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A Study of Chitosan Coating on Different types of Natural Fiber by Scanning Electron Microscopy (SEM)

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Abstract

In this study, the natural silk fiber and cotton fabric were coated by chitosan. The Scanning Electron Microscopy (SEM) is used to evaluate changes in fiber surfaces. The sample, treated at different concentrations of chitosan, is analyzed to investigate the growth inhibition effect of *Straphylococcus aureus*.

Keywords: Antimicrobial agents, Chitosan, Cotton, Scanning Electron Microscopy

Introduction

Presently, the consumer demand has growing for sanitary products in textile and garment for their safety toward human and environment. The research was focused in the discovery of new natural antimicrobials. In this respect, the antimicrobial activity of chitin, chitosan and their derivatives against different groups of microorganisms such as bacteria and fungi against different groups of microorganisms such as bacteria and fungi has received considerable attention in recent years.(Lee, *et al.* 1999; and Vigo, *et al.* 1999)

Chitosan, a major derivative of chitin obtained from deacetylation reaction of chitin, is an attractive material for improving the quality of textiles. Chitosan is a natural, nontoxic, and biodegradable polymer and is also known as an antimicrobial agent due to the action of amino group at the C-2 position of the glucosamine residue. (Vigo, *et al.* 1999) Recently, there have been many research report about the utilization of chitosan to reveal antimicrobial activity in various fiber types. (Struszczyk, 1997)

However, the use of chitosan as a finishing agent is quite limited in the after treatment of textile fabrics due to its weak binding. Accordingly, problems in binding of chitosan to textile material solved for expanding chitosan uses.

In this study, cotton fabric was coated with various concentration chitosan, and Scanning Electron Microscopy (SEM) technique was used to observe the fiber surfaces. The antimicrobial

activity (growth inhibition effect) was then further investigated to detect *Staphylococcus aureus*. (AATC, 1989; and AATC, 1993)

Materials and Methods

Coating of silk fiber

Chitosan with the degree of deacetylation of 75% is applied in the amount of 0.5 and 2 wt % in 1% acetic acid to prepare a solution for coating silk fiber.

Chitosan solution prepared by dissolving various concentrations of chitosan in 1% acetic acid (0.5 and 2 wt %) and the silk fibers were immersed in the solution for 30 minutes at room temperature to impregnate fibers. After that, the coated fiber was dried for 5 minutes at 50°C and then rinsed in running tap water before the final drying for 10 minutes at 100°C.

Treating Cotton Fabric with Chitosan

The chitosan solution prepared by dissolving various concentrations of chitosan in 1% acetic acid (0.125, 0.25, 0.5 1, and 2 wt %) were applied to the cotton fabrics with a pad-dry-cure process. The pad baths consisted of chitosan solution at various concentration in each bath. To provide the antimicrobial finish, the samples were padded through baths of 0.125, 0.25, 0.5 1, and 2 wt % chitosan solution to a wet pickup of about 85%, dried at 110°C for 3 minutes, cure at 160°C for 3 minutes and rinsed with running tap water.

Scanning Electron Microscopy

Before testing, the coated and non-coated silk fibers and the cotton fabric were prepared on specimen stub for morphology observation. For Scanning Electron Microscopy (SEM, PhilipsXL30CP), small piece of each samples were cut to fit 3 mm sample stubs. Cut samples were attached to sample stubs before coated with non-wicking adhesive. To prevent charging from the electron beam, samples were sputter-coated with gold/palladium. The cotton fabrics and silk fibers were studied at 0° tilt to observe fabric surfaces.

