

# In Situ Real-Time Determination of SO<sub>2</sub> Photochemical Oxidation in Nanoscale Sea Salt Aerosols based on Dark-Field Microscopy

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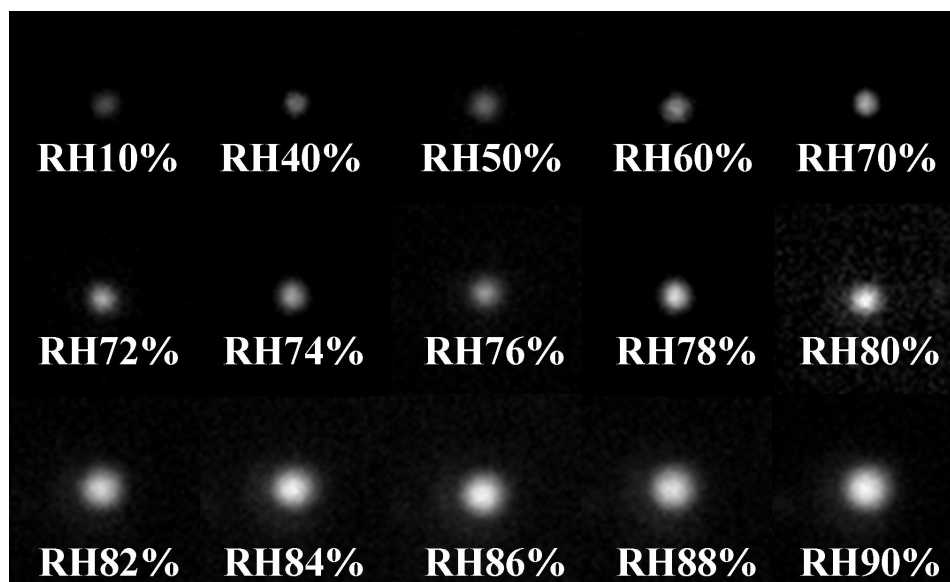
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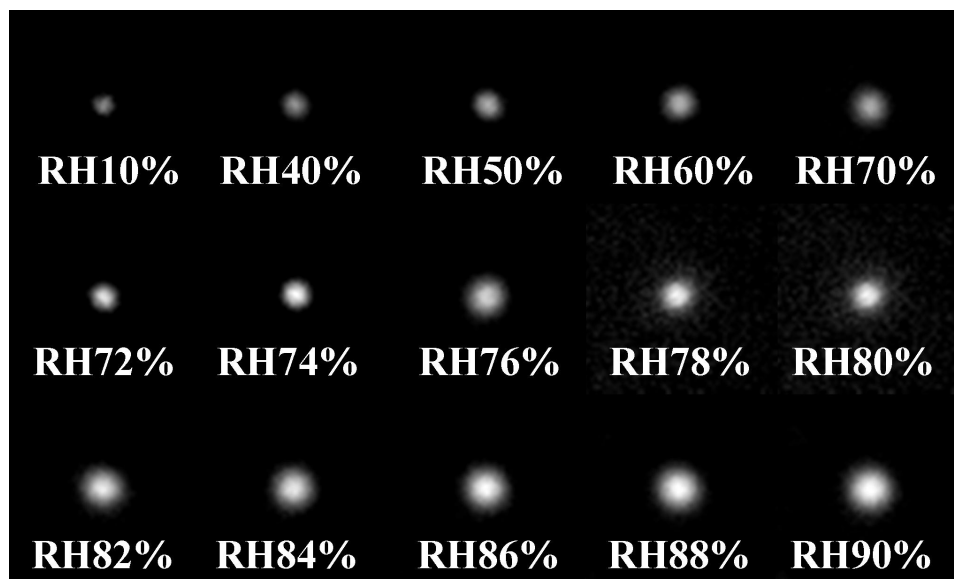
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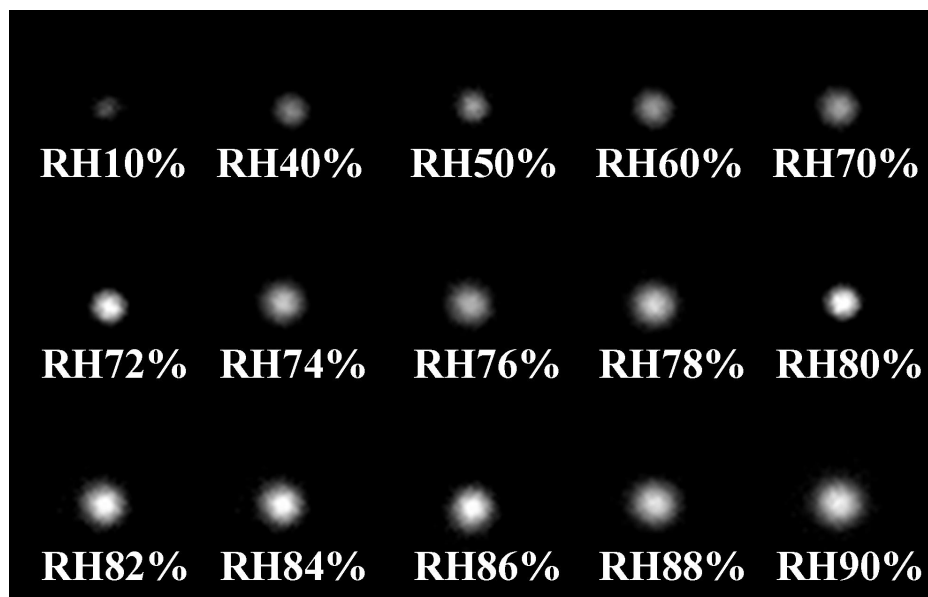
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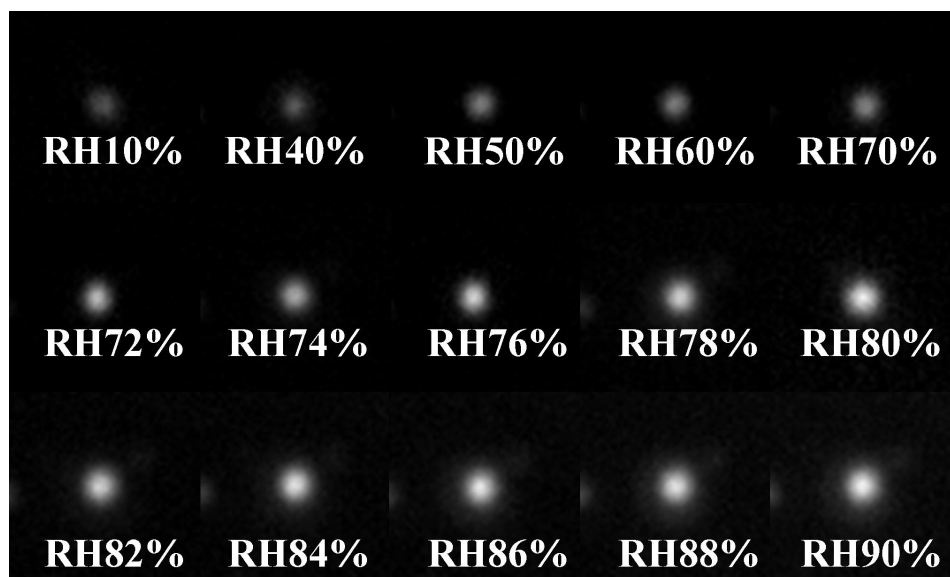
**Figure S1.** In situ dark-field images of NaCl single nano-particle(100nm) with the reaction time of 1h at humidification process.



