

## Freezing and Activation Measurements of Coated and Uncoated Arizona Test Dust Particles

D. Niedermeier<sup>1</sup>, S. Hartmann<sup>1</sup>, R. Shaw<sup>1,2</sup>, D. Covert<sup>3</sup>, Th. F. Mentel<sup>4</sup>, J. Schneider<sup>5</sup>, L. Poulain<sup>1</sup>, T. Clauss<sup>1</sup>, A. Kiselev<sup>1</sup>, E. Hallbauer<sup>1</sup>, H. Wex<sup>1</sup>, and F. Stratmann<sup>1</sup>

<sup>1</sup> Department of Physics, Leibniz Institute for Tropospheric Research, 04318 Leipzig, Germany

<sup>2</sup> Department of Physics, Michigan Technological University, Houghton, Michigan 49931, USA

<sup>3</sup> Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, Washington 98195, USA

<sup>4</sup> ICG-2: Troposphäre, Forschungszentrum Jülich, 52425 Jülich, Germany

<sup>5</sup> Particle Chemistry Department, Max Planck Institute for Chemistry, 55128 Mainz, Germany

Ice particles are formed in the atmosphere through homogenous and heterogeneous ice nucleation processes. For heterogeneous ice nucleation the controlling factors are still far from being identified and understood (e.g. Kärcher and Lohmann, 2003).

During the FROST (FReezing and activation abilities Of coated and uncoated duST particles) campaign, the Leipzig Aerosol Cloud Interaction Simulator (LACIS, Stratmann *et al.*, 2004) was used to investigate the immersion freezing behavior of coated and uncoated Arizona Test Dust (ATD) particles with a quasi-monodisperse mobility size of 300 nm. The ATD particles were coated with succinic acid ( $C_4H_6O_4$ ), ammonium sulfate ( $(NH_4)_2SO_4$ ), and sulfuric acid ( $H_2SO_4$ , at two different coating thicknesses). The particles were characterized with respect to shape, chemical composition, hygroscopic growth and droplet activation.

In general, uncoated particles and those with thin  $H_2SO_4$  or with  $C_4H_6O_4$  coatings showed almost no hygroscopic growth. Only particles coated with thick  $H_2SO_4$  and with  $(NH_4)_2SO_4$  grew noticeably above 95% RH (see Figure 1). All investigated particles activated at atmospherically relevant supersaturations (0.1 – 0.4%), with particles coated with thick  $H_2SO_4$  or with  $(NH_4)_2SO_4$  being the most effective CCN.

Uncoated particles and those with  $C_4H_6O_4$  or with thin  $H_2SO_4$  coatings started to serve as ice nuclei (IN) at higher temperatures compared to particles with thick  $H_2SO_4$  or with  $(NH_4)_2SO_4$  coatings. Although the latter two particle types featured similar hygroscopic growth and droplet activation behavior, they differed in their ability to act as IN, with ATD particles coated with  $(NH_4)_2SO_4$  being the most ineffective IN (see Figure 2).

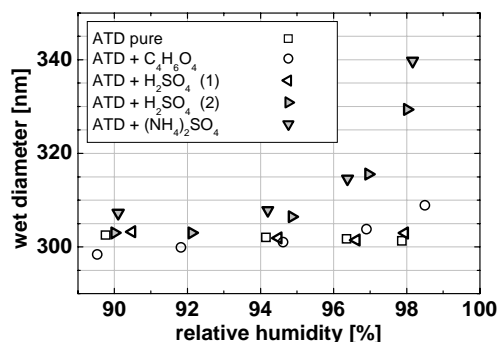


Figure 1: Hygroscopic growth of pure and coated ATD particles

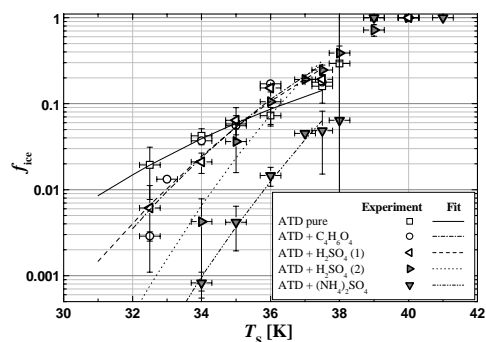


Figure 2: Freezing behavior of pure and coated ATD particles

In Fig. 2 the ice fraction  $f_{ice}$  is plotted versus the supercooling temperature  $T_s$ . The line at  $T_s = 38K$  separates the heterogeneous (on the left) and homogeneous (on the right) freezing modes.

For the immersion freezing of the highly diluted droplets investigated here, it seems that the ability of the investigated particles to act as IN is not related to water activity.

Additionally, a fit procedure, based on a simplified CNT (Classical Nucleation Theory) type nucleation rate expression, was performed for all types of IN investigated. The results are shown in Fig. 2 as lines. Good comparison between experimental data and fit suggests applicability *and validity* of CNT type rate expressions.

### References

Kärcher, B., and Lohmann, U. (2003). *J. Geophys. Res.*, 108, 4402, doi:10.1029/2002JD003220.  
Stratmann, F. *et al.* (2004). *J. Atmos. Oceanic Technol.*, 21, 876-887.