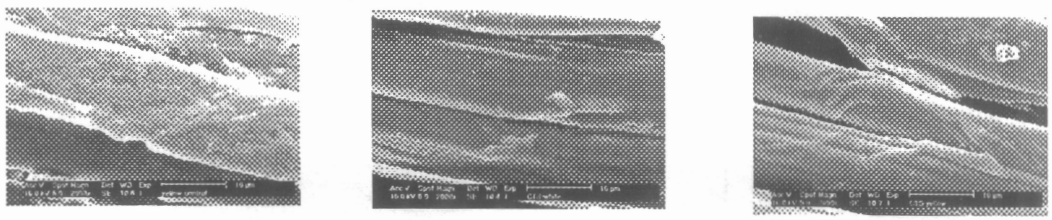
Antimicrobial Test

The antimicrobial activity of the cotton fabric samples was evaluated qualitatively. The AATCC Test Method 30-1989 was used to measure the growth inhibition effect of *Staphylococcus aureus*. In this procedure, a *Staphylococcus aureus* was spread on glass disc containing Trypticase Soy Broth (TSB) culture medium then the fabric sample with the diameter of 1.5 cm was put on the surface of glass disc, followed by cultivation at 37°C for 24 hour. The growth inhibition of bacterial was determined by measuring growth-free zone that appear on surface of glass disc and then the diameter of growth-free zone in each samples was recorded.

Results and Discussion

Surface Observation : of silk fiber samples

The comparing of SEM photomicrographs of chitosan and non-coated silk fiber samples was shown in Figure 1. The photomicrograph of non-coated and coated samples at different concentration of 0.5 and 2wt% chitosan solutions are shown in figures (a), (b), and (c) respectively. The SEM analysis of coated surface was obviously observed the deposition of chitosan on the silk fiber surfaces. The interfacial deposition of chitosan on silk fibers was shown to cover the fiber scales which can be accepted for surface resistance. It was also observed the better smooth of the coated samples while the non-coated control revealed more rough surfaces.



(a) (b) (c)

Figure 1 SEM photomicrograph of (a)non-coated , and coated silk fibers with (b)0.5 and (c) 2.0%wt chitosan solution at the magnification of 2000X

Surface Observations of Cotton Fabrics

The SEM photomicrographs in Figure 2 showed the modification in the cotton fabric surfaces of non-coated control (a) and coated samples with different concentrations ranging from 0.125%(b), 0.25%(c), 0.5%(d), 1.0%(e) and 2.0%(f) of chitosan solutions. Photomicrographs of coated fabric samples showed the laminated surfaces which produced by different quantities of chitosan deposition. The presence of chitosan on the coated surfaces had demonstrated the better smooth than the non-coated control. However, the chitosan coating on cotton fabrics was done by pad-dry-cure process which might effect on non-constancy of laminated surfaces. Some parts on the coated surfaces showed any saliently feature which appeared some parts of non-coated areas.

