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Review Article

Nano-Finishing of Animal Fibers: A Review

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Abstract

The advent of nano-technology is increasingly gaining a significant role and contribution in the development of numerous scientific disciplines. The introduction of novel materials and the achievement of higher performance standards in the functionality of known materials are emerging using the nano-technology. Production of fibers with nano-meter sized diameter provided opportunities to innovate and achieve novel or enhanced performance standards in animal fibers. Nano-particles that are currently in use are based on nano-clays, carbon nano-tubes, carbon nano-particles and metal hydroxide. A range of functional properties of fibers in terms of antimicrobial activity, wrinkle resistance, flame retardancy, water proofing, UV- blocking, self-cleaning and static free are achievable. Currently the developments are in progress and a number of areas potential to offer value addition demand more research studies.

Keywords: Nano-finishing, Fibers, Whiskers, Nano-particles, Nano-tubes, Wrinkle, Static

INTRODUCTION

Nano-technology is the branch of science and engineering devoted to designing, producing and using structures, devices and systems by manipulating atoms and molecules at nano-scale, i.e. having one or more dimensions of the order 100 nano-meters (100 millionth of a millimeter) or less (Faheem Uddin, 2008). The technology works at the molecular level, atom by atom to create large structures with improved molecular organization. Fiber finishing is a term commonly applied to different processes that the fiber material undergoes after pretreatments to enhance their attractiveness and sale appeal as well as comfort and useful finish. The technology makes textile fibers

multifunctional. With the help of nano-finishing, we can create, alter and improve textiles at the molecular level which enhances their durability and performance (Patra and Gouda, 2013).

APPLICATIONS IN TEXTILES

Various applications of nano-technology in textiles are water repellence, ultra violet protection, antibacterial, anti-static, wrinkle free, anti-pollen, self-cleaning and flame-retardant properties.

NANO-PARTICLE STRUCTURES

There are three main structures of nano-particles:

- Nano-whiskers
- Nano-net
- Nano-wrap

NANO-WHISKERS: Nano-whiskers are needle like cellulose crystals (10-20 nm) in width and several hundred nanometers in length produced by strong acid hydrolysis to remove non-cellulosic components from the source materials. They show water and oil repellency, superior durability, breathability, wrinkle resistance and keeps fabric soft and natural.

NANO-NET: Nano-net is a net with fibers on the scale of nano-meters. They are produced by dissolving nano-particles into deionized water in close flask, magnetically stirred and heated upto 60-80°C. It wicks body moisture fast. It dries quickly and gives the cooling effect.

NANO-WRAP: It comes in the form of wrap nano sheets which cover up the fibers completely making the fabric durable and strong. It improves static resistance, colour fastness and crease retention (Patra and Gouda, 2013).

SYNTHESIS OF NANO-PARTICLES

There are two ways to synthesize nano-particles:

Top-down approach: It involves breaking down the bulk materials to nano-sizes. Eg Mechanical alloying.

Bottom-up approach: In this the nano-particles are made by building atom by atom. Eg Inert gas condensation.

WIDELY USED METHODS TO PRODUCE NANO-PARTICLES

There are five widely used methods to produce Nano materials:

1. Plasma arcing
2. Chemical vapor deposition
3. Electro deposition
4. Sol-gel synthesis
5. Ball milling

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In the first two methods, molecules and atoms are separated by vaporization and then allowed to deposit in a carefully controlled and orderly manner to form nano-particle. The electro deposition involves a similar process, since individual species are deposited from solution. The sol-gel synthesis, a colloidal suspension is formed due to hydrolysis and polymerization reactions of the precursors, which on complete polymerization and loss of and loss of solvent leads to the transition from liquid sol into a solid gel phase. In ball milling, macro crystalline structures are broken down into nano-crystalline structure (Raut *et al*., 2016).

