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Development of Cotton Fabrics Property with Anti-Bacterial Surface Treatment by Nano Silver Oxide in Biomedical Application

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Abstract: ***The nanostructures are capable of enhancing the physical properties of conventional textiles, in areas such as anti-microbial properties, water repellence, soil-resistance, anti-static, anti-infrared and flame-retardant properties, dyeability, colour fastness and strength of textile materials. In the present work, silver oxide nano-particles were prepared. These nanoparticles were coated on the bleached cotton fabrics using acrylic binder and functional properties of coated fabrics were studied. Air permeability of the nano AgO coated fabrics was studied. Nano AgO coated fabric, due to its nano-size and uniform distribution, friction was significantly lower than the bulk AgO coated fabric. Surface morphology of AgO coated fabric using SEM, wash fastness, and antimicrobial properties were studied.***

Keywords: AgO nano particle, bleached cotton fabric, surface morphology, UV protection and anti-bacterial.

1. Introduction

Recently, an awareness of general sanitation, contact disease transmission, and personal protection has led to the development of antibacterial fibers to protect wearers against the spread of bacteria and diseases rather than to protect the quality and durability of the textiles [1]. Most of the processes to create antibacterial fibers entail the attachment of biocidal or bacteriostatic agents to the fabric surface, for example, N-halamine, enzyme, quaternary ammonium salt, chitosan, or zinc oxide. The various mechanisms used to attach these agents to the fabric include the graft polymerization of N-halamine monomers onto textile substrate [2].

Moreover the addition of N-halamine additives into the electro spinning dope of fibers [3], the immobilization of enzymes onto ester-cross linked cotton fabrics [4], the placement of quaternary ammonium salt onto cotton fabrics using a covalently bound adduct, the attachment of chitosan to chitosan fabrics via cross-linking agents[5], and the impregnation of zinc oxide–soluble starch nano composites onto cotton fabrics [6]. Because of the developing resistance of bacteria against bactericides and antibodies and the irritant and toxic nature of some antimicrobial agents, biomaterial scientists have focused their research on nano-sized metal particles such as Ag, titanium dioxide, and copper.

Silver, in its many oxidation states (Ago, Ag+, Ag2+, and Ag3+) has been recognized as an element with strong biocidal action against many bacterial strains and micro organisms [7]. It is believed that the high affinity of Ag towards sulfur or phosphorous is the key element of its antibacterial property. As sulpher and phosphorous are found in abundance throughout the cell membrane, Ag nanoparticles react with sulfur containing proteins inside or outside the cell membrane, which in turn affects cell viability[8].

Mastsumure [9] proposed that Ag+ ions, released from Ag nanoparticles (AgO) can interact with phosphorous moieties in DNA resulting in inactivation of DNA replication, or can react with sulfur-containing proteins to inhibit enzyme functions. These properties allow the incorporation of Ag nanoparticles into various matrices such as polymer networks, textiles, and wound dressing materials [10][11][12][13][14][15]. However, most of the processes require multiple steps and complex reagents to prepare Ag-coated matrices.

Most recently, we reported a detailed investigation of graft co-polymerization of the monomers acrylamide (AAm) and itaconic acid (IA) onto cotton fabric using Ceric Ammonium Nitrate (CAN) as the initiator in an aqueous medium at room temperature [16].

In this paper we report a process that incorporates Ag nanoparticles into a polymer grafted cotton fabric that yields an almost uniform distribution of mono dispersed Ag nanoparticles within the grafted fabric (Figure 1). This fabric was investigated for its antibacterial activity against the model bacteria *Escherichia coli*.

2. Experimental and Methodology

2.1 Preparation of nano Ag-loaded grafted fabric

A dry preweighed piece of grafted fabric was equilibrated in distilled water for 24 hr. Thereafter, the swollen fabric was put in an aqueous solution of Ag nitrate prepared by dissolving 15 mg $AgNO_3$ in 30 ml of double-distilled water for 24 hr. Next the Ag ions present in the fabric were reduced to Ag nano particles by putting the fabric in 0.66 mM sodium borohydride solution at 30^oC for 24 hr. The resulting dark brown color of the grafted fabric indicated the formation of Ag nanoparticles within the polymer network part of the grafted fabric. Finally the fabric was rinsed with distilled water for 15s and put in a dust free chamber at 40^oC

until it gained constant weight. The dark brown color of the fabric might be a limiting factor for using this fabric as decorative clothing material; however this preparation of Ag-coated fabric can be used as a universal antiseptic substrate for clinical applications. In addition, this process could be used for the fabrication of antibacterial surgical gloves and pads, face-masks, uniform of defense people, particularly for those who are deputed in cold regions like glaciers and have severe infection.

