Characterization of a new CPC and DMA for size distribution measurements down to 1nm

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Scanning Mobility Particle Sizer (SMPS) systems employing a Differential Mobility Analyzer (DMA) for sizing and a Condensation Particle Counter (CPC) for counting are widely used for measurement of aerosol particle size distributions. Such measurements of particles as small as 1nm in diameter are needed in academia and industry for applications including nucleation and growth, engineered nanoparticle synthesis, reaction kinetics and combustion research. Diethylene glycol (DEG) has been used as a working fluid to grow sub-2.5nm particles to a size detectable with a butanol-based CPC, thus enabling SMPS size distributions in this size range (Iida *et al*, 2009; Jiang *et al*, 2011b). Recently, TSI introduced the Model 3777 Nano Enhancer and the Model 3086 1nm-DMA which, when combined with a TSI 3772 CPC, 3082 Electrostatic Classifier and either 3088 or 3077A neutralizer, form a 1nm-SMPS system capable of size distribution measurements from 1-50nm. In this work, we characterized the new components of this system and combined the components into an SMPS system for size distribution measurements down to 1nm.

The response of the TSI Model 3777 Nano Enhancer + Model 3772 CPC combination to mobility classified NaCl generated by the evaporation-condensation method was compared to a TSI Model 3068B Aerosol Electrometer. A curve was fit to the data in order to calculate the CPC lower detection limit (d_{50}). The resulting counting efficiency curve (Figure 1) was compared to data from the literature for similar designs (Zhao *et al*, 2015). The response time of the combination was characterized and the additional time required for particle transit through the Model 3777 Nano Enhancer was found to be minimal. CPC false count rate was tested and found to be equivalent to the TSI Model 3776 Ultrafine CPC (<0.01 particles/cm^3). Concentration linearity was characterized and because of internal dilution in the Nano Enhancer the upper concentration limit of the 3777+3772 combination extends to 300,000 particles/cm^3.

In addition, the transfer function and penetration of the TSI Model 3086 1nm-DMA was characterized using monomobile molecular ion standards (Jiang *et al*, 2011a). Particles were generated by electrospray, and classified with a high-resolution DMA (Fernandez de la Mora *et al*, 1998) before being introduced into the Model 3086 DMA under test. The concentration upstream and downstream of the test DMA was measured in order to report the DMA penetration efficiencies. The data were inverted using a routine employing the diffusive transfer function introduced by Stolzenburg (Stolzenburg & McMurry, 2008) in order to obtain the true transfer function for the DMA under test.

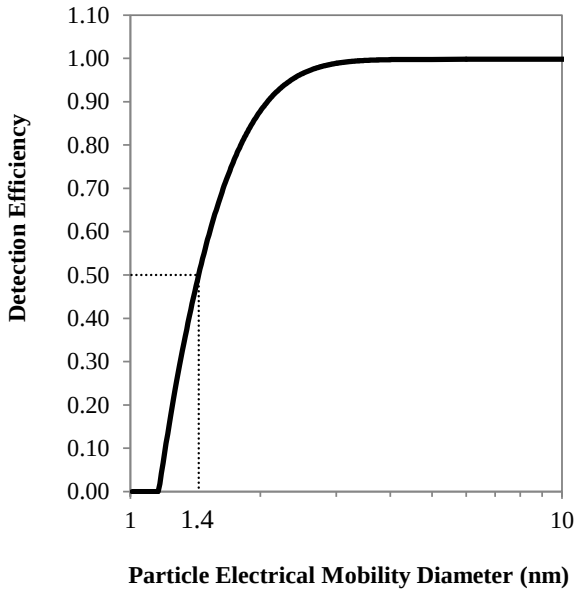

Figure 1. Detection efficiency curve and d_{50} point for the TSI Model 3777 + Model 3772 1nm-CPC combination when challenged with mobility-classified NaCl generated by the evaporation-condensation method.

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