Effects of suphuric acid and limonene ozonolysis products coatings on soot morphology and hygroscopicity

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Particles containing soot are commonly considered to have a warming effect on the climate, because they can strongly absorb solar radiations. However, secondary organic aerosols (SOA), formed by atmospheric oxidation of precursor gases, which are known to be a major fraction of atmospheric aerosols, can scatter light and act as cloud condensation nuclei (CCN), thereby having a cooling effect on the climate (IPCC, 2013). Soot, organic aerosols and sulphuric acid are likely to co-exist, in diverse mixing states, and participate in complex interactions. Coatings such as sulphuric acid and SOA can modify the morphology of soot particles and change the optical properties and cloud forming properties significantly (Mikhailov *et al.*, 2006).

Differential Mobility Analyser-Aerosol Particle Mass Analyser (DMA-APM) and the Tandem DMA techniques were used to study the effects of coatings of sulphuric acid and limonene ozonolysis products on soot particle morphology and hygroscopicity using a laminar flow system. Chemical composition of fresh and coated soot particles were also measured with a Soot Particle-Aerosol Mass Spectrometer (SP-AMS). The cloud droplet formation was measured by a Cloud Condensation Nuclei Counter (CCNC). The empirical data was compared with theoretical calculations obtained from Köhler modelling.

Fresh soot particles have a non-spherical shape. Effective densities of all sizes of coated soot particles increase, whereas the dynamic shape factors of all sizes of coated soot particles decrease with more coatings, indicating the coatings transform soot particles into more spherical shape. The sizes of primary particles were similar irrespectively of the overall soot core sizes, indicating soot particles were formed from diffusion processes. Sulphuric acid is more efficient in transforming soot particles to spherical shape than limonene ozonolysis products. Our results showed that morphology of soot particles in the atmosphere not only depends on the mass of coating of soot surface, but also depends on the chemical compositions of coatings.

Fresh soot particles did not show any activation into cloud droplets at supersaturations below 2 %. However, if small amounts of sulphuric acid or SOA condensed onto the soot particles, the required supersaturation for activation was decreased to values below 1 %. The ability of soot particles to activate into cloud droplets increased further with increasing amount of condensed sulphuric acid or SOA. Sulphuric acid was found to enhance cloud droplet formation more than SOA due to its large water solubility and corresponding ionic dissociation. The enhanced activation was affected by the physical properties of the coating component, the amount of condensed mass and the initial soot particle size.

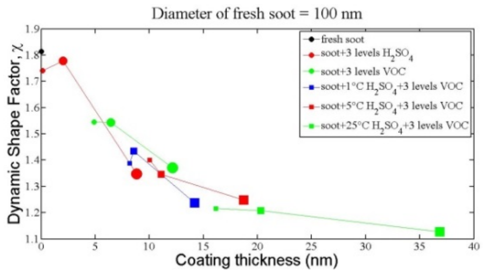

Figure 1. Dynamic shape factor of fresh and processed soot particles, initial mobility diameter of the fresh soot was 100 nm.

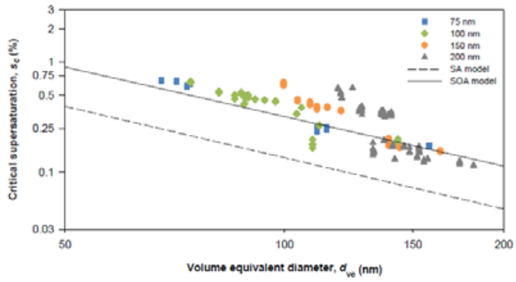

Figure 2. Critical supersaturation, s_c, versus volume equivalent diameter, d_{ve}.

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IPCC (2013). *Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the IPCC 5th Assessment Report - Changes to the Underlying Scientific/Technical Assessment.* Cambridge, U.K.: Cambridge University Press.

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