2.2 Antibacterial test for Ag-loaded cotton fabric

The antibacterial activity of the fabric was tested qualitatively and quantitatively by the inhibition zone method [17] and viable cell count method [18] respectively. In both the methods, the model bacteria were E. coli. For qualitative measurement of antimicrobial activity, the Ag-loaded fabric was cut into 6-mm diameter discs and tested using the modified agar diffusion assay (disc test). The plates were examined for possible clear zones after incubation at 30°C for 2 days. The presence of a clear zone around the circular disc on the plate medium was recorded as inhibition against the microbial species.

To examine the bacterial growth or killing kinetics in the presence of Ag nano particle-loaded grafted fabric, E. Coli cells were grown in continuously stirred 100 ml NB at 37°C supplemented with a preweighed piece of fabric. The cylindrical sample containers were placed horizontally on an orbital shaker plat fit. It is clear from Fig. 9 that in the initial phase bacterial growth is almost the same in the media containing plain and Ag-loaded fabrics. The killing action of Ag-loaded fabric began approximately 3 hr after its incubation in NB medium. This may be attributed to the fact that when Ag-loaded fabric was put in the bacterial suspension, the fabric began to take up water slowly. As water entered the grafted polymer network, Ag nanoparticles diffused out as Ag+ ions and killed the bacterial cells.

The killing activity of Ag-loaded fabric began to diminish later, probably because nearly all the Ag nano particles were consumed in binding with bacterial cells organism and agitated at 200 rpm. Growth or killing rates and bacterial concentrations were determined by measuring the optical density (OD) at 600 nm. The OD values were converted into concentrations of E. coli colony forming units (CFU) per ml using the approximation that an OD value of 0.1 corresponded to a concentration of 108 cells per ml [18].

3. Results and Discussion

Antibacterial action of Ag-loaded fabric: Figure 1 shows the results of the antibacterial action of nano Ag loaded grafted cotton fabric on the growth of E. coli. It is clear that the growth of the bacterial colonies around the AgO loaded fabric is inhibited (Fig.1a), whereas a dense population of bacterial colonies appear in the control set that contains pieces of plain fabric in the Petri dish (Fig. 1b). The observed inhibiting action of nano Ag-loaded fabric is due to the release of Ag + ions from the Ag nanoparticles present in the fabric. These Ag+ ions come in contact with bacterial cells and kill them.

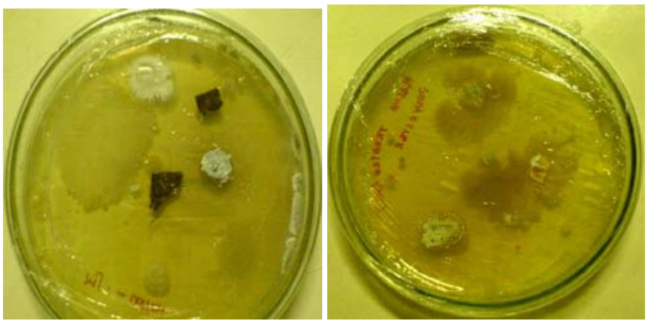

Figure 1: Effect of Ag content on bacteriacidal action (a) AgO Coated (b) plain cotton fabric

The bactericidal action of Ag-loaded fabric was expected to depend upon the extent of grafting of co-polymer onto fabric. To investigate this, two samples of grafted fabric (60% and 100% grafting) were put in a 20 mg/30 ml Ag nitrate solution and reduced with the same concentration of aqueous sodium borohydride solution.

The antibacterial action, as compared with the plain fabric, the control, is shown in Fig. 1a. Fabric with 100% grafting exhibited greater inhibiting power against growth of bacterial colonies as compared to the fabric with 60% grafting. The control, plain fabric showed a dense population of bacterial colonies.

