Functional Finishing of Cotton Fabrics by Treatment with Chitosan

Younsook SHIN, Kyunghye MIN, and Jeong In JANG
Dept. of Clothing & Textiles, Chonnam National Univ., Kwangju, 500-757, Korea

ABSTRACT

Cotton fabric was treated with chitosan solution by pad-dry(-cure) method to impart antimicrobial properties. Four chitosans of different degree of deacetylation(DAC: 65~95 %) with similar molecular weight(ca. 50,000) and one chitosan oligomer(MW 1,800, DAC 86 %) were used. Antimicrobial activity against *Staphylococcus aureus* was evaluated by the Shake Flask Method. Treated fabrics were laundered up to 20 times according to AATCC Test Method 60-1986 and antimicrobial activity of laundered fabrics was evaluated. The antimicrobial activity was increased with the concentration and DAC of chitosan used. And the cured samples showed better durability to laundering than not-cured samples. Crosslinker and binder decreased the antimicrobial activity of fabrics treated with chitosan oligomer and were not effective to improve the durability to washing.

Keywords : chitosan, chitosan oligomer, degree of deacetylation, antimicrobial activity, durability to washing, crosslinker, binder.

INTRODUCTION

Recently, consumers concern about sanitary property of textile products and their safety toward human and environment. Biodegradable natural polymers such as chitin and chitosan draw much attention on this respect. Chitosan is prepared from the deacetylation of chitin, in which hydroxyl groups on the No. 2 carbon atom are replaced by amino groups. Chitosan fiber has been produced and used as a suture or a dressing for wound treatment (1,2). The application of chitosan as an antimicrobial finishing agent has been studied in textile area (3,4). However, use of chitosan as a finishing agent for textile products by means of after-treatment is limited due to its weak binding. Accordingly, problems in binding of chitosan to textile material should be solved to expand chitosan uses.

In this study, cotton fabric was treated with chitosan, and the effect of treatment condition and DAC on the antimicrobial activity was investigated. And the effect of curing and additives

such as binder or crosslinker on the durability to laundering was also examined.

MATERIALS AND METHODS

Materials

A desized, scoured and bleached 100 % cotton fabric, four chitosan samples of similar molecular weight (ca. 50,000) with different degree of deacetylation (65, 78, 84, and 95 %, respectively) and one chitosan oligomer (MW 1,800, DAC 86%) were used. Polyurethan emulsion (TX-B-202F, Takamatsu Oils & Fats Co., Ltd., Japan) and DMDHEU (dimethylol-dihydroxyethylene urea, BASF Co., Ltd.) with catalyst ($MgCl_2$) were used as a nonionic binder and bifunctional crosslinker, respectively. Other reagents used were of laboratory grade.

Treatment of fabrics

Cotton fabrics were padded with chitosan(MW 50,000) solution dissolved in 2 % acetic acid. The padded samples were dried at 100 ℃ for 5 min and some of dried samples were further cured at 150 ℃ for 3 min. Treated samples were rinsed and conditioned at the standard condition.

In other procedure of treatment, chitosan oligomer was dissolved in distilled water, and binder or DMDHEU with catalyst was added in the padding bath. Cotton fabric was treated at the same condition as described earlier.

Evaluation of treated fabrics

Add-on was calculated from the difference in sample weight before and after chitosan treatment.

Antimicrobial activity of treated fabrics was evaluated by the Shake Flask Method in terms of the reduction rates in the number of colonies of a gram-positive test bacterium, *Staphylococus aureus*(ATCC No. 6538).

Treated fabrics were laundered 5, 10, 15, 20 times according to AATCC Test Method 60-1986. After laundering, antimicrobial activity was evaluated as described earlier.

