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Review Article

INFLUENCE OF NANO FINISHES ON THE FUNCTIONAL PROPERTIES OF TEXTILE MATERIALS

***N. Gokarneshan[1], P.P. Gopalakrishnan[2] and B. Jeyanthi[3]**
NIFT TEA College of Knitwear Fashion Tirupur 641606, India
**Author for Correspondence*

ABSTRACT
The article critically reviews the influence of the various types of nano finishes on the functional properties of fabrics so treated. Nano finishes hold the clear advantage over their conventional counter parts, with regard to improvement in specific properties while retaining the other properties and also durability. Functional properties are useful in so many applications, such as medical, uv protection, air filtration etc. Nano particles have been applied on cotton fabrics, there by forming a coating or film and improving the water repellency property. Titanium di oxide nano particles have been applied on cotton fabrics to improve their wrinkle resistance. Silver oxide nano particles have been found to be best suited for imparting anti microbial resistance and also in the treatment of wounds resulting from burns. Anti microbial finishes are intended to protect the wearer of the fabric, but the fabric to as well.Zinc oxide nano particles have been used for UV protection, wherein the method of synthesis affected the UV properties. Titanium dioxide and other compounds have been effectively used to impart flame retardant properties to the fabrics. Polymer based nano composite fibers offer a good substitute to glass fiber for air filtration, which are suitable for defense textile applications. Mixture of titanium di oxide and silver oxide nano particles have been useful for improving the anti microbial, odor elimination and anti static properties of synthetic fabrics. Zinc oxide nano particles have been used in stain elimination of textiles, and have there by rendered suitability in military garments. Use of polymer nano composites have resulted in improvements on multi varied functional applications of textiles. From the discussion it is clear that nano finish on textile materials hold great promise for multi varied functional applications. However their impact on the human body as well as environment need to be well researched before going in for commercialization.

Key Words: *Antimicrobial, Nano Particle, Soiling, UV Radiation, Wrinkle Resistance*

INTRODUCTION

Nano technology has been gaining momentum during the past decade. It has made a significant contribution in the textile arena. It deals with the science and technology at dimensions of roughly 1 to 100 nanometers, although 100 nanometers is the practically attainable dimension for textile products and applications at present (Hoon Joo *et al.,* 20050. The uniqueness of the nano particles has attracted the attention of D34ERTTRW a``researchers. Interestingly enough, textile has been one of the areas where nanotechnology could be applied. Nano particles have been applied to textile materials with the objective of producing finished fabrics with varied functional performances. Nanotechnology makes textile fibres dirt-repellent. Tiny particles measuring less than 100 nano metres on the textile fibres produce a self-cleaning effect. These surfaces are coated with billions of these nanoparticles so close together that a speck of dust wouldn't fit between them. Between a particle of dirt and the surface of the textile fibres, a layer of air is formed on which the impurities ‘hover’ and can simply be washed off with water. Even stubborn dirt is then easy to remove. The nano coating has so far been applied mainly to engineering textiles, such as fabrics for tents, awnings or sunshades. Besides, materials used for work clothing and home textiles will also benefit from this new technology in future. Nano finishes are processes wherein nano particles of metallic origin are synthesized and then applied onto textile substrate to get the desired functional properties to suit various end use requirements.

Nano silver particles have been used for imparting antibacterial properties (Kwon *et al.*, 2002), while titanium dioxide has been used for UV protection and self cleaning properties. Zinc oxide (ZnO) nano particles have been used for antimicrobial properties and protection against UV radiation (Baglioni *et al*., 2003). Nano particles are advantageous as finishing agents for textile materials with conventional finishing agents. In the case of conventional finishes, the properties imparted have less durability. Nano finishes increase the durability of the fabric properties such as wrinkle resistance, stain release, microbial resistance etc. Due to their smaller size and increased surface energy, nano particles impart better properties to the fabric, such as wash fastness, in particular. Zinc oxide has been the most preferred among other types of nano particles owing to their superiority with regard to photo-catalytic, electrical, electronics, optical, dermatological and anti-bacterial properties (Pan *et al.*, 2010. Moreover, it has three unique characteristics, namely, semi conductivity, piezoelectricity, and bio safety compatibility. These special characteristics make zinc oxide the most prospective nano material for future textile research. Silver nano particles have captured attention owing to their good physical and chemical characteristics. They are synthesized by different methods such as chemical, electrochemical, gamma radiation etc (Yakutik *et al.*, 2004). Recently silicone nano finishes have gained popularity with particular regard to their enhancement of fabric hand and thereby improving their aesthetic feel and also imparting an excellent hand (Chattopadhyay *et al.*, 2004). The size induced properties of nano particles enable the development of new applications or the addition of the flexibility to existing systems in many areas, such as catalysis, optics, microelectronics and textile finishes such as fire retardancy, shrink proofing, crease resistance, water and stain resistance, and even water repellency, which could be imparted effectively to cotton while still maintaining its characteristics The application of nano finishes enable ultra strong, durable, and specific function oriented fabrics to be effectively produced for numerous applications such as military, industrial, medical, domestic, apparel, house hold furnishing and many more (Gokarneshan *et al.*, 2010). Nano finishes have been effectively applied to cotton, wool, silk and polyester fabrics. Antibacterial finishes have been applied on cotton, wool, silk and polyester fabrics as well, with the twin objective of protecting the wearer and fabric too. SEM microscopy has been utilized for examining the fabric surface after treatment with various types of nano materials. In the case of nano finishing with synthetic textile materials, the aspects to be considered have been odor elimination, antistatic, and antibacterial properties. Nano particle dispersions have also been used in photonic applications besides textile wet processing (Sawhney *et al.*, 2008). These include improved energy saving illuminants, computer and television displays, solar panels and digital communications. Fluorescent nanoparticles are now being widely utilized for advanced biomedical diagnostic testing. An interesting review has pointed out that the emergence of nano and bio smart/emerging technologies have paved the path towards achieving more economical resource utilization, reduced energy consumption, and decline in pollutant emission (Dawson 2008).