COATING OF NANO-MATERIALS ONTO TEXTILE FIBERS

Coating is a common technique used to apply nano-particles onto textiles. The coating composition that can modify the surface of textiles are usually composed of nano-particles, a surfactant, ingredients and a carrier medium. Spraying, the coating composition is sprayed on to textiles, with the control of the depth and targeting to specific areas. Transfer printing such as rotary, flexography and inkjet printing. Washing, accomplished by using a washing solution coating nanoparticles during wash or rinse cycles in a washing machine. Padding, where nano- particles are attached to the fabrics with the use of padder applied under pressure. Nano matrix by which a functional material nano scale coating on each of monofilaments that forms a woven or knitted fabric is possible. Plasma assisted coating by which uniform coating of nano-particles without dispersion of nano-particles in liquid is possible which avoids problem of nano-particles agglomeration during dispersion (Raut *et al*., 2016).

NANO-TECHNOLOGY APPLICATIONS IN FIBERS

Due to advancement of nano-technology in the manufacturing of fibers/yarns including the development of fabric finishes, the applications and scopes are widespread in the area of textiles for the last few decades.

WATER-REPELLENCE:

The water repellent property of fabric can be improved by creating nano-whiskers, which are hydrocarbons and 1/1000 of the size of a typical cotton fiber, that are added to the fabric to create a peach fuzz effect without lowering the strength of cotton. Combination of TiO2, ZnO, Fe7O3 nanoparticles are used. Water has high surface tension and the attractive force between the molecules of water enable to form droplets when forced through a fine hole. When water is placed on a solid surface, if the attractive force of the molecules of the solid surface is greater than the attractive forces between the water molecules, water will not spread on those surfaces (Raut *et al*., 2016).

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SELF-CLEANING:

There are basically two types of stain eliminating surfaces involving nano-technology. First one, rough surfaces can be high waterproof. Dirt particles can be held by these kinds of surfaces and can be easily moved away by a simple rinse of water. The second one has a surface by photo catalytic layers. Nano-sized Ag, TiO2, and ZnO are generally used in order to obtain stain proof property. Metallic ions and compounds play an important role in sterilizing effect due to the fact that part of the oxygen in the air or water is turned into active oxygen by a catalyst containing the metallic ion, thereby destroying the organic substance to create this sterilizing effect (Raut *et al*., 2016).

UV-PROTECTIVE FINISH:

To impart UV- protection, several nano compounds or nanoparticles can be applied on fabric material. Inorganic UV blockers are more preferable to organic UV blockers as they are non-toxic and chemically stable under exposure to both high temperatures and UV. Organic ones have potential ability to penetrate the skin and capability to affect body hormone activity. Inorganic UV blockers are usually certain semiconductor oxides such as TiO2, ZnO, SiO2 and Al2O3 (Gowri *et al*., 2010).

ANTI-BACTERIAL FINISH:

For imparting antibacterial properties, nano-sized silver, titanium dioxide and zinc oxide have been used so far. Nano-silver particles have an extremely large relative surface area, thus increasing their contact with bacteria or fungi and vastly improving their bactericidal and fungicidal effectiveness. Nano-silver is very reactive with proteins. When it comes in contact with bacteria and fungus, it adversely affects cellular metabolism and inhibits cell growth (Gowri *et al*., 2010).

ANTI-STATIC FINISH:

A static charge generally develops in synthetic fibers (like polyester and nylon), as they engross less water. Cellulosic fibers provide increased dampness due to carrying static charges to prevent any static charge to accumulate. Because artificial fibers provide distressed static free characteristics, the study showed that nano TiO2, ZnO whiskers, nano ATO, and silane nanosol could provide static free characteristics to artificial strands. ATO, TiO2, and ZnO deliver static free outcomes as these possess electrical conducting properties. Whereas, silane nanosol increases antistatic characteristics because the silane gels on fiber engross humidity in the water and air regarding amino and hydroxyl groups and constrained water. The anti-static procedure can get rid of regular method limitation where the anti-static agent can be effortlessly diminished after a couple of laundries (Gowri *et al*., 2010).

