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Fundamental characteristics of particle collection by a single dielectric barrier discharge plasma actuator using magnetic fluid electrodes for air purification

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Air pollution caused by aerosols containing diesel exhaust particles poses a significant environmental challenge. Although electrostatic precipitators (ESPs) find widespread use in particle collection, the decrease in collection efficiency due to the re-entrainment of carbonaceous particles from the electrode surface remains a critical issue. To address this challenge, this study develops a single dielectric barrier discharge (DBD) plasma actuator utilizing a magnetic fluid (MF) as the exposed electrode (single MF-DBD plasma actuator). The actuator retains the MF on a metal electrode surface over a dielectric layer via magnetic force, functioning as a collection electrode. The application of an AC high voltage between the MF and an insulated electrode generates non-thermal plasma, thereby inducing an ionic wind. The application of this actuator to air purification technology enables simultaneous particle collection and self-suction via the ionic wind, promising a fanless structure that eliminates mechanical ventilation mechanisms.

This study investigates the fundamental characteristics of particle collection by the single MF-DBD plasma actuator. The target particles have a diameter of 0.3 μm, which are generally the most difficult to collect via electrostatic force. The experiments measure the collection efficiency using a particle counter and determine the discharge power via the Q-V Lissajous method.

The collection experiments using 0.3 μm carbonaceous particles demonstrate that the MF-DBD plasma actuator achieves a high collection efficiency of 96% under an applied voltage of 8.5 kV and a discharge power of 17 W. These results indicate that the liquid surface of the MF physically captures the particles through surface tension and viscosity, effectively suppressing re-entrainment.

This study demonstrates the high utility of the single MF-DBD plasma actuator as a next-generation air purification technology and highlights a novel engineering application for magnetic fluids.

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