Performance of a Newly Developed Lightweight and Cost-effective Parallel-Plate Differential Mobility Analyzer

N. Lekaki[1], M. Costi[1], G. Biskos[1,2] and A. Maisser[1]

[1]Climate and Atmosphere Research Centre, The Cyprus Institute, 1645, Nicosia, Cyprus
[2]Faculty of Civil Engineering and Geosciences, Delft University of Technology, 2628-CN, Delft, The Netherlands
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Contact: n.lekaki@cyi.ac.cy

Size resolved measurements of aerosol particles are essential in air quality monitoring for assessing their impacts on climate and human health. This poses an increasing demand for distributed measurements using instruments that can be installed on mobile platforms and dense air quality monitoring networks.

The Differential Mobility Analyzer (DMA) is the most commonly employed instrument for sizing aerosol particles having diameters in the sub-micrometre range. When used as part of aerosol sizes spectrometers, a limitation of DMAs is that the time resolution is poor (in the range of several minutes), due to the required scanning time. This can lead to loss of crucial information (when the scanning times are long) or poor counting statistics (when scanning times are short) in situations where the aerosol size distribution changes rapidly; e.g., during new particle formation (NPF) events. To avoid these limitations when using Scanning Mobility Particle Sizers (SMPSs), Stolzenburg et al. (2017) introduces the train-DMA setup (i.e., six DMAs operated at different fixed voltages and employed in parallel upstream of six CPCs), which is a very bulky and expensive setup.

In this work we manufactured a Parallel-Plate DMA (PP-DMA) that has some key advantages compared to the conventional DMA design, including low manufacturing cost, simple design and low weight. The PP-DMA consists of an insulator made of polyoxymethylene (POM; a thermoplastic with dielectric strength of >50 KV/mm), and two aluminium plates with slits for inserting the aerosol sample and extracting the monodsisperse particle flow. The inlet and the outlet of the particles to introduce the polydisperse aerosol flow in the classification zone at a 30^{o} angle were 3D printed.

The performance of the PP-DMA was evaluated in a tandem DMA system. Ammonium sulphate particles were generated by atomising a solution of 0.04 w/v and dried by passing them through a silica-gel diffusion drier. The dried polydisperse particles were then neutralized by a ^{85}Kr-source charge-neutralizer (TSI Model 3077) and then a DMA (TSI Model 3081) operated at a fixed voltage that was used to produce a nearly monodisperse aerosol. An Electrometer (TSI 3068A) was used as a reference instrument to determine the particle concentration downstream the first DMA, whereas one Condensation Particle Counter (TSI Model 3022A), was used after the PP-DMA.

Figure 1 shows the size (geometrical mean diameter; GMD)) of the monodisperse particles measured by the PP-DMA versus the particle size determined by the set operating conditions of the TSI 3081 DMA in the tandem DMA experiments. Our results show that the agreement between the expected (theoretical) and the measured GMD is within 5% for most of the operation conditions and sizes tested. Considering the easiness and low cost of manufacturing of the PP-DMA, this agreement can be considered extremely good, and promising for qualifying the PP-DMA as a solution for sizing aerosol particles in electrical mobility spectrometers.

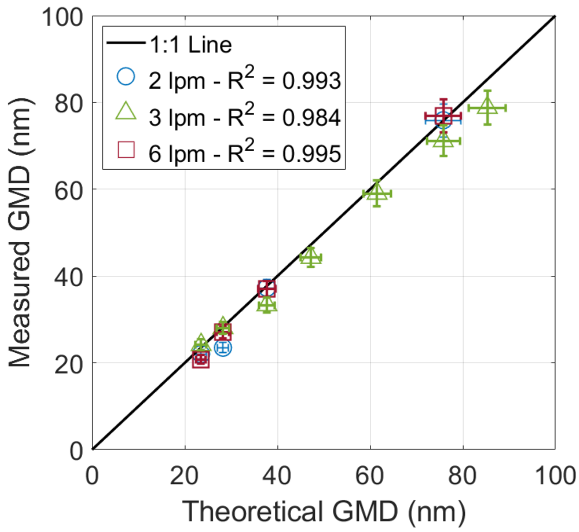

Figure 1. Measured vs. theoretically-predicted geometrical mean diameters (GMD) of the PP-DMA operated with a 0.3-lpm aerosol flow and a 2- (blue circles), 3- (green triangles), and 6- (red squares) lpm sheath flow. The error bars represent a ±5% uncertainty in the sizing.

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References

Stolzenburg, D., Steiner, G., and Winkler, Paul M. (2017) *Atmos. Meas. Tech., 10, 1639–1651.*