The size resolved cloud condensation nuclei (CCN) activity and its prediction based on aerosol hygroscopicity and composition in the Pearl Delta River (PRD) Region during wintertime 2014

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A hygroscopicity-tandem differential mobility analyzer (H-TDMA), a scanning mobility CCN analyzer (SMCA) and an aerodyne high resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) were used to measure the hygroscopicity, activation, and chemical composition of aerosol particles at the Panyu site in the Pearl River Region during 2014 wintertime. The size-resolved cloud condensation nuclei (CCN) distribution at four supersaturations (S=0.1%, 0.2%, 0.4% and 0.7%) and aerosol particle size distribution were obtained by the SMCA. The size-resolved ratio of the CCN concentration to the aerosol concentration (CCN activation ratio) was determined. The H-TDMA was used to measure the growth factor-probability density function (Gf-PDF) of dry particles at five diameters (40, 80, 110, 150, and 200 nm). The hygroscopicity parameter κ was respectively calculated based upon the SMCA, H-TMDA, and AMS measurements (κCCN, κH-TDMA, and κAMS). The results showed that the κHTDMA value was slightly smaller than the κCCN one at all diameters and for particles larger than 100 nm the κAMS value was significantly smaller than the others, which could be attributed to the underestimated hygroscopicity of the organics matters (κorg). The activation ratio (AR) calculated from Gf-PDF without surface tension correction was found to be lower than that from the H-TDMA measurement, due most likely to the uncorrected surface tension (σs/a) that did not consider the surfactant effects of the organic compounds. We demonstrated that better agreement between the calculated and measured AR could be obtained by adjusting σs/a.

The NCCN was predicted with different schemes based on H-TDMA and AMS measurements. In general, the predicted NCCN agreed reasonably well with the respective measured one using different schemes. For H-TDMA measurement, the NCCN value predicted from the real time AR measurements was slightly smaller (about 6.8%) than that from the D50 method duet to the fact that particles were assumed to be internally mixed in the D50 prediction. .For the AMS measurement, the NCCN value predicted from bulk PM1 were higher (about 11.5%) than that from size-resolved composition measurement because a significant fraction of PM1was composed of inorganic matter. The calculated NCCN at four supersaturations was consistent with the observed NCCN. The NCCN calculated from AMS measurement was undervalued at 0.1% and 0.2% supersaturations, which could be result from underestimate of κorg and overestimate of σs/a. For S=0.4% and 0.7%, there was a slightly overestimation of NCCN owing to the internal mixing assumption.

Keywords: cloud condensation nuclei, aerosol chemical composition, hygroscopicity