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Application of Nano Silver Particles on Textile Materials for Improvement of Antibacterial Finishes

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Abstract

The article reviews the role of nano silver particles in improving the antibacterial properties of textile materials. Efforts have been directed at the extracellular synthesis of highly stable silver nano particles for the development of nanosafe textile using the extracts of yellow papaya peel. Owing to their potent antibacterial activity, papaya peel derived silver nanoparticles can be incorporated into fabrics and the textile producers can make textiles free from spoilage from micro organisms. Silver nano particles have been synthesized through biological approach using natural extracts of *Acalypha indica* and applied onto cotton fabrics. Even a mere 5% treatment with herbal extracts showed superior antibacterial activity indicating usage in medical and infection prevention applications. Silver nano particles have been synthesized by the reduction of silver nitrate with sodium borohydride in an aqueous medium. The silk protein sericin extracted from the silk worm cocoons has been used as effective capping agent. The silver nanoparticles exhibit antimicrobial properties when applied onto silk fabric without significantly changing its color. In yet other interesting research nano chitosan particles have been coupled with nano silver colloid to improve the antibacterial properties of cotton fabric.

Keywords: Antibacterial property; Silver nano particles; Cotton; Silk; Nano Chitosan; Herbal extract

Introduction

Nano particles have a wide range of applications such as electronics, catalysis, chemistry energy and medicine and have thus gained commercial acceptance [1]. Besides improving their functionality, the use of nano technology can result in the production of textiles with completely novel properties or the combination of various functions [2]. Such multifunctional textiles include antistatic textiles, reinforced textiles, antibacterial, self cleaning textiles, bleaching resistant, etc. and paves the way for the use of its products in other fields outside the traditional industries [3-5]. Silver nano particles due to their strong and wide spectrum of antimicrobial activities have gained major focus among all nano particles. In order to protect against microbial contamination, silver has been incorporated into various forms of plastics such as catheters, dental material, medical devices, implants and burn dressings. These nano particles have also been used for durable finish on fabrics. As bactericides, the silver nano particles may help in solving the serious antibiotic resistance problem.

Papaya peel derived silver nano particles

Of the various techniques of nano particle synthesis available, the green synthesis technique holds advantage in controlling particle size and morphology very effectively. When compared with other conventional techniques this technique is convenient and fast. Due to their potential antibacterial activity, papaya peel derived silver nano particles can be incorporated into fabrics and the manufacturers can make textiles free from spoilage by microorganisms [6]. The significant reduction in reaction time with fruit peel extract is an important result and will enable nanoparticle biosynthesis methods to compete with other routes for the formation of nanoparticles that are currently much more rapid and reproducible.

Several strategies have been employed for the synthesis of silver nano particles including chemical techniques, physical techniques and recently, via biological techniques [7]. Biological techniques have received much attention as a viable alternative for the development of metal nanoparticles [8]. Many bacterial as well as fungal species have been used for silver nano particle synthesis [9,10]. But most of them are reported to accumulate silver nanoparticles intracellularly. On the contrary, plant extract mediated synthesis, i.e., green synthesis always takes place extracellularly, and the reaction times remain very short as compared to microbial synthesis. Extracts of many plants and weeds have shown the potential of reducing silver nitrate

for the formation of silver nanoparticles without any chemical ingredients [11,12]. Various parts of the papaya plant have been used including flower and fruits are used for the synthesis of silver nano particles. Some reports relating to the use of silver nano particles using peel extracts are available. For the first time the potential of the peels of yellow papaya as non toxic biological systems for the biosynthesis of green silver nano particles have been used.

Application of nano chitosan coupled with nano silver colloid

\Ionotropic gelatin with pentasodium tripolyphosphate is employed for the preparation of nano chitosan dispersion. Nano chitosan together with nano silver treatment when applied on cotton fabrics shows enhanced antibacterial activity [13]. An enhanced antibacterial property is observed with the reduction of nano chitosan particles and when coupled with nano silver colloid.

Chitosan holds promise in varied application such as biomedical, waste water treatment, cosmetics, dentrifices, food, agriculture, pulp and paper, and textile industries [14-16]. This is because it has many valuable inherent properties like antibacterial, antifungal, antiviral, antacid, non toxic, total biodegradability, biocompatibility with animal and plant tissues as well as film formation, fibre formation and hydrogel fibre formation properties. By virtue of its bacteria impeding property, chitosan can prevent garments develop bad odour [17-22]. It is found that complete inhibition of *Eschirichia coli* and Hay Bacillus bacteria is possible by treatment of cotton with 0.5gpL chitosan concentration [23].

Silver nano coating on cotton fabric adopting green approach

Biosynthesized sliver nanoparticles using *A. indica* leaf extract has been coated over cotton fabric through *in-situ* chemical reaction. SEM image, UV spectra proved the formation of sliver nanoparticles. The biological approach is a cost effective method as compared with the chemical synthesis [24]. Further it is proved that the sliver nanoparticles coated cotton fabric exhibit effective antimicrobial effect against microorganism. Finally the 5g *A. indica* leaf extract produces highest antimicrobial effect and release properties as compared with 3g and 4g leaf extracts. Due to the highest control release properties of this coating utilized for wound healing dressing.

