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An indoor air purification technology using a non-thermal plasma reactor with multiple-wire-to-wire type electrodes and a fiber air filter

Jae-Seung Jung, Jin-Gyu Kim*

Department of Electrical Engineering, Kyungpook National University, 80 Daehakro, Bukgu, Daegu 41566, Republic of Korea

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ABSTRACT

For indoor air purification, long-term operation of the air purifier induces the growth of germs and the proliferation of molds, and results in the performance degradation of the air filter. Non-thermal plasma technology could be an effective countermeasure against these problems. Ozone generated by the electric discharge has significant germicidal power and does not produce secondary residual contaminants. Electrostatic force can enable the air filter to function as an electric precipitator. In this study, a non-thermal plasma reactor with wire-wire type electrodes and an air filter is investigated experimentally to improve the performance of the used air filter.

1. Introduction

In the information age, people spend most of their time indoors for work and family life. Therefore, indoor air pollution and purification are gaining significant attention. For indoor air purification, fiber air filters are generally used in various devices to manage the air condition. However, long-term operation of the air filter induces the growth of germs and the proliferation of molds and also results in the performance degradation of the air filters. It has well-known that a non-thermal discharge plasma technique could be one of the innovative approaches to solve these problems [1–6].

Furthermore, several non-thermal discharge plasma techniques have already been investigated for the removal of specific air pollutants such as NOx, SOx, VOCs, and CFCs. These include non-thermal plasma techniques using a corona discharge [7–9], a dielectric barrier discharge [7,9–12] and a surface discharge [13].

Air quality due to the bacteria and pollutants can be managed by an electro-physicochemical reaction. The electro-physical reaction originates from energetic ions (electron temperature, $T_e \gg 1$ eV) and the electrochemical reaction is mainly caused by the ozone (O_3) and radicals generated by the corona discharge [7–9]. It is generally known that O_3 has a strong sterilizing ability; it also has the advantage of not generating residual contaminants because this compound resolves itself into oxygen within a short time. Therefore, it has been utilized in various industrial applications such aswater purification, disinfection, deodorization, and the removal ofair pollutants. For the sterilization with O_3; 0.6–0.9 ppm, a sterilization time of approximately 600 s is required to sterilize bacteria such as *S. Salivarius*, *E. coli*, *Bacillus Vibrio*, *Salmonella*, etc. [14,15]. Another factor that affects air quality is dust. As generally known, methods for removing dust is to use an air filter or an electrostatic precipitator. The principle of the electrostatics precipitator is to remove the dust by charging and attaching to the collecting plate due to the electrostatic force [16–18]. For this reasons, the development of an effective electric discharge is known as one of the key technology for practical non-thermal plasma reactors for the improvement of air quality [7–9,19].

In this paper, a non-thermal plasma technology is investigated experimentally to improve the performance of a long-term used air filter. O_3 and the electrostatic force generated by the electric discharge have the ability of sterilize and enhance dust collection. Additionally, it helps in maintaining the improved condition of the air filter after the electric power is turned off.

* Corresponding author.
E-mail address: kjg@knu.ac.kr (J.-G. Kim).

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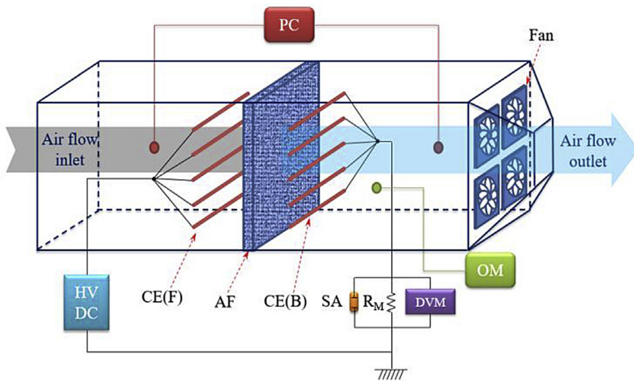
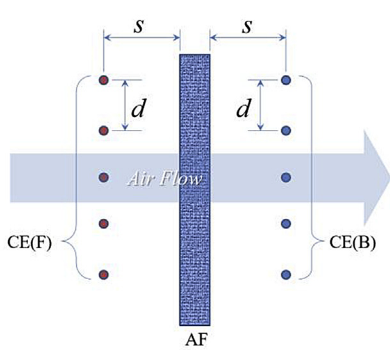
2. Experimental set-up

The schematic diagram, the air filter and electrode structureused in the experimental setup are shown in Fig. 1. The

