

Tandem of Differential Mobility Analyzer and Centrifugal Particle Mass Analyzer: application to hygroscopic growth of aerosol particles

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The interaction of atmospheric aerosol particles with water vapor is a crucial factor in determining their aerodynamic size and optical properties and hence their atmospheric lifetime, radiative forcing effects, height distribution etc. The prevalent technique to study hygroscopic behavior of aerosol particles is based on using a tandem of hygroscopic differential mobility analyzers (HTDMA) which enables to follow the particles mobility diameter as function of relative humidity, so the water uptake by aerosols has to be calculated by indirect way with some uncertainty due to lack information about particle shape and density.

In this study we introduce the approach to hygroscopic growth research based on direct particle mass measurements using centrifugal particle mass analyzer (CPMA, Cambustion Ltd). The mass-based measuring technique is more preferable to describe water uptake of aerosol using thermodynamic or parametric models (Mikhailov *et al.*, 2013).

Ammonium sulfate (AS) particles were used as a test object. A 0.01wt% AS solution was dispersed by TSI atomizer (Model 3076). The polydisperse aerosol was dried to below 10%RH by passing through a diffusion dryer and entered the DMA (TSI 3080 with X-rays aerosol neutralizer TSI 3087). The resulting monodisperse particles (mobility diameter 100 nm) then passed through a series of one (hydration mode) or two (dehydration mode) single-tube Nafion humidity exchangers. One Nafion humidity exchangers was filled with water to guarantee aerosol exposure to high (>95%) RH, another was blown through with air at controlled RH. The humidified aerosol particles passed through CPMA operating in scanning mode and reckoned by water-based condensation particle counter (TSI model 3787). A combination of scanning CPMA with CPC gives particle mass distribution (Olfert and Collings, 2005).

In hydration mode monodisperse aerosol passed only through air-conditioned humidity exchanger with increasing RH in discrete steps from 5% to 95%. At every stable RH level a mass spectrum of humidified aerosol was measured by CPMA (cycle duration about 10 min). The hygroscopic mass growth factor (G_m) was determined as ratio of modal particle mass at given RH to modal particle mass at dry condition (<10%RH). Figure 1 shows mass growth factors plotted against relative humidity (open circles). The obtained results are in good agreement with the FDHA measurements (dashed line) (Mikhailov *et al.*, 2013) which used here as reference data. Particularly in the CPMA experiments

AS particles exhibited deliquescence transition at $RH=80\pm 2\%$.

Upon dehydration monodisperse particles after DMA firstly passed through water-filled humidity exchanger and then entered air-conditioned humidity exchanger with step-down RH. The measuring procedure was the same as in hydration mode.

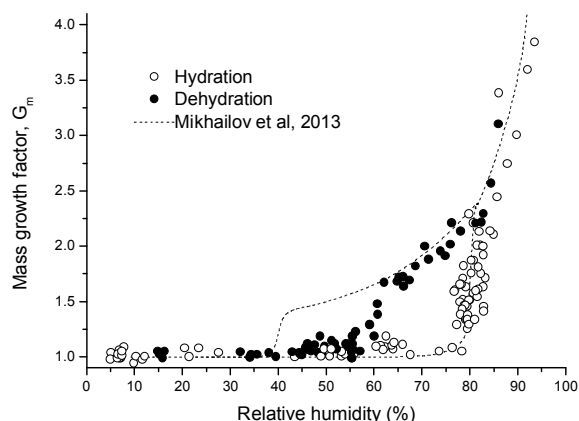


Figure 1. Hygroscopic growth of ammonium sulfate particles measured by tandem of DMA-CPMA.

The obtained data plotted in figure 1. (closed circles). Obviously efflorescence of AS solution droplets in CPMA experiments occurs at $RH=61\pm 2\%$ that is much higher than efflorescence RH in FDHA or HTDMA experiments. The observable discrepancy may be due to some impurities in AS solution or due to partial coagulation inside CPMA.

Nevertheless the described technique appears to be promising for *in situ* measurements of hygroscopic properties of aerosol particles.

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