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Heterogeneous ice nucleation and phase transition of viscous α-pinene secondary organic aerosol

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There are strong indications that particles containing secondary organic aerosol (SOA) exhibit amorphous solid or semi-solid phase states in the atmosphere. This may facilitate deposition ice nucleation and thus influence cirrus cloud properties. Global model simulations of monoterpene SOA particles suggest that viscous biogenic SOA are indeed present in regions where cirrus cloud formation takes place. Hence, they could make up an important contribution to the global ice nucleating particle (INP) budget. However, experimental ice nucleation studies of biogenic SOA are scarce.

Here, we investigated the ice nucleation ability of viscous SOA particles at the CLOUD (Cosmics Leaving OUtdoor Droplets) experiment at CERN (Ignatius et al., 2015, Järvinen et al., 2015). In the CLOUD chamber, the SOA particles were produced from the ozone initiated oxidation of α-pinene at temperatures in the range from -38 to -10˚C at 5-15 % relative humidity with respect to water (RHw) to ensure their formation in a highly viscous phase state, i.e. semi-solid or glassy. We found that particles formed and grown in the chamber developed an asymmetric shape through coagulation. As the RHw was increased to between 35 % at -10˚C and 80 % at -38˚C, a transition to spherical shape was observed with a new in-situ optical method. This transition confirms previous modelling of the viscosity transition conditions.

The ice nucleation ability of SOA particles was investigated with a new continuous flow diffusion chamber SPIN (Spectrometer for Ice Nuclei) for different SOA particle sizes. For the first time, we observed heterogeneous ice nucleation of viscous α-pinene SOA in the deposition mode for ice saturation ratios between 1.3 and 1.4, significantly below the homogeneous freezing limit. The maximum frozen fractions found at temperatures between -36.5 and -38.3˚C ranged from 6 to 20 % and did not depend on the particle surface area.

References

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