Dynamic cutpoint switching of mobility analyzer for improved aerosol characterization

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The monitoring and control of ultrafine particles in workplaces as well as in public and private spaces is an increasing trend. Detectors based on diffusion charging are already on the market and can be seen to fulfil the detection role in some applications.

The output signal, however is the active surface area of the aerosol sample, or with limited accuracy, the lung deposited surface area (Rostedt et al., 2014, Järvinen et al. 2015) The more recognized parameters, particle number concentration and mass concentration, require some knowledge of the particle size distribution. This can be achieved with size selective particle trapping at different cutpoints with electrical or diffusive means, for example (Amanatidis et al 2015).

The particle charging probability –weighed median size is derived based on calibration from the signal level ratio at different stages of the trap. This size estimate can then be used to increase the accuracy of the converted number or mass concentrations. However, for large size range instruments predefined cutpoints may be prone to noise and error. Especially, unknown shape of the size distribution may yield significant errors, when the median size deviates considerably from the predetermined cutpoint.

We present a new method to sustain optimal or near-optimal signal ratio between the signals while having a wide particle size range available for the size correction calculation.

The method relies on a diffusion charger and a zeroth order electrostatic classifier, with dynamically adjustable trap voltage, providing variable cutpoint for the classifier. The total signal is read using a low cutpoint at low voltage (reference), and subsequent signal measurement with higher, adjustable trap voltage. The adjustable trap voltage is continuously controlled so that the current signal is 50% of the reference signal. This cutpoint voltage then corresponds to the charging –weighted median particle size. As a result the cutpoint is kept in in optimal value in varied particle-size range, and correspondingly the accuracy degradation originating from deviating size range is avoided.

As the particle size distribution typically changes more slowly than the concentration, the method works while the cycle is faster than the timescale changes of the measured aerosol. During changing aerosol the known and calibrated response functions of the electrostatic classifier allows for correcting the particle size parameter.

Figure 1 shows simulated comparison of results with fixed and with adjusted trap voltages.

In addition to the basic principle, the paper deals with practical performance of a realized device studied with varied aerosol sizes and distributions. This was made using an aerosol generation system which mimics the characteristics of real traffic originated urban aerosol, not only by the particle size and size distribution but also by the physical and chemical characteristics of particles.

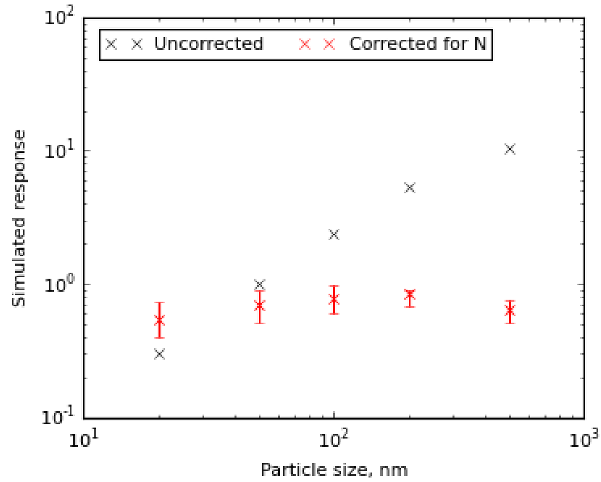

Figure 1. Simulated response with and without correction for particle number concentration from the trap adjustment. Nominal distribution width is 1.88, while errorbars denote variation with widths ranging between 1.2 and 2.4.

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