나노 사이즈의 은 콜로이드 용액을 이용한 폴리에스테르 부직포의 항균가공

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Antibacterial Finishing of PET Nonwovens with Colloidal Solution of Nano-sized Silver

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1. Introduction

Researches for nanotechnology are inherently multidisciplinary since on the biological, and chemical components and systems are essentially the same. As the synthetics develop, many people are concerned about the influences of natural environment and hygiene of manufactures. By this reason, a new area has developed in the realism of textile finishing. The aim of this work is to consolidate nanotechnology into bacteriostasis of textile.

Nanoparticles are classified into nanostructured, nanosized and nanophased materials. The former refer to condensed bulk materials that are made of grains with grain sizes in the nanometer size range, while the latter are usually the dispersive nanoparticles. It is known that material is approaching or at the level of atoms or molecules, on this scale. The nanometer size for this research here covers a wide range, that can be as 30-300nm. We review disinfection of these sized colloidal silver and antibacterial effect on fabric which was treated by padding through colloidal solution of dispersed silver nanoparticles.

2. Experimental

We used three genuses of bacteria, *Staphylococcus aureus*(ATCC No. 6538), *Escherichia coli*(ATCC No. 25922), and *Klebsiella pneumoniae*(ATCC No. 4352). *S. aureus,* and *E. coli* were applied to silver colloids on the other hand, *S. aureus* and *K. pneumoniae* were applied to polyester nonwovens for our present.

Colloidal solution samples of silver nanoparticles is placed on germ containing agar plates; inoculated with gram-positive bacteria (*S. aureus*) and gram-negative bacteria (*E. coli*), and incubated in an agar medium.

The fabric was bleached, and needle punched nonwovens weighting 130g/m^2. Experiments were performed on samples with maximum dimensions of 10cm x 10cm.

Disinfectant was made by dilution of 3% colloidal silver solution with distilled water and was padded on fabric with fixed pressure to a wet pickup of 100% through a bath containing silver nanoparticles. The fabric was dried in air at room temperature for 12 hours. Approximate concentrations of added colloidal silver were calculated from the weights of fabric before and after treatment.

Textile specimens were placed on germ containing agar plates; inoculated with gram-positive bacteria (*S. aureus*) and gram-negative bacteria (*K. pneumoniae*), and incubated in an agar medium at 37±1℃ for 18 hours.

Field emission scattering electron microscope (FESEM) was performed with a JEOL JSM-6330F on the sample prepared to observe the nano-sized silver particles on polyester fibers in nonwovens.

3. Results and Discussions

3.1. Disinfection of nano-sized colloidal silver

The concentration coefficient of colloidal silver was determined by a laboratory procedure, dilution of 3% silver colloids with distilled water at RT as 40ppm, 70ppm, 100ppm, and 150ppm. The applied sizes of silver particles were controlled by using different surfactants when we manufactured the first 3% solution of colloidal silver. We used 30nm, 70nm, 150nm, and 300nm colloidal silver to define the concentration effect of disinfection against *Staphylococcus aureus* and *Escherichia coli*. The injected number of bacterial colonies on each agar plate, was settled as 7.9 x 10^4 for *S. aureus* and 7.4 x 10^4 for *E. coli*. These colonies did not very increased or decreased spontaneously on agar plates without colloidal silver after 5min, 15min, and 30min.

But the reduction of colonies of *S. aureus* was at least 49.4% when an agar plate contained 70ppm of 150nm silver colloidal after only 5 min. The maximum reductive percents of colonies were 85.3% at 150ppm after 5 min, 97.5% at 70ppm after 15 min, 99.6% after 30 min. All maximum values were exposed at the smallest diameter, 30nm of colloidal silver. Because of this excellent growth exhibition against *S. aureus*, we did not detect all colony counts of *E. coli*. The reduction of *E. coli* was 95.2% at 100ppm of 70nm silver colloidal after 5 min at the minimum. On the other side, the maximum reduction of bacteria was 99.9% at

150ppm of 300nm silver colloidal after 15 min by a shade of differences with other data. We supposed smaller sizes of particles should be better disinfectant, however the test results had very small tolerances contrary to our expectation since the antibacterial effect of colloidal silver was excellent in particular as all of percent reduction of bacteria was over 95.0%. This result is significant of importance of particle sizes and concentrations. Colloidal silver had better disinfection when the particles were small sized and high concentrated in dilution.

3.2. Disinfection of polyester nonwovens after padding through nano-sized colloidal silver

The concentration of colloidal silver for fabric treatment was determined by a laboratory procedure; we diluted 3% of colloidal silver of which particle diameter was 30nm on the average, with distilled water at RT as 10ppm, 20ppm, 30ppm, 50ppm, 200ppm. 400ppm, 800ppm and 3,000ppm after due consideration about a wet pick up ratio against fabric weight. For the successive treatment of fabric with colloidal silver, the dilution was agitated continuously. The growth inhibition of *Staphylococcus aureus* and *Klebsiella pneumoniae* was reported as the percent reduction in the number of colonies on the treated fabric, as compared with the number of colonies on untreated control fabric.

The injected number of bacterial colonies on each agar plate, was settled as 1.3 x 10^5 for *S. aureus* and 1.4 x 10^5 for *K. pneumoniae*. These colonies increased excessively on each agar plate at 37±1℃ for 18 hours naturally.

But the inhibition of colony count of *S. aureus* was 99.9% when agar plates contained the padded fabric through 30ppm, 50ppm, 200ppm, 400ppm, 800ppm, and 3,000ppm(Table I). And the reduction of *K. pneumoniae* was also 99.9% when agar plates contained the treated fabric through 200ppm, 400ppm, 800ppm, and 3,000ppm and was 99.8% when contained the treated fabric through only 50ppm(Table II).

This resutlts show that over 50ppm of nano sized colloidal silver particles in the polyester nonwovens have an excellent antibacterial activity not only against Gram-positive bacteria (*S. aureus*) but also against Gram-negative bacteria (*K. pneumoniae*).

The nano sized silver particles on fibers in polyester nonwovens were observed on SEM pictures. Almost silver particles are sufficiently dispersed on the fibers and some particles are aggregated each other. But even agglomerate particles of which diameters are approximately 100nm, seems to be not seriously effective to antibacterial activity.

4. References

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Table I. Disinfection of nano-silver colloids with *Staphylococcus aureus*

Concentration (ppm of fabric weight)	The number of bacterial colonies		Reduction (%)
	untreated fabric	treated fabric	
3000	5.5×10^6	<10	99.9
800	5.9×10^6	<10	99.9
400	4.7×10^6	<10	99.9
200	4.7×10^6	<10	99.9
50	5.5×10^6	<10	99.9
30	5.1×10^6	5.4×10^5	89.5
20	5.1×10^6	8.1×10^5	84.2
10	5.5×10^6	4.9×10^6	10.6

Table II. Disinfection of nano-silver colloids with *Klebsiela pneumoniae*

Concentration (ppm of fabric weight)	The number of bacterial colonies		Reduction (%)
	untreated fabric	treated fabric	
3000	5.8×10^6	<10	99.9
800	5.7×10^6	<10	99.9
400	5.3×10^6	<10	99.9
200	5.3×10^6	<10	99.9
50	4.9×10^6	9.8×10^3	99.8
30	5.9×10^6	2.3×10^3	59.8
20	5.9×10^6	3.1×10^6	48.2
10	4.9×10^6	4.3×10^6	12.8