RESULTS AND DISCUSSION

Effect of chitosan concentration on the antimicrobial activity

The effect of chitosan concentration on the antimicrobial activity is shown in Fig. 1. Antimicrobial activity of MW 50,000 chitosan is increased with concentration and approached to a

maximum value at 0.5 %, and then it is not changed significantly. Chitosan of DAC 65 % shows reduction rate below 40 % even if chitosan concentration increases, which means it is not effective against *S. aureus*. Chitosan of DAC 78 % displays the maximum reduction rate of 93 % at 0.5 % chitosan concentration and it is not increased thereafter. Chitosan of DAC above 84 % shows similar reduction rates and reaches to the reduction rate of 100 % above 0.5 % chitosan concentration. Regardless of DAC, reduction rate is not increased anymore above 0.5 % of treatment concentration for chitosan of MW 50,000. Chitosan oligomer displays ca. 80 % of reduction rate at 0.5 % concentration and reaches to 100 % of reduction rate at 1.5 % concentration.

Effect of degree of deacetylation on the antimicrobial activity

As shown in Fig. 2, reduction rate is increased with DAC at the same chitosan concentration. The increase of DAC plays a positive role onto antimicrobial activity because amine groups imparting antimicrobial activity increase as DAC increases. However, antimicrobial activity is not significantly increased above DAC 84 %. Effect of DAC on the antimicrobial activity is more evident at lower chitosan concentration.Chitosan of DAC 65 % does not show significant antimicrobial activity. And chitosan of DAC 78 % shows significant antimicrobial activity at the concentration above 0.5 %, but does not reach to 100 % reduction rate up to 1.0 % of chitosan concentration.

Effect of additives on the antimicrobial activity

Antimicrobial activity is decreased with the concentration of binder or crosslinker(DMDHEU) as shown in Fig. 3. This means that DMDHEU binds with hydroxyl groups in cellulose and amine groups in chitosan resulting the decrease of antimicrobial activity. Polyurethan binder seems to mask amine groups. DMDHEU is less detrimental to antimicrobial activity compared with polyurethane binder.

Durability to laundering of treated fabrics

The effect of curing on the durability to laundering of antimicrobial activity is shown in Fig. 4. At any treatment condition and DAC, reduction rate decrease with laundering cycle. Reduction rate decrease sharply up to 5 laundering cycles and reaches to an equilibrium state at 20 laundering cycles. Cured samples show superior durability to not-cured samples. Curing effect is shown more remarkably at higher chitosan concentration. In the case of chitosan oligomer, binding to cellulose fiber seems to be weaker than chitosan of MW 50,000. Compared with chitosan oligomer only treated fabrics, binder or crosslinker is not effective to improve the durability to laundering of chitosan treated fabrics.

CONCLUSION

Add-on of treated fabrics is increased with chitosan concentration, but is not dependent on curing and DAC. Antimicrobial activity is increased with chitosan concentration and reached to a maximum at 0.3~0.5 % depending on DAC. Antimicrobial activity is increased sharply with DAC up to 84 % and then is not increased significently thereafter. Curing improves the durability to laundering of antimicrobial activity of fabrics treated with chitosan of MW 50,000. Addition of binder or crosslinker increases add-on, but decreases the antimicrobial activity of treated fabrics with chitosan oligomer. Binder or crosslinker seems not effective to improve durability to laundering of the fabrics treated with chitosan oligomer.

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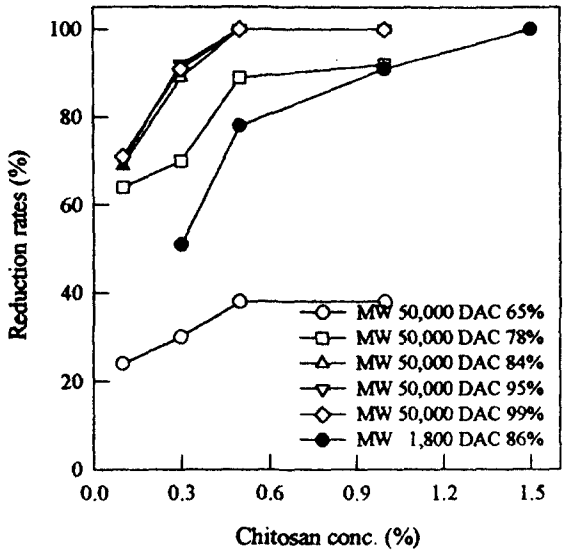

Fig. 1. Effect of chitosan concentration on the antimicrobial activity.