Influence on Functional Properties

Influence on Water Repellency:

Treatment with nano particles improves the water repellent property of fabric by creating nano whiskers that are 1/1000 the size of cotton fiber, and create a peach fuzz effect without lowering the strength of cotton fabric (Wong 2006). The spaces between the whiskers are smaller than the water drop, but larger than water molecules. Hence the water remains above the whiskers on the fabric surface (Schueller *et al.*, 1999). The water repellant property of fabrics is obtained by creating combination of micro and nano whiskers with low surface energy, which are generated by wax crystals in the range of size 10-3 for a typical cotton fibre, which are added the fabric to create a peach fuzz effect. This facilitates like a cushion of air on the fabric surface without lowering the strength of fabric. When water hits on the surface of fabric, it beads on the points of whiskers, the beads compress the air in the cavities between the whiskers creating extra resistance. In technical terms the fabric has been rendered super non wettable or super hydrophobic(less than 45^0 contact angle). The whiskers also create fewer points of contact for dirt. When water is applied to soiled fabric, the dirt adheres to the water far better than it adheres to the textile surface and is carried off with the water as it beads up and rolls off the surface of the fabric.

Another option has been the development of nano sphere. The impregnation of nano sphere with gel forming additives cause water repellency and thereby prevents dirt particles from attaching themselves on to the fabric. The mechanism is similar to the one observed in lotus plant (Cheng *et al.*, 2009). Hydrophobic property could also be imparted to a cotton fabric by coating it with thin nano particulate plasma film, which is a kind of fluorocarbon chemical. The audio frequency plasma of some kinds of fluorocarbon chemical has been applied to deposit a nano particulate hydrophobic film onto a cotton fabric surface to improve its water repellent property. The cotton fabric has been rendered super hydrophobic owing to its rough surface, without any change in its softness and abrasion resistance (Kathirvelu, 2003).

Influence on Wrinkle Resistance:

In the case of conventional finishing, resins have normally been used for imparting wrinkle resistance to cotton fabrics. However, the application of resin imposes limitations, causing a decrease in tensile strength of fibre, abrasion resistance, water absorbency and dye ability, as well as breathability. Hence, later research has been focused on the use of nano titanium dioxide and nano silica (Kathirvelu *et al.*, 2003) in order to improve the wrinkle resistance of cotton and silk fabrics. Nano titanium dioxide has been applied on cotton using carboxylic acid as catalyst and subjected to UV radiation in order to catalyze the cross linking reaction between the cellulose molecules and acid. This helps to improve the resistance of the fibre by strengthening the hydrogen bonds between molecular chains and thereby orienting them in the amorphous regions, and thus prevent the slipping of molecular chains. Nano silica has been applied on silk fabrics using maleic anhydride as a catalyst. This treatment proved effective in improving the wrinkle resistance of silk fabrics.

Influence on Microbial Resistance:

The antibacterial property of untreated and treated cotton, wool and silk fabrics have been evaluated by assessing the loss in breaking load due to soil burial test (Figure 1). The investigations have revealed that treatment with silver nano particles improves the bacterial resistance in all the three types of treated fabrics, which is proved by the loss in breaking load. This could be attributed to the fact that the metallic ions and metallic compounds exhibit a certain degree of sterilizing effect.

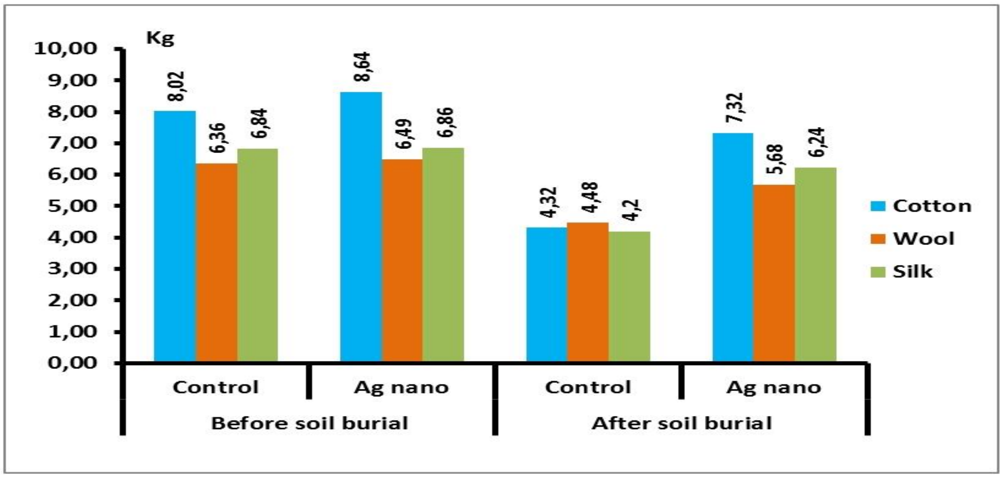

Figure 1: Effect of silver nano particles on resistance towards bacterial attack

This effect arises from the activation of part of the oxygen present in air or water, by catalysis with the metallic ions. This dissolves the organic substance to produce sterilizing effect (Chattopadhyay *et al.,* 2010).

The good improvement in bacterial resistance of fabrics treated with silver nano particles is due to the larger surface area of contact of the nano particles with bacteria or fungi. Moreover, they are reactive to proteins and thereby affect the cellular metabolism and also multiplication and growth of fungi and bacteria that cause infection, odor, itchiness and sores to the wearer of the fabric.

(Chattopadhyay *et al.,* 2010**).** Silver nano particles have been applied on silk fabrics (Song *et al.,* 2001). The nano particles have been produced using a chemical method by reducing silver nitrate with reducing agents such as hydrazine and glucose. Silk fabric has been treated with silver nitrate in acidic pH between 3 and 4. Good antimicrobial activity has been observed against *S.Aureus* and the fabrics have been maintained upto 80% antimicrobial activities after 5 cycles of washing. In yet another interesting recent work (Ghosh *et al*., 2010). Antimicrobial activities have been observed on cotton fabrics by applying meso silver particles and silver chloride compounds (SILPURE). Evaluation has been done on the antibacterial assessment with treated as well as untreated fabrics. The zone of inhibition has been considered and the bacterial growth has been assessed as shown in Table 1.