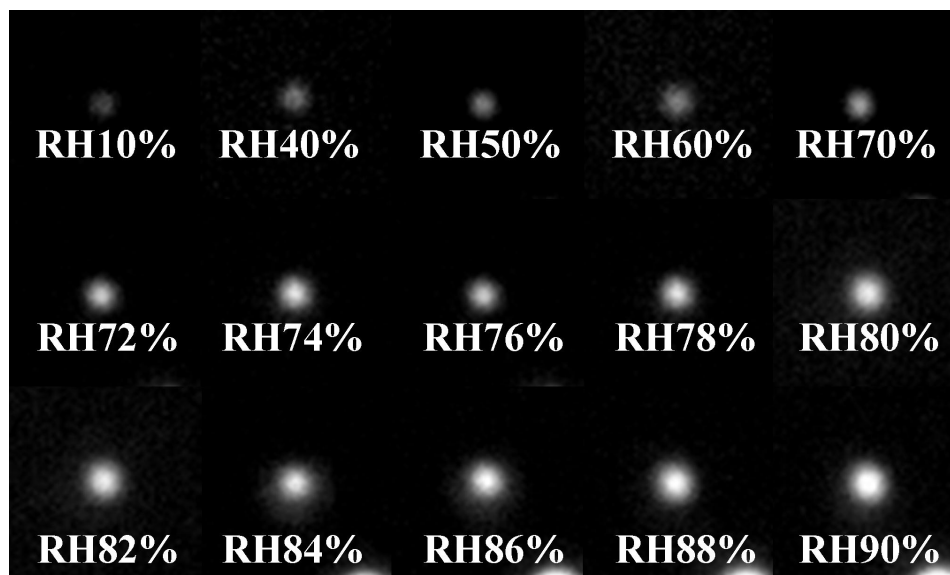
**Figure S2.** In situ dark-field images of NaCl single nano-particle(100nm) with the reaction time of 2h at humidification process.



