Characterization of a post-DBD aerosol bipolar diffusion neutralizer for SMPS size distribution measurements

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Aerosol processes imply increasing research efforts to control the charge distribution of aerosols for size measurement, sampling, transport, and material processing. The main method used for the measurement of submicron particles size distributions is based on differential mobility analysis (DMA) and requires to charge aerosol with a well-defined charge distribution (Fuchs, 1963; Wiedensohler, 1988) to convert aerosol mobility distribution to aerosol size distribution.

A bipolar charger based on post-Dielectric Barrier Discharge (DBD) has been evaluated as neutralizer for submicron particles size measurements by mobility analysis. The aim is here to test such post-DBD neutralizer for the measurement of aerosol size distribution in the range from 15 to 730 nm.

The post-DBD neutralizer consists of a DBD used to produce bipolar ions and a charging chamber downstream the DBD, where the sampled aerosols and ions from the DBD are mixed. Aerosol is injected in post-DBD to avoid aerosol precipitation in the discharge gap and the related discharge destabilization. The DBD is a plane-to-plane arrangement. Two planes of alumina (thickness of 0.5 mm) are separated by a gap of 1.6 mm and polarized by cylinder electrodes with 4 mm diameter and 30 mm length. The flow section is 1.6 mm height × 50 mm length. The discharge occurs as thin and brief filamentary discharges (100 µm diameter and 20 ns duration). Each filament is a transient and localised source of positive and negative ions initially located and the cathode and anode side of the filament respectively (Borra 2006, Bourgeois 2009). Ions are blown from the discharge using air or N_2 flow. During the 100 ns ion transport from the discharge to the charging chamber, the positive and negative ions are mixed to reach homogeneous bipolar ion cloud.

Post-DBD ions densities and mobilities can be controlled by flow rates and DBD voltage, and thus that charge distribution could be adjusted for aerosol neutralization. Bipolar ion currents injected in the post-DBD charger control the maximal aerosol concentration that can be neutralized and the $n_{ion}.\tau$ product. Charge distributions were measured versus DBD voltage, aerosol diameter and concentration for monodisperse aerosols from 15 to 730 nm as detailed in Alonso (2000).

An example of a size distribution measured with ^{85}Kr and post-DBD neutralizers using the data inversion of the software without any modification is presented on Figure 1 at F=60 kHz, V_p=8 kV and 0.3 L.min^{-1} for both sampled aerosol and post-DBD ion flows.

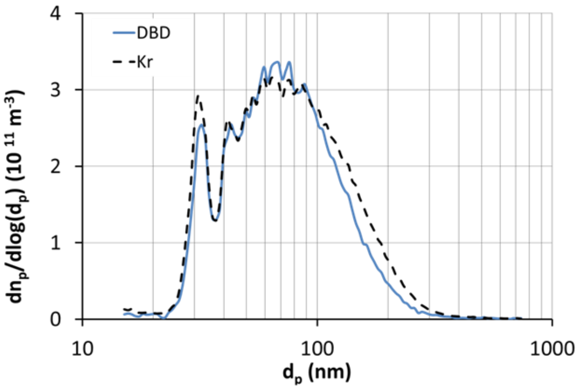

Figure 1. size distribution of poly-modal aerosol produced by nebulization of SiO_x particle suspension d_p = 34 nm & n_p = 2 × 10^{11} m^{-3} with air flow in the DBD.

The size distributions are similar with ^{85}Kr and post-DBD neutralizer, for aerosol with diameters from 20 to 730 nm and concentration up to 6×10^{12} m^{-3} with a total concentration of the size distribution only affected within less than 10 %. The differences arise from the slightly different mean charge in post-DBD than in ^{85}Kr that could be corrected using the real charge distributions in the data inversion.

As expected from Gunn's law, the mean charge and the squared standard deviation are proportional to particle diameter and constant whatever the aerosol concentration is.

This post-DBD bipolar charger can neutralizer submicron aerosol and is suitable for SMPS size distribution measurements with air, or with nitrogen injection in the DBD to suppress ozone production from air DBD.

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