Design and optimization of a Medium Flow Differential Mobility Analyzer (MFDMA)

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Differential Mobility Analyzers (DMA) are used to provide a monodisperse aerosol with a narrow particle size distribution by the classification of particles accoring to their electrical mobility (Flagan, 1999). Particle sizes which can be selected in a DMA are limited by the dimensions of the classification area and slightly by the used sheath gas. Commonly DMAs are used in combination which a particle counter (CPC) to measure the particle size distribution. A typical TSI long DMA (3081) is used with a sample to sheath flow ratio of 0.3/3 lpm and maximum attainable particle sizes of 700 nm. If more measurement instruments behind a DMA should be applied, a higher sample flow rate is needed. For larger particle diameters up to 600 nm and sample flow rates of 1.5/15 lpm a new DMA was designed, simulated and manufacured.

The design of the Medium Flow Differential Mobility Analyzer (MFDMA) was supported by CFD-Simulations with calculations of the trajectories of high density particles in the DMA. Moreover the tranfer behaviour of the DMA was simulated and particle losses due to impaction at the in- and outlet could be reduced (Figure 1.).

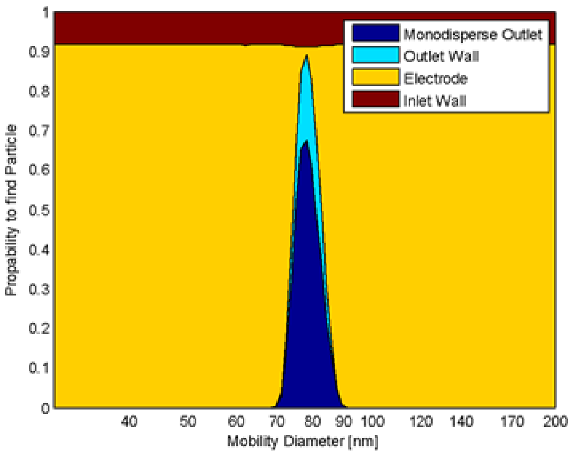

Figure 1. Simulation of the transfer behaviour of the MFDMA for particles with a diameter of 74 nm and a density of 19 g/cm³. The locations of particle losses can be estimated.

Size selection experiments

Experimental measurements of the size selection performance were done with a short and long version of the MFDMA. The size distribution after the DMA is measured with a SMPS system. Figure 2. shows the geometric standard deviation (GSD) of the classified size distribution of the short MFDMA in comparison to a TSI long DMA. The MFDMA delivers a monodisperse aerosol in the tested size range which was limited by the applicable voltage.

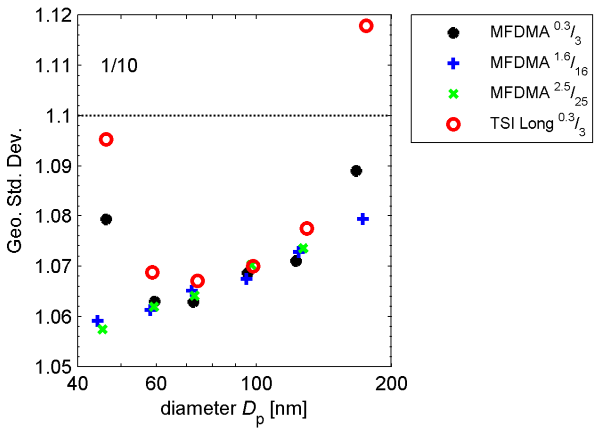

Figure 2. Geometric Standard Deviation of size selected particles with the short MFDMA and TSI long DMA.

The transfer function of an ideal DMA is a triangular function characterized by its half width and height. For the MFDMA it can be determined by a deconvolution of the experimental data with the SMPS transfer function. This allows for a comparison with the simulated transfer function.

Runtime experiments

During the size selection measurements, the MFDMA was used with higher aerosol flow rates up to 8 lpm and under higher particle load. Thus tests were conducted to apply the MFDMA to supply monodisperse metal nanoparticles for technical aerosol processes. Therefore, runtime experiments were done with aerosol to sheath flow rates of 5/20 and 8/24 with particle loading up to 1 g/h. To determine the exact runtime a constant voltage is applied to the electrode. The voltage together with the classified particle size distribution are measured continuously.

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