Supplementary Information:

Study of the slow water transport in MgSO₄ aerosol droplets

at gel-forming relative humidities

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Surface analysis with physisorption analyzer method

The system included an air oven, which was kept at constant temperature (313 K) to avoid vapor condensation during the vapor adsorption and desorption experiments, as well as the influence from external environmental temperature changes. The manifold tube was connected to turbo pump, helium port, vapor generator, pressure sensors, $P_0$ station, and three further sample stations. The $P_0$ station was a cell at a saturated water vapor pressure at 298 K, and can provide water vapor with a given pressure for the sample station. In our case, one sample station was used for the measurements; two are shown in Figure S3 for illustration purposes. The vapor generator was a glass bulb in which liquid water (vapor source) was held. For this work, in conducting humidifying and dehumidifying experiments, the temperatures of the sample stations were controlled by using a thermostatic water bath, and temperature was set at 298 K. The samples needed to be pretreated. Herein, the MgSO$_4$ particles in the sample cell were heated for 3 hr at 150 degree centigrade under vacuum before measurement, which ensured formation of the anhydrous state.

An isochoric method was used for instrumental measurement and the system volume was measured precisely to determine the adsorption. As shown in Figure S3(b), the dead volume $V_d$, the volume in the sample cell, was measured for every experiment because it changed when the sample cell and the amount of sample were changed. After installing the sample cell and evacuating the measurement system, helium was dosed into the reference volume buffer, $V_s$, and the pressure $P_{1i}$ was measured using the pressure sensor P1. Notably, the reference volume buffer $V_s$ has been calibrated. Then, the valve C between $V_d$ and $V_s$ was opened to diffuse He gas into the space of $V_d$, and closed several
seconds later. The pressure at the pressure sensor P1 and P2 were recorded as $P_{1e}$ and $P_{2e}$, respectively. The $V_d$ can be determined applying the following equation.

$$V_d (1) = \frac{(P_{li} - P_{le}) \times V_i}{P_{2e}} \quad (1)$$

Then, additional helium gas was continually dosed, and the above measurement processes were repeated. $V_d(2), V_d(3)\ldots V_d(n)$ were calculated in the same manner, and average value of $V_d$ determined.

After obtaining $V_d$, the adsorptive gas (water vapor) was dosed to $V_s$ through the valve-A. Due to adsorption, the adsorptive gas pressure decreased, and the adsorption was calculated from the pressure difference before and after the adsorption. The gas volume $V_1$ in $V_s$ (cm$^3$(standard state)/g$^{-1}$), which changed before and after the adsorption, was expressed as the following equation. $W_s$ and $T$ are the sample weight and the absolute temperature of $V_s$, respectively.

$$V(1) = \frac{(P_{li}(n) - P_{le}(n)) \times V_s \times 273.15}{101.325 \cdot W_s \cdot T} \quad (2)$$

The gas volume $V_2$ in $V_d$, which changed before and after adsorption, can be determined from the $(n-1)^{th}$ point equilibrium pressure $P_{2e(n-1)}$ in $V_d$, and the $n^{th}$ point equilibrium pressure $P_{2e(n)}$ in $V_d$, as follow.

$$V(2) = \frac{(P_{2e(n-1)} - P_{2e(n)}) \times V_d \times 273.15}{101.325 \cdot W_s \cdot T} \quad (3)$$

The sample’s adsorption change $\Delta V$ in the $n$-th point’s adsorption process is equal to the gas volume in $V_s$ and $V_d$ that changed before and after adsorption. Therefore, the adsorption $V(n)$ at the adsorption equilibrium pressure $P_{2e(n)}$ was

$$V(n) = V(n-1) + V1 + V2 \quad (4)$$
The adsorption water vapor \( V(n), \text{cm}^3\text{(STP).g}^{-1} \) can be converted into WSR by using the equation

\[
WSR = \frac{V_a \ [\text{cm}^3 \text{(STP).g}^{-1}] \times M \ [\text{g.mol}^{-1}]}{22400 \ [\text{cm}^3\text{.mol}^{-1}]}
\]

in which \( M \ [\text{g.mol}^{-1}] \) was the molar mass of the inorganic salt. The measurements of desorption were similar to those of adsorption.
**Figure S1.** Schematic diagram of experimental setup used for single droplet optical tweezing.
Figure S2. Schematic diagram of the FTIR-ATR experimental setup.
Figure S3. Schematic diagram of physisorption analyzer in which water vapor is used as adsorbate (a) and that of BELSORP-max measured dead volume (b).