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Measurement of the charge of airborne 3–10 μm spherical dielectric particles charged in an AC unipolar charger

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Abstract

The charges of airborne 3, 5 and 10 μm spherical dielectric test particles passing through a novel AC unipolar charger have been measured individually. The measurements show the effectiveness of the charger and provide statistics on the particle charges measured. The 3 μm particles were charged to significantly higher values than expected. These log-normally distributed particle charges were found to have an average significantly above the saturation level for dielectric particles. This is most probably because of increased surface conductivity due to sodium and chlorine surface impurities from dried surfactant used for the storage of such particles.

Keywords: Pauthenier; Saturation; Charge; Particle; PSL; Polystyrene; Masuda; Boxer; Charger; Duke; Scientific; Microspheres; Unipolar; Uni-polar; Surface; Conductivity

1. Introduction

The charging of small airborne particles is useful in a wide range of applications where the controlled movement of particles is required. Examples include electrostatic precipitators, drug inhalation, electrostatic coating and particle analysis systems. The charging of aerosols can be achieved by photovoltaic excitation, static electrification, radioactive ionisation and flame charging. Diffusion charging and field charging are also particularly effective methods which require bombardment of the aerosol with unipolar ions. This can be achieved by using corona discharge where air molecules are ionised in the region of a highly charged electrode and are attracted to a grounding electrode. Using DC corona discharge results

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in small, charged particles being deflected by the electrostatic field and deposited on the grounding electrode. To avoid unwanted particle deposition an AC electric field can be used as demonstrated by Hewitt (1956).

Jaworek, Adamiak, Krupa, and Castle (2001) and Lackowski (2001) of the Institute of Fluid Flow Machinery (IFFM) at the Polish Academy of Sciences have developed a novel alternating electric field charger which has been characterised by Lackowski, Jaworek, and Krupa (2003). This charger is a simple design to fabricate and is much less complex than the Masuda, Washizu, Mizuno and Akutsu (1978) boxer charger which was assessed by Zevenhoven, Wierenga, Scarlett, and Yamamoto (1994). The University of Hertfordshire was provided with a similar charger and custom-made high-voltage power supply by IFFM and its performance was assessed. The results of this assessment are included in this paper and are of interest because of the effectiveness, relative simplicity and, therefore, reduced cost of the IFFM particle charger.

2. Charger description

The AC unipolar charger shown in Fig. 1 uses two arrays of sharp needles pointing towards each other across the aerosol flow which is directed along the middle of the charger between two grids. By applying a voltage gradient between one set of needles and the grids (electric field $\sim 3\,\mathrm{kV/cm}$) in the first half cycle of an applied AC square wave (100–200 Hz), the ionised air molecules from one needle tip are attracted across the aerosol flow; in the second half cycle the process reverses. Aerosol passing through the charger is highly charged as the particles are bombarded by many cycles of ion flux. When charged, the particles drift across the charger due to the electric field, and as the applied field reverses so does the drift direction. For a square-wave driving voltage the particles, therefore, trace out a zig-zag or W shaped path as shown

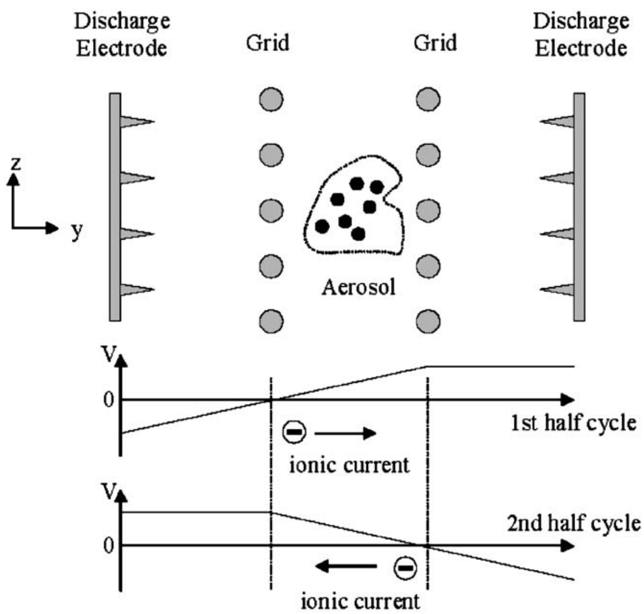

Fig. 1. Schematic diagram of the charger (end view) and the applied voltages.