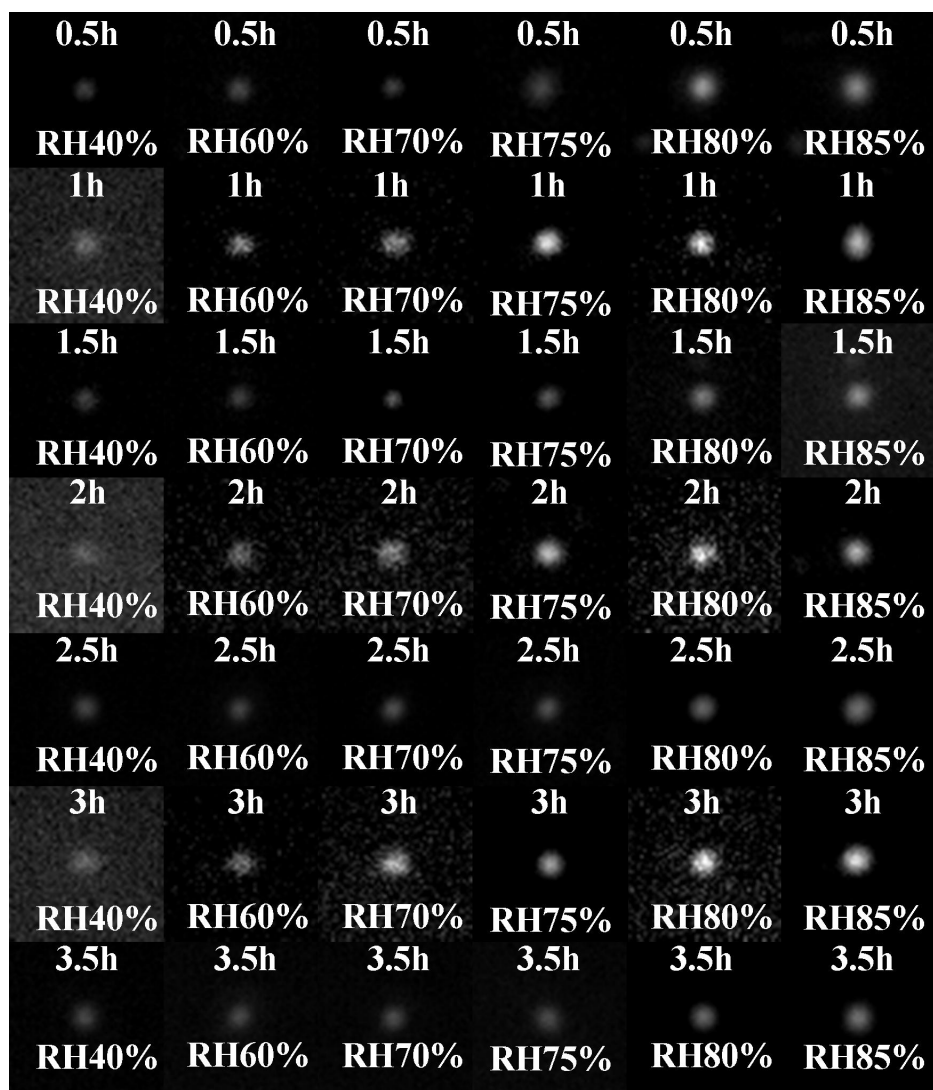
**Figure S3.** In situ dark-field images of NaCl single nano-particle(100nm) with the reaction time of 3h at humidification process.



