Geophysical Research Abstracts,
Vol. 11, EGU2009-5905, 2009
EGU General Assembly 2009

Environmental Scanning Electron Microscopy (ESEM) of Atmospheric Ices

H. Grothe (1), P. Baloh (1), K. Whitmore (2), and D. Waller (3)

(1) Institute of Materials Chemistry, Vienna University of Technology, Vienna, Austria (grothe@tuwien.ac.at, +431 25077 3890), (2) Institute of Solid State Physics, Vienna University of Technology, Vienna, Austria (karin.whitmore+e052@tuwien.ac.at, +43-1-58801 13726) , (3) Sector of Biological and Soft Systems, University of Cambridge, Department of Physics, Cavendish Laboratory, Cambridge, CB3 0HE, United Kingdom (dw284@cam.ac.uk, +44 1223 765 108)

Water ice and nitric acid hydrates exhibit very different particle morphologies, which have an enormous impact on its ability to scatter and reflect light. This has an effect not only on the detection of ice particles by satellite instruments or ground-based optical remote sensing but also interferes with earth's radiation balance. Since detailed morphological investigations in the atmosphere are hampered due to an interference of the microscopic technique to the ice particles, one is dependent on laboratory model experiments.

In the past, a scanning electron microscope required a sufficient vacuum in the sample chamber in order to prevent a diversion of the electron beam. Modern environmental electron microscopy uses an imaging gas (water or nitrogen), which connects different advantages and prevents several handicaps. Firstly, the imaging gas works as secondary-emission multiplier. Secondly, the gas discharges the sample surface regularly and makes insulators accessible to SEM. Thirdly, a mixture of water and nitrogen prevents dehydration of the sample.

Here, we present ESEM pictures of nitric acid hydrates and water ices. These particles exhibit morphological changes during an annealing program which can be related to respective phase changes, which have been corroborated by X-ray diffraction and vibrational spectroscopy in former experiments. [1,2] Different techniques of sample preparation have been applied, which range from gas phase deposition, to quenching techniques and oil-matrix isolation of frozen droplets. Beside the assignment of ice and hydrate particles and the evaluation of their impact on the spectroscopic data, we could also identify phase separations into hydrates/ice and impurities. This is an interesting result since it gives an idea of the topology of frozen atmospheric particles, which comprise a mixture of different organic and inorganic substances.[3]

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