Pulse-Height Analysis with an Unmodified Monochromatic Condensation Particle Counter

K.Barmpounis[1,2], A.Ranjithkumar[2], A.Schmidt-Ott[2] ,M.Attoui[3] and G.Biskos[1,2]

[1]Energy Environment and Water Research Center, The Cyprus Institute (CyI), Nicosia, 2121, Cyprus
[2]Faculty of Applied Sciences, Delft University of Technology, Delft, 2628-BL, The Netherlands
[3] University Paris Est Creteil, University Paris-Diderot, LISA, UMR CNRS 7583, France
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Presenting author email: k.barmpounis@cyi.ac.cy

Apart from its function as a nanoparticle counter, the condensation particle counter (CPC) has sizing capabilities when operated in the pulse-height analysis (PHA) mode. By recording the intensity of the scattered light pulses with a multichannel analyzer (MCA), the final droplet size can be determined with a certain accuracy. This information can then be used to determine the initial particle size.

Previous work (Marti et al., 1997; Saros et al., 1996) has shown that use of monochromatic light introduces multimodal pulse height (PH) spectra, as a result of Mie scattering, and as such, monochromatic light is not suitable for pulse-height analysis. Especially at a 90° scattering angle, large variation of the scattered light intensity is induced by small changes in the size of the droplets. This problem can be circumvented by replacing the monochromatic source with a white light source, which in turn requires hardware modification (Dick, 2000), as most commercial CPCs operate with solid state laser sources.

In this work we show that an unmodified commercial CPC operating with monochromatic light, is suitable for PHA in the particle size range of 1.5 to 5.5 nm (full size range data not shown here). We report the operating conditions under which such operation is possible and compare our results with simulations of particle growth dynamics. The importance of a highly monodisperse aerosol sample is highlighted as a crucial parameter for unlocking the PH capabilities of monochromatic light CPCs.

The experimental setup consisted of a glowing wire generator (GW), a high resolution DMA (half-mini DMA, SEADM) and an ultrafine CPC (TSI 3025) that employs its original optical detection system. Polydisperse tungsten particles were produced by the GW and subsequently specific sizes were selected with the DMA. For each particle size the PH spectrum was recorded with a MCA.

Fig.1 shows measured pulse-height spectra from particles of different initial size. The x-axis of Fig.1 shows the MCA channel (i.e. pulse height in arbitrary units) while the y-axis shows the normalized frequency of detected pulses of each MCA channel. Results show that particles of different initial size produce clearly distinguishable and reproducible PH spectra.

A measure of the PH resolving power is the distance of a PH peak (x) relative to a fixed MCA channel value (x_R). Fig. 2 shows the experimental peak ratio (x/x_R) of the PH spectra for eight initial particle diameters. The theoretical final droplet size was calculated (Ahn and Líu, 1990) and it was found to agree very well with the experimental data.

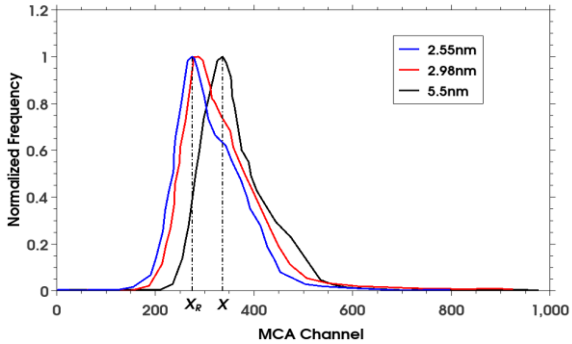

Figure 1. Experimental PH spectra produced by three different initial particle sizes.

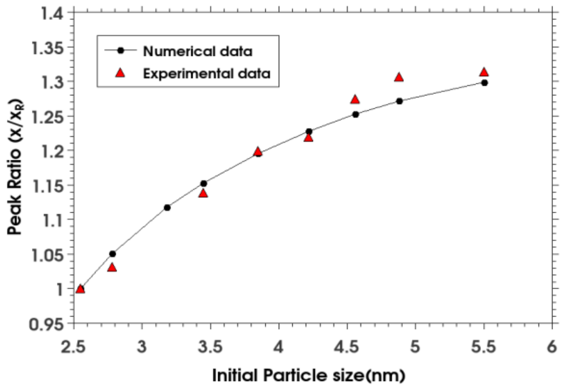

Figure 2. Relative position of the PH spectra peak vs initial particle size.

In summary, we experimentally show that monochromatic light is suitable for PHA in continuous flow CPCs, for nanoparticle sizes in the range of 1.5-5.5 nm. The degree of monodispersity of the aerosol sample is a key parameter for a successful PHA with monochromatic light.

References

Marti J.J., R.J. Weber, P.H. McMurry, F. Eisele, D. Tanner & A. Jefferson, 1997. J. Geophys. Res. 102(D5), 6331–6339.Saros

Saros M.T., R.J. Weber, J.J. Marti, & P.H. McMurry, 1996. Aerosol Sci. Technol. 25(2), 200–213.

Dick, W. D., McMurry, P. H., Weber, R. J., and Quant, R.:, J.Nanopart. Res., 2, 85–90, 2000

Ahn, K and Y. H. Liu,B, J.Aer.Sci, Vol 21, No 2, 249-261, 1990.