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Effect of Dc Electric Field and Air Flow Rate on Scavenging Of Liquid Aerosol by Electrospray

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Abstract This experiment is centred on examining how the charge of droplets and the airflow rate for spray generation impact the removal of liquid aerosols. The study involves generating liquid aerosols with an aerodynamic diameter ranging from 10 to 1000 nm using Di-Ethyl-Hexyl-Sebacat (DEHS) solution. Two distinct air flow rates, namely 40 slpm and 100 slpm, are maintained within the air-atomizing nozzle to create fine water droplets. The findings from the experiments demonstrate that charged droplets are more effective in removing particles compared to uncharged droplets.

1. Introduction

Electrostatic precipitators, air purifiers utilizing electro-spraying technology, and the use of charged droplets have all been devised as electrically powered solutions to decrease the presence of fine particulate matter in the atmosphere. Due to the Coulombic force of attraction, the fine particle quantity is drastically controlled. W. Balachandran et.al (2003) revealed a notable improvement in removal efficiency when using charged droplets in comparison to uncharged ones. Specifically, the removal efficiency for charged smoke particles was found to be four times greater than that of uncharged smoke particles. In an experimental investigation, the impact of particle shape and water-attracting properties on the effectiveness of both charged and uncharged sprays in capturing particles was explored by S. Lipeng et al. (2019) Uncharged droplets exhibited greater effectiveness in collecting nearly spherical particles compared to clustered ones. However, this efficacy declined when the droplets were electrically charged. Additionally, the charging of droplets enhanced the ability to remove hydrophobic particles, specifically DEHS. W. Tessum et al. (2014) conducted a research study to explore the impact of surfactant presence in spray, particle charge, and diameter on scavenging efficiency. The findings revealed that particles exceeding 2 microns in diameter were removed more effectively than smaller particles. Additionally, using a charged spray with surfactant, featuring opposite polarity to the particle charge, resulted in the notable removal of highly charged particles. T. Gary et al. (2007) experimental demonstrated that the electrospray-based purification technique proved to be highly efficient across a broad spectrum of particle sizes, all the while conserving water and power resources more effectively.

2. Experimental methodology

Figure 1 depicts all the equipment used to carry out this experiment. The experimental chamber is fabricated from acrylic sheets that are 5 mm thick, with dimensions measuring 600 mm in height, 200 mm in length, and 200 mm in width. To create the spray within the chamber, an internal air-atomizing nozzle is installed at the top of the chamber. This spray is generated by pumping tap water to the nozzle using a Crompton self-priming pump (Model mini strong I) and supplying compressed air through a Powertex Model PPT-COM-50L oil-cooled compressor. The water flow rate is maintained at 0.6 lpm, as measured by a rotameter, while the compressed air flow rate varies from 40 to 100 slpm and is measured using a mass flow controller. The droplets are charged by applying DC electric potential at 9 kV. To produce the liquid aerosol of Di-Ethyl-Hexyl-Sebacat (DEHS), an aerosol generator is employed, varying the vapor pressure between 150 to 300 hPa. The generated aerosol is introduced into the experimental chamber through an 8 mm inlet port, using compressed air at a flow rate of 10 lpm. To assess the size distribution and mass concentration of the aerosol, a GRIMM Scanning Mobility Particle Sizer (SMPS) with a Condensation Particle Counter (CPC) Model 5416 is connected to the outlet of the chamber.

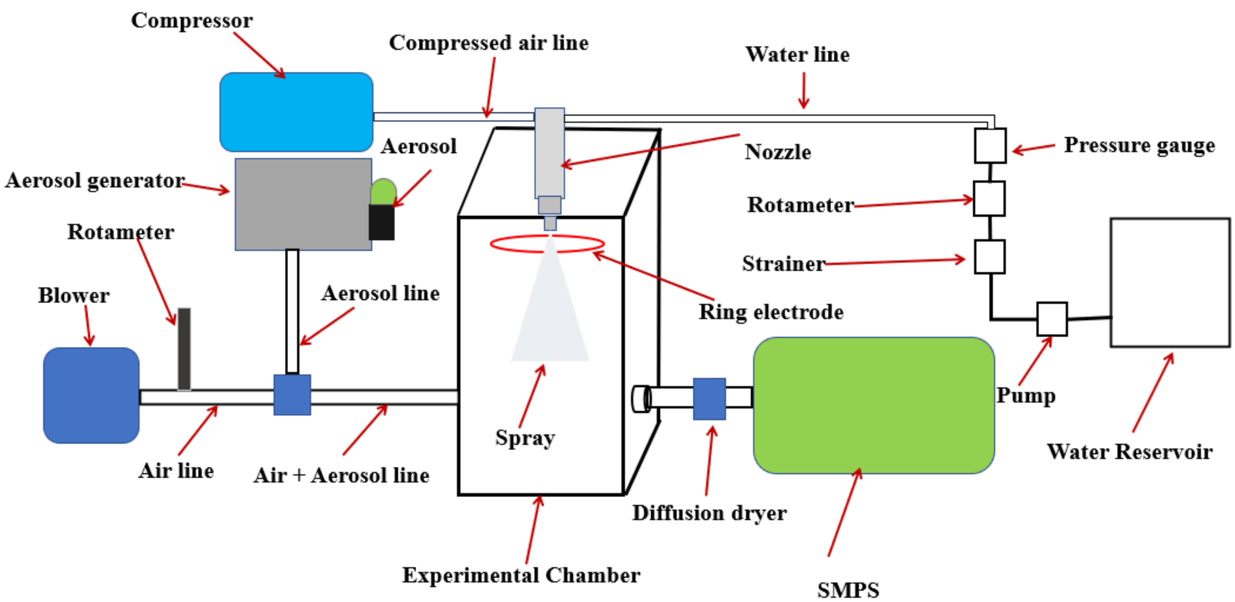

Fig1: Layout of experimental setup for scavenging of liquid aerosols by charged and uncharged spray generated through air-atomizing nozzle.

