

Anonymous Referee #1

We would like to thank the reviewer for the constructive comments. The detailed responses are given as follow:

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1. More information about the compounds studied is needed: Chemical formula for the compounds did the sodium and ammonium salts of di-acids have one or two ammonium/sodium ions, density, and molar weight.

**Response:**

One table listing the information on the properties of salts being studied will be added into the MS.

**Modifications in the MS:**

Table 1: Properties of salts being studied

Species	Molecular formula	Molar weight [g mol <sup>-1</sup> ]	Density [g cm <sup>-3</sup> ]	Solubility [g/100 mL]
Ammonium sulfate	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	132.14	1.77 <sup>a</sup>	74.4 (20 °C) <sup>e</sup>
Sodium acetate	C <sub>2</sub> H <sub>3</sub> NaO <sub>2</sub>	82.03	1.53 <sup>a</sup>	46.4 (20 °C) <sup>e</sup>
Disodium oxalate	Na <sub>2</sub> C <sub>2</sub> O <sub>4</sub>	134.00	2.34 <sup>a</sup>	3.7 (20 °C) <sup>e</sup>
Diammonium oxalate	C <sub>2</sub> H <sub>8</sub> N <sub>2</sub> O <sub>4</sub>	124.10	1.50 <sup>a</sup>	4.45 (20 °C) <sup>e</sup>
Disodium malonate	C <sub>3</sub> H <sub>2</sub> O <sub>4</sub> Na <sub>2</sub>	148.03	1.75 <sup>a</sup>	59.06 (25 °C) <sup>f</sup>
Disodium succinate	Na <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>4</sub>	162.05	1.68 <sup>a</sup>	39.70 (25 °C) <sup>f</sup>
Disodium tartrate	C <sub>4</sub> H <sub>4</sub> Na <sub>2</sub> O <sub>6</sub>	194.05	1.82 <sup>b</sup>	25 (25 °C) <sup>g</sup>
Diammonium tartrate	C <sub>4</sub> H <sub>12</sub> N <sub>2</sub> O <sub>6</sub>	184.15	1.60 <sup>c</sup>	63 (20 °C) <sup>e</sup>
Sodium pyruvate	C <sub>3</sub> H <sub>3</sub> NaO <sub>3</sub>	110.00	1.54 <sup>d</sup>	47.5 (20 °C) <sup>f</sup>
Disodium maleate	C <sub>4</sub> H <sub>2</sub> O <sub>4</sub> Na <sub>2</sub>	160.04	1.79 <sup>d</sup>	96.0 (25 °C) <sup>h</sup>
Humic acid sodium salt	---	2,000-500,000	---	NA

a: (Broul et al., 1981)

b: [http://www.chemicalbook.com/ProductMSDSDetailCB3297454\\_EN.htm#2](http://www.chemicalbook.com/ProductMSDSDetailCB3297454_EN.htm#2)

c: <http://www.guidechem.com/dictionary/3164-29-2.html>

d: (Peng and Chan, 2001)

e: wiki soluble table

f: (Rozaini and Brimblecombe, 2009)

e: <http://www.thegoodscentscompany.com/data/rw1303591.html>

g: <http://www.musashino.com/english/products/pyruvate/spy.html>

h: (Peng and Chan, 2001)

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What was the residence time from DMA1 to DMA2 in the H-TDMA?

**Response:** The residence time of particles at nominal RH before entering into the DMA2 is around 2.5 seconds in our system. This residence time may be not significantly long enough for some organic compounds to attain equilibrium state (Chan and Chan,

2005;Peng and Chan, 2001;Duplissy et al., 2008) , for example, Sodium pyruvate (Peng and Chan, 2001). This will be clarified in the MS.

**Modifications in the MS:**

“The residence time of particles at nominal RH before entering into the DMA2 is around 2.5 seconds in our system. This residence time may be not significantly long enough for some organic compounds to attain equilibrium state (Chan and Chan, 2005;Peng and Chan, 2001;Duplissy et al., 2008), for example, Sodium pyruvate (Peng and Chan, 2001).”

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Was the aerosol RH and the sheath flow RH the same?

**Response:**

The RHs for the aerosol and sheath flow of DMA2 are kept to be the same during the measurement. It will be clarified in the MS.

**Modifications in the MS:**

“RH for aerosol humidifier was kept to be the same with the one of sheath air of DMA2 during the measurements.

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Which particle size was used?

