# Transfer Functions and Resolutions of Seven Differential Mobility Analyzers for Sub-2 nm Particle Classification

M. Heim[1], J. Jiang[2], M. Attoui[3], N.A. Brunelli[4], P.H. McMurry[1], K. Iida[5], R.C. Flagan[4], K. Giapis[4], G. Mouret[6], G. Steiner[7], G. Kasper[1], P. Aalto[8], and M. Kulmala[8]

[1]Karlsruhe Institute of Technology; [2]University of Minnesota; [3]University of Paris XII; [4]California Institute of Technology; [5]National Institute of Advanced Industrial Science and Technology; [6]University of Nancy; [7]Vienna University; [8]University of Helsinki

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Differential mobility analyzers (DMAs) that classifying particles according to their electrical mobility have been used extensively as a particle size analyzer and classifier. Most DMAs are operated in the size range from approximately 3 to 1000 nm. The classification of nanoparticles down to molecular dimensions has become of special interest in many disciplines, such as atmospheric nucleation research, nanomaterial synthesis, and nanoscale analytical chemistry. The transfer functions of most commercially available DMAs for sub-2 nm particle classification have not been systematically evaluated before. It is mainly due to the lack of sub-2 nm particle standard. The tandem DMA method was often used to evaluate DMA transfer function. In the 1-2 nm size range, diffusion broadening can significantly degrade the DMA resolution such that it is difficult to generate pseudo-monodisperse particles using a conventional DMA as the first DMA. Recent developments in high flow DMAs greatly improved the resolution in nanometer size range and allowed molecular monodisperse mobility standards to be demonstrated (Rosser and Fernández de la Mora 2005; Ude and Fernández de la Mora 2004).

Using the newly developed monodisperse mobility standards (Ude and Fernández de la Mora 2005), the transfer functions of seven differential mobility analyzers for sub-2 nm particle classification were evaluated. These DMAs included the TSI nano-DMA (Chen et al. 1998), the Caltech RDMA (Zhang et al. 1995) and nano-RDMA (Brunelli et al. 2009), the Grimm nano-DMA, and three original and modified Vienna type DMAs (Winklmayr et al. 1991). Calibration was performed using tetra-propyl ammonium ($N^+[C_3H_7]_4$), tetra-heptyl ammonium ($N^+[C_7H_{15}]_4$), and tetra-dodecyl ammonium ($N^+[C_{10}H_{21}]_4$) ions with mobility diameters of 1.16 nm, 1.47 nm, and 1.7 nm, respectively. These monomobile ions were generated by electrospray and classified by the high resolution Herman DMA (Ude and Fernández de la Mora 2005). Measurements were focused at an aerosol to sheath flow ratio of 1:10 and the sheath flowrate of 10-25 lpm. Several other practical aerosol flow and sheath flow combinations were also examined. In addition to transfer functions we report the DMA transmission efficiencies and resolutions, and results are compared with theoretical predictions (Stolzenburg 1988). Figure 1 shows the results for the TSI nano-DMA. The measured resolutions in the 1-2 nm range are comparable with previous data for larger particles. Stolzenberg's diffusive transfer function theory agrees with experimental results very well.

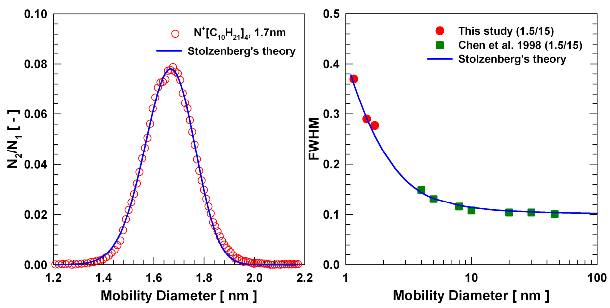


Figure 1 Comparison between Stolzenberg's theory and the experimental results of the TSI nano-DMA: signal after DMA (left) and full width at half-maximum for different sizes (right)

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