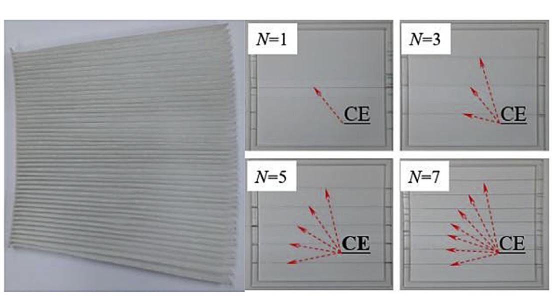


AF	: Air Filter
CE(F)	: Forward Corona Electrode
CE(B)	: Backward Corona Electrode
DVM	: Digital Volt Meter
HVDC	: High Voltage DC supply
OM	: Ozone Monitor
PC	: Particle Counter
R_M	: Resistor for Measurement
SA	: Surge Arrestor

(a) Schematic of the experimental set-up



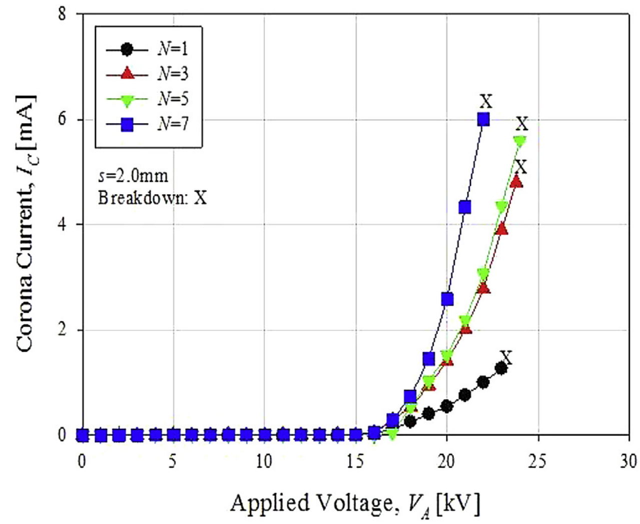
(b) Position of corona electrodes and an air filter



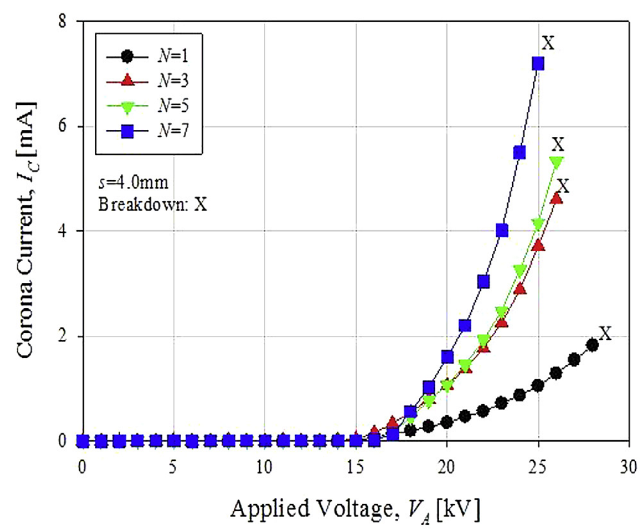
(Air filter) (Multi-wire electrodes)

(c) Photographs of the air filter and wire electrodes used for the experiment

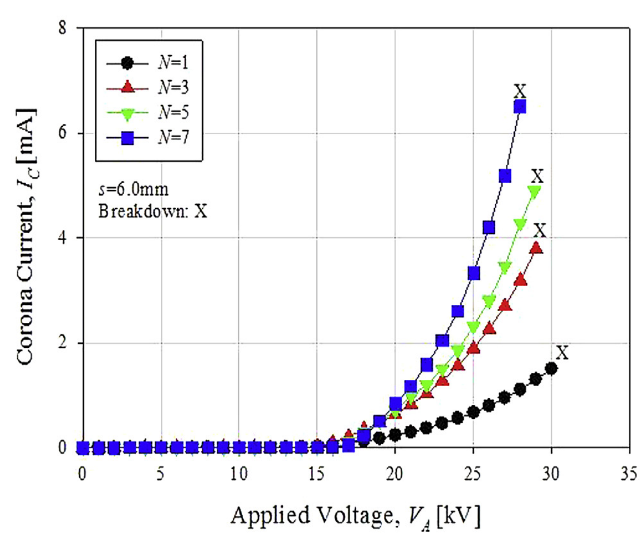
Fig. 1. Experimental set-up of the proposed plasma reactor with wire-wire type electrodes and an air filterfor the indoor air purification.



(a) s=2.0 mm



(b) s=4.0 mm



(c) s=6.0 mm

Fig. 2. I_C–V_A characteristics of the proposed plasma reactor by the variation of s and N.