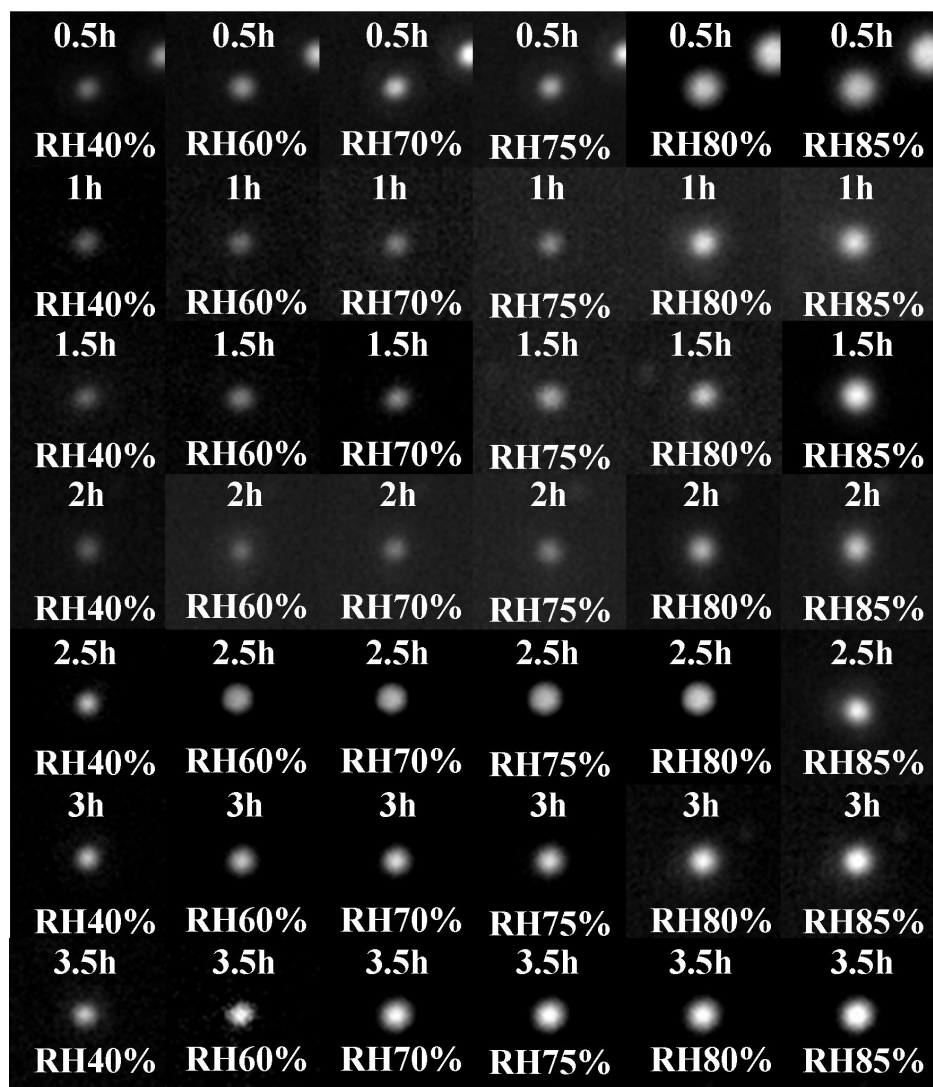
**Figure S4.** In situ dark-field images of NaCl single nano-particle(100nm) with the reaction time of 4h at humidification process.



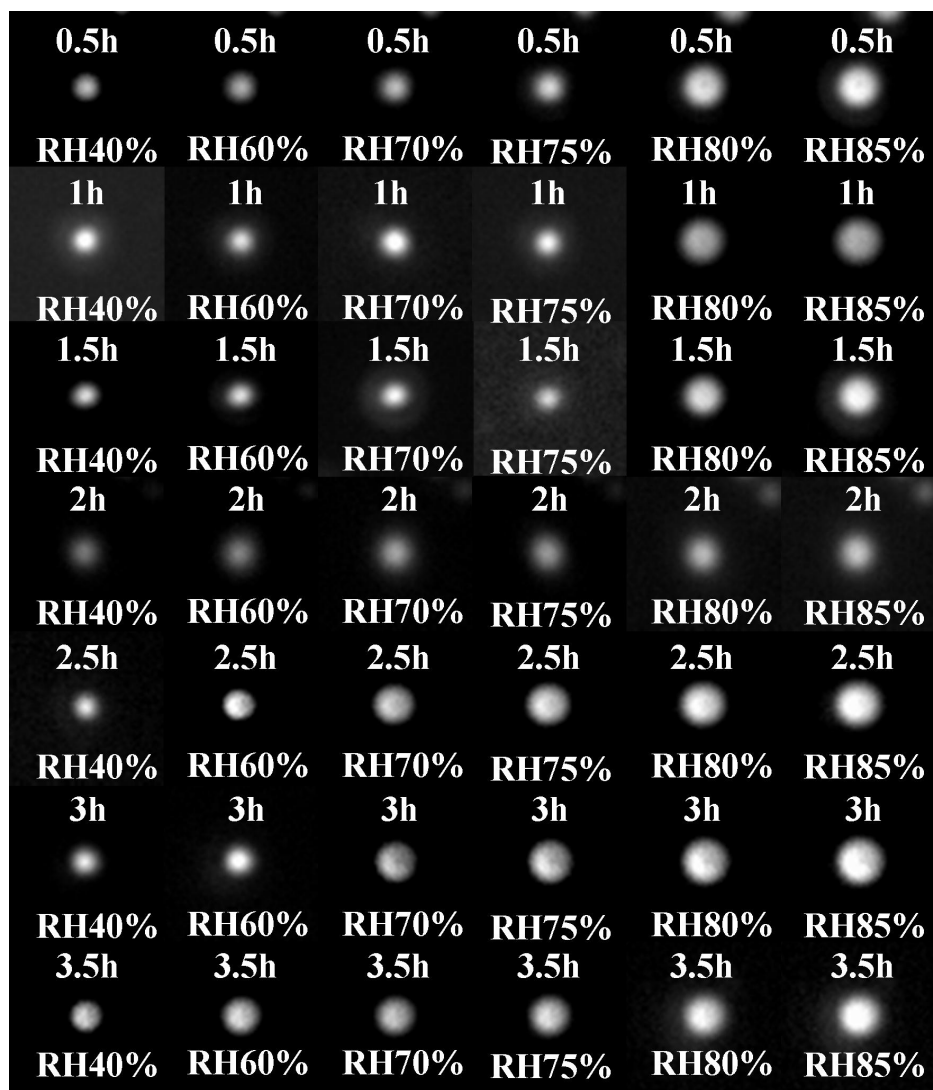
**Figure S5.** In situ dark-field images of NaCl single nano-particle(100nm) with the reaction time of 5h at humidification process.