Table 1: Evaluation of antimicrobial activity for fabrics treated with nano silver (Ghosh *et al*., 2010**)**

Fabric Type	**Growth of *S. Aureus* Under Specimen**	**Zone of Inhibition *S. Aureus* (mm)**
SILPURE-treated cotton fabric	No	1.66
Meso silver-treated cotton fabric	No	1.21
Untreated cotton fabric	Yes	0

When the treated fabrics were made to contact the bacterial culture, the silver particles diffused from the fabric onto the area of bacterial growth. Thus both types of treated cottons showed no bacterial growth in the contacted portions, while the untreated cotton exhibited bacterial growth in the contacted area. Both the treated fabrics exhibited zones of inhibition as indicated in the table above, whereas there was no zone of inhibition in the case of untreated fabrics. This clearly establishes the fact that the treated fabrics show resistance to *S. Aureus* due to the presence of silver.

In a recent study, polyvinyl pyrrlodine (PVP) coated silver nano powder has been applied on wool as well as cotton fabrics (Raja, 2010). The synthesis yielded nano particles in the size range of 50 – 60 nm obtained in powder form. Quantitative tests have been carried out to determine the microbial resistance of wool and cotton fabrics (Table 2). The results indicate that the treated wool and cotton fabrics have 100%, 97% and 99% efficacy against micro-organisms, namely, *S. Aureus, E. coli and P. Aeruginosa* respectively. The antimicrobial efficacy is present in the treated wool fabric even after 20 washes. The increased durability of finish may be due to the ability of PVP present in the silver nano powder to form hydrogen bond with the hydroxyl groups of wool and cotton and coordinate bond with the silver nanoparticles. Thus, the developed silver nano particles in powder form with PVP can be used to provide durable antimicrobial finishing to the textiles in addition to operational benefits such as easy handling, simple method of application and assured presence of nanoparticles without agglomeration. The synthesized PVP coated silver nano powder is useful for application on delicate fabrics, home textiles, knitted goods and wound dressings, etc.

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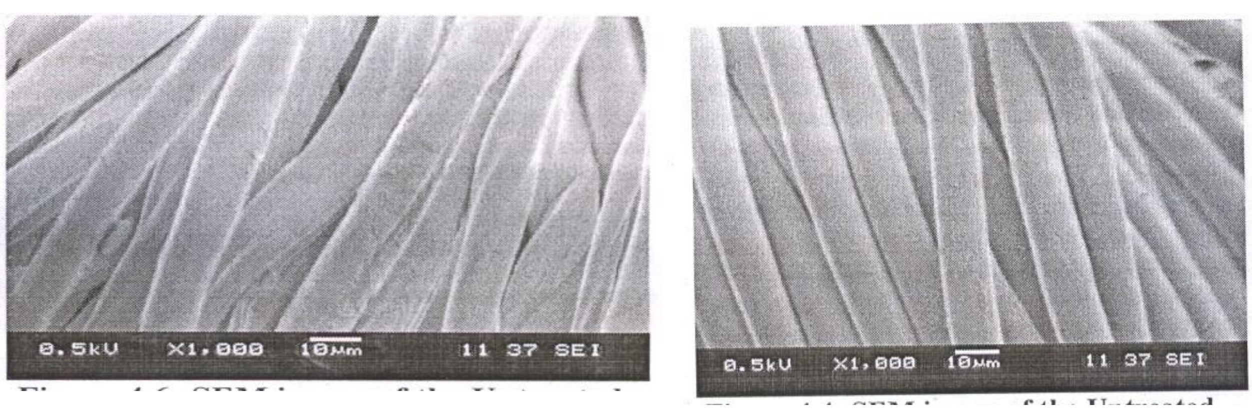
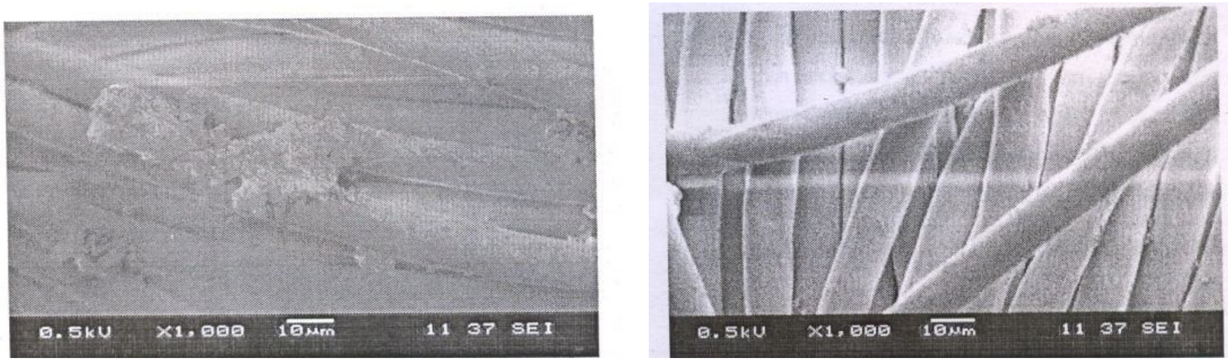
Table 2: Percentage reduction in bacterial count after 24 hour incubation (AATCC 100) (Raja A.S.M *et al.*, 2010)

Bacteria	Sample	At Start	After 24 Hour	% Reduction
S. Aureus	Control	$1.78X10^6$	$8.6 X 10^6$	Nil
	Silver Nano Powder Treated			
	Without Washing	$5.6 X 10^5$	$3.4 X 10^3$	99.96
	After 10 Washes	$5.2 X 10^5$	$3.3 X 10^3$	99.96
	After 20 Washes	$5.07 X 10^5$	$3.27 X 10^3$	99.96
E. *Coli*	Control	$7.3X10^6$	$4.3 X 10^7$	Nil
	Silver Nano Powder Treated			
	Without Washig	$6.5 X 10^6$	$1.36 X 10^6$	96.83
	After 10 Washes	$6.22 X 10^6$	$1.33 X 10^6$	96.90
	After 20 Washes	$6.39 X 10^6$	$1.37 X 10^6$	96.81
P. Aeruginosa	Control	$2.5X10^6$	$3.9 X 10^7$	Nil
	Silver Nano Powder Treated			
	Without Washig	$2.1 X 10^6$	$2.5 X 10^5$	99.35
	After 10 Washes	$2.08 X 10^6$	$2.62 X 10^5$	99.32
	After 20 Washes	$2.2 X 10^6$	$2.8 X 10^5$	99.28



A **B**

Figure 2: SEM image of the untreated 45/55% polyester/cotton fabric (*Parthasarathi V et al., 2009****).*** A - SEM images of the untreated 45/55% polyester / cotton fabric. B - SEM images of the treated 45/55% polyester / cotton fabric treated with Titanium Dioxide (*Source: Parthasarathi et al.,* 2009).



