INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

IJARIIT

ISSN: 2454-132X

Impact Factor: 6.078

(Volume 7, Issue 4 - V7I4-1328)

Available online at: https://www.ijariit.com

Antimicrobial textiles based on Nanosilver

Meenal Singh
meenalsingh70@gmail.com
Indian Institute of Technology, Delhi

ABSTRACT

In recent years, Anti-microbial textiles have been an area of great research due to many of their desired properties like reducing infection transmission in the medical environment, enhanced performance, and improving odor control. Their basic feature is to protect the fabric from rotting caused by microbes. Antimicrobial textiles fulfill functions such as preventing cross-infection, arresting microbial metabolism, and protecting the textile from staining, discoloration, and quality deterioration.

Keywords— *Rot Proofing, Nanosilver, Antimicrobial, UV-Transmittance, Hydrophobicity, Microencapsulation*

1. INTRODUCTION

In recent years, antimicrobial textiles have been an area of great research due to many of their desired properties like reducing infection transmission in the medical environment, enhanced performance and improving odour control. Their basic feature is to protect the fabric from rotting caused by microbes. Antimicrobial textiles fulfill functions such as preventing cross infection, arresting microbial metabolism and to protect the textile from staining, discoloration and quality deterioration. We can subdivide these textiles based on their finishing as-

1. Rot proofing to prevent physical deterioration
2. Hygiene finishes preventing dust mites and unwanted microbes
3. Aesthetic finishes for odour control

The Antimicrobial properties in the textiles can be obtained through either natural or synthetic agents. The natural agents such as Chitosan obtained from chitin, Neem, Tulsi, Pomegranate, Chaff Flower, Turmeric, Clove, etc. The synthetic agents include Quaternary Ammonium Compounds and peroxyacids and Metals and Metal salts such as Silver, Zinc, Copper. These textiles based on Nanosilver and Nanocopper have been discussed in depth in this paper.

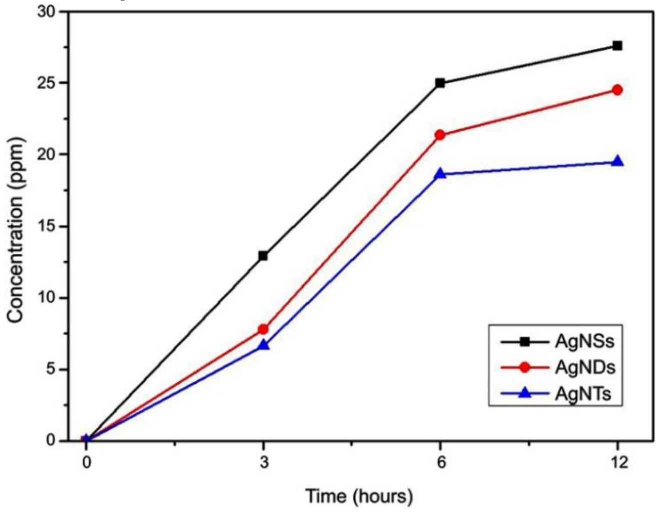
2. NANO-SILVER

Silver ions, compounds and nanoparticles have been widely used for ages due to its broad spectrum of antifungal and antimicrobial activity and low toxicity towards mammalian cells.It has been previously used in water purification, bone prosthesis, cardiac devices, catheters etc. Silver attacks a wide range of microbes so it is very unlikely for them to develop resistance against it in comparison to antibiotics. Silver nanoparticles due to their large surface area have even more efficient antimicrobial activity. These nanoparticles penetrate inside the microbial cell as well as interact with the sulphur containing proteins and phosphorous compounds like DNA on the cell membrane. Inside the cell nanoparticles form a low molecular weight region at the center of the cell due to which the cell conglomerates. They ultimately cause the cell death by cell division and inhibiting the respiratory process. The silver nanoparticles release phosphate, succinate, proline and glutamine in case of *E.coli* to hinder microbial action.

2.1 Effect of size and shape of nanoparticles on the Anti-microbial activity:

Enhanced reactivity of the silver nanoparticles have been observed when their size is less than 10 nm as they interact better with the microbes and produce electronic effects. This confirms the dependence of microbial action on the nanoparticle size. The optical absorption spectra shifts to the longer wavelengths with increasing size due to the Surface Plasmon Resonance (SPR).

The shape dependence of antimicrobial activity of silver nanoparticles can be seen from the graph shown. The average surface areas of the Ag NSs, Ag NDs and Ag NTs was found to be 1,307±5 cm^2, 1,104±109 cm^2 and 1,028±35 cm^2, respectively. The spherical shaped AgNp having the highest surface area produces the greatest concentration and hence the better activity.



The size, morphology and properties of the nanoparticles is controlled by the design of their synthesis like Polysaccharide Method, Tollen’s method, Irradiation method etc.

