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Supplement of

Hygroscopic behavior of atmospheric aerosols containing nitrate salts and water-soluble organic acids

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Three-parameter fit.

The continuous hygroscopic growth of organic species could be fairly presented by a three-parameter equation proposed by Kreidenweis et al. (2005):

$$GF = \left[1 + \left(a + b \cdot a_w + c \cdot a_w^2\right)\frac{a_w}{1 - a_w}\right]^{1/3} \quad \text{(S1)}$$

where a_w is the water activity, and a, b, and c represent best-fit values for the water activity-based growth curves. The coefficients a, b and c determined using Eq. (S1) and GF-a_w measurement data are given in Table S1. The coefficients for oxalic acid are from the study by Mikhailov et al. (2009).

Table S1. The fitting parameters of the hygroscopic growth curve for the pure component aerosols with the Eq. (S1).

Substance	*a*	*b*	*c*	R^2
Oxalic acid	0.6185[a]	-1.2315[a]	0.9511[a]	0.9952[a]
Malonic acid	0.2512[b]	0.2493[b]	-0.1236[b]	0.9959[b]
Phthalic acid	0.4368[b]	-0.6003[b]	0.2737[b]	0.9910[b]

[a] From Mikhailov et al. (2009); [b] From Jing et al. (2016)

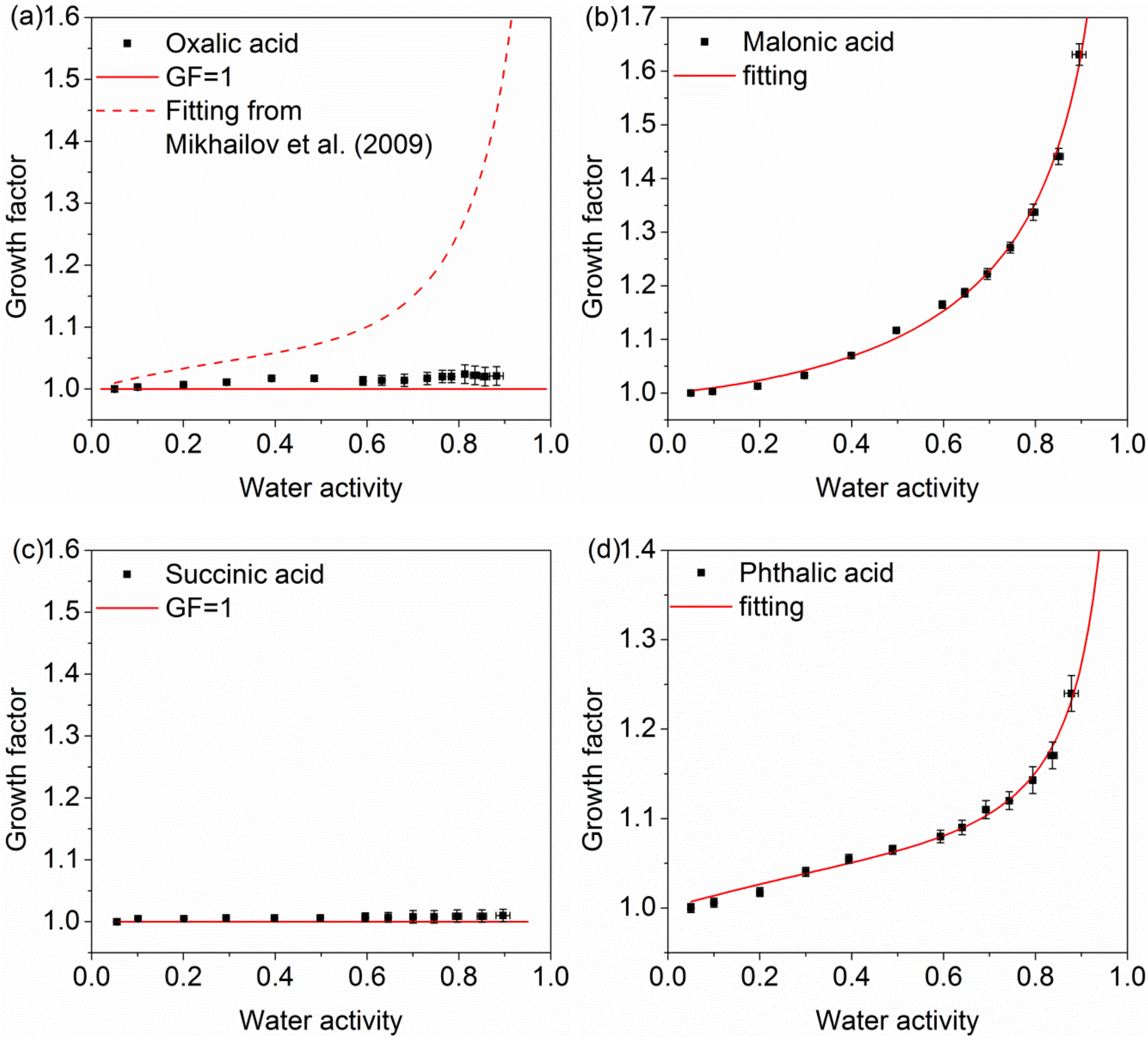

Figure S1. The hygroscopic growth of 100 nm organic acid particles including oxalic acid (a), malonic acid (b), succinic acid (c) and phthalic acid (d) as a function of water activity. The fit curve derived from the Eq. (S1) is given for oxalic acid, malonic acid and phthalic acid. For oxalic acid, the fit curve from Mikhailov et al. (2009) is presented as the dashed line.

Raman observations.

Optical micrographs of sample particles were recorded using a confocal micro-Raman setup (Horiba, LabRAM Aramis). The sample particles generated from a atomizer were sprayed onto a polytetrafluoroethylene (PTFE) substrate fixed to the bottom of a sample cell. The RH in the sample cell was adjusted by a humidification device similar to that of the HTDMA system. The single particles were observed by a 50 ×/NA0.5 microscope objective at a given RH for 15 min. The excitation source of this spectrometer was using an argon-ion laser beam (532 nm) with an output power of 25 mW. The spectrum in the range between 100 and 4000 cm^{-1} (spectral resolution 1 cm^{-1}) was obtained with a 1800 gmm^{-1} grating, twice repeated scans, and 5 s exposure time.