**Response:**

The diameter of particle being measured is 100 nm. This has already been clarified in the MS once. We will make clearer.

**Modifications in the MS:**

“The hygroscopic growth factor (GF) is defined as the ratio of the particle mobility diameter,  $D(RH)$ , at a given RH to the dry diameter,  $D_d$ , 100 nm in this study.”

“The GFs of 100 nm organic salt particles as a function of water activity are presented in Fig. 1.”

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Data analysis:

Some of the salts form hydrated crystals from bulk solutions. It could be discussed if this is also the case for sub-micrometer particles

**Response:**

The hydration state of the atomizer-generated sub-micrometer particles may be different from that of crystals formed from bulk solutions. For examples, experimental study (Peng and Chan, 2001) shows that  $\text{Na}_2\text{SO}_4$  particles formed from levitated droplets in an electrodynamic balance (EDB) is anhydrous, but not decahydrate salt, which is the most stable form at 25 °C (Cohen et al., 1987). Mensah et al. (2010) also observed that oxalic acid aerosol generated by atomizer show a reduced crystal water content compared to its

thermodynamically stable state. However, we cannot analyze the hydration state of these particles using the hygroscopicity measurements.

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Deliquescence RH can be estimated based on solubility. Also the lower DRH for mixtures can be interpreted theoretically based on solubility.

**Response:**

The deliquescence RH can be estimated according to (Seinfeld and Pandis, 1998):

$$DRH/100 = \alpha_{ws}$$

Here, DRH is the deliquescence relative humidity, and  $\alpha_{ws}$  is the water activity of the saturated solution of the salt. The water activity values can be calculated from thermodynamic arguments using aqueous salt solubility data. But, the authors think it is not necessary to estimate the DRH of organic salts being studied. One hand, there is less information on the thermodynamic parameters of organic salts. Another hand, the DRH of these salts have already been identified by some measurements, e.g., (Peng and Chan, 2001).

Regarding the lower DRH of mixture, this will be explained by citing some previous published results (Ling and Chan, 2008; Yeung and Chan, 2010). They used an electrodynamic balance (EDB) and the Raman spectroscopy system to investigate the partial crystallization and deliquescence of particles containing ammonium sulfate and dicarboxylic acids. These experimental results are more straightforward to explain our observations.

**Modifications in MS:**

The humidograms of mixtures and pure ammonium sulfate (AS) are shown in Fig. 2. There is a clear shift in DRH to lower RH with increasing organic mass fraction, indicating that these organic salts have significant effects on the deliquescence of AS. With increasing organic mass fraction, a smoothing of the deliquescence behavior is observed. This phenomenon was also observed for mixtures of AS and individual dicarboxylic acids such as citric acid, succinic acid, and malonic acid by previous studies (e.g. Zardini et al., 2008; Hameri et al., 2002). Ling and Chan (2008) and Yeung and Chan (2010) investigated partial deliquescence of AS and dicarboxylic acids mixtures using an EDB and a Raman spectrometer. They observed that malonic acid with lower DRH contributed to take up water at low RH, and deliquescence of AS gradually took place starting from 69% RH, then the mixture completely deliquescent at 75%. Some organic acid including glutaric, pinonic, adipic, and phthalic acids with low water solubility show no influence on the deliquescence behavior of ammonium sulfate (Cruz and Pandis, 2000; Hameri et al., 2002).

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The hygroscopic growth (water activity) should be compared to that found by Peng et al. (or other literature values) when available.

**Response:**

The growth factors derived from our measurements will be compared to these found in the literature. The results are listed in the following table. In addition, the growth factors of the corresponding organic acids are also given in this table.

**Modifications in MS:**

The following table summarizing these data and polynomial fitting parameters was added into the MS.

Species	GF (90%) in literature	Species	GF (90%) in literature
Ammonium sulfate	1.67-1.72 <sup>a</sup>		
Sodium acetate	1.91 <sup>b</sup>	acetic acid	NF
Disodium oxalate	1.0 <sup>b</sup>	oxalic acid	1.00 <sup>d</sup>
Diammonium oxalate	1.0 <sup>b</sup>		
Disodium malonate	1.78 <sup>b</sup>	malonic acid	1.48 <sup>d</sup>
Disodium succinate	1.85 <sup>b</sup>	Succinic acid	1.00 <sup>d</sup>
Disodium tartrate	NF	tartaric acid	1.39 <sup>e</sup>
Diammonium tartrate	NF		
Sodium pyruvate	1.76 <sup>b</sup>	Pyruvic acid	NF
Disodium maleate	1.76 <sup>b</sup>	Maleic acid	1.51 <sup>d</sup>
Humic acid sodium salt	1.18 <sup>c</sup>	Humic acid	1.06 <sup>c</sup>

a: (Duplissy et al., 2008); b: (Peng and Chan, 2001); c: (Gysel et al., 2004)  
d: (Wise et al., 2003); e: (Peng et al., 2001)