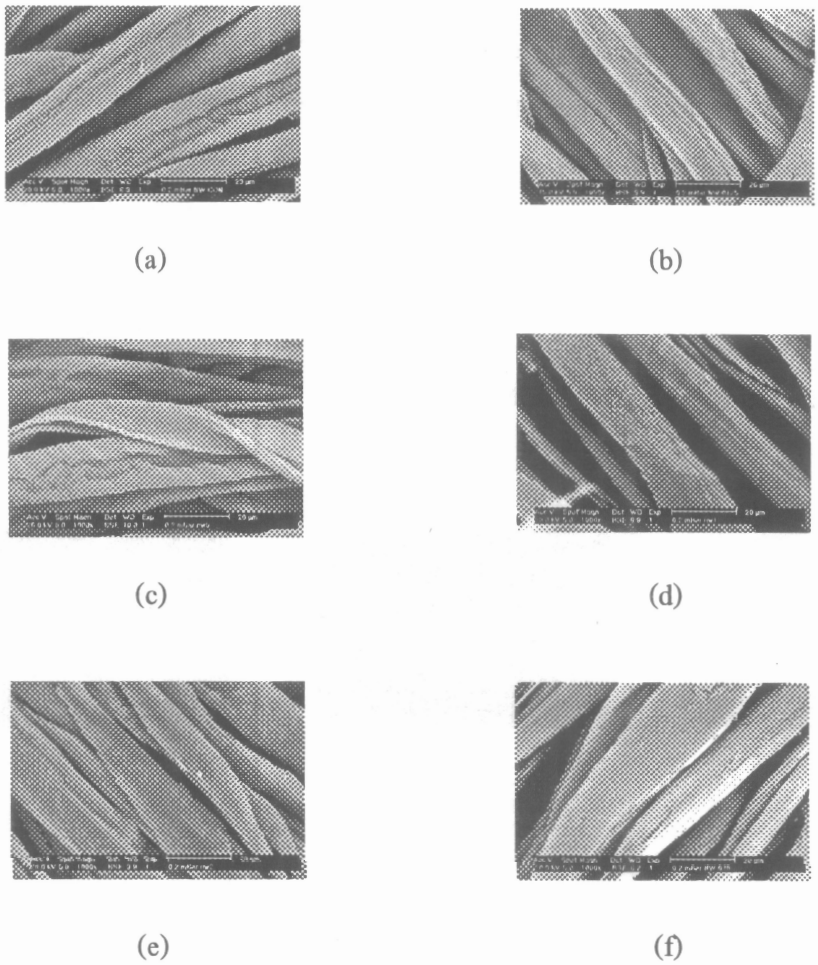


Figure 2 SEM photomicrographs of (a) non-coated and coated samples with (b)0.125, (c)0.25, (d)0.5, (e)1, and (f)2wt% chitosan solution at the magnification of 1000X.

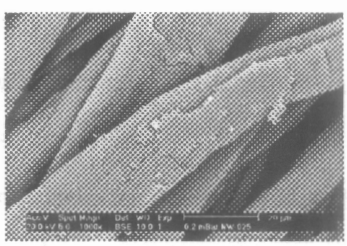


Figure 3 SEM photomicrograph of treated cotton fabric containing some salient features of non-coated cotton area.

Antimicrobial Activity Test

The investigation of the antimicrobial activity of chitosan coated cotton was done on growth inhibition of *Staphylococcus aureus* by the techniques of measurement of any growth-free zone surrounding the disc. There was no growth-free zone appearing around the discs of both coated and non-coated samples. However, the non-coated control samples contained high growth of many colonies of *S.aureus* on the disc while there was no any microbial growth appeared on chitosan coated disc. The absence of clear-zone on coated samples might due to the unable diffusion of chitosan from the disc.

Table 1 Some properties of cotton fabrics coated by chitosan solution

Cotton Fabrics	Tensile Strength (N/50mm)	Elongation (%)
Non-coated sample	25.50	23.0
Coated with 0.125wt% chitosan	25.28	24.0
Coated with 0.25wt% chitosan	20.63	24.0
Coated with 0.5wt% chitosan	22.51	23.0
Coated with 1.0wt% chitosan	21.47	22.5
Coated with 2.0wt% chitosan	21.04	20.5

Chitosan has many chemical qualities to function on textile finish. The properties of tensile strength and elongation of chitosan coated cotton fabrics were also investigated as shown results in table 1. It was found that there was no significantly change of both tensils strength and elongation at the low concentration of chitosan solution. However, the decrease in tensile strength and elongation values were observed corresponding with increasing of the concentration of the chitosan solutions. Chitosan has shown the chemical qualities to function on the cotton fabric surfaces. The sorption behavior of chitosan on the cotton fabrics was lead to the modification of surface properties.

Conclusion

The coating of chitosan on natural fibers of silk and cotton were evaluated for surface observation antimicrobial activity and mechanical properties of tensile strength and elongation. The coating of chitosan on the surfaces of the silk fibers and cotton fabrics was studied by SEM

photomicrograph. The interfacial deposition of chitosan on the silk and cotton fibers were observed in different smoothness of the surfaces between the coated and non-coated fibers as shown in the photomicrographs. The cotton fabrics were investigated for antimicrobial activity test by measuring the growth-free zone surrounding the discs. There was no growth-free zone appear in both samples of coated and non-coated cotton fabrics. However, there was a lot of colony counts of *S. aureus* on the non-coated disc samples while it was absent on the coated disc samples. The mechanical properties of tensile strength and elongation of the cotton fabric samples were also investigated. The effect of chitosan coating on the surface of the cotton fabrics appeared to decrease the tensile strength and the elongation of the cotton fabrics.

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