GENERATION OF HIGHLY MONODISPERSE PARTICLES VIA ELECTRICAL MOBILITY ANALYSIS

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Introduction

Differential Mobility Analyzers (DMAs) are generally recognized as the instruments which first opened wide the way to precise studies of submicron aerosols. Basically two main applications can be performed: obtaining the particle size distribution of a cloud of polydisperse aerosols and generating a continuous stream of particles in a very narrow size range. The latter has important implications in the production of nanopowders and functional materials via gas-phase synthesis. So far DMAs have served reliably to scientific community down to ~20 nm, but due to the high Brownian diffusivity of nanoparticles its generation with high resolution has been impracticable. Nevertheless, developments over the last decade have made DMAs suitable also for the separation of particles of a few nanometers in diameter, and even smaller ions. Here we summarize the current research work in this field at CIEMAT. Experimental and numerical studies are being addressed in support of two novel DMAs conceived to cover the particle size ranges of 50-300 nm (Vienna, Fig. 1) [1,2] and 1-50 nm (IONER).

Differential Mobility Analyzers

The most common DMA design involves two concentric cylindrical electrodes where a free particle stream flow drags a population of charged particles within the axial sense and a radial electric field is established by applying a potential difference between the electrodes [3]. Monodisperse particles of any size can be selected by varying the voltage applied to the DMA. It is known that the broadening of the transfer function of a DMA caused by Brownian diffusion can be reduced by two means: (a) a geometrical design taking the axial separation between inlet and outlet aerosol slits comparable to the gap between the electrodes, and (b) increasing the Reynolds number (Re) of laminar operation of the flow in the DMA to values as large as possible [4,5]. Flow dynamics in the two DMAs mentioned above has been investigated both experimentally and numerically (CFD Fluent 6.0). The goal is to achieve high Re with the same pumping capacity by minimizing the pressure drop within the instruments. Additionally, flow features such as boundary layer separation, vortex formation and turbulence must be avoided as they would be fatal on resolution. On the other hand, the transfer function of the DMAs has been measured for small ions (1-2 nm equivalent diameter) produced by electrospray technique and calculated with Fluent 6.0. Experimental and numerical values of the resolution have been compared to the values predicted by sound theories on DMAs [3,4].

Results

Experimental calibration of the DMA IONER with an standard aerosol of 1.66 nm diameter yielded record resolutions with relative Full Width at Half Height (FWHH) as low as 1% (Fig. 2). Numerical predictions of the pressure recovery factor in the same DMA (57%) are in good agreement with measured values (60%), while ideal value is 80% (Fig. 3).

Acknowledgements

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References

[1] W. Winklmayr, G. P. Reischl, A. O. Lindner, A. Berner, Journal of Aerosol Science **22** (1991), 289.
[2] G. P. Reischl *et al.*, Aerosol Science and Technology **27** (1997), 651.
[3] E. O. Knutson, K. T. Whitby, Journal of Aerosol Science **6** (1975), 443.
[4] J. Rosell-Llompart *et al.*, Journal of Aerosol Science **27** (1996), 695.
[5] J. Fernández de la Mora. Journal of Aerosol Science. 33 (2002), 411.

Figures

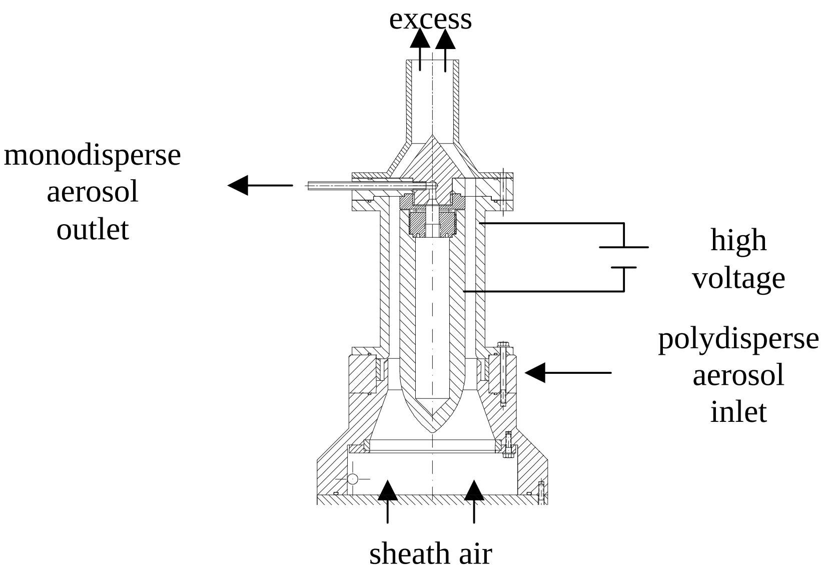

Figure 1. Sketch of a Vienna DMA for particles in the size range 50-300 nm.

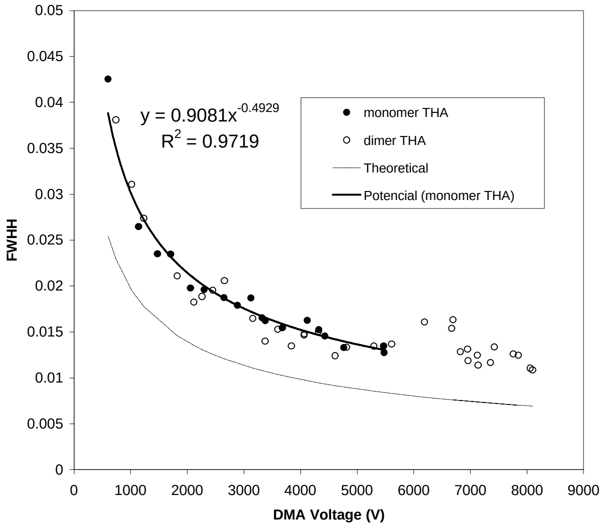

Figure 2. Experimental calibration of the DMA IONER yielding record resolution of 1% for particles of ~1 nm diameter.

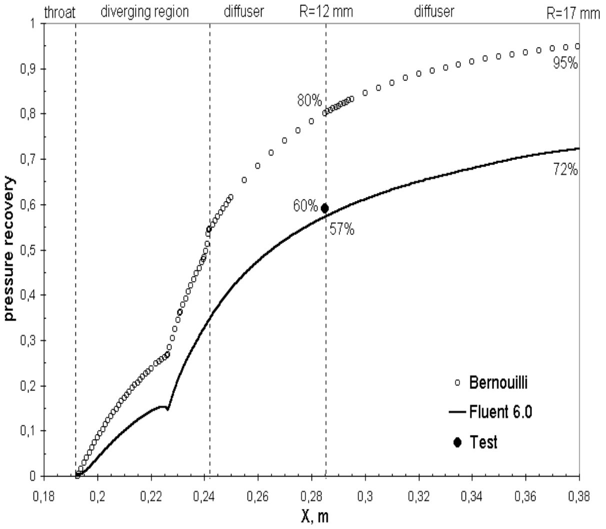

Figure 3. Numerical predictions of the pressure drop and pressure recovery within the DMA IONER.