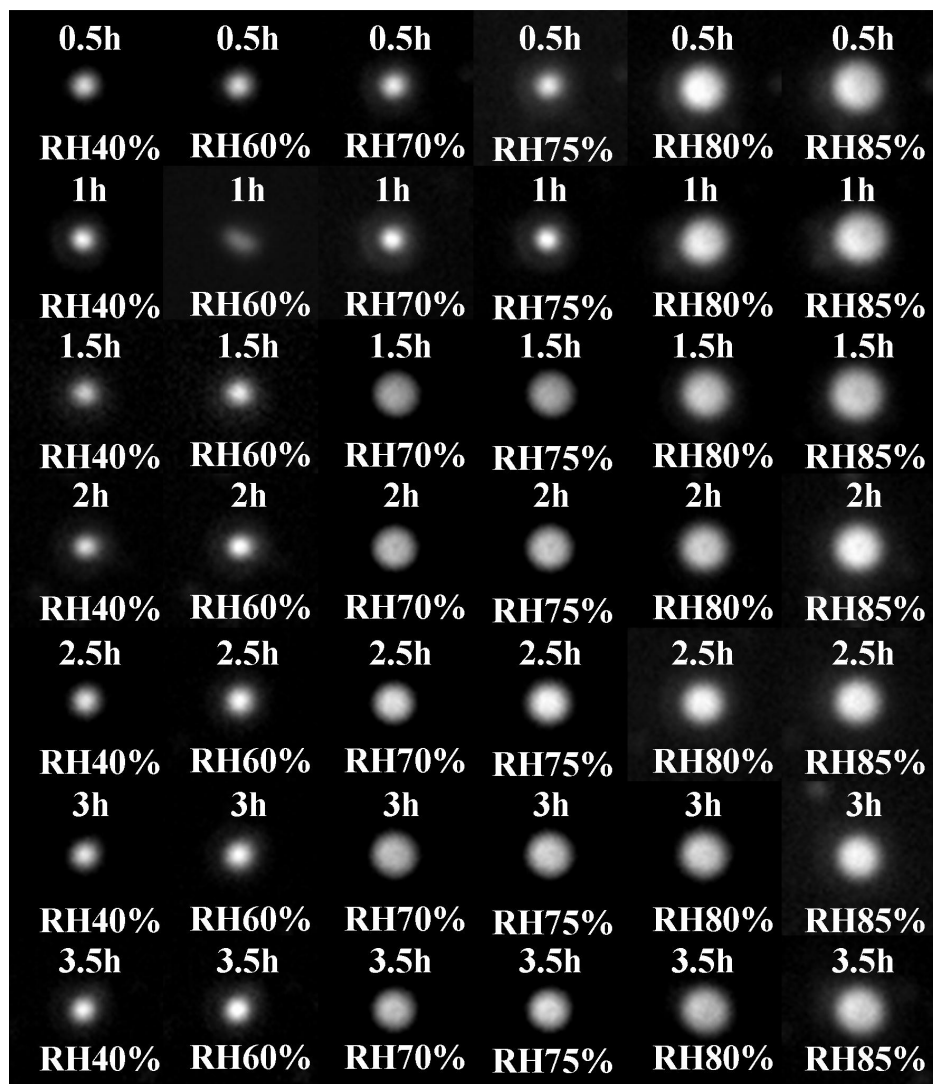
70 **Figure S6.** In situ dark-field images of NaCl single nano-particle (50 nm) with the reaction time of from 0.5 h to 3.5 h at humidification process.



