Antimicrobial Fabrics Coated with Nano-Sized Silver Salt Crystals

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ABSTRACT

Antimicrobial fabrics find many applications in medical, hygiene, protection, sport, health care, personal care, filtration, and other markets. For example, such fabrics are used in wound dressings or bio-hazard protective clothings, and are nowadays compared in terms of "zone of inhibition" and "kill rate" of bacteria which are both related to the antibacterial activity. However, antimicrobial fabrics differ in biocidal performance. While many antimicrobial treatments for fabrics confer bacteriostatic activity i.e. impede growth of the inoculum bacteria under the fabric, very few allow diffusion and sustained release of antimicrobial agents leading to a zone of inhibition, especially after washing or autoclaving. This paper presents a new water based colloidal solution of a silver salt, which was applied as a coating to different fabrics. AATCC 147 Parallel Streak Standard Method was performed in order to evaluate antibacterial activity of diffusable antimicrobial agents on treated fabrics.

Keywords : antimicrobial coating, nanocrystal, biocidal, silver, bio-hazard

1. INTRODUCTION

Recently, there has been a growing interest to develop antimicrobial textiles and composites [1-3] and especially water based solutions for application to textiles for odor management and control of infectious agents. For example, the control or prevention of infectious deseases by using antimicrobial textiles find much of importance in medical, wound dressings, healthcare (including disposables), personal care products, veterinary, military and biodefense, protective suits, clothing, household goods and filtration.

Antimicrobial water based solutions available nowadays differ in composition. Among the different chemicals used, there are quaternary ammonium compounds such as alkyltrimethylammonium halogenides and chlorinated organic compounds such as chlorinated phenols. However, such chemicals may not confer an efficient control of pathogens over time because such chemicals are highly soluble in water and may be consumed rapidly or leached by ageing processes such as heat exposure, washing, or autoclaving.

Recently, several water based systems propose the introduction of antimicrobial metallic nanoparticles into aqueous solutions. However, such suspensions of metallic nanoparticles, especially heavy metals such as silver and copper, tend to be unstable and a separation process can be observed involving coagulation and precipitation of metallic nanoparticules. Then, metallic nanoparticles in these solutions have the propensity to form deposits that can not or hardly be redispersed.

In addition, metallic silver, silver oxides, and silver salts are known to have antimicrobial properties; unfortunately, slow-release systems, such as metallic silver, do not confer a large zone of inhibition neither high kill rate because of limited availability of silver ions in such metallic systems. Iodine-based delivery systems are very efficients and allow fast-release of antimicrobial agent; however, iodine treated substrates may present poor stability to autoclaving and staining problems.

Therefore, there is a strong demand for stabilized water based antimicrobial solutions capable to confer to substrates improved antibacterial activity, sustained release of antimicrobial agent, and wide-range biocidal properties.

2. PREPARATION

A colloidal solution of a silver salt was applied as a coating to different fabrics. The silver salt solution consists of a water-based, surfactant-stabilized silver salt suspension. Fabric samples were dip coated into a bath containing the colloidal solution at room temperature. Alternatively, for a sample, a polymer resin was added in the bath formulation to obtain a resin-coated fabric. All treated samples were dried at 150-160^{o}C, 3 to 5 min.

3. RESULTS

3.1 Microscopy

SEM images were obtained for different fabrics treated with the silver salt suspension and are presented in Figures 1-3. As it can be seen, nano-sized crystals were deposited and presented a uniform surface distribution. The silver salt nanocrystals typically range from several tens to a few hundreds of nanometers.

An additional feature of treated fabrics is that the original aspect and colors of the fabric are not changed.

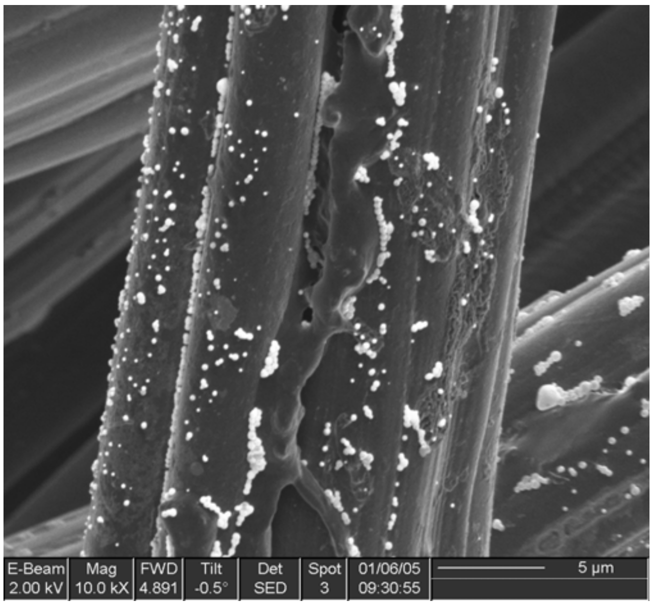

Figure 1. Adsorptive activated carbon fabric coated with antimicrobial silver salt particles.

3.2 Antimicrobial activity

Antimicrobial activity can be demonstrated by many antibacterial activity assessments [4-6]. Among these, AATCC 147 Parallel Streak Standard Method is a semi-quantitative method which permits to evaluate antibacterial activity of diffusable antimicrobial agents on treated fabrics. A test result for a fabric treated with the silver salt suspension and a control fabric is presented at Figure 4, where the tested bacteria was Staphylococcus Aureus.

