Impact of size and concentration on the particle charging properties of an annular DBD

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Many scientific and industrial applications such as electrostatic precipitation, neutralization or electrostatic measurement techniques require the charging of aerosol particles (Kwon et al., 2006). Especially for the widely used scanning mobility particle sizers (SMPS) a well defined charge distribution is essential in order to transfer the electrical mobility spectrum into a meaningful size distribution. For this purpose usually diffusion chargers are applied in which the collision between bipolar ions and particles lead to an equilibrium particle charge distribution (Fuchs, 1963). In most cases radioactive sources like [241]Am, [85]Kr or [210]Po are applied for the generation of bipolar ions in reasonable concentrations. However legal restrictions complicate and often even prohibit the use of radioactive sources. Another efficient way of particle charging without legal restrictions is the use of gas discharge neutralizers. Beside corona chargers the use of dielectric barrier discharges for aerosol particle charging was reported (Borra, 2005, Byeon et al., 2008). The aim of this work is to specify a commercially available annular dielectric barrier discharger (aDBD) regarding charging properties as function of particle size and concentration.

Therefore we investigated the particle losses and charge distribution induced by the aDBD as well as the deviation between electrical mobility spectra of polydisperse aerosols neutralized with an aDBD and [241]Am source respectively. The aDBD was operated with a peak to peak voltage of 7.4kV and a frequency of about 20 kHz as well as a sample flow rate of 0.3 lpm. The particle background induced by the aDBD was measured to be below 100 cm⁻³. Size distributions and particle concentrations were measured between 10 nm and 950 nm using a differential mobility analyzer (Grimm, l-DMA) and condensation particle counter (Grimm CPC, 5.416). Diesel soot, DEHS and NaCl particles were applied at concentrations between $1x10^4$ cm⁻³ and $3.5x10^6$ cm⁻³. While DEHS and NaCl particles were suspended in air using an atomizer (Grimm, 7.821) diesel soot particles were directly supplied by a common diesel motor.

Figure 1 compares the SMPS mobility spectra resulting from [241]Am and aDBD neutralized NaCl aerosol particles. We observed a very good agreement to size at low concentrations and for large particles. However for small particles and at high concentrations significant differences occur. Below 90 nm mobility equivalent diameter we observe an increasingly reduced particle concentration compared to [241]Am with decreasing diameter. These differences mainly arise due to electro-collection on an additional electrode which assures a stable plasma operation.

Between 90 nm and 950 nm the size distributions are in good agreement for total number concentrations below $2x10^4$ cm⁻³. Higher concentrations induce an increasing deviation which however is constant for the entire size range. This deviation as function of the total number concentration can be approximated by a pseudo voigt profile which may be applied in order to correct SMPS measurements under high concentrations.
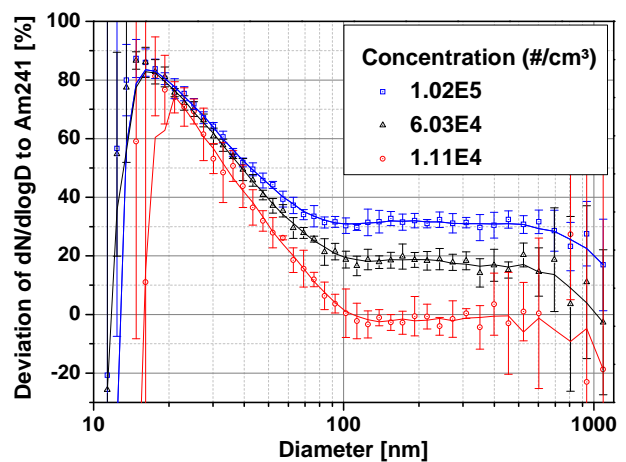

Figure 1: Deviation of a NaCl electrical mobility spectrum measured with an SMPS-aDBD combination to an Am241 neutralizer as function of particle size and concentration. Error bars represent the 95% confidence interval out of 5 measurements.

In this contribution we present the impact of particle concentration and size on the charging properties of the Grimm aDBD neutralizer and discuss the contribution of particle losses and charge distribution on the observed deviations to [241]Am

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