A **B**

Figure 3: A - SEM image of the untreated 100% cotton knitted fabric. B - SEM image of 100% cotton knitted fabric treated with 1% titanium dioxide (Parthasarathi V *et al.,* 2009).

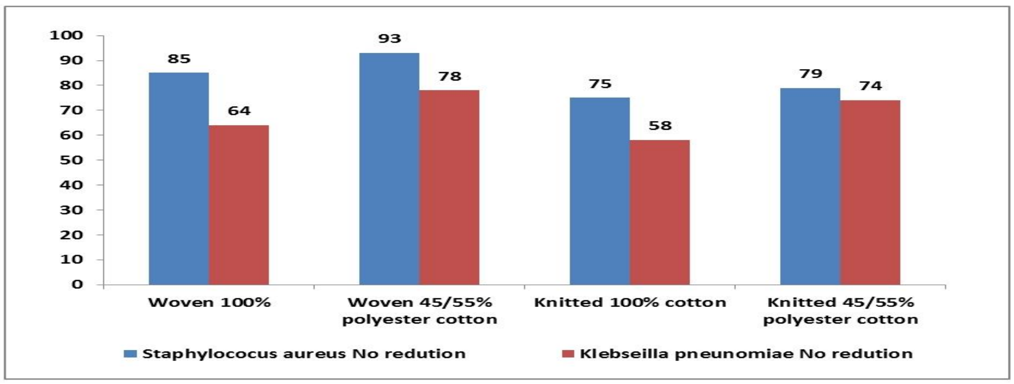


Figure 4: Antibacterial activity of titanium dioxide nano particles treated fabrics (Parthasarathi V *et al.*, 2009)

TiO_2 are preferable to other inorganic forms of titanium because of its higher efficiency in preventing infection. In the control fabric the growth of both *Staphylococcus Aureus* and *Klebseilla Pneunomiae* was found on the fabric as well as surrounding the fabric. In TiO_2 treated fabric there was no bacterial growth on the fabric, but it was found surrounding the fabric. The woven fabrics treated with titanium dioxide exhibit better reduction than the knitted fabrics because of their construction. Among the composition 45/55% polyester/cotton blend shows better reduction than the 100% cotton because of the resistance property of polyester (Figure 4).

The antibacterial activity of the standard as well as the treated fabrics (mixture of nano-TiO_2 and nano-Ag) is shown in figures 5A and 5C, against *S.Aureus*. Figures 5B and 5D, exhibit the antibacterial activity in the case of *E.Coli* (Marija Gorenšek I *et al.,* 2010). In both the cases the test fabrics have been irradiated with UV light for 6 hours prior to evaluation. The figures 5C and 5D clearly indicate that the fabrics treated with mixture of nano-TiO_2 and nano-Ag particle, exhibit a higher level of antibacterial activity, but the standard samples shown in figures 5A and 5B exhibited little or no antibacterial activity. The comparative figures reveal that the circle in the middle area is the fabric sample and the curvi-materials are the bacteria on the standard bacterial liquid. The curvi-material in figures 5A and 5C on the circular area is continuous and clear. This phenomenon indicates that the antibacterial activity of the standard fabric is almost ineffective. The curvi-material in Figures 5B and 5D is disappearing. This shows that in the case of the treated fabric, the antibacterial agent has destroyed the bacteria and thus rendered the fabric significantly effective. It could also be visualized that the UV light irradiation before antibacterial testing could photo-sensitize the nano-TiO_2/nano-Ag to destroy the bacteria.

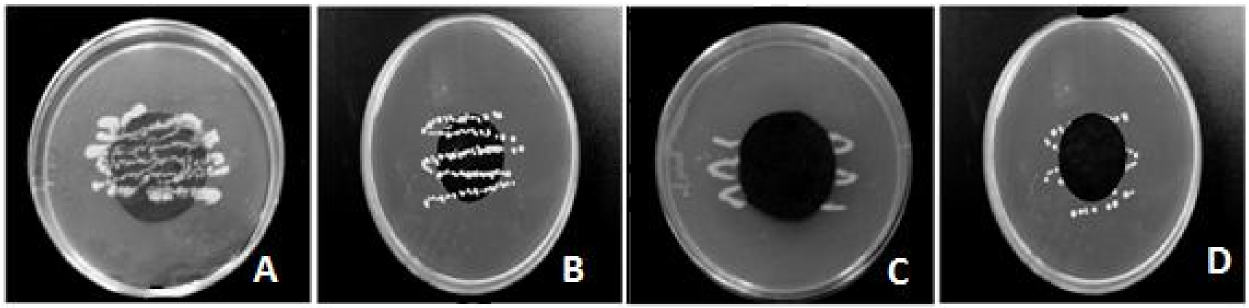


Figure 5: Anti bacterial activity for (A and C) *S. Aureus* and (B and D) *E. coli*. (A and C) Control samples. (B and D) Fabric samples finished with mixed nano-TiO_2/nano-Ag (2.0wt%/125 ppm). *(Marija Gorenšek et al., 2010)*

Washing and abrasion tests have been done to evaluate the anti bacterial activity of fabric samples treated with mixture of nano-TiO_2 and nano-Ag. The test results reveal that the antibacterial activity of treated fabrics decreased with increased number of washes and abrasion. The decrease has been to the extent of 3.5 – 6% after 15 washes and 12-13% after 3000 abrasion cycles. Thus the effectiveness of the nano-TiO_2/nano-Ag/water-borne-polyurethane has been practically proved by the excellent antibacterial, odor elimination, washing fastness and abrasion resistance.

