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Pedersen, Jens Olaf Pepke

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Ion-induced nucleation of the sulfuric acid – water system

J. O. Pepke Pedersen
Technical University of Denmark, National Space Institute, Copenhagen, Denmark (jopp@space.dtu.dk)

Ions can enhance nucleation under atmospheric conditions as shown by theory, observations, and experiments, but the exact mechanism still remains to be determined. In particular nucleation of the dipolar sulfuric acid – water system has been investigated since ion-induced nucleation is expected to increase the nucleation rate at the critical cluster size, where the charge makes the small clusters more thermodynamically stable than their neutral counterparts and thus reduces the energy barrier to nucleation.

Also the initial growth rates of small ion clusters are found to be enhanced by the dipole-charge interaction between the core ion and the strongly dipolar condensing sulfuric acid and/or water molecules. In the initial phase these ion-molecule interactions greatly accelerate the kinetics of molecular association. During the later stages of aerosol growth (from 2-3 nm and larger) the effect of the ion is expected to become small and the growth rate will be dominated by the vapor pressure of the condensing species.

We have studied ion-induced nucleation of the sulfuric acid – water system under a variety of conditions from an ultra-low background radiation environment 1100 meter underground to ionization densities far above the natural levels found in the atmosphere using a particle accelerator. Together with recent advances in modeling this has increased our understanding of the nucleation mechanism and the role of ions.