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Nano-hygroscopicity tandem differential mobility analyzer for investigating aerosol nanoparticle hygroscopic properties

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Abstract: Interactions between water molecular and nanoparticles is of great significance during atmospheric processes, such as new-particle formation, their subsequent growth, phase transition as well as multiphase chemistry. However, current knowledge of the physico-chemical properties of these nanoparticles is insufficient due to the limitation of measurement techniques and data availability. This emphasizes the need for tackling the technical difficulties in nanoparticle measurements and extending their corresponding datasets, which are less documented previously. Hence, we present a design and performance of a nano-hygroscopic tandem differential mobility analyzer (nano-HTDMA) apparatus with high accuracy and precision for the hygroscopic growth measurement of aerosol nanoparticles down to $\sim$ 6 nm in size. After comparison of the configurations of different H-TDMA setups with their advantages and inconveniencies, the methods for calibration and validation of the nano-HTDMA system are presented. The verification focused on resolving the discrepancies between the experimental results in this investigation with previous measurements of the hygroscopic behavior of a test substance (e.g. ammonium sulfate). No significant size effect on the deliquescence and efflorescence relative humidity (DRH & ERH) of ammonium sulfate particles was observed, which is consistent with results from previous measurements. To validate more in depth the performance of the instrument, we extended our measurements for sodium sulfate nanoparticles, of which a noticeable size-dependent deliquescence and efflorescence was clearly observed. Summarizing all technical modifications and improvements, the nano-HTDMA design proved to be capable of providing high quality data of the hygroscopic behavior of sub-10 nm particles and directly applicable to exploring the size dependence of atmospheric properties of these nanoparticles.