TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Mechanical Engineering   Institute of Process Engineering and Environmental Technology   Research Group Mechanical Process Engineering

Determination of the charge distribution of unipolar charged aerosols

Lars Hillemann, Michael Stintz, Christoph Helsper

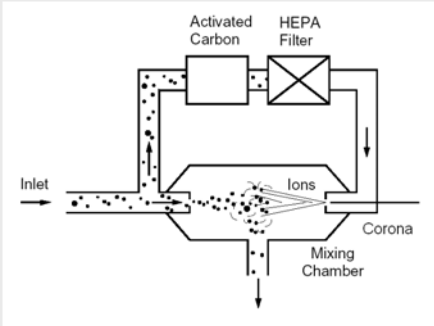
Motivation

Bipolar chargers are widely used in aerosol science because their charge distribution is well understood [1]. They produce a high ratio of singly charged particles. Therefore they are suitable for aerosol conditioning in mobility spectrometers like the SMPS. Unfortunately, these chargers employ a radioactive source to generate an ion atmosphere. These sources are problematic in terms of transportation and charging efficiency. Thus, unipolar charging can be an alternative solution. For the employment of this technique as a part of a mobility spectrometer the charge distribution has to be known.

Diffusion charging in mixing flows

One main advantage of diffusion charging of particles is the independency of this process from the particle material. This requires the separation of the ion generation process from the charging zone, where the ions are attached to the particles. This prevents them from undergoing field charging, which is much stronger but material-dependent. Thus the available types of chargers differ in the strategy of ion transport into the charging zone.

The Figure shows the schematic setup of the charger under consideration. Its main part is a mixing chamber, where particles get in contact with the unipolar ion atmosphere during convective circulation. The ions are produced by a corona wire and swept into the mixing chamber with the clean bypass airflow.

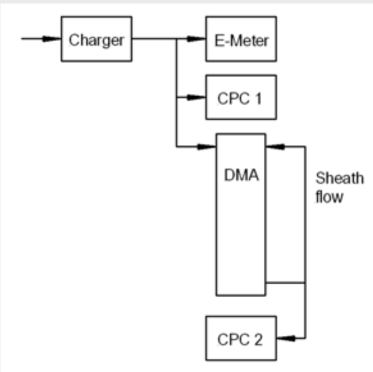


Internal set-up of the corona-jet-charger

Measurement of charge distributions

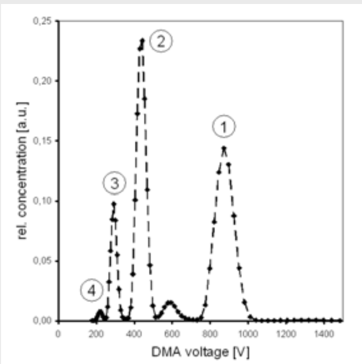
The discrete charge distribution was determined by operating the charger with monodisperse aerosol and subsequently classifying these particles according to their mobility. This means separating the particles with respect to the number of charges they are carrying.

The mobility analysis was done with a DMPS-setup. In parallel, the particle output of the charger was quantified by a condensation particle counter and an electrometer. The data of these devices deliver the generated mean charge and this gives a good possibility to verify the results.



Experimental set-up to detect uncharged particles

A slightly modified setup was used to quantify the fraction of uncharged particles. The mobility of these particles is zero, thus they are unaffected by the electrical field in an electrostatic classifier. Connecting a CPC to the exhaust port of the classifier running at maximum voltage enables for detecting the uncharged particles (see figure above).



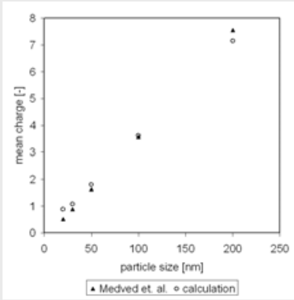
Measured concentration spectrum due to different numbers of charges

For the calculation of the charge distribution from the particle mobility spectrum the model of the DMA by Wang & Flagan was used [2]. This model determines the response of a DMA for a known aerosol input and its charge distribution. Comparing the model-data with the measurement a minimization algorithm was used to evaluate the charge distribution.

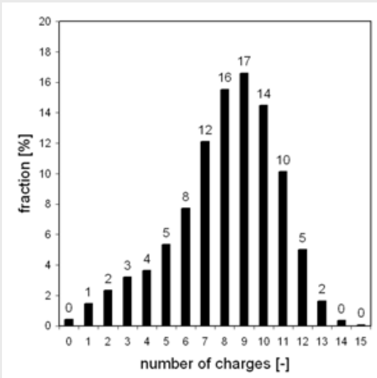
Results

The bar graph below shows an example of the calculated results recorded for 200-nm-particles. The charge distribution has a maximum at charge number 9. The mean charge calculated from this distribution is about 7.1 charges per particle. This gives a good compliance with the mean charge of the device measured by Medvet et. al. [3].

The influence of the concentration was tested by varying its value while measuring the mean charge. For the selected particle sizes in the range mentioned above the mean charge was independent from the particle concentration in the considered span (< 2000 p/cm3).



Comparison to Medvet et. al. [3]



Calculated charge distribution for 200-nm-particles

As standard particle material ammonium sulfate was chosen. Additionally several particle materials were employed for measuring the mean charge. Among them DEHS-oil and soot was used to generate monodisperse aerosols in different size ranges. Despite the different surface properties and the surface area only minimal differences in the mean-charge-value were observable.

[1] A. Wiedensohler, J. Aerosol Science, 19 (1988), 387-389.
[2] S. C. Wang, R. C. Flagan, J. Aerosol Science, 20 (1989), 1485-1488.
[3] A. Medved, F. Dorman, S. L. Kaufman, J. Aerosol Science, 31 SUPP/1 (2000), 616-617.

FH Aachen Hochschule Aachen

Prof. Dr.-Ing. Christoph Helsper
University of Applied Science Aachen,
Ginsterweg 1, D-52428 Jülich
Phone: +49 241 6009-53114 Fax: +49 241 6009-53199
Email: helsper@fh-aachen.de
Web: http://www.fh-aachen.de

MVT

Dipl.-Ing. Lars Hillemann, PD Dr.-Ing. Michael Stintz
TU Dresden, Inst. of Process Engineering and Environmental Technology
Research Group Mechanical Process Engineering, D-01062 Dresden
Phone: +49 351 463 32914 Fax: +49 351 463 37058
Email: lars.hillemann@tu-dresden.de
Web: http://www.mvt-tu-dresden.de