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The hygroscopic growth can also be estimated from molar weight, density and van't Hoff factor (one would probably have to make assumptions on dissociation). It would be interesting to see these in order to learn about how well hygroscopic growth can be estimated and for extrapolating to other organic salts. I would even say that without this, the results are of limited value, since they are only valid for a small number out of thousands of organic salts and other compounds.

**Response:**

The growth factor can be estimated according to the following equations (e.g., Svenningsson et al., 2006):

$$RH = a_w \exp\left(\frac{4\sigma M_{water}}{\rho_{water} RTD_{wet}}\right) \quad [1]$$

$$D_{wet} = GF * D_{dry} \quad [2]$$

$$a_w = \frac{n_{water}}{n_{water} + in_s} = \frac{1}{1 + iM_{water} m_s} \quad [3]$$

$$m_s = \frac{n_s}{mass_{water}} = \frac{\rho_s \frac{\pi}{6} D_{dry}^3 / M_s}{\rho_{water} \frac{\pi}{6} (D_{wet}^3 - D_{dry}^3)} = \frac{\rho_s}{M_s \rho_{water} (GF^3 - 1)} \quad [4]$$

$$i = (a_w^{-1} - 1)(GF^3 - 1) \frac{M_s \rho_{water}}{M_{water} \rho_s} \quad [5]$$

Here,

$a_w$ : water activity

$\sigma$ : the surface tension

$M_{water}$  and  $M_s$ : the molecular weight of water and the solute

$\rho_{water}$  and  $\rho_s$ : the density of water and the solute

$R$ : the universal gas constant

$T$ : temperature

$D_{wet}$ : the diameter of the droplet

$GF$ : Growth Factor

$D_{dry}$ : the diameter of dry particle

$n_{water}$  and  $n_s$ : the number of moles of water and the solute

$i$ : van't Hoff factor

$m_s$ : the molality of the solute

However, as the reviewer said, we need make assumptions about the van't Hoff factor. To make an assumption, the easiest way is to assume that the van't Hoff factor is equal to the number of discrete ions. This is only valid for diluted solution, which is not the case in this study.

Here, we estimate the van't Hoff factor using equation [1]-[5] instead of making assumption. Because the particle dry diameter is used in equation [4] to calculate the molality of the droplet, this equation is only valid when the compound in the dry particle fully dissolved in the water. The water activity at which the dry particle completely dissolved is identified when the molality calculated using equation [4] is larger than the solubility of organic salt.

The calculated van't Hoff factors will be compared with the number of discrete ions under ideal condition. This may give some clues for other organic salts, which are not measured in this study.

### **Modifications:**

The van't Hoff factor  $i$  can measure the non-ideality of a solution. McDonald (1953) and Low (1969) introduced a general extension Raoult's low with the van't Hoff factor:

$$a_w = \frac{n_{water}}{n_{water} + i n_s} = \frac{1}{1 + i M_{water} m_s} \quad [3]$$

Here,  $n_{water}$  and  $n_s$  is the number of moles of water and solute, respectively. The molality of the solute  $m_s$  can be presented as (Svenningsson et al., 2006):

$$m_s = \frac{n_s}{mass_{water}} = \frac{\rho_s \frac{\pi}{6} D_{dry}^3 / M_s}{\rho_{water} \frac{\pi}{6} (D_{wet}^3 - D_{dry}^3)} = \frac{\rho_s}{M_s \rho_{water} (GF^3 - 1)} \quad [4]$$

where  $\rho_s$  and  $M_s$  respectively are the density and molecular weight of the solute. Here, we assume water and solute volumes are additive. By combining equation [3] and [4],  $i$  is given as:

$$i = (a_w^{-1} - 1)(GF^3 - 1) \frac{M_s \rho_{water}}{M_{water} \rho_s} \quad [5]$$

Equation [4] is valid only when/after the dry particle fully dissolved in the water. The water activity at which the dry particle completely dissolved is identified when the molality calculated using equation [4] is larger than the solubility of organic salt. The mean van't Hoff factors of ammonium sulfate, sodium acetate, disodium malonate, disodium maleate, and sodium pyruvate were calculated and listed in Table 2.

