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Nano-HTDMA for investigating hygroscopic properties of sub-10 nm aerosol nanoparticles

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Interactions between water and nanoparticles are of great significance for atmospheric multiphase processes, physical chemistry, and materials science. Current knowledge of the hygroscopic and related physicochemical properties of nanoparticles, however, is insufficient due to limitations of the available measurement techniques. Here, we present the design and performance of a nano-hygroscopicity tandem differential mobility analyzer (nano-HTDMA) apparatus. To enable high accuracy and precision in hygroscopicity measurements of sub-10 nm aerosol nanoparticles, systematic and comprehensive calibration criteria of nano-HTDMA have been developed and applied, including sheath/aerosol flow rates, DMA voltage, relative humidity (RH) sensor, temperature sensor, and particle sizing. After calibration, the nano-HTDMA system has been shown to have an accurate sizing and a small sizing offsets between the two DMAs (<1.4%) for aerosol nanoparticles with diameters down to 6 nm. Moreover, to maintain the RH-uniformities that prevent the pre-deliquescence and non-prompt phase transition of nanoparticles within DMA2, the RH of sheath flow is kept as same as that of aerosol flow at inlet of DMA2, and the humidification system and the DMA2 system are placed in a well-insulated and air conditioner housing (±0.1K). Using nano-HTDMA system. We investigate the hygroscopic behavior of aerosol nanoparticles of two inorganic substances (e.g., ammonium sulfate and sodium sulfate). A strong size dependence of the hygroscopic growth factor is observed for ammonium sulfate and sodium

sulfate nanoparticles with diameters down to 6 nm, respectively. For size dependence of phase transition, we find a weak size dependence of DRH and ERH of ammonium sulfate nanoparticles with diameters from 6 to 100 nm but a pronounced size dependence of DRH and ERH between 20 and 6 nm for sodium sulfate nanoparticles.