CCN activation of insoluble silica aerosols mixed with soluble pollutants

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Insoluble particles, e.g. mineral dust, silica and soot, can act as CCN if they acquire some deliquescent material. Extensive data and theories on CCN activation of completely soluble and insoluble particles exist but the CCN activation of coated particles has been investigated less. In this study laboratory measurements were conducted on CCN activation of insoluble silica particles coated with soluble species. The experimental results were compared to the theoretical calculations using the framework introduced by Kumar *et al.* (2011b).

Measurements

Particles with insoluble core and soluble coating were generated and analyzed in this study. Fumed silica was used as the insoluble particle. Three different kinds of species were used as soluble coatings: ammonium sulphate, sucrose and a protein (bovine serum albumin known as BSA). The fractions of soluble species were 5%, 10% and 25% of total particulate mass in the original aqueous solution, which was atomized and dried to yield the mixed particles. Particle number distribution measurements were conducted using a scanning mobility particle sizer (SMPS). Size-resolved CCN activity was carried out using the Scanning Mobility CCN Analysis (SMCA) and the structure of atomized particles from aqueous suspension was defined by transmission electron microscopy (TEM).

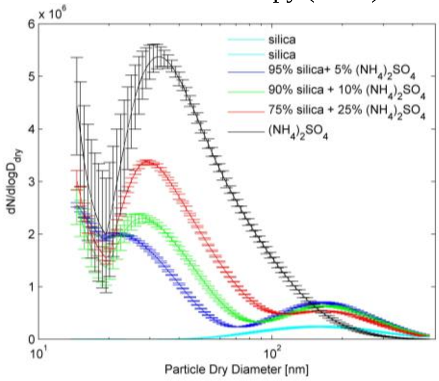

Figure 1: SMPS data for number size distributions of silica particles coated with $(NH_4)_2SO_4$.

Theory

κ-Köhler theory (Petters & Kreidenweis, 2007) was used to estimate the critical supersaturation of soluble particles. Critical supersaturation of pure silica particles, on the other hand, were calculated using the FHH adsorption theory (Sorjamaa and Laaksonen, 2007; Kumar *et al.*, 2009 & 2011a). For mixed soluble and insoluble particles a shell-and-core model (Kumar *et al.*, 2011b) was used in the calculations.

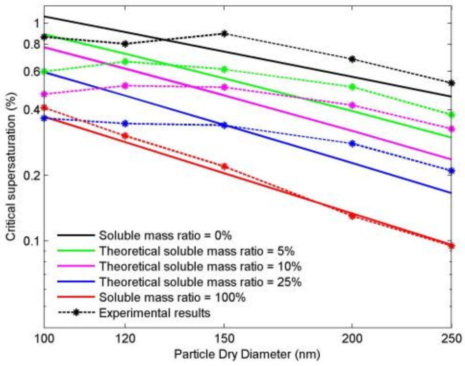

Figure 2: Calculated and experimental critical supersaturations for silica + sucrose particles

Conclusions

Pure and mixed particles of silica and soluble compounds (AS, sucrose and BSA) were generated. Morphology of silica and BSA agglomerates changed with particle size, while $(NH_4)_2SO_4$ and sucrose were spherical. The mixed particles resembled pure silica agglomerates. For pure soluble components the results were in good agreement with k-Köhler theory and for pure silica reasonable agreement was observed with adsorption theory, but deviation from the size-dependence was observed. The reason of these deviations could be e.g. uncertainty in the adsorption parameters and the effect of changing particle morphology with size. Mixed particles had reasonable agreement with the framework by Kumar et al., but shell-core model failed to reproduce the size-dependence of the CCN activation, probably due to the complex particle morphology.

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