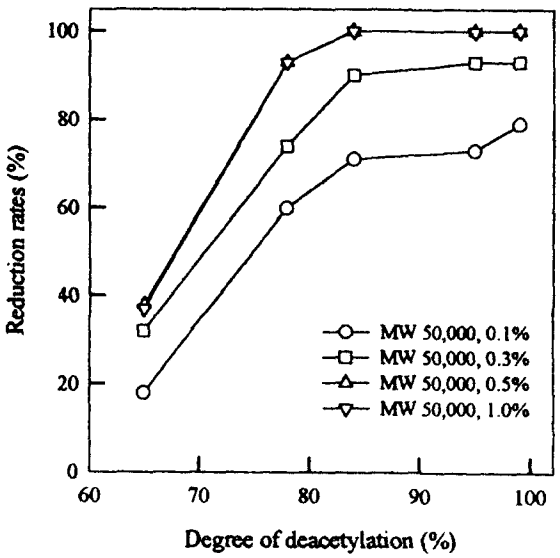

Fig. 2. Effect of degree of deacetylation on the antimicrobial activity.

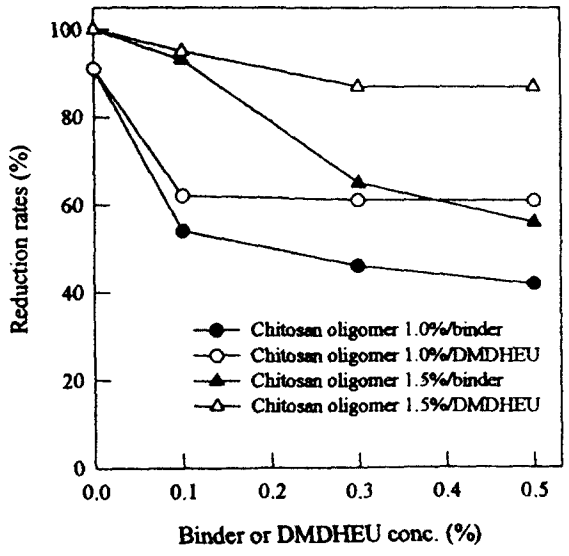

Fig. 3. Effect of binder or DMDHEU on the antimicrobial activity.

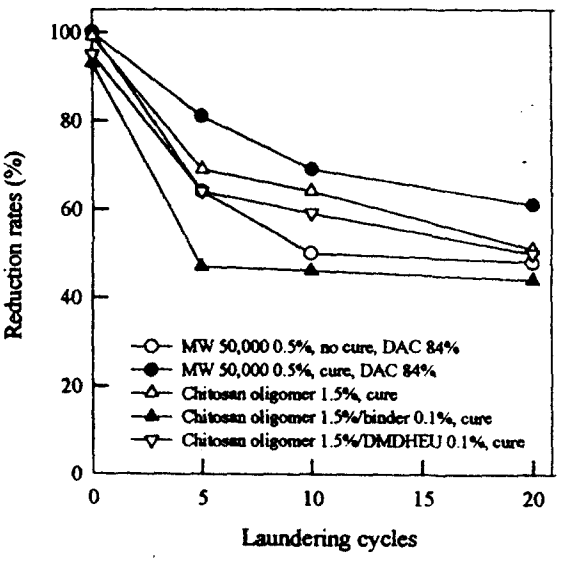

Fig. 4. Effect of treatment condition on the durability to washing.