A Study on Antimicrobial Efficacy of Nano Silver Containing Textile

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ABSTRACT

Antimicrobial activity of nano silver containing cotton fabric was examined on various kinds of microbes. The antibacterial effect was evaluated by an AATCC 200 test, a quantitative method. The results showed that the finished fabric exhibited excellent inhibitory efficacy on Staphylococcus aureus, Escherichia coli, Staphylococcus aureus methicillin resistance strain (MRSA) and Pseudomonas aeruginosa. The silver nanoparticles on the surface of textile fibers were investigated by scanning electron microscope.

Key words: Silver, Nanoparticles, Antimicrobial activity, Cotton

INTRODUCTION

Silver is known as a disinfectant for centuries and widely used in the treatment of clinical diseases, including newborn eye prophylaxis, topical burn wounds, orthopaedic infections (Klasen, 2000). Presently, silver is an excellent candidate for antimicrobial finishes in textile sector (Yeo et al., 2003; Lee et al., 2003). When silver metal has a size of nano level, the high specific surface areas and high fraction of surface atoms of silver nanoparticles will lead to high antimicrobial activity comparing to bulk silver metal.

In textile goods, especially those consist of cotton fiber, provide large surface area with excellent environment to promote the bacterial growth. This often leads to objectionable odor, dermal infection, product deterioration, allergic responses, and other related diseases. There are many types of microorganisms which cause public health concern. Some important examples include Methicillin Resistant *Staphylococcus aureus* (MRSA), *Klebsiella pneumoniae, Staphylococcus epidermidis, Pseudomonas aeruginosa*, and *Enterococcus faecalis* are common pathogens in wound infections (Wright et al., 1998). Therefore, antimicrobial finishing should be necessary features of protective textile materials, especially in some high-risk environments, such as medical applications.

The purpose of this study is to examine the antibacterial activity of silver nanoparticles containing cotton fabric against *Staphylococcus aureus, Staphylococcus aureus methicillin resistance strain (MRSA), Escherichia coli* and *Pseudo-*

monas aeruginosa which are the microbes commonly exposed to household and hospital environments.

MATERIALS AND METHODS

Nano silver finished cotton fabric samples were prepared by the Metallurgy and Materials Science Research Institute, Chulalongkorn University via chemical process. The final products consisted of 350 ppm silver nanoparticles were used in this work. The antibacterial properties of treated cotton fabrics were quantitatively evaluated against *Staphylococcus aureus* and *Staphylococcus aureus methicillin resistance strain (MRSA)*, Gram-positive bacterium and *E. coli* and *Pseudomonas aeruginosa*, Gram-negative bacterium, according to AATCC 200 test method. The antimicrobial activity was expressed in term of percentage reduction of the organism after a contact with the test specimen compared to the number of bacterial cells surviving after contact with the control. The percentage reduction was calculated by using the following equation,

$$\% R = [(B-A)/B]*200$$

where R is the reduction rate, B is a number of bacterial colonies from control specimen after 0 hr contact time, and A is a number of bacterial colonies from treated specimen after 24 hrs contact time. The surface morphology of silver nanoparticles on cotton fabric was observed with a scanning electron microscope while the qualitative chemical composition of silver nanoparticles was assayed by x-ray energy dispersive microanalysis (EDS) after coated with gold.

RESULTS AND DISCUSSION

The antimicrobial activities of cotton fabrics containing silver nanoparticles against microorganisms by AATCC 200 test method are shown in Table 1. The results show that the treated cotton has an excellent antimicrobial effect. All silver treated fabrics showed very high activities against all the microorganisms with up to >99.99% reduction.

The mechanism of silver antibacterial action is only partially understood. Sondi and Salopek-Sondi (2004) reported that silver nanoparticles interact with building elements of the bacterial membrane, causing structural changes and degradation and finally cell death. This is similar to the results of Cho and coworkers (2005) which suggested that the surface cell walls of *Staphylococcus aureus* and *E.coli* were disrupted by silver nanoparticles.

Table 1. Antimicrobial activities of cotton fabrics containing silver nanoparticles against microorganisms by AATCC 200 test method.

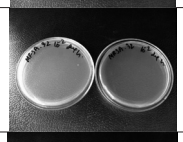
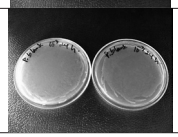
Test microorganism	Photo of bacterial colonies at 24 hr.		% Reduction
	Control sample	Treated sample	
Staphylococcus aureus			99.05
Staphylococcus aureus methicillin resistance strain (MRSA)			98.88
Escherichia coli			>99.99
Pseudomonas aeruginosa			>99.99

Figure 1 shows SEM micrograph of silver nanoparticles on cotton fabric surface. It is demonstrated that silver nanoparticles are well distributed on the cotton fiber surface. The size of silver nanoparticles at about 200 nm can be observed. Figure 2 is close-up of silver nanoparticles on the cotton fiber and EDS analysis on the indicated area. The EDS spectrum shows a small peak corresponding to silver.

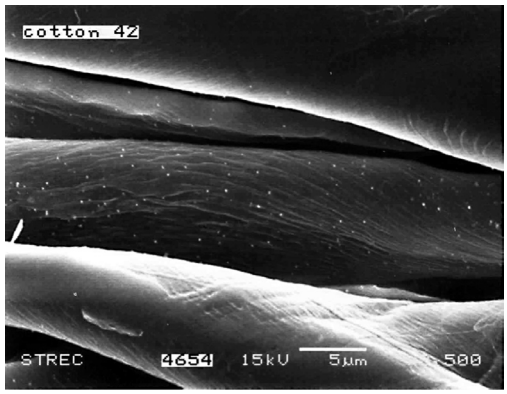


Figure 1. SEM micrograph of silver nanoparticles on cotton fabric.

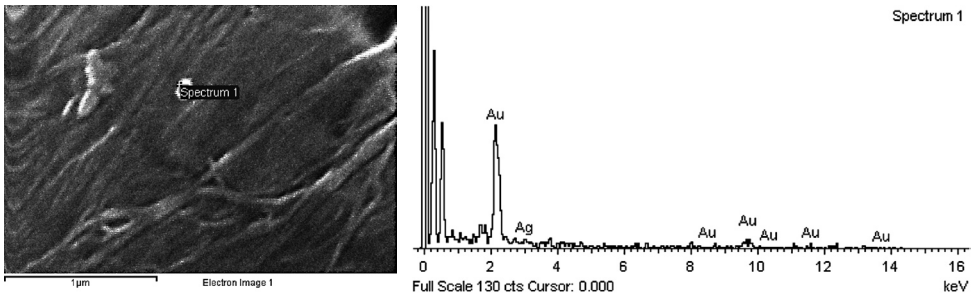


Figure 2. The EDS analysis of silver nanoparticles finished cotton fiber.

CONCLUSION

This study shows that silver nanoparticles on cotton fabrics have excellent antibacterial activity against *Staphylococcus aureus, Staphylococcus aureus methicillin resistance strain (MRSA), Escherichia coli,* and *Pseudomonas aeruginosa*. The SEM results show the silver nanoparticles on cotton surfaces have relatively good dispersibility.

ACKNOWLEDGEMENTS

This research was supported financially by the Metallurgy and Materials Science Research Institute, United Textile Mills Co., Ltd. and the National Innovation Agency of Thailand.

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