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FROST – FReezing Of coated and uncoated duST particles

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In April 2008, the measurement campaign FROST (FReezing Of coated and uncoated duST particles) was conducted at the ACCENT (Atmospheric Composition Change – the European NeTwork of excellence) infrastructure site LACIS (Leipzig Aerosol Cloud Interaction Simulator). During the campaign, size selected coated and uncoated Arizona Test Dust (ATD) particles were characterized with respect to shape, chemical composition, hygroscopic growth and activation, and their ability to act as IN (Ice Nuclei).

The ATD particles were dispersed by means of a fluidized bed generator. Coatings were applied in different furnaces, operated at different temperatures. The coatings were either succinic acid, sulphuric acid, or ammonium sulphate. A DMA (Differential Mobility Analyzer) was used for selecting particles with a mobility diameter of 300 nm.

The following measurements were done: Three AMS (Aerosol Mass Spectrometers, e.g. Schneider et al. (2005) and references therein) were used to determine particle composition. Particles were collected on grids for subsequent TEM (Transmission Electron Micoscropy) analysis. Hygroscopic growth factors were determined by means of a HH-TDMA (High Humidity Tandem Differential Mobility Analyzer) that measured up to relative humidities (RH) of 98% (Hennig et al. (2005)). The critical super-saturations needed for the activation of the investigated particles into cloud droplets were measured with a continuous flow CCNc (Cloud Condensation Nucleus counter) from DMT (Droplet Measurement Technologies, Roberts and Nenes (2005)). The LACIS flow tube was extended to a length of 8 m, so LACIS could be used to examine the immersion freezing behaviour of the coated and uncoated ATD particles.

By a bulk analysis and by the AMS measurements, the ATD particles were found to contain water soluble material, however in small quantities. By means of the online AMS measurements, it was possible to distinguish between thin and thick H2SO4 coatings. For the thin coatings, the H2SO4 was found to have reacted with material contained in the ATD, so that almost no free H2SO4 was found. For the thick coatings, obtained at higher coating temperatures, H2SO4 was detected. In general, uncoated particles and those coated with thin coatings of H2SO4 or of succinic acid, showed almost no hygroscopic growth. Particles coated with thicker coatings of H2SO4 and of ammonium sulphate grew noticeably above 95% RH (growth factors of about 1.1 at 98% RH). Both, coated and uncoated ATD particles, were found to activate at atmospherically relevant super-saturations (0.35% for pure ATD, 0.2% for succinic acid and thin H2SO4 coatings, 0.15% for thick H2SO4 and for ammonium sulphate coatings). Combining measured hygroscopic growth with activation data, a dynamic shape factor of the ATD particles of about 1.8 was derived, corroborating the deviation of the particle shape from that of a sphere. Uncoated ATD particles and particles coated with succinic acid or thin coatings of H2SO4 nucleated ice at higher temperatures, i.e. were more efficient IN, than particles with thick H2SO4 or ammonium sulphate coatings. Although the latter two were similar in hygroscopic growth and activation behaviour, they differed in their ability to act as IN, with ATD particles coated with ammonium sulphate being the most ineffective IN. This finding suggests that the investigated particle's ability to act as IN might not be related to water activity for the immersion freezing processes investigated in this study.

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