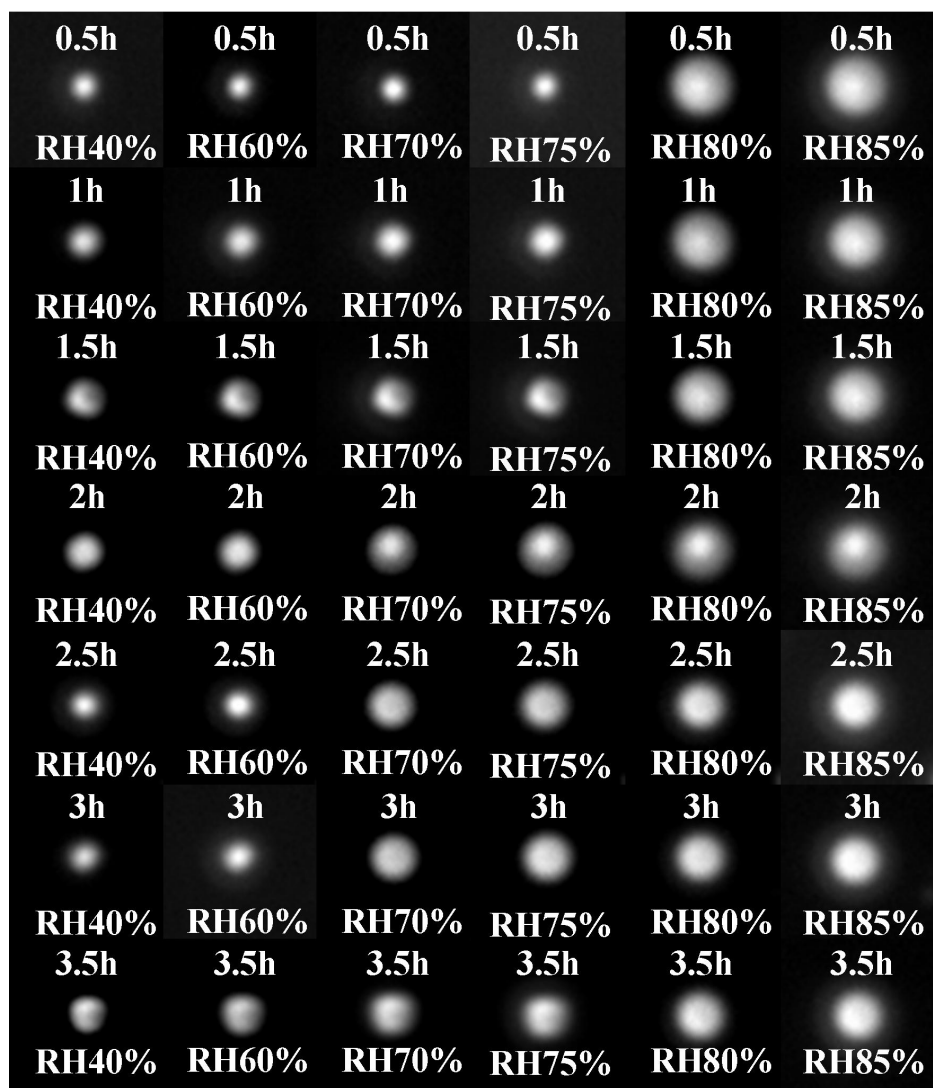
**Figure S7.** In situ dark-field images of NaCl single nano-particle (150 nm) with the reaction time of from 0.5 h to 3.5 h at humidification process.



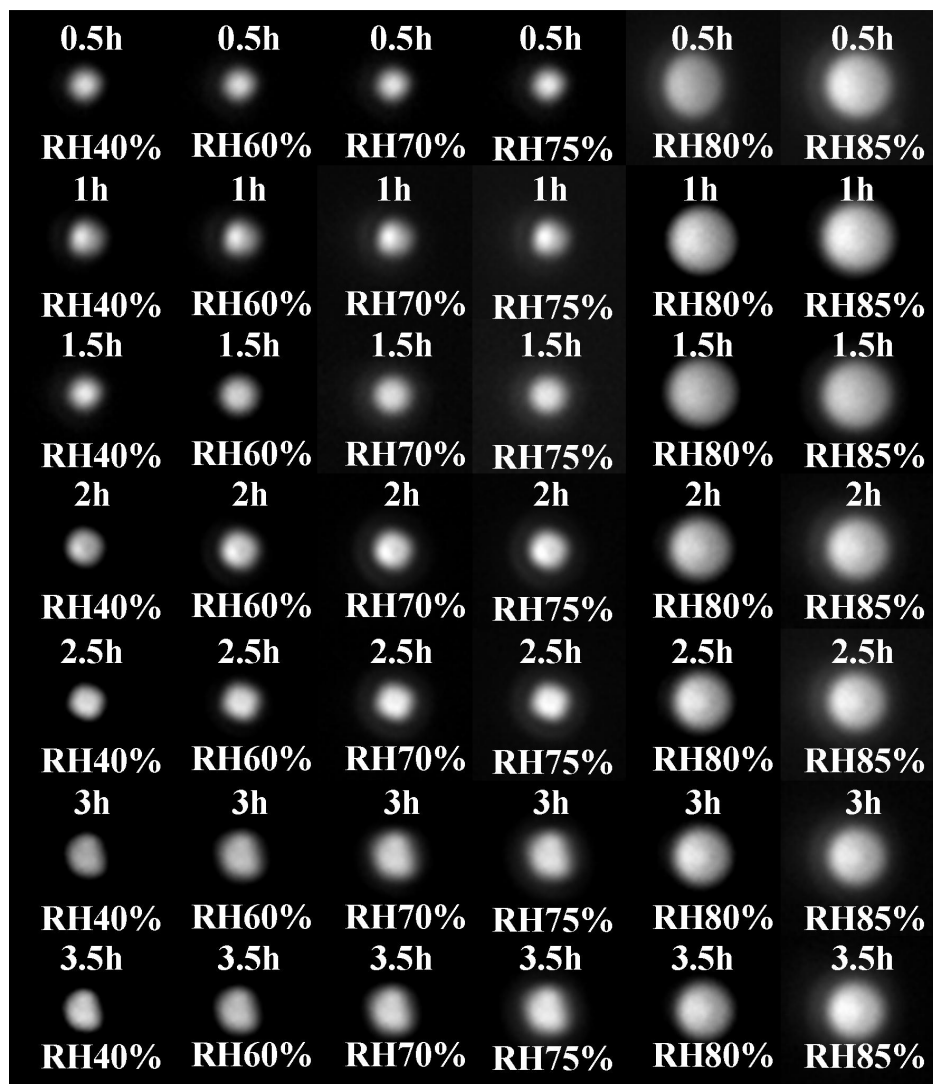
**Figure S8.** In situ dark-field images of NaCl single nano-particle (200 nm) with the reaction time of from 0.5 h to 3.5 h at humidification process.



