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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Analysis of the hygroscopic and volatile properties of ammonium sulphate seeded and un-seeded SOA particles" *by* N. K. Meyer et al.

**N. K. Meyer et al.**

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Response to anonymous referee #2

Electrosprayed ammonium sulphate seed particles are used in this study. Is the SMPS able to determine reliably such a narrow distribution and determine the width of the generated distribution?

Response: Simplified SMPS analysis algorithms such as the one used in this study (TSI's AIM software) are based on the simplifying assumption that the number size distribution is virtually constant across the width of the DMA's transfer function. This assumption becomes inadequate for very narrow size distributions (or broad DMA transfer functions).



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The geometric standard deviation of the size distributions observed during this experiment were ˜1.3 for the initial seed, eventually reducing to a geometric st. dev. of ˜1.13 after several hours of condensational growth. By applying an SMPS inversion algorithm without simplifying assumptions we have found equal values for the width of the inverted size distribution as with the original algorithm. This shows that the simplifying assumptions are still valid in our case, and the corresponding derived results remain unchanged.

Kelvin effect is taken into account in various calculations presented in the article. How is the surface tension and density of the particle estimated in a case of seeded experiments, when the particles are by definition composed of both inorganic and organic constituents?

Response: The surface tension of pure water is used, as mentioned on p. 8638, line 28. ("In addition the HGF corrected for the Kelvin effect at aw=0.85 (HGF*; assuming surface tension of pure water)...").

The density is not needed for the ZSR calculations because the volume fractions are directly obtained from the SMPS data. An exception is line 6 on page 8643, where the volume fraction of SOA has been converted into a mass fraction for comparison with literature data referring to mass fraction. In this case we have used the following values for the densities: " ... under the assumption that the SOA density is 1.3 g/cm3 (Varutbangkul et al., 2006; Alfarra et al., 2006) and the AS density is 1.77 g/cm3."

Hygroscopicity of the un-seeded experiments are not discussed and no data is shown.

Response: The hygroscopicity of pure a-pinene samples measured in the same chamber under very similar conditions has been discussed in one of our previous references (Duplissy, J., Gysel, M., Alfarra, M. R., Dommen, J., Metzger, A., Prevot, A. S. H., Weingartner, E., Laaksonen, A., Raatikainen, T., Good, N., Turner, S. F., McFiggans, G., and Baltensperger, U.: The cloud forming potential of secondary organic aerosol under near atmospheric conditions, Geophys, Res. Lett., 35, L03818,



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doi:10.1029/2007GL031075, 2008.). The results obtained in this campaign agree with the previously published ones and therefore there was no need to separately discuss the hygroscopicity of unseeded experiments. On p. 8641, lines 8-12 we have presented a brief description on the scaling of the GF. Further Figures 5,6 and 7 include a line corresponding to HGF of pure SOA particles, which was scaled to the mode diameter and relative humidity as explained on p. 8641.

VH-TDMA analysis is conducted for the particles 5 hrs after the start of the illumination. The authors state that the condensation processes have ceased by this time. However, according to Fig 1, the mode grows still grows in a considerable rate, which I suspect to be faster than coagulation alone. The authors should present total number concentrations in Figure 1 to give the reader an idea about the role of coagulation in the growth. What is the role of apparent growth due to size dependent wall losses?

Response: In our case the coagulation processes are not that important as the particle size distribution is relatively monodisperse (sigma_g=1.13). The smallest value of the coagulation coefficient occurs when both particles that are colliding are of the same size (monodisperse sample) (see for example Seinfeld & Pandis, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, p.661). As mentioned in the reply for Reviewer 1, we agree with the reviewer that that the mode still keeps growing even after 5 hours. Our calculations after correcting for the wall losses show that the observed growth after 5 hours is small and not due to coagulation but still only due to some condensation. Presenting the total particle number would require presenting the calculations for coagulation and wall losses which would be outside the scope of this manuscript. We have therefore chosen not to present this data.

The SOA mass concentration from the AMS (Fig 2) seems to level off after 5 hrs, but how much could this be attributed to the methods used to calculate mass concentration from the AMS spectrum (and possibly neglecting organo-sulphates)?

Response: The fact that the SOA mass concentration levels off after 5 hrs is commonly



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observed in chamber experiments and it is caused by the slow down of the condensation process and the counter effect of wall losses. The methods used to calculate mass concentration from the AMS spectrum had nothing to do with this behaviour. In fact, the reported AMS mass includes all non-refractory organic material and it is calculated from the signal at all mass fragments including those where organo-sulphate would be expected to contribute to.

pp. 8635: Please include time resolution of all the instruments used in the study.

Response: A sentence was added on p.8635, line 20: "The SMPS performed a scan every 3 minutes while the CPC continuously measured with a 1s time resolution."

Type of Vaisala RH-probes?

Response: There was an error in the text. We have used Rotronic Hygro Clip SC05 probes not Vaisala ones. The sentence on line 20, page 8635 has been changed to reflect this.

Last sentence: add reference to the VH-TDMA setup.

Response: Reference Johnson, et al. 2004, was added to the last sentence.

What were the dry sizes of the VH-TDMA setup? Were they varied as the mode grew during the experiments?

Response: The VH-TDMA measurements were conducted after the mode had significantly reduced its growth so there was no need to vary the dry size. The dry diameters of the presented VH-TDMA results (see Fig.4) were 100nm. The H-TDMA measurements (presented on Fig 3.) were conducted during the growth phase but at a constant dry diameter of 33nm. As this was not explicitly mentioned in the paper we have modified sentence on line 18, p.8637 to: "The evolution of the hygroscopic growth factor (HGF), for a 33 nm dry diameter particle, was measured continuously from the moment the lights in the chamber were turned on every 2 minutes for around 1.5 h." In addition the time resolution of these measurements was also mentioned.



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pp. 8636 paragraph 1. Wall losses affect the size distribution always, not only after 5 hrs as the authors state.

Response: We agree with the reviewer and changes on this page were made as explained previously.

pp. 8641 paragraph 2: I don't understand percentile values calculated from the size distribution.

Response: The calculation of the seed core diameter and the SOA volume fraction has been clarified by providing explicit equations and rewording the corresponding paragraph.

Figure 1 should include total number concentration along with the size distribution evolution.

Response: We do not believe that adding the total concentration would give any better insight into the problem. This comment was addressed previously.

Technical comments:

pp. 8642 paragraph 2 line 26, This indicates...

Response: "implies"; was changed to "indicates" as reviewer suggested.

pp. 8643 paragraph 3: H-classifier?

Response: This has been changed to "an additional 3 s in the H-DMA".

pp. 8646 paragraph 2, Use different expression for the SOA coatings in sentence 2.

Response: We do not agree with the reviewer and have left this sentence unchanged.

Legend boxes extend onto the axis in Figures 5, 6 and 7.

Response: Given the extensive details presented in these graphs, we feel that there representation is both satisfactory and novel. We hope the reviewer might understand



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this.

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