WRINKLE-FREE FINISH:

Resin is generally utilized to add wrinkle resistance to a piece of fabric. The limitations for applying resin include a reduction in the fiber tensile strength, water permeability, dye properties,

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abrasion resistance and breathing ability. For this, multiple researchers have used nano-TiO2 and nano-silica for recovering the wrinkle defiance of silk and cotton. The outcome showed nano-silica used as a catalyst with maleic anhydride can effectively recover the wrinkle resistance of silk (Gowri *et al*., 2010).

ANTI-POLLEN FINISH:

It is claimed that particles of 30 nm sizes are attached to the surface of yarns thus the smoothness of the finish on the surface and the antistatic effect does not let pollen or dust come close.

FLAME RETARDANT FINISH:

NYACOL nano-technologies has developed colloidal antimony pent oxide which has been applied for flame retardant finish in fabrics owing to its very high thermal stability. Nano- antimony pent oxide is used with halogenated flame retardants for a flame-retardant finish to the garments (Raut *et al*., 2016).

DISADVANTAGES OF NANO-FINISHING OF FIBRES

It raises environmental concerns because various chemicals used in the production of nano-particles can leach from the final products and find their way into the water sources after washing of the textiles. Garments manufactured under different conditions may have different stabilities and durability and so lose material at different rates (Chakrabarty and Jasuja, 2022).

MEASURES TO BE DONE

Public needs to be educated regarding the proper washing methods and encouraged to use low temperature, low agitation washing with an appropriate organic detergent.

Recycling the processed textile will decrease the production and release of toxic nano-materials from disposal.

Concerns regarding health risks of the workers need to be addressed.

MARKET PLACES OF NANO-TEXTILE FIBERS

Degussa Japan based company produces nano-particles which gives hydrophobic self-cleaning surfaces to textile.

Schoeller textiles –AG, Switzerland base company developed water repellent fabrics using nano-sphere technology.

A self-cleaning cotton fabric known as nano-care was developed and is marketed by an American company nano-tex, and stain resistant jeans and khakis also produces water repellent cotton surfaces by modifying the cylindrical structure of the cotton fabrics then by applying nano-particles on fabric (nano-sphere technology) which creates nano whiskers.

Ciba specialty chemicals developed microcapsules of nano-particles which releases antimicrobials during dyeing or finishing processes.

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Hyosung R&D private institute developed a nano-silver containing nylon fibers which can use for sports and military applications.

Nano-horizons (US) produces nano-silver coated sports clothing.

Kanebo spinning, Japan produces polyester yarn with 20 layers (50 nanometers) to absorb moisture.

Also, Toray Industries INC, Japan developed ultra-fine nanometer nylon threads with superior moisture absorption properties.

CONCLUSION

Nano-technology, an emerging technology is no longer just a vision for the future but a ubiquitous technology with a lot of potential to impact on every aspect of modern technology.

Nano-technology, with all its challenges and opportunities, is an unavoidable part of our future. The possibilities with it are immense and numerous.

Nano-finishing can be described as a "Synonym for Innovation".

REFERENCES

Chakrabarty, S. and Jasuja, K. (2009). Applications of nanomaterials in the textile industry. *In book: Nanoscale Engineering of Biomaterials-Properties and Applications*, DOI: **10.1007/978-981-16-3667-7_20**.

Uddin, F. (2008). Some aspects in textile nanofinishing. *Conference: The 86th Textile Institute World Conference. Vol:* Proceedings, ***86***.

Gowri, S., Almeida, L., Amorim, M. T. P., Carneiro, N., Souto, A. P. and Esteves, M. F. (2010). Polymer nanocomposites for multifunctional finishing of textiles- a review. *Textile Research Journal*, **80** (13): 1290-1306.

Patra, J. K. and Gouda, S. (2013). Application of nanotechnology in textile engineering: an overview. *Journal of Engineering and Technology Research*, Vol. **5**(4), 2006-9790.

Raut, S. B., Vasavada, D. A. and Chaudhari, S. B. (2016). *International Journal on Textile Engineering and Processes*, Vol. **2**, I. 4, 2395-3578.

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