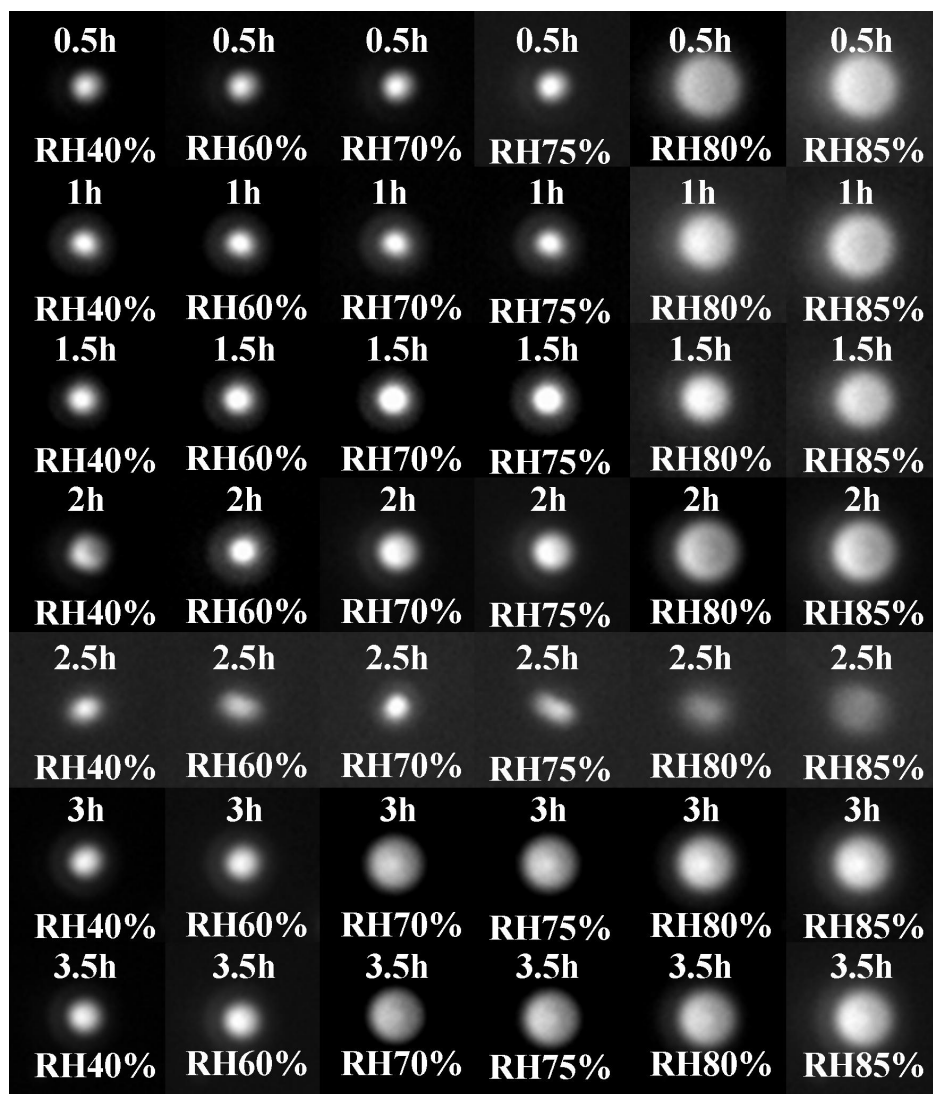
**Figure S9.** In situ dark-field images of NaCl single nano-particle (250 nm) with the reaction time of from 0.5 h to 3.5 h at humidification process.



**Figure S10.** In situ dark-field images of NaCl single nano-particle (300 nm) with the reaction time of from 0.5 h to 3.5 h at humidification process.

