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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Ice nucleation abilities of soot particles determined with the Horizontal Ice Nucleation Chamber" *by* Fabian Mahrt et al.

Anonymous Referee #2

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This manuscript describes the ice nucleation activities of different types of laboratory generated soot particles using the horizontal ice nucleation chamber (HINC). They performed ice nucleation experiments for four different size (mobility diameter) selected particles using DMA. Furthermore, they investigated particle morphology using TEM, and DMA-CPMA; temperature induced mass loss using thermogravimetric analysis; and water uptake using dynamic vapor sorption measurements. They attempted to link all these measurements with the ice nucleation activities of different types of soot.

Overall, the authors found that soot particles are not active in the mixed-phase cloud condition but some of the soot types are active in the cirrus cloud regime. The authors suggested that pore condensation and freezing (PCF) mechanism may be responsible for ice nucleation. Overall, the paper is clearly written and quite detailed. I appreciate

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Discussion paper

all the details provided by the authors. Some suggested clarifications are listed below. I recommend this paper for publication after the comments outlined below are taken into account.

General comments:

1) One of the main concerns is the size distribution of the particles investigated here. Even though the authors size selected the particles using DMA, but due to fractal morphology of soot the physical diameters are quite different than mobility diameter. Depending on the soot morphology and flow, the difference between geometric diameter and mobility diameter varies. I suggest to add the size distribution of soot particles if available. Authors provided SMPS size distribution for FS soot in the supplementary material but it will be useful to provide size distribution for all the soot types, especially for FW200 soot. If SMPS data is not available, then the authors can use TEM images to provide size distribution of soot particles (like they provided the size distribution of soot monomers). For example, looking at the TEM images of FW200 (the most effective INP investigated here), it seems like these particles are quite bigger in size compared to other soot particles investigated here. Authors should also discuss about the multiply charged particles in DMA.

2) It seems like the differences in onset saturation ratio between 228K and 233 are significant for FW200 soot for both 300 nm and 400 nm size. Can you explain why?

3) LB-RC soot nucleated ice in the circus cloud regime below homogeneous freezing and second most efficient INP investigated here for 300 nm size selected soot even though the surface area of LB_RC soot is less than an order of magnitude lower compared to FW200 soot (Table B1). Why LB_RC soot is relatively active even with low surface area? Overall size of the LB_RC soot aggregate is smaller compared to FW soot but monomers of LB_RC is too large (152 nm) compared to typically monomer size of soot in the atmosphere.

4) Overall, the discussion of soot aggregate porosity is rather qualitative and they tried

to make a link with PCF freezing. Perhaps authors can use the BET surface area measurements to make conclusions or make an attempt to provide more quantitative information on the porosity.

Minor comments:

1) Page2, line6: typically in the atmosphere primary particle diameter of soot particles ranges from 15-60 nm. Several hundreds of nanometer sounds too large to me.

2) Page 13, line 34: please provide the number of aggregates and monomers analyzed.

3) Page 14, line 1: "the most ice active FW200 soot shows particularly densely clustered aggregates" – why the DMA-CPMA derived fractal dimension is low then compared to other soot investigated? May be it's related to coating that added to mass. For example, FS particles seem more coated and has higher Dfm compared to other soot samples.

4) Page 14, lines 5-10: "...soot particles with smaller spherules are more likely to nucleate ice via a PCF mechanism"- I didn't follow this part. How did you come to this conclusion?

5) Figure 4: perhaps the authors can consider to plot using log-log scale, then show the power fit. Then it will be easier to read the fractal dimension.

6) Table B4: please provide the error for pre-factor and fractal dimension.

7) It is interesting that FW200 soot samples show significant mass loss from TGA experiments and also show highest ice nucleation ability. Significant mass loss below 200C suggest that there were volatile material. I didn't follow why authors refer this observation as presence of hydrophilic sites? Why there were condense water? May be I missed something how the experiments were performed. Also, I'm surprise by the amount of mass loss. It suggest that there were quite a bit of volatile material in the soot sample. Information about the chemical composition of soot samples would have been helpful.

8) Page 23, line 15: May be add some examples of atmospheric processing of soot after long-range transport when soot particles become more compact (change contact angle) or coated with other materials.

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