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How does the hygroscopic growth of the salts compare to the acids (when data is available in the literature)?

**Response:**

The hygroscopic growth factors of organic acids found in the literature are listed in the table, see table 2.

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Is the hygroscopic growth (RH) consistent with a constant kappa?

**Response:**

kappa should not be constant with relative humidity. Whether the extent to which it varies matters (and over which range of RH) is an open debate. The kappa calculation was deleted from MS.

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Table 1: I have two comments to the polynomial fits. First, wouldn't it make more sense to use water activity instead of RH? Thus the effect of particle size would be minimized. Secondly, the polynomial fits used, are not well behaving, i.e. the coefficients alternate between relatively high positive and negative values. This is especially the case for ammonium sulphate and sodium pyruvate. Would it be possible to find a more well behaving way of fitting the data that is related to the physico-chemical understanding and goes towards 1 for RH/water activity = 0?

**Response:**

Water activity was calculated from the relative humidity according to:

$$a_w = \frac{RH}{\exp\left(\frac{2\sigma_{s/a} M_w}{RT\rho_w D_l}\right)}$$

Where,  $a_w$ ,  $\sigma$ ,  $M_w$ ,  $R$ ,  $T$ ,  $\rho_w$ ,  $D_l$  are water activity, the surface tension, the molecular weight of water, the universal gas constant, the density of water, and the droplet diameter.

The droplet diameter is the product of growth factor and dry particle diameter. As an approximation, the Kelvin effect is calculated for pure water.

An equation presenting the relationship between RH and growth factors proposed by Dick et al. (2000) is used to perform the polynomial fitting:

$$GF = \left[ 1 + \left( a + ba_w + ca_w^2 \right) \frac{a_w}{1 - a_w} \right]^{1/3}$$

Here, water activity is used instead of RH. The fitting parameters are shown in the table 2.

**Modifications in the MS:**

Water activity ( $a_w$ ) was calculated from the relative humidity and used in the following analysis to minimize the effect of particle size:

$$a_w = \frac{RH}{\exp\left(\frac{4\sigma_{s/a}M_{water}}{RT\rho_{water}D_{wet}}\right)} \quad [1]$$

Where,  $\sigma_{s/a}$ ,  $M_{water}$ ,  $R$ ,  $T$ ,  $\rho_{water}$ , and  $D_{wet}$  are the surface tension, the molecular weight of water, the universal gas constant, temperature, the density of water, and the droplet diameter, respectively.  $D_{wet}$  is the product of growth factor ( $GF$ ) and the diameter of dry particle ( $D_{dry}$ ). As an approximation, the Kelvin effect is calculated for pure water.

An equation proposed by Dick et al. (2000) is used to perform the polynomial fitting to present the relationship between water activity and  $GF$ s of individual compound:

$$GF = \left[ 1 + \left( a + ba_w + ca_w^2 \right) \frac{a_w}{1 - a_w} \right]^{1/3} \quad [2]$$

The fitting parameters are given in Table 2.

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Minor comments:

Abstract, p 7694, l 14-15: It says “Köhler theory underestimated kappa for mixtures: : :”. This does not state what the Köhler theory used is based on. “Köhler theory” could be replaced by “simple mixing rule” or similar.

**Response:**

The sentence in the MS is modified as “*The results show that the simple mixing rule underestimated for mixtures without considering the water solubility of ammonium oxalate.*”

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P 7694 l 21. Hygroscopic properties of atmospherically relevant inorganic salts and their importance have been recognized more than 20 years ago. See e.g. the work by Fitzgerald et al.

**Response:**

The sentence in the MS is modified as “*Up to now, the atmospherically relevant inorganic salts and their effects on aerosols hygroscopic properties are better-recognized.*”

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P 7699 | 4-5 Check language

**Response:**

Yes, we did.

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P 7702 | 17 “critic”. Do you mean citric?

**Response:**

Yes, it is! We will correct it in the MS.

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P 7702 | 14 I have two comments on the discussion about depression of water uptake by the organic salts: 1) The expression “depress” is misleading, unless you refer to other effects than the organic salts replacing ammonium sulphate with compounds that are not as hygroscopic. 2) On what do you base that the results are not expected? The kappa value based on the mixing rule is close to the experimental value.

