



Importance of the mixing state for ice nucleating capabilities of individual aerosol particles

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The effects of aerosol particles on heterogeneous ice formation are currently insufficiently understood. Modelling studies have shown that the type and quantity of atmospheric aerosol particles acting as ice nuclei (IN) can influence ice cloud microphysical and radiative properties as well as their precipitation efficiency. Therefore, the physicochemical identification of IN and a quantitative description of the ice nucleation processes are crucial for a better understanding of formation, life cycles, and the optical properties of clouds as well as for numerical precipitation forecast.

During the CLACE 5 campaign in 2006 at the high alpine research station Jungfraujoch (3580 m asl), Switzerland, the physicochemical parameters of IN within mixed-phase clouds were studied. By the use of special Ice-Counterflow Virtual Impactor, residual particles of small ice nuclei (IN) and the interstitial aerosol fraction were sampled separately within mixed-phase clouds.

The size, morphology, elemental composition and mixing state of more than 7000 particles of selected IN- and interstitial-samples were analyzed by scanning electron microscopy (SEM) combined with energy-dispersive X-ray analysis (EDX). For selected particles, the mineralogical phase composition was determined by transmission electron microscopy. In order to receive detailed information about the mixing state (coatings, agglomerates, heterogeneous inclusions) of the IN- and interstitial-samples, the complete individual particle analysis was performed operator controlled.

Four different particle types were identified to act as IN.

- 1) Carbonaceous particles, which were identified to be a complex mixture of soot (main component), sulfate and nitrate.
- 2) Complex mixtures of two or more diverse particle groups. In almost 75% of these particles silicates or metal oxides are the main-component.
- 3) Aluminium oxide particles, which were internally mixed with calcium and sulphate rich material and
- 4) Pb bearing particles.

The high abundance of Pb-bearing particles in the IN-samples (up to 24% by number) was an unexpected finding. Besides a smaller content of larger PbO and PbCl₂-particles the main component of the particles within this type are predominantly sea salt, soot or silicates, while Pb in these particles is only present as small (50 – 500 nm) heterogeneous Pb or PbS inclusions.

In all 4 particle types identified as IN, the mixing state seems to play an essential role. Therefore it can be concluded that the determination of the main-component of a particle is not sufficient for the prediction of its IN-capability.