An interesting study reports that nano particle doped textile systems are capable of destructively destroying a variety of chemical agents and can provide comparable levels of protection to existing carbon based systems, but at lower weights (Scott *et al.*, 2009). Due to their small size, high surface area, and destructive chemical capabilities, nano particles represent a major leap in protection capabilities. Work is still needed to validate that these material systems are robust enough to survive the military environment, but initial tests are very positive. If successful, these materials have the potential to meet the holy grail of protective materials, a self-detoxifying material.

A silver based water soluble nano composite has been used both in functional finishing and reactive dyeing/ and functional finishing of linen, cotton and viscose fabrics (Rai *et al.*, 2009). It has been observed that even after 15 cycles of laundering the nano composite as well as its combination with reactive dyes exhibited excellent antibacterial functionality in the case of finished and finished/dyed fabrics. However, the other performance properties of the fabrics have been slightly affected. The increase or decrease in the functional and other properties has been influenced by the type of cellulose substrate.

Silver nano particles derived from metal silver, have regained their stand as a potential antimicrobial agent. As a wide spectrum of pathogenic bacteria have developed resistance to many types of antibiotics, the use of silver nano particles have become even the more important (Ibrahim *et al.*, 2012). Thus silver nano particles have been able to find entry into many medical applications such as silver based dressings, and silver coated medicinal devices (nano gels, nano lotions etc.).

Recently increasing public concern about hygiene has been driving many investigations for anti-microbial modification of textiles. However, using many anti-microbial agents has been avoided because of their possible harmful or toxic effects. Application of inorganic nano particles and their nano composites would be a good alternative (Dasterji *et al.*, 2010). Inorganic nano-structured materials have good anti-microbial activity potential for textile applications. A number of inorganic anti microbial agents are available and these include TiO_2 nano-particles, metallic and non-metallic TiO_2 nano-composites, titania nanotubes (TNTs), silver nano-particles, silver-based nano-structured materials, gold nano-particles, zinc

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oxide nano-particles and nano-rods, copper nano-particles, carbon nanotubes (CNTs), nano-clay and its modified forms, gallium, liposomes loaded nano-particles, metallic and inorganic dendrimers nano-composite, nano-capsules and cyclodextrins containing nano-particles.

Influence on UV Properties

UV blockers are of organic and inorganic types. The inorganic types are more suitable for their non toxicity and chemical stability to high temperature as well as UV radiation (Wong Y.W.H *et al.,* 2006). Inorganic UV blockers include TiO_2, ZnO, SiO_2 and Al_2O_3, which are semiconductors. Among these TiO_2 and ZnO are commonly used (Saito *et al*., 1993). Nano size titanium dioxide and zinc oxide particles have been found to be more efficient at absorbing and scattering UV radiation effectively and thus have been able to more effectively block the UV radiation. This could be attributed to nano particles having larger surface area per unit mass and volume in comparison with the conventional ones, which makes them more effective in blocking UV radiation. According to Rayleigh's theory the scattering of UV radiation between 200nm and 400nm, the optimum particle size will be between 20nm and 40nm (Burniston N *et al.,* 2004). Among the various research works, one such reports on the UV blocking for the cotton materials for sol-gel method. A thin layer of TiO_2 that is formed on the fabric offers excellent UV protection and the effect lasts even after 50 home launderings (Saito *et al*., 1993). Besides TiO_2, ZnO nanorods ranging between 10-50 nm length have been applied on cotton fabrics for UV protection (Daoud *et al*., 2004). The study indicated that the ZnO nanorods have given an excellent UV protection factor.

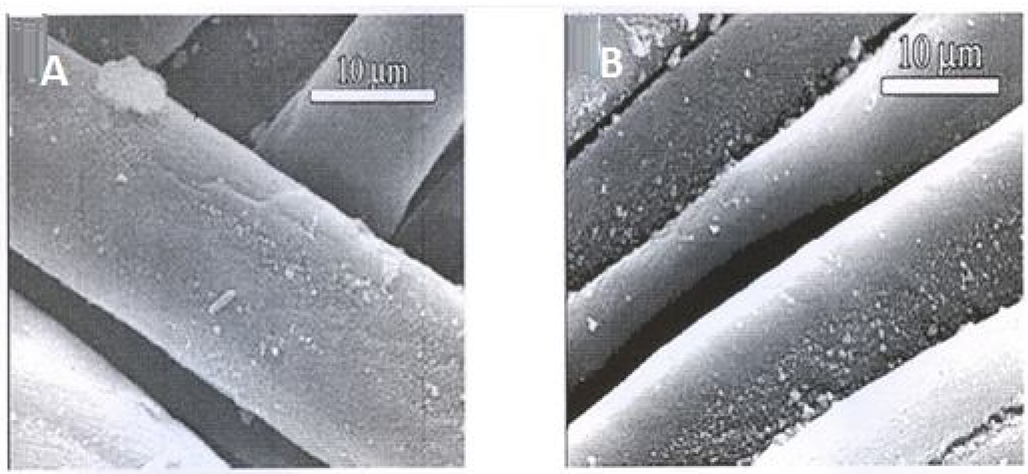

Figure ***6: SEM images of ZnO nano particles on*** **A** - Polyester/cotton before washing and **B** - Cotton after washing *(Kathirvelu et al.,* 2009)

Zinc oxide nano particles have been applied on polyester cotton woven and knits, which have been reactive dyed. Infrared spectroscopy and X ray investigations have revealed that the morphology and size of the nano particles are greatly influenced by the experimental conditions (Kathirvelu *et al*., 2009). Interestingly, the increase in the reaction temperature from 90^0C in water to 150^0C in 1,2-ethanediol has reduced the nano particle size from 20nm to 9nm. SEM studies on nano treated fabrics (Figure 6) show that the ZnO nano particles are well distributed on the fabric surface. The extent of nano particle adhesion to the fibre surface is primarily determined by particle size. The larger nano particles get removed from the fabric surface by washing, while the smaller ones penetrate deeper and strongly adhere to the fabric matrix as revealed through SEM. The average size of the nano particles obtained through one method of synthesis are found to be 20 ± 5 nm and another method of synthesis has been found to be 10 ± 1 nm.