2.2 Different ways of application on nano-silver

A wide variety of methodologies have been developed for application of the AgNp onto the fabric surface. Some of them are briefly mentioned below :

1. **Spun Additives:** The antimicrobial activities are introduced in the fibre stage itself by incorporating the antimicrobial agent in the polymer matrix that is the melt or spinning dope solution during the fibre/yarn manufacturing process.
2. **Padding:** The agents containing the bindes and cross linkers are padded onto the fabric and then led through air dryers.
3. **Spraying:** For non-woven textiles a solution containing the antimicrobial agent is prepared and then sprayed onto the fabric under suitable isolated surroundings.
4. **Polymer Modification:** Bio active functional groups are copolymerized thus resulting in long lasting antimicrobial action.
5. **Microencapsulation:** Capsules that are covalently fixed on the fibres regulate the release of antimicrobial agents.

2.3 Antimicrobial Efficiency under mechanical stress

Antimicrobial properties of the AgNp coated textile needs to retain even after sustaining the mechanical stress of various washich cycles. So further the durability of incorporated AgNPs in the material is evaluated through a washing test of the sample after 1,3,5, and 10 cycles for 40 min each in 200ml of deionized water. As expected, it was observed that the silver concentration did not deteriorate in the samples with barrier layer. And for all types of bacteria the performance of silver nanoparticles was constant. The graph of silver conc in the sample and the graph of reduction in bacteria test performed are also provided -

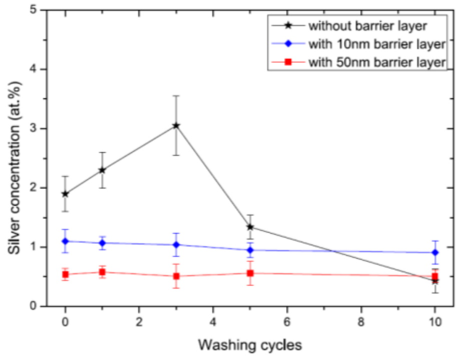


Figure 7. Silver concentration of the samples after mechanical washing cycles. The reservation layer thickness and amount of incorporated AgNPs is fixed through all the tests. The variation of the barrier layer thickness (0, 10, 50 nm) is used to prevent release of AgNPs in a series of washing cycles (1, 3, 5 and 10 washing cycles). Silver content is measured by XPS technique.

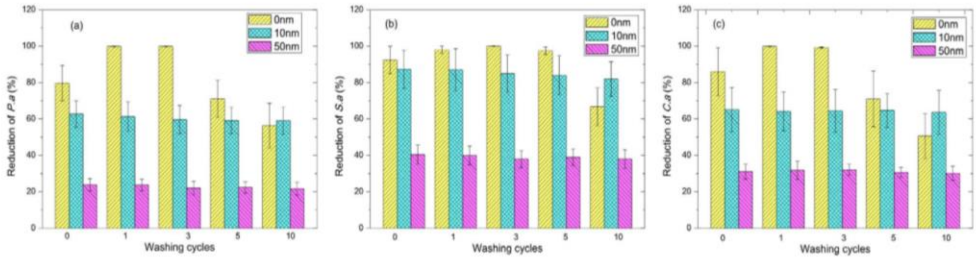


Figure 8. Antimicrobial activity of samples after mechanical washing cycles. The samples presented in fig. 7 are used: without a barrier layer, with a 10 nm barrier layer and a 50 nm barrier layer. After a series of washing cycles (1, 3, 5 and 10 washing cycles), the samples were tested for antimicrobial activity against: (a) *P. aeruginosa*; (b) *S. aureus*; (c) *C. albicans*.

2.4 Antimicrobial properties of nanosilver finish cotton fabric:

For coating the cotton fabric with AgNps to prepare Cotton-Ag involves two major steps-

1. Preparing a wet state by immersing the fabric in 30 ml aqueous solution of 6 M KOH and then rinsing off with distilled water.
2. The treated fabric is then put in 0.02 M AgNO3 aq. Solution for 30 min. Then it is oven dried at 65 °C for 60–90 mins.

The pristine and cotton-Ag samples are coated with a low surface energy layer by immersing them in a prehydrolyzed alcoholic HDTMS(1 %) solution. Various properties of these Cotton-HDTMS and Cotton-Ag-HDTMS are observed now. For Antibacterial properties it can be observed from the below figure that leaching of Ag+ ions forming an inhibition zone is what causes antibacterial effects.

