Review to "Laboratory study of heterogeneous ice nucleation on black carbon containing aerosol" by Nichman et al. ACPD, 2018

The manuscript by Nichman et al. presents a laboratory investigation of the ice nucleation ability of black carbon (BC) particles of different type and sizes in the cirrus regime. The topic of BC ice nucleation is of high relevance for atmospheric science and climate, and as such for ACP.

General comment:

The manuscript is well structured and written. I would like to congratulate the authors, who have significantly improved the quality of the manuscript, compared to the previous discussion paper. The five aspects influencing BC ice formation identified by the authors (see P5) are discussed in fair detail, even though I found the introduction quite long and partly hard to read. However, the discussion of the measurement uncertainties in terms of RH and T is poor. This makes it hard to follow parts of the comparisons between the different soot types and the argumentation for some of the figures.
Overall, I recommend the manuscript for publications, after some minor and specific comments, which I list below, have been addressed:

Specific comments:

- P1L23: Change to "…that govern the ice nucleation activity of BC."
- P1L31: Delete "lamina".
- P2L16: Do you mean cloud types?
- P2L18: "While field…". This statement should be followed by references. I suggest deleting this sentence here, as you have a detailed discussion of both aspects further down.
- P2L34: Kanji et al. (2017) and Hoose and Möhler (2012) are review-type articles, sourcing data from other studies. Please delete these here and cite primary studies instead. Also, add: Häusler et al. (2018)
- P3L7: "…(PCF) mechanism." Should be followed by a reference.
- P3L11: delete "heterogeneous", this is clear since you say below homogeneous freezing.
- P3L36: Change to "can be expressed"
- P4L1: None of the given references makes sense to me. Are you just trying to cite studies that have used ns? Consider deletion.
- P4L11: Check formatting: "2014" of Marcolli is not in parenthesis, while other studies are. Add David et al. (2019).
- P4L13: Delete "diameter"
- P4L20: Add reference after "diameter range".
- P4L24: Add Umo et al. (2019)
- P5L3: I suggest tuning this down and saying: "… have not fully been established."
- P5L29: Check formatting/indent.
- P6L14: Define "BET"
- P6L17: "Submicron"
- P6L17: Delete "burner"
- P6L22: Replace "test" by "method"
- P7L17: "organic molecules." Should be followed by a reference.
- P8L35: This is not completely true, ice supersaturation can/is also be achieved when water-saturation conditions are created in SPIN. Please rephrase and formulate more carefully.
- P9L16: Are your ice nucleation data corrected for multiple charged particles? Please specify the sizes of double charged particles for the mobility diameters used by you. Could it be that the OPC detects a large, double-charged BC particle as ice?
- P9L24: Can you set this 1% threshold into context of the maximal activate fraction observed during your RH-scans. Please comment on this in the manuscript.
- P9L34: I could not find the definition for "SS_i".
- P10L4: Add Mahrt et al. (2018)
- P10L7: Why do you write "Heterogeneous ice nucleation". On P4L10 you state that water in pores freezes "homogenously". Please clarify in manuscript.

- P10L13: “The displayed…” This statement is not supported by your data shown in Fig. 4, in particular by the data points around T = 228 K. Please clarify. This would become even clearer if you were to include error bars in your data points, similar to your Fig. 3.
- P10L29: Again, it is very hard to justify and/or follow this statement without error bars in Fig. 4.
- P11L33: The reported size dependence seems consistent with that observed in studies by Friedman et al. (2011), Mahrt et al. (2018) and Crawford et al. (2011) that you cite above. You might want to refer back to these studies.
- P11L36: Replace “,” by “.”
- P12L2: “Hence, the…”: I assume that every data point in your Fig. 6 represents a single run. Please comment on how reproducible these are within the manuscript. Also, if I consider the error bars reported in your Fig. 3 I am not sure how different your 100 and 800 nm ethylene soot in Fig. 6 are. Please include error bars in Figs. and in discussion of data.
- P13L7: Delete space between “sample” and “.”
- P13L10: Include space before “However”
- P13L27: Delete space before “The”
- P14L10: Please define “channel process”
- P14L17: Please change to “INP”
- P14L32: Consider to replace “down” with “along”
- P16L3: Who is “MF”?
- Figs. 3, 4, 6, 7, 8: The y-axis should be labeled as “Supersaturation **ratio** with respect to ice”, or simply “S_{ice}”, to be consistent with your terminology. “Supersaturation over ice” as used is wrong. I recommend to be consistent through out all figures within the manuscript.

Crawford, I., et al. (2011), 'Studies of propane flame soot acting as heterogeneous ice nuclei in conjunction with single particle soot photometer measurements', *Atmospheric Chemistry and Physics,* 11 (18), 9549-61.

David, R. O., et al. (2019), 'Pore condensation and freezing is responsible for ice formation below water saturation for porous particles', *Proceedings of the National Academy of Sciences of the United States of America,* 116 (17), 8184-89.

Friedman, B., et al. (2011), 'Ice nucleation and droplet formation by bare and coated soot particles', *Journal of Geophysical Research-Atmospheres,* 116.

Häusler, T., et al. (2018), 'Ice Nucleation Activity of Graphene and Graphene Oxides', *Journal of Physical Chemistry C,* 122 (15), 8182-90.

Mahrt, F., et al. (2018), 'Ice nucleation abilities of soot particles determined with the Horizontal Ice Nucleation Chamber', *Atmospheric Chemistry and Physics,* 18 (18), 13363-92.

Umo, N. S., et al. (2019), 'Enhanced ice nucleation activity of coal fly ash aerosol particles initiated by ice-filled pores', *Atmos. Chem. Phys.,* 19 (13), 8783-800.