

Review of

Application of a Hygroscopicity Tandem Differential Mobility Analyzer for characterizing PM Emissions in exhaust plumes from an Aircraft Engine burning Conventional and Alternative fuels

By Max B. Trueblood et al.

The paper consists of two main parts: 1) quality control of a hygroscopicity tandem differential mobility analyser (H-TDMA) and 2) experimental data in aircraft engine. The H-TDMA is designed for fast response and stable humidity conditions. The quality control is done with care and shows a well functioning system. The experimental data gives important information. There are, however, some things that are unclear and I recommend publication after major revision.

General comments and questions:

1 The authors define the hygroscopicity parameter *soluble mass fraction* (SMF). This value depends on the knowledge or assumptions of the chemical character of the soluble material. In the literature, several parameters have been used for hygroscopicity. Kappa defined by Petters and Kreidenweis (2007 and the discussion in ACPD) being the one mostly used today. But before that ϵ representing the soluble fraction under assumptions of the chemical composition was used. ϵ was abandoned, due to risks of misunderstanding. Why are you choosing to use a new parameter, similar to the one earlier abandoned?

2 I have some comments on section 3 and the equations. a) Shouldn't it be $(X_w^3 - X_d^3)$ in eq. 1? It comes from the expression of the amount of water, I think. As far as I can see this has consequence for eq.8 and 9.

b) Eq. 1 is only valid for SR close to 1 (see e.g. Prupacher and Klett, page 173 in the 1997 edition). Have you analysed the errors made at the SR values relevant here (0.85-0.99 according to line 27 on page 4)

c) Even though the equations 2 and 3 are often expressed as they are here, I think it is unfortunate to give constants that actually have a unit, without expressing the unit. E.g. the constant in eq. 3 (4.3) includes the values of ρ_w and M_w as well as π . The value is 4.3 only if ρ_w is given in kg/litre and M_w in g/mole, and these are not the units in the SI system. The constant 1000 in eq. 7 comes from not using SI units for M_s . Also, the result of this is that eq 9 is given in terms of π in some parts and with "combined" constants in other parts. As far as I can see, it would have been possible to simplify it, if the full expression of eq. 3 would have been used.

3 A more general comment to the calculations and the equations. Soot particles are in general agglomerates of many primary particles and their volume equivalent diameters are in general smaller than the mobility diameters. The particles can thus gain some secondary aerosol mass and water without increasing their mobility diameter. GF determined by H-TDMA systems can thus be below 1. I recommend that you take this into account or at least discuss it as a source of error.

4 Small changes in GF for values close to one can have large influence on the cloud forming ability of the particles. Can you specify for example the lowest GF that is significantly larger than 1? Or the uncertainty in small GFs in general?

5 P.8 l.31-32: It says: “ the SR-calc for the largest two or three particle diameters was computed and an average was obtained”. Does this mean that the theoretical curves in figure 2 are fitted to the largest sizes?

6 P.11 Fig.3 Are you sure that this is an effect of slow growth, and not of artefacts due to mismatch between DMA voltage and CPC counting? Have you tested with really slow voltage scans? Or scanning both up and down?

7 Are there any ways to control the SR or do you have to work with the SR you get? Why are you working with such a high SR? I think it would be good to motivate this in the paper.

8 You have chosen to work with an aerosol to flow ratio of 3/15. A lower aerosol flow would increase the resolution and decrease the problem caused by a varying $dN/d\log D_p$. Could you discuss this in more detail?

Details:

P.1 l. 31 Spell out all abbreviations, e.g. UHC.

P.3 l. 8-9 Have you tested if the charger is strong enough to neutralize the aerosol?

P.3 l.28-29 Have you made sure that the whole cooling volume is cooled equally effective and that there are no “pockets” of water that is not circulated?

P.4 l.9 Are the 104 increments equally separated on a linear or a logarithmic scale or separated in another way?

P.4 l.21 Performing HV2 sweeps on 12 different particle sizes in 9 minutes is very impressive!

P.4 l.27 The range in SR given is wide. Why is that?

P.6 Fig.1 Make sure that all symbols are defined. For example P1 and P2.

P.6 l.11 There is an extra “nm” in the beginning of the raw.

P.9 l. 13 Was the diameter 13,49 nm confirmed experimentally?

P.10 Fig.2 Consider the precision in the SR values. Also, please describe if the SR values are SR-calc or determined from the dew point sensor.

P.13 Fig.5 There seem to be a drop in SR over the period presented. Could you quantify this drop and expand the SR scale to make it more sensitive.

P.15 l.2 Why do you only present data from the 143 m location?

P.15 l.8-11 Did you see any bimodal GF distributions? I am especially thinking of the cases when the contribution from the engine was relatively small. Would it be possible to distinguish the engine particles from the ambient ones by there growth factors?

P.16 l.7 I guess you mean that the GF is close to 1 and not to 0? And in my opinion the GFs are not close to 1, they rather seem to be 1.2. What

could be the reason for this? It makes a large difference for their cloud forming ability.

P.16 l.11 Did you apply the factor 0.869 for all data, independent of the soluble fraction, that is also for particles that probably has no or very little sulphuric acid?

Fig. 7-11 Specify that the SMF assumes that the soluble material is sulphuric acid (if this is the case). Also for the low sulphur fuels.

The figures in general: Please provide error bars. The quality control should be able to result in error bars.

Reference:

Petters, M. D. and Kreidenweis, S. M.: A single parameter representation of hygroscopic growth and cloud condensation nucleus activity, *Atmos. Chem. Phys.*, 7, 1961-1971, <https://doi.org/10.5194/acp-7-1961-2007>, 2007.