

Interactive comment on “Oxalic acid as a heterogeneous ice nucleus in the upper troposphere and its indirect aerosol effect” by B. Zobrist et al.

Anonymous Referee #2

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General comments:

In this manuscript, the authors present measurements of the heterogeneous ice nucleation ability of a range of crystalline dicarboxylic acids, and they show that only oxalic acid in the form of oxalic acid dihydrate is an effective ice nucleus. The authors used their laboratory results in a microphysical box model and climate model to show that heterogeneous nucleation of ice on oxalic acid dihydrate may be important in the atmosphere.

The manuscript is well written and presents new and interesting results. To my knowledge this is the first conclusive study to show that crystalline organic material can play

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an important role as an ice nucleus in the atmosphere. This paper falls within the top 10 % of this field. I recommend publication after the authors have had a chance to address the following comments:

Specific comments.

Page 3575, line 20: Do the results depend significantly on the conditioning temperature? In other words, do the heterogeneous freezing results depend on how close the conditioning temperature is to the melting point of oxalic acid dihydrate. The results from Zuberi et al.[Zuberi et al., 2001] show that ice nucleation on solid ammonium sulfate is very sensitive to the conditioning temperature. If the conditioning temperature is close to the melting point, then the crystalline material is not an effective ice nucleus, but if the conditioning temperature is close to the eutectic then the crystalline material is an extremely effective ice nucleus. Have the authors observed a similar effect for oxalic acid dihydrate? Have they investigated this in detail? This would be a worthwhile set of measurements as it has implications to how heterogeneous ice nucleation on oxalic acid dihydrate is included in models.

The authors observed that the dihydrate forms only after ice precipitates. This is presumably by heterogeneous nucleation on ice. Also the authors are using supermicron droplets, which are larger than the particles that will freeze in most cases in the upper troposphere. Will oxalic acid dihydrate form in submicron droplets (after ice precipitates) as well as in supermicron droplets (after ice precipitates)? In other words, does the probability of forming the dihydrate depend on droplet size? The authors may want to discuss this point briefly in the manuscript for completeness.

Table 1: Perhaps change “literature data of melting points (T_m) are indicated in the brackets.” to “ T_m indicates the ice melting point and literature data of melting points are indicated in the brackets”.

Zuberi, B., A.K. Bertram, T. Koop, L.T. Molina, and M.J. Molina, Heterogeneous freezing of aqueous particles induced by crystallized $(\text{NH}_4)_2\text{SO}_4$, ice, and letovicite, Jour-

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