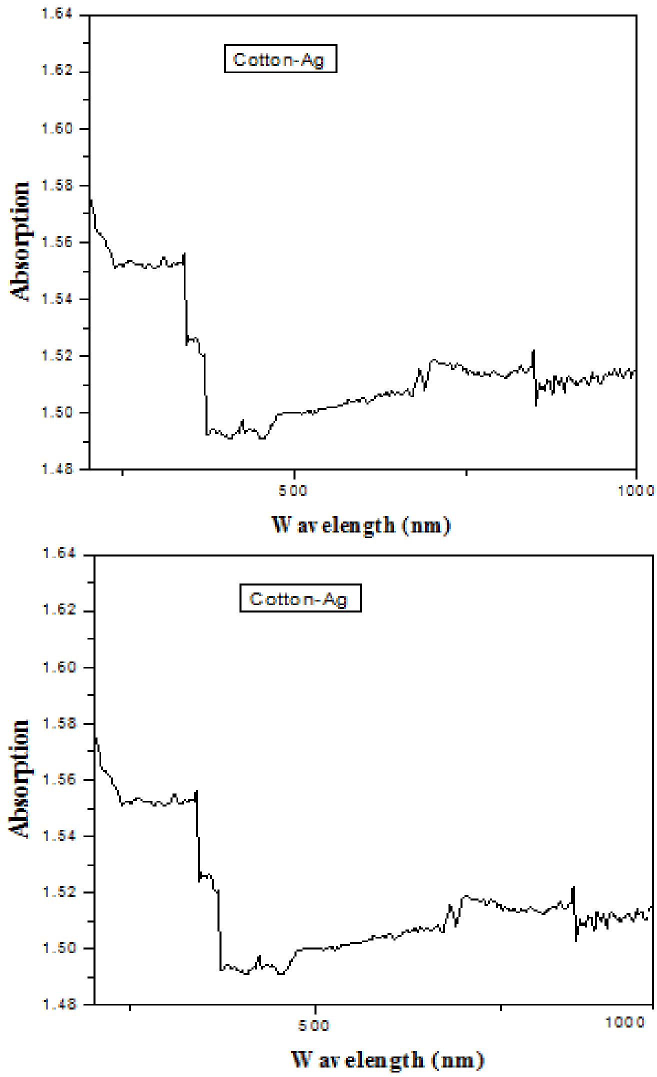

Figure 2: UV Spectrum of the AgO nano coated and plain cotton fabric

The observed finding can be explained by Ag nanoparticles entrapped to a greater extent in the fabric with the relatively higher percentage of grafting (i.e.,100%) due to the availability of a greater number of binding sites for Ag+ ions. Ag-loaded fabric with 100% grafting showed more inhibiting power against bacteria. It may be concluded that the greater the amount of grafting on the fabric, the greater is its power to inhibit bacterial growth. We prepared two Ag-loaded samples with different Ag ion content by immersing the grafted fabrics in $AgNO_3$ solutions of different concentrations (20 mg/30 ml and 50 mg/30 ml), followed by reduction with sodium borohydride.

The results of these antibacterial tests (Fig. 1b), clearly indicated that the fabric prepared by immersion in $AgNO_3$ solution with a concentration of 50 mg /30 ml demonstrated greater biocidal activity as indicated by larger area of inhibition zone. Therefore, Ag content of the fabric is a key factor in controlling its antibacterial activity. The killing action of Ag-loaded fabric began approximately 3 h after its incubation in NB medium. When Ag-loaded fabric was put in the bacterial suspension, the fabric began to take up water slowly. As water entered the grafted polymer network, Ag nanoparticles diffused out as Ag+ ions and killed the bacterial cells. The killing activity of Ag-loaded fabric began to diminish later, probably because nearly all the AgO nanoparticles were consumed in binding with bacterial cells.

UV protection and surface morphology

Figure 2 shows the UV absorption properties of bleached cotton and cotton fabrics coated with nano-AgO. In control fabric, average of 20% of UV light was absorbed, while the rest passed through the fabric. In case of bulk-Ag coated fabric, about 45 % of the UV light was absorbed by the fabric.

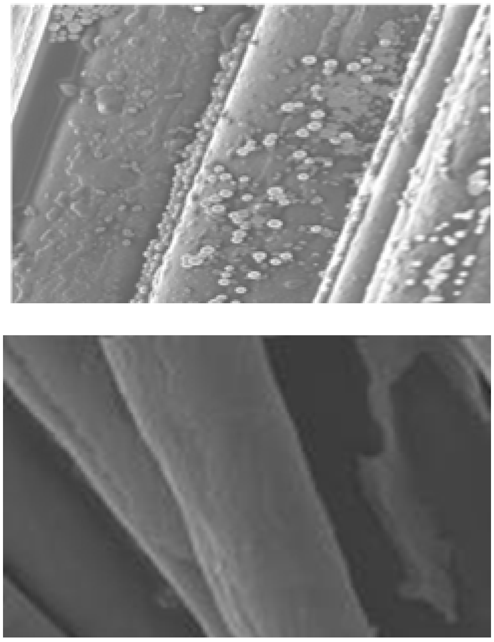

Figure 3: SEM of AgO nano coated and plain cotton fabric

In case of nano-Ag O coated fabric, a maximum of 75% absorption of UV light was noticed. The increased surface area of nanoparticles and their uniform distribution on the fabric surface might have increased the UV absorption efficiency.

4. Conclusion

From these studies we concluded that the in situ formation of Ag nano particles in acrylic binder network of cotton fabric was an effective method for the preparation of antibacterial fabrics. The almost uniform distribution of narrow dispersed Ag nanoparticles is a major advantage of this method. These fabrics show biocidal action against the bacteria *E.coli*, thus showing great potential to be used as an antiseptic dressing or bandage, which are in high demand for biomedical applications.

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