Measurement of aerosol charge distributions

A. Järvinen[1], P. Heikkilä[1], J. Keskinen[1] and J. Yli-Ojanperä[1]

[1]Aerosol Physics Laboratory, Tampere University of Technology, Tampere, FI-33720, Finland
Keywords: aerosol charge distribution, DMA, ELPI.
Presenting author email: anssi.jarvinen@tut.fi

Aerosol charging state is typically analysed by Differential Mobility Analysers (DMA) in sub 100 nm size range in single, parallel or tandem configuration (Maricq, 2005). In case of larger particles, only a limited number of methods are available. In the micrometer size range the BOLAR instrument (Yli-Ojanperä *et al* 2014) is able to measure size resolved particle size distributions, but the size range between the BOLAR and the DMA is troublesome. One of the possible methods is the measurement of the net charge by an Electrical Low Pressure Impactor (ELPI), but this gives only coarse estimation of the aerosol charging state. We introduce a new method, which is capable of measuring particle charge distributions in a wide size range from approximately 20 nm to micrometers.

The developed method relies on the measurement of electrical mobility by a DMA and aerodynamic size by an ELPI. Because the size is measured with the ELPI, the DMA measurement defines the particle charging state. In this type of measurement neutralizer is not used prior to the DMA and the charger of the ELPI is bypassed or switched off. The DMA voltage is scanned and the penetrating fraction is measured in real time with the ELPI. The fast particle size measurement reduces the total time significantly compared to the Tandem-DMA. Another advantage is that particles are not charge conditioned in the measurement. Charge conditioning of particles is sometimes incomplete, and thus results unreliable mobility based size measurement. As balance of advantages, the developed method has some limitations. The particle effective density needs to be known. This may be evaluated if the particle material and morphology is known or it can be measured. The second limitation is the resolution, which is lower compared to the Tandem-DMA, because the particle size is measured by an impactor.

We tested the method by producing reference particles of known effective density and charging state. Singly charged particles generated by the Singly Charged Aerosol Reference (SCAR, Yli-Ojanperä *et al* 2010) were used to test the method from 50 to 200 nm size range. Further measurements were conducted using the same narrow particle size distributions, which were subjected to diffusion charging, resulting in higher charge levels per particle. The ELPI+ charger (Järvinen *et al* 2014) was tested along with a mini corona charger (Arffman *et al* 2014) because from these devices the charging efficiency is reported.

In Figure 1 we show the charge distribution for 100 nm particles after the mini corona charger. The concentration peak is observed at 4 elementary charges per particle, while in Arffman *et al* (2014) the charging efficiency is determined to be approximately 6 for the same particle size. The charge distribution has a wide tail towards larger values, resulting in an average charge value of approximately 6.5 over the entire distribution, which is in good agreement with the previously reported charging efficiency value of 6. In addition to these results, we have observed that singly charged particles generated by the SCAR carry a single elementary charge according to the developed method.

The new method is also suitable for evaluating more complicated charge distributions and it allows determination of particle concentration as a function of particle size and charging state.

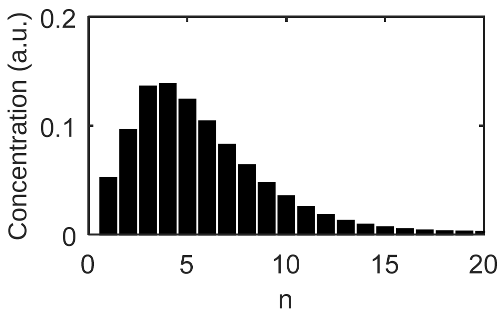

Figure 1. The particle charge distribution after the mini corona charger. The n is the number of elementary charges per particle

This work was supported by Dekati Ltd. under a project name CHARM.

Arffman, A., Yli-Ojanperä, J., Kalliokoski, J., Harra, J., Pirjola, L., Karjalainen, P., Rönkkö, T. and Keskinen, J. (2014) *J. Aerosol Science* **78**, 97–109.

Järvinen, A., Aitomaa, M., Rostedt, A., Keskinen, J. and Yli-Ojanperä, J. (2014) *J. Aerosol Science* **69**, 150–159.

Maricq, M.M. (2005) *Combustion and Flame* **141**, 406–416.

Yli-Ojanperä, J., Mäkelä, M., Marjamäki, M., Rostedt, A. and Keskinen, J. (2010). *J. Aerosol Science* **41**, 719–728.

Yli-Ojanperä, J., Ukkonen, A., Järvinen, A., Layzell, S., Niemelä, V. and Keskinen, J. (2014). *J. Aerosol Science* **77**, 16–30.