Table 3: UPF values of different samples for UV-A (315-400nm) and UV-B radiations (295-315nm).
(*Kathirvelu et al.*, 2009)

Sample	UPF Value	
	UV-A	**UV -B**
Untreated		
Cotton (woven)	1.05	1.07
Cotton (knitted)	0.98	1.00
P/C blend (woven)	2.30	5.50
P/C blend (knitted)	1.80	4.40
Treated		
Cotton (woven) with z_1	4.92	5.23
Cotton (woven) with z_2	8.45	10.29
Cotton (knitted) with z_1	4.00	4.70
Cotton (knitted) with z_2	8.80	9.50
P/C blend (woven) with z_1	10.23	15.76
P/C blend (woven) with z_2	11.80	16.20
P/C blend (knitted) with z_1	9.62	14.53
P/C blend (knitted) with z_2	11.10	15.87

#Z_1 – ZnO nanoparticles synthesized through synthesis 1.
#Z_2 – ZnO nanoparticles synthesized through synthesis 2.

The UV spectra for nano treated as well as untreated fabrics have been measured with regard to absorption, transmission and reflection. The spectra have revealed that untreated cotton doesn't absorb UV radiation while treated cotton strongly absorbs UV radiation in the region between 200nm-300nm. Nano treated cotton as well as polyester cotton blend fabrics have shown increase in UV absorption over the entire range that has been investigated. The UPF values and the percentage of UV transmission for various types of fabrics are shown in Table 3.
The results indicate higher protection from UV radiation for treated cotton fabrics. Moreover, woven fabrics show better UV shielding properties in comparison with knits. Also P/C blends show better UV absorption in comparison with 100% cotton, owing to the better absorption properties of polyester component in the blend. The results agree with the findings of earlier researchers (Wang *et al.*, 2004). The improvement in UV absorption of the fabric treated with ZnO nano particles opens up the possibilities of protecting the human body against solar radiation and also for other technological applications. The nano finishing with ZnO improves the UV absorption, and also enhances the anti bacterial activity, and self cleaning properties of the fabrics so treated. It thus opens up the possibility of multi functional finishing of textile materials with single treatment.
In yet another novel work, multifunctional properties have been imparted on cotton fabrics, which included UV protection also (Wang *et al.*, 2001). Cotton fabric has been pretreated with a reactant resin, which acted as a cross linking agent. Citric acid has been used as an additive in the presence of $MgCl_2.6H_2O$, as a catalyst followed by drying. This has been followed by loading of TiO_2 nano particles and lastly curing. The cotton fabrics so treated exhibited excellent improvement in UV protection properties besides other properties investigated. A high wash durability has also been observed.
In a novel approach, functional finishes have been imparted to linen fabrics (Ibrahim *et al.*, 2010). The fabric surface has been modified by creation of interactive sites such as –COOH, or –NH_2 groups, through utilization of oxygen or nitrogen plasma. This has been followed by treatment with certain types of ionic

dyes, metallic salts, nano-scale metal or metallic oxides. Such treatment has resulted in fabrics with well improved UV protection properties.

Influence on Flame Retardant Property:

Flame retardant property has been imparted to cotton woven fabric by the use of nano titinaium dioxide, sodium hydrophosphite, maleic acid, and triethanol amine(TEA) by adoption of the conventional pad dry cure method (Lessan *et al.*, 2011). The decomposition behavior of the treated fabrics has been analyzed through thermal gravimetric analysis and differential thermal analysis. Investigations have been done on various parameters that include low oxygen index(LOI), char length, char yield before and after 5 washing cycles, and the whiteness index of the treated cotton fabrics. The results have shown that a 5% increase in the sodium hydroxide increases the LOI from 18.6 to 23. This leads to obtain a lower initial decomposition temperature and a higher char formation. Also presence of 6% TEA greatly prevents the cotton fabric from yellowing during the curing process.

Nano clay has been used in textile applications for a number of functional effects (Ghosh 2011). Nano composite comprise of nano scale clay particles and a surrounding polymer. Though a variety of clay particles are available, montmorillonite is most commonly used in textile coatings. The combination of hardness, scratch resistance and flexibility is a highly desired feature in many coating applications. This can be achieved through the introduction of unmodified clay, montmorillonite (Na+MMT) in a polymer resin based on different textile material. Nano clay has an important role in acting as a flame retardant. The exact mechanism of the combustion inhibition caused by nano clays has not been ascertained. However, it has been presumed that while the polymer matrix is burned and gasified during combustion, the incorporated nano clays accumulate at the surface and form a barrier to prevent oxygen diffusion and thus slow down the burning process.

Influence on Medical Applications (Burn Treatment):

Nano silver has been used in medical applications, particularly in the treatment of wounds resulting from burns. Wound dressings are manufactured by means of a bi-layer of silver-coated, high-density polyethylene mesh with a rayon adsorptive polyester core. The dressing made from nano crystalline silver forms a non-adherent, non-abrasive surface. In vitro studies have shown that the sustained release of this ionized nano crystalline silver maintains an effective anti-bacterial and fungicidal activity. In addition, nano crystalline silver dressings have been clinically tested in a variety of patients with burn wounds, ulcers and other non-healing wounds facilitating wound care by adequate debridement, bacterial and moisture balance.

Wound dressings have also been developed, that combine an electro spun polyurethane nano fibrous membrane and silk fibroin nano fibres. These electro spun materials are characterized by a wide range of pore size distribution, high porosity, and high surface area-to-volume ratio, which are favourable parameters for cell attachment, growth and proliferation. The porous structure is particularly important for fluid exudation from the wound, avoiding wound desiccation, and impairing exogenous microorganism infection.

Influence on Air Filtration:

Presently glass fibers and charcoal are being widely used in air filter applications. The use of glass fibers tends to cause environmental and health problems. Hence eco friendly composite systems based on natural fibers can be used as an alternative to glass fibers. Moreover, the existing filters are unsuitable for the filtration of chemical contaminants. This limitation can, however, be overcome by the use of polymer based nano fibers embedded with nano particles (Gowri *et al.*, 2010). Such fibers would enhance the filtration efficiency, protection duration, non contamination selection efficiency, and weight reduction. It holds promise for defence textile applications where sensing and protection are of prime importance.