Over the last few decades, various research work was happening around the world made to produce antibacterial coated textile materials due to the enormous growth of microbial infections via textile surfaces [25,26]. Attempts have been made to develop a non-toxic, cost effective and eco-friendly source of antimicrobial finishing textiles for health care application. Cotton fibres are mostly utilized as raw material towards medical and healthcare products [27]. However the moisture absorbability of cotton fibres is very high, which makes them more prone to microbial attack under certain conditions of humidity and temperature. Cotton may acts as a nutrient, becoming suitable medium for bacterial and fungal growth [28]. Therefore, cotton fibres are treated with numerous chemicals to get better antimicrobial cotton textiles [29-31]. Among the various antimicrobial treatments, nano material based treatment is very effective. Silver nano particles (AgNPs) have shown strong inhibitory and antibacterial effects [32].

It has been reported that strong toxicity of silver nanoparticle against wide range of microorganisms is well known [33]. Further the antimicrobial activity of silver nanoparticles against *Escherichia colli's* a model of Gram-negative bacteria has been studied. Chemical reducing method is one of the important technique followed in synthesis of sliver nano particles, which is normally associated with environmental toxicity [34].Therefore the development of sliver nano particle through natural extract is consider as most important method. Biosynthesis of silver nanoparticles using bacteria, fungi, yeast and plants were well documented.

Mechanism of reaction

Disc diffusion technique has been used to assess the antibacterial activity of *A. indica* silver nano particles against both against Gram positive and Gram negative pathogenic microorganisms. The antimicrobial activity of the coated silver nano particles on cotton fabrics has been measured as zone of inhibition. Silver nanoparticles displayed almost similar range of antimicrobial activity against studied pathogens, which was understood through diameter of inhibition zone. Many studies have concluded the biocidal properties of silver nano particles against microorganisms. It is believed that the silver nano particles attach the negatively charged cell surface, then change its physical and chemical properties of the cell membranes and the cell wall and disturb the permeability and osmoregulation, electron transport and respiration [35]. Secondly the silver nanoparticle produces further damage by permeating into the cell, interact with the DNA [36]. Thirdly, the silver nanoparticle releases the silver ions producing higher biocidal effect on the microorganisms.

Use of silk sericin in the synthesis of silver nanoparticles

Sericin extracted by a simple procedure from the cocoons of silk worms has been used effectively in the preparation of silver nanoparticles as a capping agent. Sericin effectively prevents coagulation of the silver nano particles and keeps them in a moderately stabilized condition in an aqueous medium [37]. The spherical particles of average size 15nm are fairly monodispersed. Further, the sericin-capped silver nano particles when applied to silk fabric impart antimicrobial properties to it. As silver nano particles are very small, have high surface energy and are unstable, capping agents should be used to capture them in the early stage of reaction and these include pvp, gelatin,

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polyglutamic acid, sophorolipids, mixtures of different agents, and pva [38-43].

Earlier, during the preparation of silver nano particles, silk protein fibroin has been used as reducing and capping agent [44]. Recently sericin has attracted attention since it has useful properties and has many areas of applications [45,46]. Attempts have been made to prepare even smaller sized silver nano particles using sericin as the capping agent. After application of the nano particles on silk fabrics the antimicrobial efficiency of the nano particles has been confirmed. The treated silk fabric exhibits no significant change in colour, despite the yellow colour of the solution, and this has been found to be an improvement over the earlier method [47].

Conclusion

Among the various types of metal oxide nano particles used in textile finishing, silver oxide has assumed more prominence, more particularly for its very good antimicrobial property. Papaya peel derived silver nano particles, owing to its potent antibacterial activity can be incorporated into fabrics and the manufacturers can render textiles free from ruination by microorganisms An important finding is that there is a considerable decrease in reaction time with fruit peel extract which would help in nanoparticle biosynthesis methods to compete with other methods of formation of nano particles which are presently far more rapid and reproducible. Biological approach involving biosynthesized silver nano particles using *A. indica* leaf extract proves to be a cost effective method in comparison with the chemical synthesis method.

Also, the silver the cotton fabrics coated with silver nano particles show effective antimicrobial effect against microorganism. This coating is being used in would healing dressing owing to the highest control release properties. Nano chitosans have been synthesized by ionic gelation of pentasodium tripolyphosphate and chitosan. The cotton fabric have been pretreated with normal and nano chitosan solutions by pad dry cure technique. An enhanced antibacterial property is observed with the reduction of nano chitosan particles and when coupled with nano silver colloid. Silver nanoparticles have been synthesized by the reduction of silver nitrate with sodium borohydride in an aqueous medium. The silk protein sericin, extracted from the cocoons of *Bombyx mori* silkworms, has been used as an effective capping agent. Such particles also show antimicrobial properties when applied onto silk fabric without significantly changing the colour of the fabric.

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