**Response:**

Yes, we agree. This demonstration is not very clear. It will be removed from the MS.

**Modification in the MS:**

Remove “*This is not expected because the non-hygroscopic fraction of ammonium oxalate should depress the water uptake of the mixtures compared to pure ammonium sulfate particles.*”

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P 7702 | 19 The Köhler theory is not proposed by Petters and Kreidenweis. They proposed a parameterization of the Köhler theory, which is very similar to what Fitzgerald proposed many years ago. The light that they put on the issue has, however, catalyzed a lot of progress in the scientific field.

**Response:**

Yes, we agree. The citation is removed from the sentence in the MS.

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P 7702 | 22 Isn't this mixing rule the same as the one proposed by Zdanowski, Stokes and Robinson (ZSR method)?

**Response:**

The simple mixing rule given in the equation [2] is derived from the ZSR assumption (Petters and Kreidenweis, 2007). Therefore, there is no any difference between them.

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**Reference:**

- Broul, M., Nyvlt, J., and Sohnel, O.: Solubility in inorganic two-component systems: Physical sciences data, Elsevier, Amsterdam., 6, 1981.
- Chan, M. N., and Chan, C. K.: Mass transfer effects in hygroscopic measurements of aerosol particles, *Atmos. Chem. Phys.*, 5, 2703-2712, doi:10.5194/acp-5-2703-2005, 2005.
- Cohen, M. D., Flagan, R. C., and Seinfeld, J. H.: Studies of concentrated electrolyte-solutions using the electrodynamic balance .1. Water activities for single-electrolyte solutions, *Journal of Physical Chemistry*, 91, 4563-4574, 1987.
- Cruz, C. N., and Pandis, S. N.: Deliquescence and hygroscopic growth of mixed inorganic-organic atmospheric aerosol, *Environmental Science & Technology*, 34, 4313-4319, 2000.
- Dick, W. D., P. Saxena, and McMurry, P. H.: Estimation of water uptake by organic compounds in submicron aerosols measured during the southeastern aerosol and visibility study, *Journal of Geophysical Research*, 105(D1), 1471–1479, 2000.
- Duplissy, J., Gysel, M., Sjogren, S., Meyer, N., Good, N., Kammermann, L., Michaud, V., Weigel, R., Martins dos Santos, S., Gruening, C., Villani, P., Laj, P., Sellegri, K., Metzger, A., McFiggans, G. B., Wehrle, G., Richter, R., Dommen, J., Ristovski, Z., Baltensperger, U., and Weingartner, E.: Intercomparison study of six htdmas: Results and general recommendations for htdma operation, *Atmos. Meas. Tech. Discuss.*, 1, 127-168, 2008.
- Gysel, M., Weingartner, E., Nyeki, S., Paulsen, D., Baltensperger, U., Galambos, I., and Kiss, G.: Hygroscopic properties of water-soluble matter and humic-like organics in atmospheric fine aerosol, *Atmos. Chem. Phys.*, 4, 35-50, 2004.
- Hameri, K., Charlson, R., and Hansson, H. C.: Hygroscopic properties of mixed ammonium sulfate and carboxylic acids particles, *Aiche Journal*, 48, 1309-1316, 2002.
- Ling, T. Y., and Chan, C. K.: Partial crystallization and deliquescence of particles containing ammonium sulfate and dicarboxylic acids, *J. Geophys. Res.*, 113, D14205, 10.1029/2008jd009779, 2008.
- Low, R. D. H.: A generalized equation for the solution effect in droplet growth, *Journal of Atmospheric Sciences*, 26, 608-610, 1969.
- McDonald, J. E.: Erroneous cloud-physics applications of raoult's law, *Journal of Meteorology*, 10, 68-70, 1953.
- Mensah, A. A., Buchholz, A., Mentel, T. F., Tillmann, R., and Kiendler-Scharr, A.: Aerosol mass spectrometric measurements of stable crystal hydrates of oxalates and inferred relative ionization efficiency of water, *Journal of Aerosol Science*, 42, 11-19, 2010.
- Peng, C., Chan, M. N., and Chan, C. K.: The hygroscopic properties of dicarboxylic and multifunctional acids: Measurements and unifac predictions, *Environmental Science & Technology*, 35, 4495-4501, 2001.

