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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Technical Note: Formation of airborne ice crystals in a wall independent reactor (WIR) under atmospheric conditions" *by* E. Fries et al.

Anonymous Referee #1

Received and published: 19 August 2008

Overall this is useful paper, which is trying to describe the experimental set up to measure the uptake of organic compounds by ice crystals. However the paper require an extra laboratory work, and a more detailed analysis and discussions that to be carried out before it can be published under the Technical Note section of the ACP. Following are the comments that have to be satisfied before it can be published.

General comments:

Authors have assumed that if the temperature falls below zero deg C the ice crystals are formed inside the WIR, which may not be true. If the available water vapor inside the WIR is sub-saturated with respect to ice then no ice crystal formation will be observed.

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To clarify further I want authors to add a plot of water vapor distribution inside the WIR. This water vapor distribution figure can help in mapping the areas of WIR where the water vapor supersaturation with respect to ice exists.

Also I would like authors to carry out an experiment to confirm the ice crystal formation using the well known aerosol particles inside the WIR. Experimental validation is necessary to prove the ice crystal formation theory described in the paper. Just a theoretical description is not enough to publish this paper under Technical note. An ice detector or any detector capable of detecting ice can be used at the WIR exit to observe the ice crystals.

Specific comments:

Page 13018 lines 22-23: the value 2.82 mg per second is not actually how fast the ice can grow. It is the total mass of the water vapor summed over the horizontal cross section of the WIR per unit time. Therefore this could not be used as ice growth rate because the number concentration of ice crystals and distribution of water vapor is unknown inside the WIR. It is also possible that if the heterogeneous ice nucleation has not occurred and therefore available water vapor is not been depleted then there is not ice crystal growth taking place inside the WIR. I suggest authors to restructure this analysis.

Page 13020 lines 13-15: the authors describe the objectives of the work i.e. 'the study of interactions of hydrocarbons and other organic compounds with airborne ice crystals', but how this work will be carried is not been explained. It would be nice to see few sentences or a paragraph describing the experimental procedure to carry out above objectives.

Page 13021 line 5: Excess moisture was removed ..., how much? Define the working and performance characteristics of the cold trap.

Page 13021 lines 10-11: how do you confirm that after removing excess moisture the

ACPD

8, S6141–S6146, 2008

Interactive Comment

air was saturated with respect to ice.

Page 13021 lines 12-13: sentence 'Once the cold and saturated air mass ..., is it 'Once the cold, saturated air mass .... If not I could not see two different inlets for cold air mass and saturated air mass in Fig 1a page 13035. Please explain in detail. Also how do you confirm the air mass flows almost in the reactor centre of the WIR? I suggest authors to plot the velocity profile distribution across the WIR to confirm this understanding.

Page 13023 line 11-12: sentence 'Assuming the amount of water vapor exceeds the amount needed for ice crystal formation' how this assumption is validated.

Page 13024 line 1-2: the term C from the equation (5) is defined at relative humidity of 100%. Is it the relative humidity with respect to ice or water?

Page 13024 lines 6-8: Reference the equations. I could not find these equations in standard thermodynamics text books.

Page 13024 line 16: The equation (8) needs detailed explanation. Here it is described that the term C is calculated using equation (5), but C is already defined in that equation. The value of C is assumed as water vapor concentration at particular temperature and relative humidity with respect to either ice or water. This means C is water vapor concentration at saturated conditions over the ice or water. Also Csat of equation (8) is also defined as water vapor concentration at saturated conditions. This means C equals Csat and thus the saturation ratio is always equal to one. If this is true then there are no supersaturation conditions exist and no ice crystal formation inside the WIR. It is unclear how C and Csat are calculated in equation (8).

Page 13024 line 16: I recommend authors to write the reference, wherein the similar kind of saturation ratio calculation approach is used and similar kind of experimental set up is described in this paper.

Page 13024 line 16: I also recommend authors to plot the saturation ratio versus temperature graph for various values of C and Csat OR something similar to understand

ACPD

8, S6141–S6146, 2008

how saturation ratio varies across the WIR.

Page 13025 line 22-26: Here the various factors that might influence the ice formation are described. Another very likely factor that might influence is if there are pockets of water vapor sub-saturation conditions inside the WIR. An extra figure showing the fields of water vapor distribution inside the WIR would be really useful.

Page 13026 line 20-21: sentence 'According to DeMott et al. (2003', here the authors are assuming that by using the same residence time as DeMott (2003) ice crystals can be formed inside the WIR. This may not be true. Along with residence time, other few conditions such as temperature, relative humidity with respect to ice and ice nuclei are also important. Do all these conditions were satisfied in the present WIR set up? If not then I suggest authors to revise the sentence stating something on these lines 'residence time is not the only criteria to be satisfied for ice crystal formation'.

Page 13026 lines 21-24: revise the sentence (the conclusion based on residence time may not be true).

Page 13032 line 4-6: I could not find this reference. Could you please write in detail.

Page 13037 and 13038: I would like see the explanation why the temperature contour plots are not symmetrical. For e.g. in Fig. 2a the plot of 30 L per min, which is showing the temperature distribution across the vertical cross section of the WIR. About the central axis of WIR the temperature distribution is not symmetrical. Similarly all the six temperature contour plots are asymmetrical and might be suggesting that some kind of turbulence is occurring inside the WIR. From the experimental point of view the symmetrical temperature contour plot is expected, if not observed means equilibrium conditions inside the WIR are not achieved. Experiment performed under non-equilibrium conditions may not give similar results every time the experiments are repeated.

Page 13037 and 13038: I suggest authors to plot velocity distribution field inside the

ACPD

8, S6141–S6146, 2008

Interactive Comment

WIR. This might help in understanding the asymmetrical behavior of temperature distribution inside the WIR.

Page 13039 Fig 3: What are the errors or uncertainties in the temperature measurement?

Page 13042 Fig 6: I could not see the importance of this graph in describing the overall experimental set up.

Technical comments:

1. The reference DeMott is misspelled as de Mott across the paper.

2. The legends and axis labels of the figure 2a and 2b are too small to read.

Summary:

Primarily this paper is describing the theoretical procedure to generate ice crystals in a reactor called as wall independent reactor (WIR). The paper also describes the experimental set up including the WIR. After reading this paper I am not clear of a) whether such a experimental set up really exist i.e. is it been constructed and operational?, and b) if exist can it generate ice crystals at desired temperature and saturation ratio using known aerosol particles. Lack of experimental results strengthens this doubt. Most of the terms in this paper are assumed, and not verified and validated. Finally, to be published as a Technical note in ACP along with satisfying above comments, I would also like to see the performance validation with well known aerosol particles (for e.g. ammonium sulfate, silver iodide etc) of the proposed experimental set up here. I strongly suggest authors to read the recent paper (Stetzer et al. 2008) to restructure the present paper.

Stetzer, Olaf and Baschek, Björn and Lüönd, Felix and Lohmann, Ulrike [2008],The Zurich Ice Nucleation Chamber (ZINC) - A New Instrument to Investigate Atmospheric Ice Formation

ACPD

8, S6141–S6146, 2008

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ACPD

8, S6141–S6146, 2008

Interactive Comment