Influence on Odor Elimination Properties

Nano finishes have also been applied onto synthetic textile materials for improvement of odor, antimicrobial effect, and antistatic as well. Knitted polyester fabrics have been padded twice with a mixture containing various amounts of nano meter grade titanium dioxide (1.5-3.0 wt%) and silver nano particle(100-200 ppm), which have been thoroughly mixed with water borne polyurethane(5wt%) using homogenizer. The wet pick up has been 90%. The padded fabrics have been dried at 60^0C for 30 min, baked at 120^0C for 8 min, soaped with 1g/l soap at 40^0C for 5 min, washed with distilled water at room temperature for 5 min, and then dried at 60^0C. Such fabrics have been defined as finished/treated fabrics, while those finished with only water borne polyurethane aqueous emulsions have been defined as control fabrics (Chyung-Chyung Wang *et al*., 2009).

The odour elimination and antibacterial property is very essential for hospital applications wherein good hygiene is of utmost importance. Nano titanium dioxide particles have been combined with that of silver to get the desired effect on odour elimination and antibacterial effect, by using water borne polyurethane as the finishing emulsion. The odor elimination ability of the treated fabrics has been evaluated by using three odor chemicals, namely, ammonia gas, acetic acid, and trimethylamine. The results have been compared with those of standard as well as treated samples (Table 4).

The results in the above table indicate that nano-TiO_2 and /nano-Ag particles exhibit better odor elimination properties with both the amounts of particles used and also the duration of the UV light irradiation for the three kinds of odor chemicals. Moreover, the odor elimination value for the standard sample has been relatively lower (<7%). Meanwhile it slightly increased with the increasing of the time of UV light irradiation. The standard sample had only little ability of odor elimination. It may have been caused by the odor absorption among the spaces of the fibre within the fabric sample.

Table 4: Odor elimination values of treated fabrics *(Chyung-Chyung Wang et al., 2009)*

Types of Odor	UV Irradiated Hours	Control	Kinds and Concentrations of Particles					
			Nano–TiO_2 (1.5 wt %)	Nano– TiO_2 (2.0 wt %)	Nano– TiO_2 (3.0 wt %)	Nano – Ag (125 ppm)	Nano – Ag (200 ppm)	Nano–TiO_2 (1.5 wt%) / Nano – Ag (125 ppm)
Ammonia	0	2.7	3.0	-	-	3.5	-	3.5
	0.5	3.5	44.4	54.5	62.7	10.9	16.7	61.0
	1	5.2	56.8	70.6	71.2	14.9	24.0	86.8
	1.5	6.7	64.1	75.0	74.8	20.2	30.9	91.5
Acetic Acid	0	1.5	1.8	-	-	1.8	-	2.2
	0.5	2.2	34.5	43.3	54.4	8.9	13.3	57.8
	1	3.7	58.3	66.6	70.0	13.8	20.4	86.5
	1.5	5.2	61.8	71.8	74.8	17.2	25.1	89.1
Trimethyl Amine	0	3.0	3.0	-	-	3.3	-	3.5
	0.5	3.8	31.2	45.0	53.0	8.7	14.5	49.7
	1	4.6	40.4	53.0	57.5	10.7	18.8	57.9
	1.5	5.4	45.9	56.3	61.3	13.1	22.5	63.4

Influence on Stain Elimination Properties

ZnO nano particles have been applied on cotton and polyester/cotton fabrics, so as to assess their stain elimination function (Kathirvelu *et al.*, 2010). A setback with the ZnO is that it is very ineffective in utilizing the energy from the sun, and as a consequence the fabrics so treated require more time to breakdown the stains. It acts as a catalyst by breaking down the dirt molecules and generates electrons that ionize the oxygen present in the air. The ZnO nano particles release the electrons by means of the photoelectric effect. In the solar spectrum, only 3% is being utilized by the high energy blue and UV light. Hence a very small portion of the solar spectrum is available for the ZnO nano particles in order to breakdown the stains.

The cleaning process commences with the excitation of electrons to the conduction band. The electrons so excited should react with the oxygen atoms in the air, which in turn should react with the dirt particles. The amount of electrons freed from ZnO nano particles, and also their accessibility, influence the reactions that take place. In the case of big stains, a great deal of energy is required in order to enable the fabric to completely break it down. The ability of the stain eliminating fabrics to break down the organic compounds is restricted by a number of factors. Sunlight provides the best means for the stain elimination process. A deeply stained garment should be exposed for a complete day so as to remove the stain. However, the stain elimination garment would be ideally suited for military applications, wherein the garment exposure to sun is for long periods. Stain release test results of untreated as well as treated fabrics are given in Table 5.

The test results indicate that in the case of untreated cotton knit, the stain release effect is poorest, as it is bulkier than the woven fabric. In the case of untreated cotton woven fabric and untreated p/c knit, the stain release effect is found to be the same as is indicated by the ratings. The untreated p/c woven fabric rates the best among all the untreated fabrics so studied. The blended fabrics exhibit better stain release effect in comparison with their cotton counterpart, due to the hydrophobic nature of the polyester component in the blend. The stain release rating shows a considerable increase from 3 – 7 with regard to untreated as well as treated cotton wovens. A similar trend is observed in the case of untreated and treated cotton knits, wherein the rating increases from 2 – 6. Similar trend is also observed in the case of p/c woven's where the ratings increased from 4 – 8, and in the case of p/c knits (untreated and treated) the same trend is again observed (3 - 7).

Table 5: Stain - release rating for the different fabrics *(Kathirvelu et al., 2010)*

Test Method: AATCC 175* Stain-Release Test Result Values of			
Fabrics	Untreated Fabrics	Fabrics Treated with ZnO Particles of Synthesis 1	Fabrics Treated with ZnO Particles of Synthesis 2
100% cotton (woven)	3	7	8
100% cotton (knitted)	2	6	7
P/C-blend (woven)	4	8	9
P/C-blend (knitted)	3	7	8

*Note: *The fabrics are exposed to direct sunlight for 15 min before simple rinsing with water.*
Rating, 1 = severe staining (poor stain release); 10 = no staining (the best stain release).

The results ultimately indicate that the improvement in stain release effect is same in cotton and p/c fabrics and so also wovens and knits. The studies ultimately point out that the application of ZnO nano particles improves the stain release effect on fabrics so treated, irrespective of the type of material and the fabric structure. However, the method of synthesis of nano particles influences the extent of stain release. The method of synthesis causes change in the size of the nano particles, which in turn changes the surface area of contact. In the case of fabric treated with smaller nano particle size, the surface area of contact is increased, which increases the photo catalytic activity and there by improves the stain release effect.