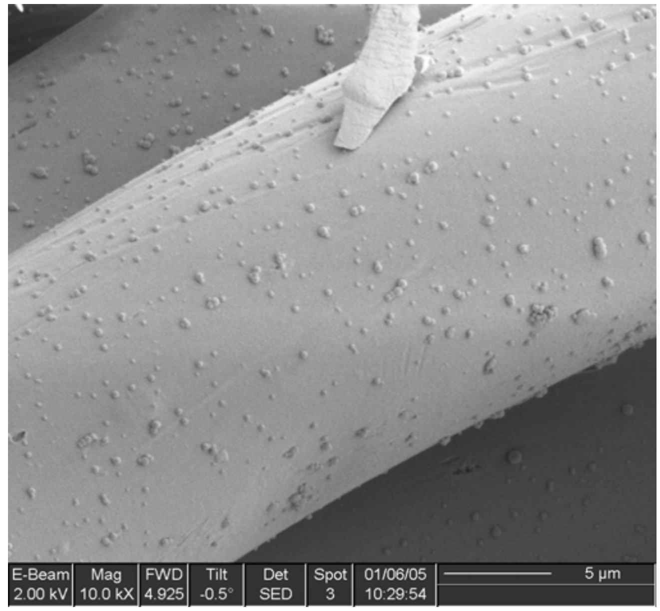

Figure 2. Nylon fabric with antimicrobial silver salt particles.

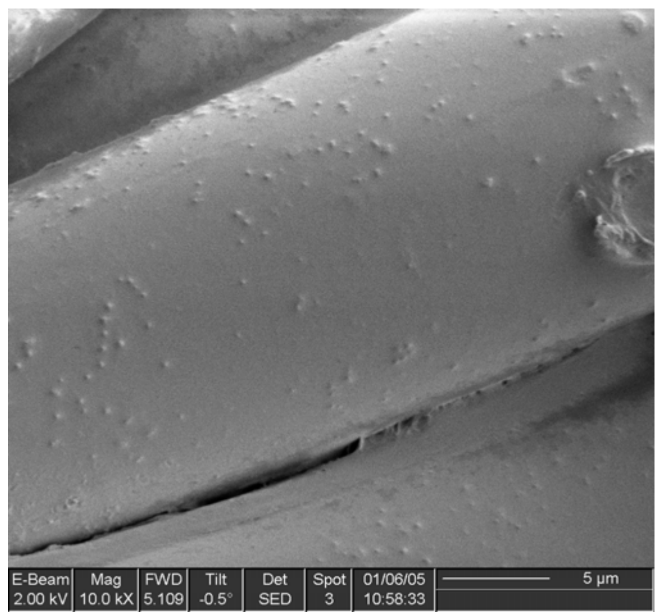

Figure 3. Nylon fabric with antimicrobial silver salt particles embedded into a thin polymer coating.

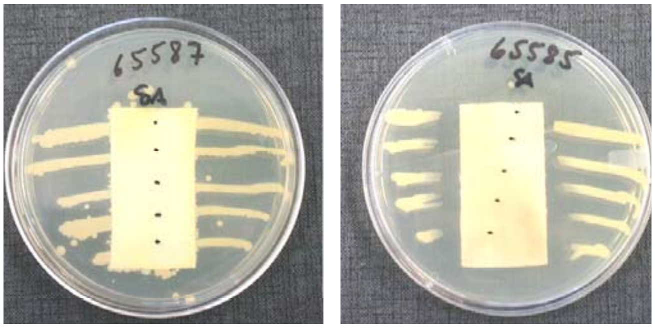

Figure 4. AATCC 147 test result against S.Aureus for a non-treated fabric sample as a reference (left) and for a silver salt treated fabric (right) exhibiting, respectively, no peripheral inhibition and a measurable zone of inhibition.

Table 1 presents AATCC 147 test result against Staphylococcus Aureus (gram positive) and Escherichia Coli (gram negative) bacteria for non-treated and silver salt treated fabric samples. Samples were both tested non-sterile and sterile. Sterilization was achieved using an autoclave, thereby submitting samples for 15 min, at 121^{o}C and 15 psi.

For the control fabric, growth of E. Coli and S. Aureus was observed under the specimen while no growth appeared for the treated fabric. The zone of inhibition for the control sample was 0 mm, in comparison to 2-3 mm for the treated fabric before and after autoclaving. It can be seen from these results that the silver salt treated fabric maintained a high level of performance after autoclaving (sterile specimen).

	E. coli		**S. Aureus**	
Fabric	Non-sterile	Sterile	Non-sterile	Sterile
	Growth under the specimen			
Not treated	Yes	Yes	Yes	Yes
Silver salt treated	No	No	No	No
	Zone of inhibition (mm)			
Not treated	0	0	0	0
Silver salt treated	2.2	2.0	3.0	2.0

Table 1. AATCC 147 test results against S.Aureus and E. Coli for non-treated (control) and silver salt treated fabric samples.

4. CONCLUSION

A surfactant-stabilized colloidal solution of a silver salt was applied as a coating to different fabrics to confer antimicrobial properties. Resulting from the application of this silver salt suspension, nano-sized crystals were deposited and presented a uniform surface distribution on the fibers. AATCC 147 antibacterial results on a silver salt treated sample showed growth inhibition and large zone of inhibition for both gram positive and gram negative bacteria tested. In addition, the treated fabric maintained a high level of performance after autoclaving. Such biocidal properties are provided by an improved and sustained release of silver ions.

Another advantage provided by such silver salt is that its use do not alter the visual aspect nor the colors. For example, in many applications, it would be preferable if the antimicrobial water based solution do not stain the substrate once applied and that the treated substrate may by used either into a dry or humid environment as well, without staining.

For substrate finishing, such antimicrobial suspension can be used to prepare coating formulations for substrates as diverse as textile fabrics, papers, filtration materials, woven and non-wovens materials, membranes, and composites.

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