Bipolar diffusion charging of aerosol nanoparticles by means of AC-corona discharge and soft X-ray devices

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An essential requirement for most handling and measuring techniques of aerosol nanoparticles is their predictable charge condition. Until recently radioactive sources (α- or β-ray emitters) were used for this purpose. Due to safety issues and increasingly strict regulations for the usage of radioactive materials there is a need for a suitable substitute.

Here we study the charging probability of aerosol nanoparticles using two different bipolar, non-radioactive charging devices – the AC corona discharge based "Electrical Ionizer" (Model 1090, MSP Inc.) and the soft X-ray based "Advanced Aerosol Neutralizer" (Model 3087, TSI Inc.). The measurements were performed with a tandem DMA arrangement as shown in Fig. 1. Monodisperse unipolar mainly singly charged sucrose particles were produced in the size range of 5 – 40 nm using an electrospray aerosol generator with a subsequent classifier DMA operating at a constant voltage. These aerosol particles were then routed through the particular charger in question into the analyzer DMA-CPC system by which the electrical mobility distribution of the particles exiting the investigated charger was measured. Both DMAs were operating at the same polarity. Additionally, a second CPC was placed in front of the investigated charger to observe possible particle concentration fluctuations and to consider it during data evaluation. The aerosol flow rate through a charger could be changed by adding particle free air to the aerosol after the classifier DMA and was varied in the range between 0.6 and 5.0 liters per minute.

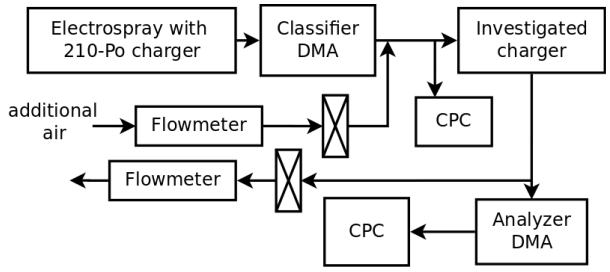

Figure 1. Schematics of the experimental setup.

With the investigated charger turned off no ions were produced and the charge condition of particles remained unchanged. In this case the distribution of charged particles entering the analyzer DMA was the same as the distribution of the particles leaving the classifier DMA (in an ideal case all particles were singly charged) resulting in the measurement of the total particle fraction by the analyzer DMA. Alternatively, when the charger was turned on the aerosol particles were expected to reach a charge equilibrium (Fuchs, 1963, Wiedensohler, 1988) in the charger and consequently only the charged fraction was measured by the analyzer DMA. These data was used to calculate the charging probability (N_charged/N_total) shown in Fig. 2. First results show a good agreement with the predicted charge distribution, with a deviation for the Electrical Ionizer below 10 nm in diameter. However, it has to be stated that the indicated limit for operation of this charger is at a diameter of 10 nm. Further measurements with different nanoparticles are in progress.

Moreover, for both of the investigated chargers also the long-term performance was studied operating the chargers for > 36 h and continuously scanning the charged particle distribution with the analyzer DMA. Results of investigations in progress will be reported.

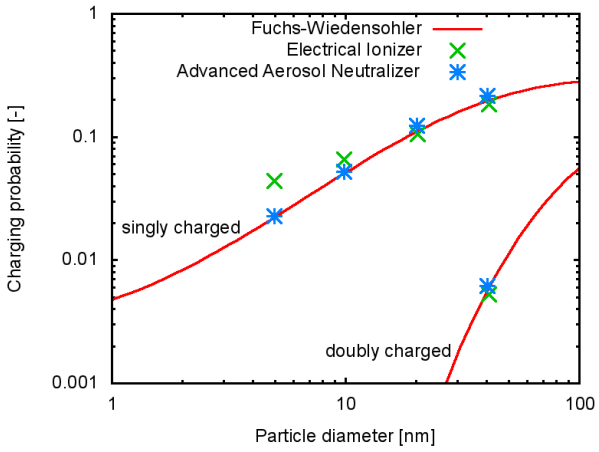

Figure 2. Comparison of the measured charging probability of negatively charged sucrose particles at a flow rate of 1.5 lpm with the Wiedensohler approximation to the model by Fuchs (1963). (Note that the lower size limit for the "Electrical Ionizer" given by the manufacturer is 10 nm).

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Fuchs, N.A. (1963) *Geofis. Pura Appl.* **56**, 185-193.
Wiedensohler, A. (1988) *J. Aerosol Sci.* **19**, 387-389.