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Changes in Hygroscopicity and Cloud-Activation of Diesel Soot upon Ageing

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Introduction

The contribution from fresh diesel exhaust particles to the cloud condensation nuclei (CCN) population is negligible (e.g. Tritscher et al., 2011). However, complex gas-to-particle conversion processes in the atmosphere form secondary organic aerosol (SOA) from emitted exhaust gases and particles, which significantly may influence the cloud drop formation process. Results from two Lund University smog chamber campaigns (#I & #II), are presented. The CCN and hygroscopic properties of diesel soot particles and the accompanying organic coating were investigated during ageing.

Methods

Exhaust from a light-duty diesel vehicle at warm idling were transferred to a smog chamber and photochemically aged (Nordin et al., 2012). VOCs and IVOCs (Intermediate Volatile Organic Compounds) in the diesel exhaust were used as SOA precursors. Selected amounts of toluene and m-xylene were added to allow investigations of the full particle transformation from agglomerates to spheres.

Hygroscopic properties were analysed using a Hygroscopic Tandem Differential Mobility Analyzer (H-TDMA; Nilsson et al., 2009), and the cloud-activation properties were measured using a Cloud Condensation Nucleus Counter (CCNC; DMT 100). A soot particle aerosol mass spectrometer (SP-AMS, Aerodyne Research) determined the composition of the soot cores and the particle coatings. The particle mass-mobility relationship was characterized using a Differential Mobility Analyzer-Aerosol Particle Mass Analyzer (DMA-APM; Kanomax Japan 3600). During Campaign II, the CCNC measurement procedure was changed from the traditional Stepping-ΔT to Scanning Flow CCN Analysis (SFCA) (Moore & Nenes, 2009), enabling rapid measurements of the supersaturation spectra with high time resolution, revealing more detailed, accurate and continuous results.

Conclusions

During the ageing process, the transformation of the hygroscopic behaviour and its link to the effect on cloud droplet activation were related to the organic fraction in the particle as well as particle size and morphology. The properties of the organic material strongly influence the activation of the coated soot particles, both regarding the change of chemical composition, and also the change of critical supersaturation (SSc, Fig.1) upon UV exposure.