PE4) 먼지 입자 포집에 의한 항균 필터의 항균 성능 저하에 관한 실험적 연구

Experimental Study about Performance Decay of Antimicrobial Air Filters by Dust Loading

Wei Ju · 윤기영 · 박재홍 · 김양선 · 심 솔 · 황정호
연세대학교 기계공학과

1. Introduction

Bioaerosol, especially in the field of indoor air environment, is being attached increasing attention as one of focuses of exposure to air pollution (Harriet, 1990). Silver has been regarded as a kind of antimicrobial agent for a very long time (Sharma et al., 2009). Generally speaking, the antimicrobial characteristics of antimicrobial treated air filters can be observed by general antimicrobial test. The actual process that the antimicrobial filter works, however, is not like this. The bioaerosols attach the filter during filtration as the dust particles are filtered. According to a series of qualitative experiments, dust-loaded or non-dust-loaded panel filter pairs with different antimicrobial agents lead to different results of microbial growth tests (Foarde et al., 1999). In this study, the effect of dust loading amount on the antimicrobial characteristics of filters is investigated by quantitative experimental methods, namely examining the antimicrobial ability of antimicrobial High Efficiency Particulate Air (HEPA) filters containing silver nanoparticles (NPs) as antimicrobial agent and a certain amount of dust particles.

2. Method

Silver NPs were coated on HEPA filters using a spark discharge method, shown in Figure 1(a). Alternatively, a Scanning Mobility Particle Sizer (SMPS) system is taken the place of the filter holder firstly in order to measure the size distribution of coated silver NPs. The measurement result is graphed in Figure 1(c) while the size and concentration parameters are summarized in attached table, which 2kV and 1mA is employed for spark discharger. The experiment-used antimicrobial filter samples are prepared at routine room temperature, which are distinguished and labeled by the coating times: 0, 5, 20, and 60 minutes, respectively. With the parameters, including total number concentration of silver NPs C_N, carrier gas flow rate $\dot{Q}$, and effective area of filter samples A, the coating number density ρ_N can be calculated, using equation $\rho_N = \frac{C_N \cdot \dot{Q} \cdot t}{A}$, according to different coating times, and summarized in Table 1.

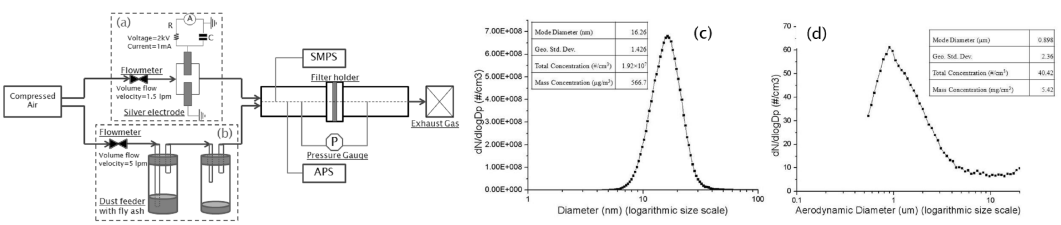

Fig. 1. Experimental schematic diagram and particle size distributions of Ag NP and fly ash.

Before the silver NPs are coated, the filters are sterilized with an autoclave under 121℃ and 0.1MPa during about 60min. Then dust loading using different amount of fly ash is then coated onto the refabricated silver-deposited HEPA filters for the purpose of simulating the real situation as shown in Figure 1(b). An Aerodynamic Particle Sizer (APS) system is installed in front of the filter holder firstly in order to measure the size distribution of fly ash particles, which is summarized in Figure 1(d). For the purpose of controlling the amount of dust loading, the pressure drop between the upside and downside of filter sample, measured by a pressure gauge, is taken as the controlled variability in this study.

Table 1. Number density of silver NPs on HEPA filter samples.

Coating time	Total concentration	Volume flow rate	Effective area	Number density
$t(\min)$	$C_N(\#/cm^3)$	$\dot{Q}(cm^3/\min)$	$A(cm^2)$	$\rho_N(\#/cm^2)$
0	1.92×10^7	1.5lpm=>1500	15.7854	0
5				9.12×10^9
20				36.48×10^9
60				109.44×10^9

After dust loading, the antimicrobial tests are taken to these filter samples by disc diffusion method. This method is based on the appearance of a belt-like inhibition zone around the antimicrobial agent in a petri dish with nutrient agar and bacteria after incubation for about 24 hours. And it means, the larger the diameter of the inhibition zone is, the stronger the antimicrobial ability is regarded as. Two different kinds of bacteria are selected for the antimicrobial tests, *E.coli* as Gram-negative bacteria and *S.epidermidis* as Gram-positive bacteria.

3. Results

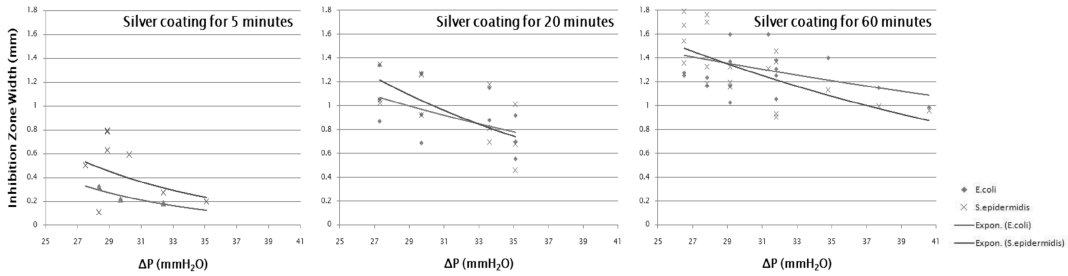

Fig. 2. Inhibition zone width variations of different silver coating time: 5, 20 and 60 minutes.

The results of antimicrobial tests with filter samples containing silver NPs and dust loading particles are summarized in Table 2, emphasizing that no inhibition zone was observed on samples containing no silver NPs. Here it can be concluded that the antimicrobial ability decreases when more dust loading is filtered although more silver nanoparticles play a role in enlarging the inhibition zone. More repeat experiments with dust particles of different sizes are scheduled to be taken on next step in order to observe the impact not only of dust amount but also of particle size distribution.

Acknowledgements

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