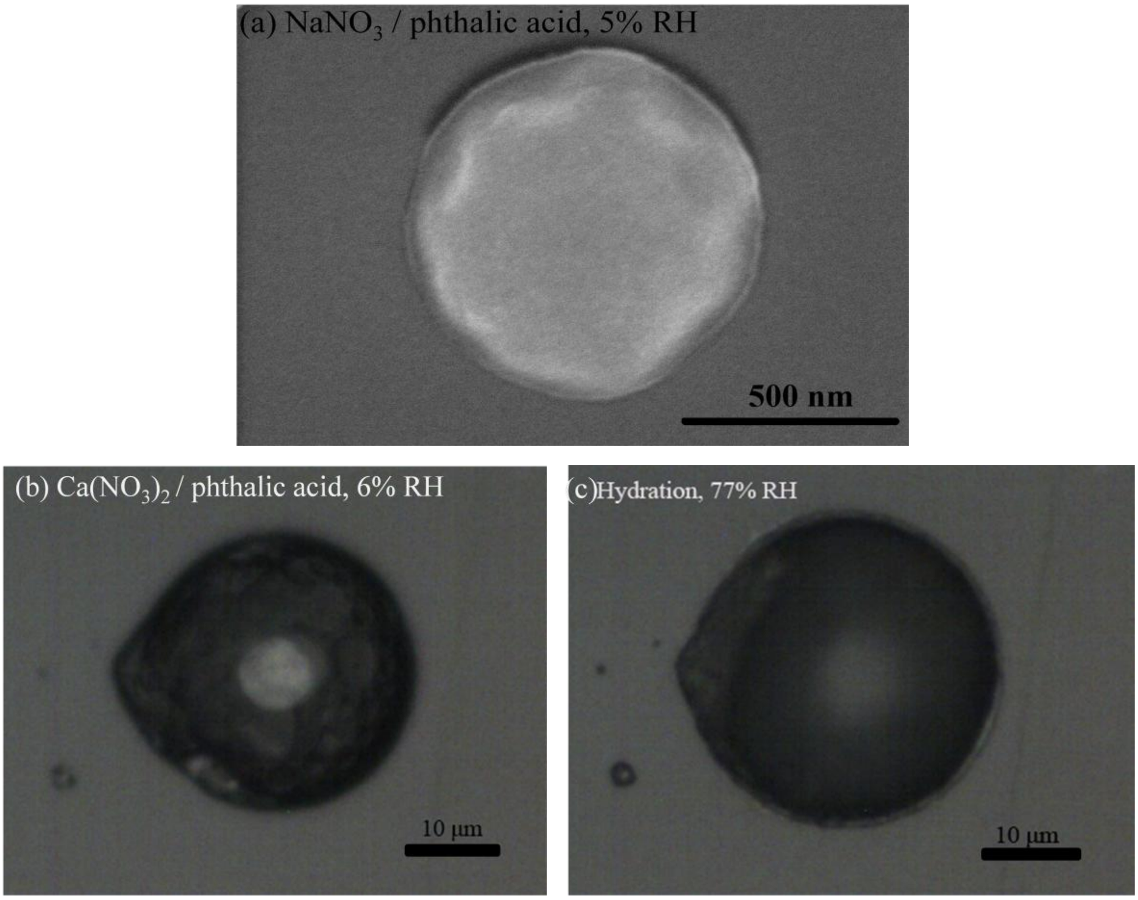

Figure S2. (a) SEM micrographs of the $NaNO_3$/phthalic acid mixed particle conditioned under dry conditions. Optical micrographs of the $Ca(NO_3)_2$/phthalic acid mixed particle at 6% RH (b) and 77% RH (c) upon hydration.

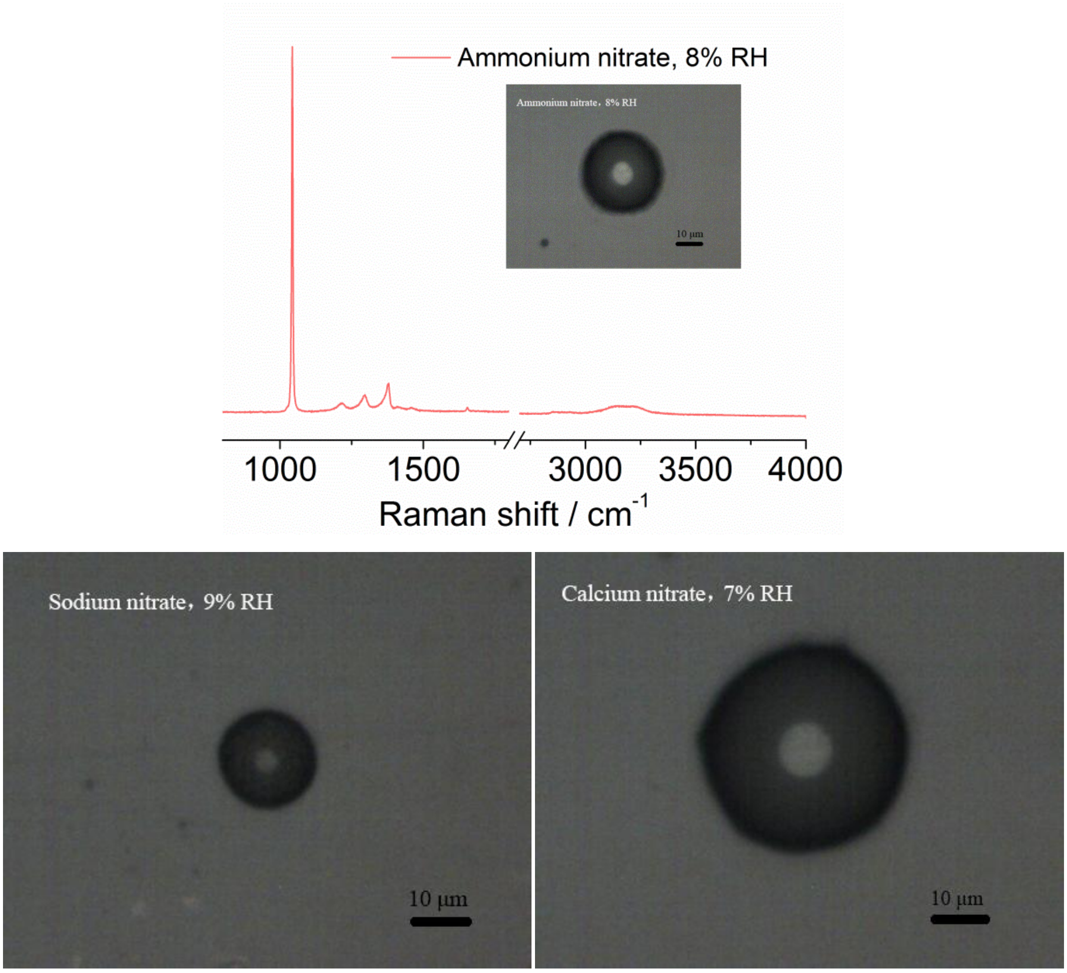

Figure S3. Optical micrographs of nitrate salt particles at low RH less than 10%: ammonium nitrate (upper), sodium nitrate (left), and calcium nitrate (right). The Raman spectrum is also shown for ammonium nitrate.

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