Polymer Nano Composites in Multi Functional Finishes

Polymer nano composites have been produced through the introduction of inorganic nano particles as additives into polymer solutions (Ibrahim N.A *et al.*, 2010). The polymer nano composites so produced have shown enhanced improvement in a number of functional properties. Some of the most effective ones are moisture management, hydrophobic/water repellency, UV protection, antimicrobial and antistatic finishes. The application of nano composites in textile applications holds good promises. One is the improvement in functional properties and performance of existing materials. The other possibility is the production of textiles with combined functional properties and also increases the safe use of nano particles in technical textiles. It also opens up the opportunities for textile sensors.

Environmental and Health Considerations

The promises of nanotechnology are high for the unique, specific behavior, and properties at nano scale, which can lead to exceptional new products and more environmental friendly processes and several drivers are promoting its use in the textiles and clothing sector such as technology innovation, demand for advanced products, enhancement of competitive position. However, there are also barriers which can hamper their success such as the transfer of the scientific results from the lab to production, the existence of competing technologies, the lack (sometimes) of adequately skilled people, the possible hazards associated with the use of nanotechnology. The latter is a particular important issue and the evaluation of the potential risks associated with nano-related textile products and processes along their entire lifecycle is a task of fundamental importance to be dealt with. At present, there are not specific regulations for nanotechnology nor nanotechnology-related textile products. Much of the concern is focused on "free" engineered nano materials and their effects on the environment, health and security (EHS). The European Commission also shows this, highlighting that, with the necessary adaptations for nanotechnologies, existing regulatory schemes can go some way in regulating the emerging field without constraining the growth too much. With this in mind, the focus is more on the improvement of instruments to ensure compliance with existing legislation. The combination of existing regulations and voluntary measures, remaining vigilant and proactive to find appropriate and proportionate actions, can be accepted as transitory solution. However, the request for specific regulation for nano-technology related products is mounting and the initiatives in the textile sectors (as well as those in other sectors) will have to confront with the evolution on that matter. Drivers and barriers have a different impact depending on the sector of application. The cost-benefit dilemma will always come into play. Which of the two will prevail will determine the rate of success.

Like any new technology, nano materials carry with them potential both for good and for harm. The most salient worries concern not apocalyptic visions, but rather the more prosaic and likely possibility that some of these novel materials may turn out to be hazardous to our health or the environment. Even naturally occurring nano particulates can have a deleterious effect on the human body. If natural nano particulates can harm us, we would be wise to carefully consider the possible actions of engineered nano materials . The size of nanoparticles also means that they can more readily escape into the environment and infiltrate deep into internal organs such as the lungs and liver. Adding to the concern, each nano material is unique. Although researchers have conducted a number of studies on the health risks of individual materials, this scattershot approach cannot provide a comprehensive picture of the hazards—quantitative data on what materials, in what concentrations, affect the body over what timescales

Despite holding promises for the textile industry, there are some restrictions and unknown health risks relating to the rapid growth and development of nano technology. For instance, it is extremely difficult and complex to process carbon fibers <200nm with traditional textile practices and procedures (Sawhney *et al.,* 2008). There are doubts regarding safety of personnel involved in production, conversion and even use of nano fibers and their products about their short and long term health risks, particularly the probable risks of pulmonary diseases due to the nano size of the particles involved.

A number of studies have been carried out on the toxicological properties of nanoparticles. Although the various toxicological aspects and the diversity of the nanomaterials assessed are just beginning, many deleterious effects have been documented, particularly in animals. Insoluble or low solubility nanoparticles are the greatest cause for concern. Several studies have shown that some of them can pass through the various protective barriers of living organisms. The inhaled nanoparticles can end up in the bloodstream after passing through all the respiratory or gastrointestinal protective mechanisms. They are then distributed in the various organs and accumulate at specific sites. They can travel along the olfactory nerves and penetrate directly into the brain, just as they can pass through cell barriers. These properties, extensively studied in pharmacology, could allow organic nanoparticles to be used as vectors to carry medications to targeted body sites. The corollary is that undesirable nanoparticles could be distributed throughout the body of exposed workers. Some of these nanoparticles have shown major toxic effects.

Given the many unknowns related to nanoparticles, their potential health effects and the documented toxicity risks of ultrafine particles in humans, the establishment of strict prevention procedures is still the only way to prevent any risk of development of occupational diseases. The populations potentially exposed to nanoparticles should be prudent and apply safe measures of source elimination, exposure control and individual protection, both in production and in implementation and use of these products.

From all discussions it comes to conclusion that nanotechnologies; production and application is not without risk for health and environment. It can create severe issues during its application in technical textile production. It may be during application or while wearer uses it. There are more chances of passing nano-particles through all body filters and react with cells in different parts of body. It is recommended that we should be more careful and should watch negative impact of nanoparticles in producing technical textiles.

CONCLUSION

As already seen in the previous discussions, each type of nano material produces its own distinct effect on the fabrics so treated. The treatment with silver nano particles improves antimicrobial resistance. PVP coated silver nano particle is found to be useful for application on delicate fabrics, home textiles, knitted goods, home textiles, etc. Fabrics treated with nano zinc oxide particles have been found to significantly improve UV absorption capacity, besides improving the antibacterial and self cleaning properties. The UV properties can be utilized for protection of the body against solar radiation and for other technological applications. The improvements in other properties suggest the possibility of multifunctional finishing of textiles with a single treatment. Nano titanium dioxide treated woven and knitted fabrics have shown excellent antibacterial activity against some specific bacterium types. In the case of PET fabrics, the value of odor elimination, ultra violet light transmission, and antibacterial for the mixture of nano-TiO_2 and nano-Ag was higher than the summed value for the individual nano-TiO_2 and nano-Ag. The odor elimination ability for individual nano-TiO_2 was better than the individual nano-Ag, but the antibacterial activity was found to follow the opposite trend. Thus the recent research findings hold promises in varied technical applications such as medical, sportswear, defence textiles etc., in the near future. However, ecological considerations need to be carefully weighed before popularizing the nano finishes on textile substrates. The effects on the human body also need to be closely investigated.

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