

## ***Interactive comment on “Phase transitions and hygroscopic growth of aerosol particles containing humic acid and mixtures of humic acid and ammonium sulphate” by C. L. Badger et al.***

**Anonymous Referee #2**

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Comment on: “Phase transitions and hygroscopic growth of aerosol particles containing humic acid and mixtures of humic acid and ammonium sulphate”

by C. L. Badger, I. George, P. T. Griffiths, C. F. Braban, R. A. Cox, and J. P. D. Abbatt

This paper presents measurement of the hygroscopicity (i.e., deliquescence and efflorescence relative humidity as well as the hygroscopic growth) of humid acid (HA) particles and their mixtures with ammonium sulfate (AS). The authors employ two methods to do the measurements, FTIR and TDMA. Although the FTIR and the TDMA measurements are not performed for the same particle compositions, the results provided in this

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paper show that HA particles uptake water at low relative humidity (RH) values, and when mixed with AS the hygroscopicity of the particles is different from that of the two substances, and changes with composition. The paper can be accepted for publication at the Atmospheric Chemistry and Physics Discussions after the authors address the following points:

1. In p.9584 I.4-5 is mentioned that “only one study considered the effect of these humid and fulvic acids”. Which study is that? A reference would be helpful at this point.
2. In section 2.1 the authors state that particles for both the FTIR and the TDMA method were generated by atomizing bulk solutions. They do not specify, however, if the solutions used for atomization were also the same. From their discussion of the results it is evident that the compositions used in the two experiments were different. Also, it is not very clear whether in the discussion on the variation of the pH of some solutions the authors refer to aerosols generated for the FTIR or the TDMA experiments. Characteristic information of the typical size distribution of the polydisperse aerosols (e.g., mean diameter, gds, and total number concentration) would be helpful in this discussion.
3. No efflorescence-mode TDMA measurements are provided parallel to the FTIR measurements, making the TDMA work seem somehow incomplete. Was there a specific reason that TDMA efflorescence measurements were not made? I would strongly encourage the authors to add these measurements in the revised version of the manuscript.
4. The residence time in the conditioner of the FTIR apparatus was between 6-8 s whereas in the TDMA apparatus that was approx. 3 min. What was the reason for maintaining different conditioning times in the two experiments? Given the high sensitivity of organic particle growth on their exposure time to the humid environment, shouldn't the two measurements be consistent in this respect?
5. Some more information of the TDMA experimental setup would be helpful for the

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readers that might want to perform similar measurements in the future. For example, the authors mention that they get a monodisperse size distribution downstream of DMA 1 (p.9588 l.4), but do not provide any information on the geometric standard deviation of this distributions, or the DMA settings (mainly sheath to aerosol flow ratio). A reference of the Hauke DMA and also information on whether the authors use a recirculation or an open sheath-flow system would be helpful in this discussion.

6. From Fig.2 it seems that the permapure humidifier downstream of DMA 1 was operated using a controlling flow parallel to the aerosol flow. This is not recommended by the manufacturer because it can result in a non-uniform humidification of the aerosol sample along the nafion humidity exchanger. This can possibly cause measurements of lower DRH values with the TDMA.

7. The authors define the hygroscopic growth factor as the ratio of the median diameter at the RH of the measurement over the median diameter of the dry aerosol (p.9588 l.20-23). It should be stressed that the TDMA measurements provide the growth factor based on the mobility-diameter, and not the physical (or volume-equivalent) diameter. Therefore, the definition of the growth factor the authors provide does not fully describe what is presented as TDMA measurements. It is accurate only if the shape correction factor of the dry particles is unity (assuming that the deliquesced particles are spherical). It would be more accurate if the authors refer to the growth factor as mobility-diameter based since no information is provided, or is available in the literature for the shape of the particles studied in this paper.

8. The authors perform TDMA measurements for two sizes (50 and 100-nm mobility diameter) to investigate any effect of particle size. The results show that 50 and 100 nm particles behave very similarly, indicating that size does not have any effect in. This corroborates the TDMA studies provided by Hameri et al. (2000) who investigated the size effect on the deliquescence of AS nanoparticles. The authors might want to mention that at some point.

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9. It seems that by measuring the size distribution of the polydisperse aerosol used in the FTIR experiments and using the water uptake measurements presented for the different compositions, the growth factor of the particles can be estimated. This should be a rather easy calculation to compare with the TDMA measurements.

References Hämeri, K., M. Väkevä, H.-C. Hanson, and A. Laaksonen, Hygroscopic growth of ultrafine ammonium sulphate aerosol measured using an ultrafine tandem differential mobility analyzer, *J. Geophys. Res.*, 105, 22231-22242, 2000.

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