Peng, C. G., and Chan, C. K.: The water cycles of water-soluble organic salts of atmospheric importance, *Atmospheric Environment*, 35, 1183-1192, 2001.

Petters, M. D., and Kreidenweis, S. M.: A single parameter representation of hygroscopic growth and cloud condensation nucleus activity, *Atmospheric Chemistry and Physics*, 7, 1961-1971, 2007.

Rozaini, M. Z. H., and Brimblecombe, P.: The solubility measurements of sodium dicarboxylate salts; sodium oxalate, malonate, succinate, glutarate, and adipate in water from  $t = (279.15 \text{ to } 358.15) \text{ K}$ , *Journal of Chemical Thermodynamics*, 41, 980-983, 2009.

Seinfeld, J. H., and Pandis, S. N.: *Atmospheric chemistry and physics: From air pollution to climate change*, JOHN WILEY & SONS, INC, New York, 1998.

Svenningsson, B., Rissler, J., Swietlicki, E., Mircea, M., Bilde, M., Facchini, M. C., Decesari, S., Fuzzi, S., Zhou, J., Monster, J., and Rosenorn, T.: Hygroscopic growth and critical supersaturations for mixed aerosol particles of inorganic and organic compounds of atmospheric relevance, *Atmospheric Chemistry and Physics*, 6, 1937-1952, 2006.

Wise, M. E., J. D. Surratt, D. B. Curtis, J. E. Shilling, and M. A. Tolbert: Hygroscopic growth of ammonium sulfate/dicarboxylic acids, *Journal of Geophysical Research*, 108(D20), 4638, 10.1029/2003JD003775, 2003.

Yeung, M. C., and Chan, C. K.: Water content and phase transitions in particles of inorganic and organic species and their mixtures using micro-Raman spectroscopy, *Aerosol Science and Technology*, 44, 269-280, 10.1080/02786820903583786, 2010.

Zardini, A. A., Sjogren, S., Marcolli, C., Krieger, U. K., Gysel, M., Weingartner, E., Baltensperger, U., and Peter, T.: A combined particle trap/HTDMA hygroscopicity study of mixed inorganic/organic aerosol particles, *Atmos. Chem. Phys.*, 8, 5589-5601, 2008.

Table 2: Polynomial coefficients of the growth curve parametrization as well as *GFs* at RH=90% and Vant't Hoff Factor.

Salts	$a_w$	a	b	c	GF (90%) This study	GF (90%) In literature	Organic acid	GF (90%) In literature	Van't Hoff Factor
Ammonium sulfate	0.8-0.9	0.23018	0.92875	-0.7282	1.70	1.67-1.72 <sup>a</sup>			2.04
Sodium acetate	0.4-0.9	0.51418	0.67867	-0.65864	1.79	1.91 <sup>b</sup>	acetic acid	NF	1.80
Sodium oxalate	-	-	-	-	1.00	1.0 <sup>b</sup>	oxalic acid	1.00 <sup>d</sup>	
Ammonium oxalate	-	-	-	-	1.05	1.0 <sup>b</sup>			
Sodium malonate	0.2-0.9	-0.25346	3.20915	-2.5515	1.78	1.78 <sup>b</sup>	malonic acid	1.48 <sup>d</sup>	2.95
Sodium succinate	0.2-0.9	-0.11095	3.25171	-2.92462	1.69	1.85 <sup>b</sup>	Succinic acid	1.00 <sup>d</sup>	
Sodium tartrate	0.2-0.9	-0.52175	2.19924	-1.38076	1.54	NF	tartaric acid	1.39 <sup>e</sup>	
Ammonium tartrate	0.2-0.9	-0.01105	0.3971	-0.236	1.29	NF			
Sodium pyruvate	0.8-0.9	0.66856	-0.45491	0.28678	1.70	1.76 <sup>b</sup>	Pyruvic acid	NF	1.95
Sodium maleate	0.1-0.9	-0.31807	3.41428	-2.69608	1.78	1.76 <sup>b</sup>	Maleic acid	1.51 <sup>d</sup>	3.30/2.94
Humic acid sodium salt	0.1-0.9	0.10856	0.28154	-0.33565	1.19	1.18 <sup>c</sup>	Humic acid	1.06 <sup>c</sup>	

a: (Duplissy et al., 2008); b: (Peng and Chan, 2001); c: (Gysel et al., 2004); d: (Wise et al., 2003); e: (Peng et al., 2001)