finish", *Indian Journal of Fabre and Textile Research*, 2010, December, 342-348.
- [6] Rathinamoorthy R. and Sumothy M., "Nanofinish adds value to functional textiles", *Textile Asia*, 2010, July, 41-44.
- [7] Rathinamoorthy R., "Textile nano fibers for drug delivery", *Textile Asia*, 2010, April, 29-31.
- [8] Shanmugasundaran O.L., "Application of nanotechnology in textile finishing- A Review", *Textile Review*, 2009, November, 135-139.
- [9] Chinchole Y.D. and Saraskan R.U., "Application of nanotechnology in textiles and other fields", *Textile Review*, 2009, December, 19-29.
- [10] Buiyle G., "Nanoscale finishing of textiles via plasma treatment", *New Cloth Market*, 2009, December, 39-46.
- [11] Sivakumar G.S. and Prince P.A., "Nanofinishing: The next wave in nano finishing", *Textile Review*, 2009, December, 14-18.
- [12] Kathirvelu S., D Souza L. and Dhurai B., "Study of stain eliminating textiles using ZnO nano particles", *Journal of Textile Institute*, 2010, June, 520-526.
- [13] Mangat M.M., "Health safety and environment aspect of nanotechnology a technical textiles", 2010, April, 17-20.
- [14] Priya S.S. and Selva kumar N. "Basics on synthesis of nano metal oxide sols and nano TiO<sub>2</sub> and its uses on textile materials", *Colourage*, 2009, November, 77-83.
- [15] Chaudhary S.N., Krishna A. and Borkan S.P., "Developments in protective textiles", *Asian Textile Journal*, 2009, December, 37-43.
- [16] Paul R., "Nano Cotton Fabrics with high ultraviolet protection", *Textile Research Journal*, 2010, March, 454-462.
- [17] Raut S.B., Vasavada D.A. and Chaudhary S.B., "Nano-particles-application in textile finishing", *Manmade Textiles in India*, 2010, December, 432-437.
- [18] Ibrahim N.A., Refaie R. and Ahmed A.F., "Novel approach for attaining cotton fabric with

Multifunctional properties”, Journal of Industrial Textiles, 2010, July, 65-83.

[19] Applications of nano technology in textiles by **Dr. Poonam G. Bhagchandani.**

[20] Lei Qian and Juan P. Hinestroza, “Application of nanotechnology for high performance textiles”, JTATM, summer 2004.

[21] [www.WhatIs.com](http://www.WhatIs.com)

[22] [www.nanotechobservers.com](http://www.nanotechobservers.com)

[23] [www.wikipedia.com](http://www.wikipedia.com)

[24] [www.nanowerks.com](http://www.nanowerks.com)

[25] [www.technical-textiles.com](http://www.technical-textiles.com)