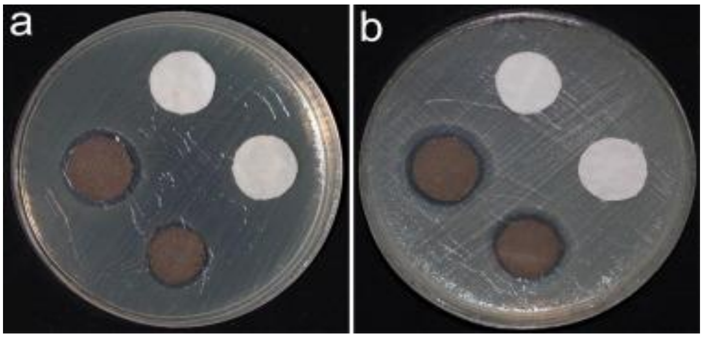
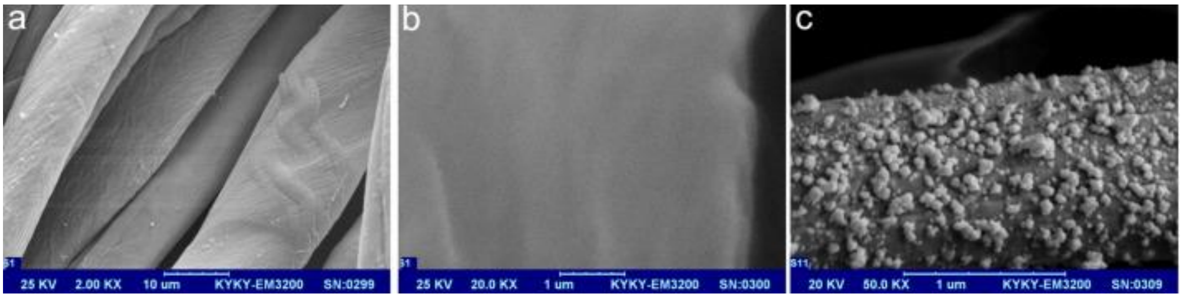


Figure. Antibacterial activity of the fabrics placed on the agar plate inoculated with (a) E. coli and (b) S. aureus. (top) Pristine fabric (right), Cotton-HDTMS, (left) Cotton-Ag and (bottom) Cotton-Ag-HDTMS.

a. SEM Images

Fig. a & b show the smooth longitudinal fibril structure of the pristine structure whereas we can clearly see in fig. c rough surface created due to the in-situ deposition of the AgNps. The smaller AgNps have been adsorbed onto the fibres whereas some micro particles have also been developed due to the agglomeration of AgNps.



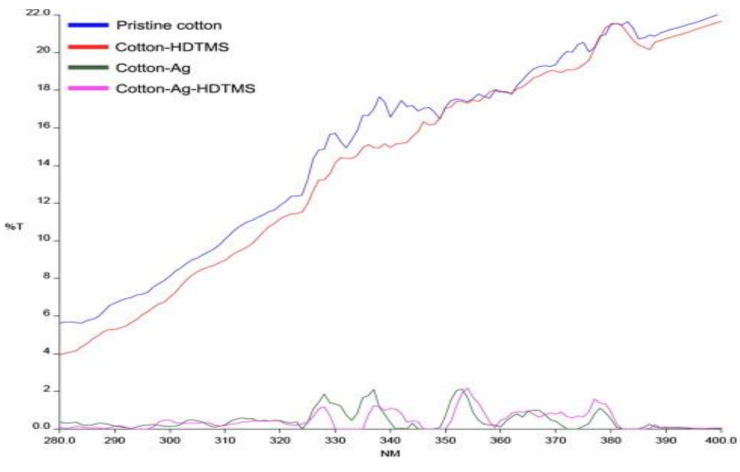
b. Hydrophobicity properties

As visible from the above images a hierarchical structure is formed on the surface of microfibers. The surface energy is further reduced due to HDTMS thus causing a hydrophobic effect. On analysing the wetting of the fabrics it is observed that the water is completely spread on the pristine surface due to the hydroxyl groups on the cellulosic surface of cotton. In Cotton-Ag the same wetting properties are observed. However, for Cotton-HDTMS the contact angles were found to be 135.5 ± 5.2° and for Cotton-Ag-HDTMS it increased further indicating super hydrophobicity. This is because the surface roughness increases due to AgNp coating.

c. UV Blocking

The figure below shows the UV-transmittance spectra of the fabrics. It can be observed that the nanoparticle coated fabric prevents both UV-A and UV-B penetration providing excellent UV-blocking. UV radiations with wavelength between 300-320 nm cause the most damage to human skin. UPF values help to calculate the UV blocking ability. UPF is the ratio of average irradiation on skin to that with fabric. The dark brown colour of the AgNp coated fabric can be attributed to the high UV-blocking ability.

Fabric	UPF
Cotton	9.4
Cotton-HDTMS	10.4
Cotton-Ag	270
Cotton-Ag-HDTMS	296



3. REFERENCES

[1] https://www.sciencedirect.com/science/article/pii/S1878535213002748
[2] https://www.ijeset.com/media/0001/8N7-IJESET604.pdf
[3] https://pubs.rsc.org/en/content/articlelanding/2016/ra/c6ra05799c/unauth#!divAbstract
[4] https://www.nature.com/articles/srep10138
[5] Antibacterial Cotton Fabric Functionalized with Copper Oxide Nanoparticles
[6] M.D. Teli & Javed Sheikh(2014) Bamboo rayon-copper nanoparticle composites as durable antibacterial textile materials, Composite Interfaces, 21:2, 161-171, DOI:10.1080/15685543.2013.855528