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Technical Note

Real-time measurement of submicron aerosol particles having a log-normal size distribution by simultaneously using unipolar diffusion charger and unipolar field charger

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Abstract

Recently, Park et al. [(2007). Development and performance test of a unipolar diffusion charger for real-time measurements of submicron aerosol particles having a log-normal size distribution. *Journal of Aerosol Science*, *38*, 420–430] have introduced a methodology for performing simple and fast measurements of submicron aerosol particles having a log-normal size distribution, using a unipolar diffusion charger, an electrometer, and a condensation particle counter (CPC). The methodology can be applied to particles of 30–700 nm and requires an assumption of their geometric standard deviation in size. In this paper we propose a much cheaper but faster method which involves substituting a unipolar field charger and another electrometer for the CPC. With the data obtained using this dual-charger system, we developed a data inversion algorithm and estimated the particle size distribution by minimizing the differences between the measured aerosol currents and the calculated values. To compare the size distribution with the data measured using a scanning mobility particle sizer (SMPS), sodium chloride (NaCl) particles smaller than 0.1 μm in diameter, and dioctyl sebacate (DOS) particles with a diameter of 0.1–0.7 μm, were used. The estimated results for the NaCl and DOS particles were within 10% of the data measured with the SMPS, while a 33% deviation from the SMPS results was obtained in Park et al. [(2007). Development and performance test of a unipolar diffusion charger for real-time measurements of submicron aerosol particles having a log-normal size distribution. *Journal of Aerosol Science*, *38*, 420–430]. Furthermore, the detection time obtained with the use of our dual-charger system was faster (< 3 s) than the 5 s obtained by Park et al. [(2007). Development and performance test of a unipolar diffusion charger for real-time measurements of submicron aerosol particles having a log-normal size distribution. *Journal of Aerosol Science*, *38*, 420–430].

Keywords: Diffusion charger; Field charger; Corona discharge; Unipolar; Log-normal size distribution

1. Introduction

For the sizing of particles in the submicrometer diameter range, many instruments have been studied using test particles generated in the laboratory. Today, the most common commercial instruments in use are the scanning mobility particle sizer (SMPS, TSI) and the scanning mobility particle sizer and condensation nucleus counter (SMPS + C,

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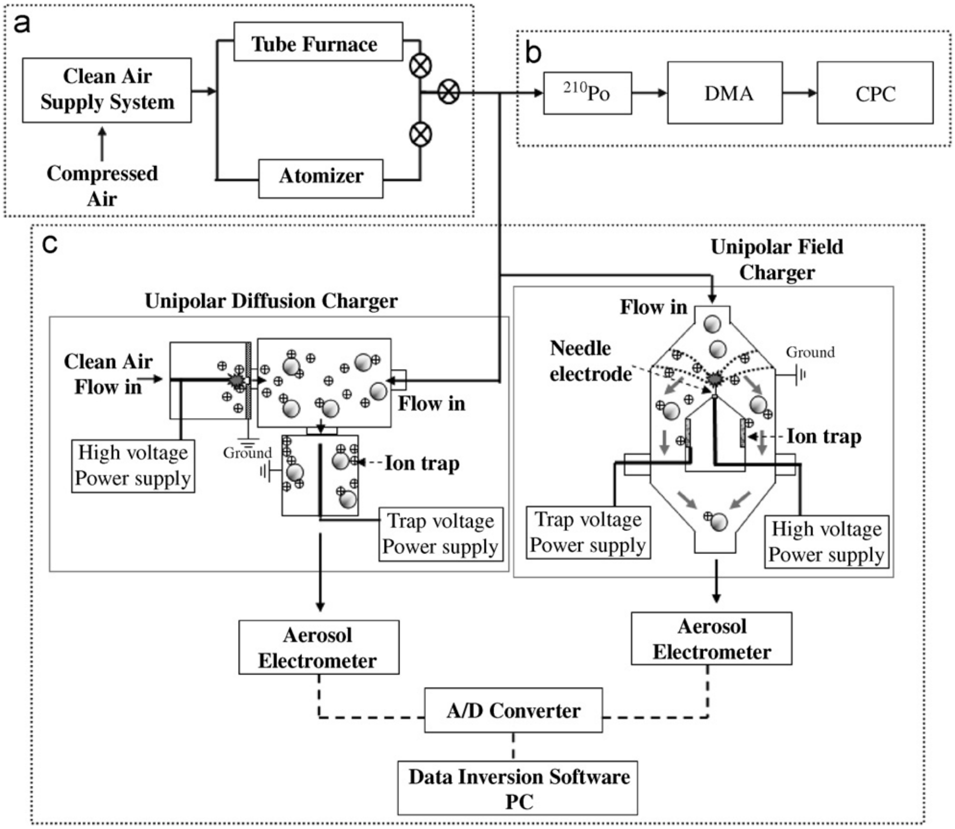

Fig. 1. Schematic of dual-charger system and experimental set-up.

GRIMM). For example, the SMPS sizes particles by their electrical mobility equivalent diameter and operates in the range of diameters from about 10–700 nm. The SMPS has been used in pretests to measure the size distribution of submicron particles carried by air and emitted from a particle generation device, for example, an atomizer. The SMPS has excellent size resolution, but needs between 3 and 5 min to perform even a single measurement. Therefore, if the size distribution is not within the range desired in the main experiments, the concentration of the atomizing solution has to be changed. Then the particle size distribution needs to be measured again. This repetitive procedure is very time consuming.

Recently, real-time measurements by using corona charger have been studied. Ntziachristos, Giechaskiel, Ristimaki, and Keskinen (2004) proposed the method of measurement for the characterization of automotive exhaust aerosol. Shin, Pui, Fissan, Neumann, and Trampe (2007) and Woo, Chen, Pui, and Wilson (2001) measured surface area of aerosol using corona charger. Also, the Electrical Aerosol Spectrometer (Tammet, Mirme, & Tamm, 2002), Differential Mobility Spectrometer (Biskos, Reavell, & Collings, 2005; Symonds, Reavell, Olfert, Campbell, & Swift, 2007), Engine Exhaust Particle Sizer (Johnson, Caldow, Pocher, Mirme, & Kittelson, 2004; Wang et al., 2006) and Electrical Low Pressure Impactor (Keskinen, Pietarinen, & Lehtimäki, 1992; Marjamaeki, Keskinen, Chen, & Pui, 2000) have been studied for the rapid measurement of size distributions. These commercial aerosol instruments estimate the size distribution using the current measurements from the individual channels to separate particles according to their electrical mobility or their aerodynamic diameter, in conjunction with a data inversion algorithm.

In our previous work (Park, An, & Hwang, 2007), we introduced a relatively simple and fast measurement method using a unipolar diffusion charger with an aerosol electrometer and condensation particle counter (CPC). CPCs are widely used as they can count the number concentration of an aerosol with high resolution, however, they use unhealthy and inflammable chemicals (butanol) in some models and they are also expensive. Instead of using a CPC, in this paper we propose the use of a unipolar field charger. Our system, which is shown in Fig. 1, consists of a unipolar diffusion