RESULT & DISCUSSIONS

This section delves into the effectiveness of removing fine liquid aerosols using both charged and uncharged sprays generated by an air-atomizing nozzle at varying air flow rates. In this experimental study, Di-Ethyl-Hexyl-Sebacat (DEHS) solution is employed as the aerosol medium. The results reveal that the removal efficiency of fine liquid aerosols through uncharged sprays is minimal. However, when the droplets are charged, the particle removal efficiency significantly increases, as illustrated in Figure 2. The experiments are conducted with different air flow rates, specifically 40 slpm and 100 slpm. It is observed that at the lower air flow rate of 40 slpm, the scavenging efficiency surpasses that at the higher air flow rate of 100 slpm, as indicated in Figure 2. This disparity is attributed to the fact that at higher air flow rates used to create the spray, the droplet size becomes exceedingly fine, essentially resembling an aerosol. Consequently, at higher air flow rates, the spray itself transitions into an aerosol state, which is quantified by the Scanning Mobility Particle Sizer (SMPS).

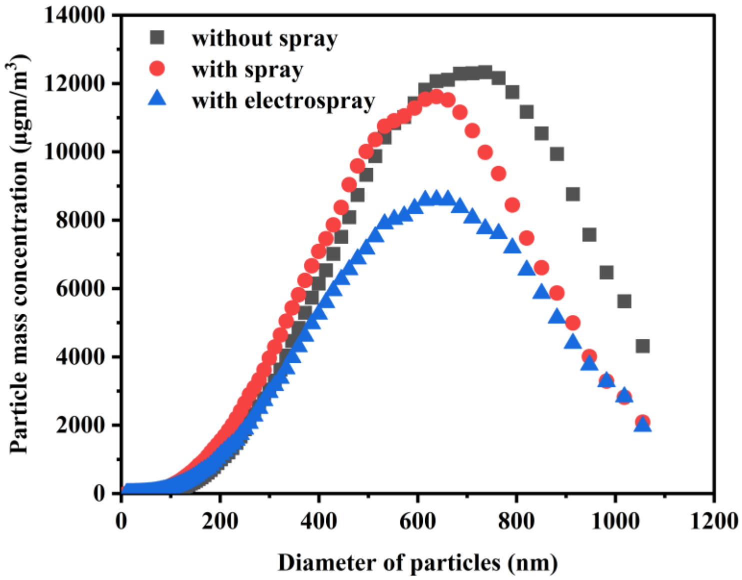

Figure 2. Effect of uncharged spray and charged spray at 9 kV applied potential with air flow rate of 40 slpm for spray generation on scavenging of DEHS aerosol.

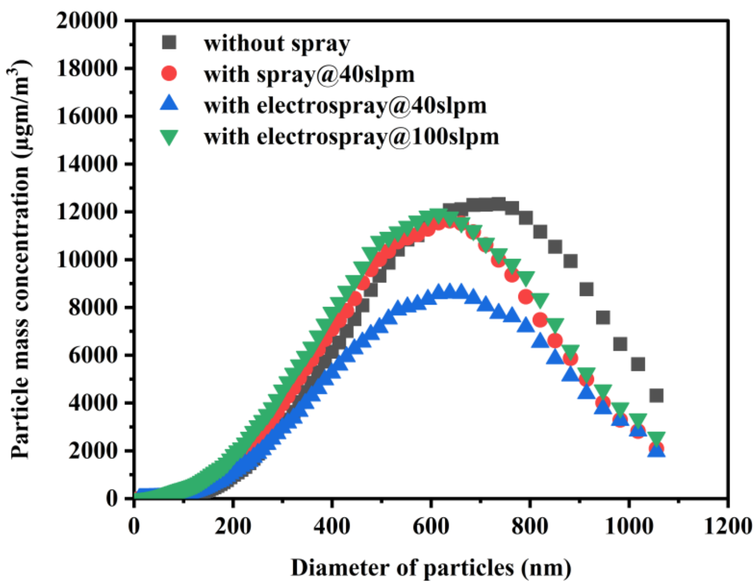

Figure 3. Effect of uncharged spray and charged spray at 9 kV applied potential with air flow rate of 40 slpm and 100 slpm for spray generation on scavenging of DEHS aerosol.

Conclusions

In this paper, the scavenging of the liquid aerosol by charged droplet generated through air-atomizing nozzle is studied. The vital finding of this study has been depicted in the followings.

1. With enhancement of air flowrate (from 40 slpm to 100 slpm) to air atomizing nozzle, the droplet size generated through the nozzle decreases.
2. The scavenging efficiency of aerosol by uncharged droplet is less than charged droplet.
3. At higher air flow rate to air atomizing nozzle leads to decrease in scavenging efficiency. As tiny droplets enter into the SMPS and SMPS counts droplets as aerosol.
4. Charged droplets are the most effective method of removing fine particles.

Acknowledgements

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