

Interactive
Comment

Interactive comment on “High variability of the heterogeneous ice nucleation potential of oxalic acid dihydrate and sodium oxalate” by R. Wagner et al.

Anonymous Referee #2

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General comments:

The authors present a comprehensive set of experimental data on heterogeneous ice nucleation performed at the AIDA facility in Karlsruhe, Germany. The use oxalic acid dihydrate and sodium oxalate as ice nuclei (IN) to investigate heterogeneous ice nucleation in the deposition and condensation mode. The results are convincing and it is a very well written and structured paper which contributes to the present discussion on the ice nucleation process. They applied different techniques to produce IN, which leads to different results in the freezing ability. This clearly highlights that the structure and morphology of the ice nucleus is important for the ice nucleation ability. Future in-

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vestigations, probably in the AIDA; could help to get a broader picture of the influence of the morphology, structure and/or state (crystalline, semi-solid and/or glassy) on the ice nucleation ability of different IN: I recommend the paper to be published in ACP after the authors have stated on the following comments.

Specific comments:

Page 11514, line 11: Can the rapid crystallization be a problem, that you don not form a pure crystal, but a poly-crystalline or an amorphous particle? Would it be possible to change the rate, which likely will lead to slightly different surface and thus different ice nucleation ability?

Page 11520, line 9: Why only roughly equal? Is the AIDA chamber not homogeneously distributed?

Page 11525, lines 10-15: How do you get the “exact” Sice values? I clearly matters how much the gas temperature is higher, since Sice is very sensitive to the temperature. Isn't it?

Page 11531, line 9: Could it be that the particles are even glassy or (semi)-solid? I guess no, because of the data shown in Fig. 4. Do you know the glass temperatures of oxalic acid solutions?

Page 11534, line 15: What about the accuracy of Sice? Is the variation of Sice between 1.03 and 1.05 in Exp. 1 and 2, respectively, already significant? Could that difference result from a slightly different temperature?

Page 11534, lines 16-17: Is it possible that the most efficient oxalic dihydrate particles are the larges ones? Can you prove that by your measurements?

Page 11535, line 1: What about the variation of Sice between 1.06 and 1.08 for Exp. 3 and 4, respectively? See comment above.

Page 11536, line 19: Is it fair to state that the possible gel-like amorphous particles

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in the Prenni et al. 2001 study where not effective IN. In a recent study in the AIDA (Murray et al. 2010) glassy citric acid particles are efficient IN. Both particles are amorphous (see e.g., Mikhailov et al. 2009), but obviously only the citric acid particles act as IN. You might state on that.

Page 11539, line 27-28: How are you sure that the sodium oxalate is not dissolved again and that you observe homogeneous ice nucleation instead of condensation nucleation? I don't see the connection between the possible dissolving of sodium oxalate and the homogeneous ice nucleation (see also comment of Referee 1 concerning the temperature sensitivity.). I believe that the authors should discuss their uncertainties (Temperature, Sice) more clearly. See also comment above.

Page 11541, line 20: See comment above. I'm not fully convinced that sodium oxalate does not fully dissolve. What about solubility data?

Page 11541, line 23: The re-crystallization took a longer time than the first crystallization, right? If so, could it be that there was no crystallization in the first case, but rather the formation of an amorphous particle?

Page 11553, line 12: Which form of oxalic acid would probably crystallize in the atmosphere? It would be great when the authors could address somewhat deeper the atmospheric implications.

Page 11560, Table 1: Could you also add a column with the size of the particles or link it to Figure 3.

Page 11561, Figure 1: It would be helpful to include also RH with respect to ice, since that's the quantity, which one is interested in.

Page 11563, Figure 3: The oxalic acid dihydrate particles are clearly larger when they are produced by rapid cooling (panel a) compared to panels c and e? Why? Is it only a size difference or also is the composition different, e.g. is some water remaining in the particles in panel a?

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Minor comments:

Page 11515, line 8: replace “.. of tropospheric aerosols” by “... the tropospheric aerosol.”

Page 11533, line 3: replace “forth” by “fourth”

Page 11533, line 8, Shouldn't you refer to Fig 5 instead of Fig. 4.

Page 11534, line 3: replace “forth” by “fourth”

Page 11535, line 15, Panel e means the fifth panel. Why do you refer to that one?

Page 11540, line 10: replace “forth” by “fourth”

Page 11547, line 1: replace “forth” by “fourth”

References

Prenni, A. J., DeMott, P. J., Kreidenweis, S. M., Sherman, D. E., Russell, L. M., and Ming, Y.: The effects of low molecular weight dicarboxylic acids on cloud formation, *J. Phys. Chem. A*, 105, 11240–11248, 2001.

Mikhailov, E., Vlasenko, S., Martin, S. T., Koop, T., and Pöschl, U.: Amorphous and crystalline aerosol particles interacting with water vapor: conceptual framework and experimental evidence for restructuring, phase transitions and kinetic limitations, *Atmos. Chem. Phys.*, 9, 9491–9522, 2009, <http://www.atmos-chem-phys.net/9/9491/2009/>.

Murray, B. J., Wilson, T. W., Dobbie, S., 5 Cui, Z., Al-Jumur, S. M. R. K., Möhler, O., Schnaiter, M., Wagner, R., Benz, S., Niemand, M., Saathoff, H., Ebert, V., Wagner, S., and Kärcher, B.: Heterogeneous nucleation of ice particles on glassy aerosols under cirrus conditions, *Nature Geosci.*, 3, 233–237, 2010.

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