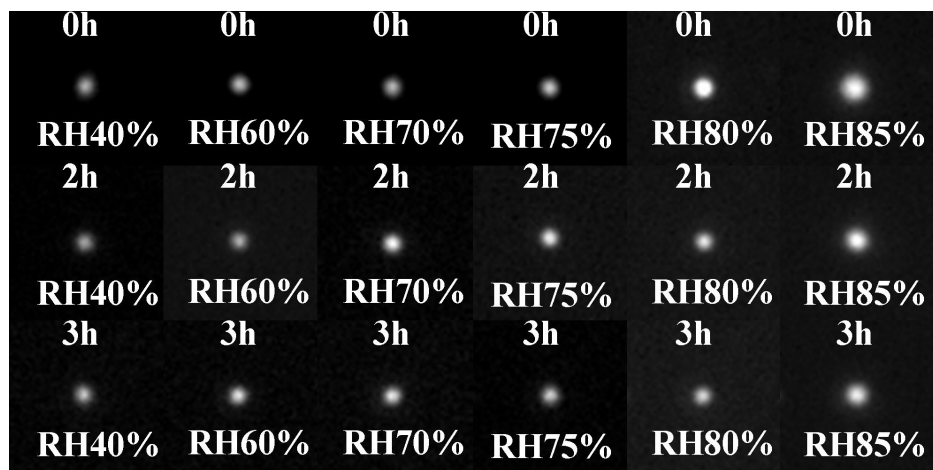


85 **Figure S11.** In situ dark-field images of NaCl single nano-particle (350 nm) with the reaction time of from 0.5 h to 3.5 h at humidification process.

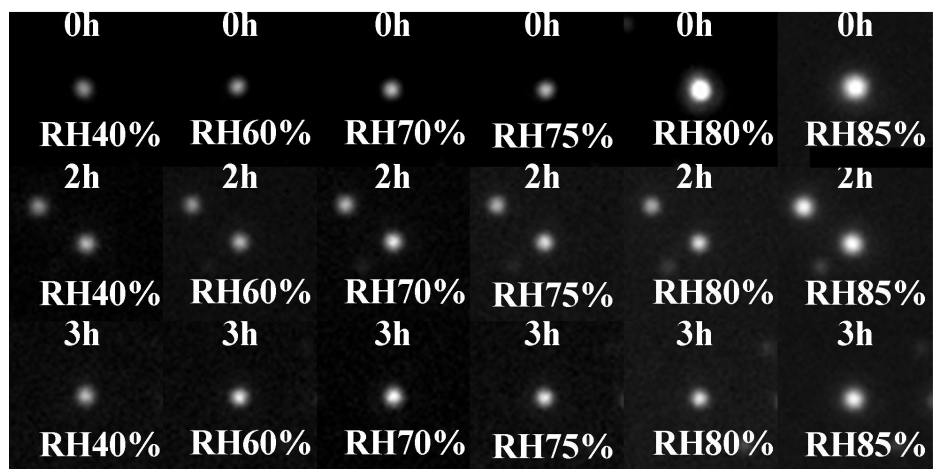


**Figure S12.** In situ dark-field images of NaCl single nano-particle (400 nm) with the reaction time of from 0.5 h to 3.5 h at humidification process.

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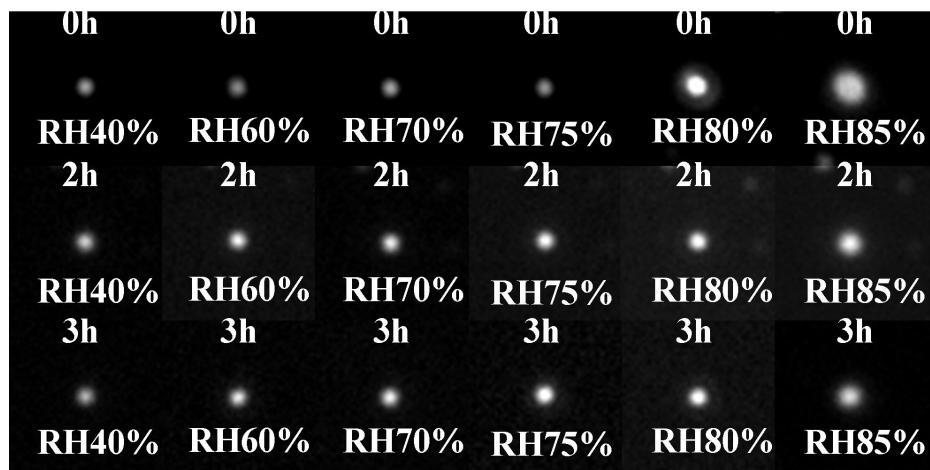


**Figure S13.** In situ dark-field images of NaCl-SOS mixed nano-particle with 5% OVF and aged for 0 h, 2 h and 3 h at humidification process.

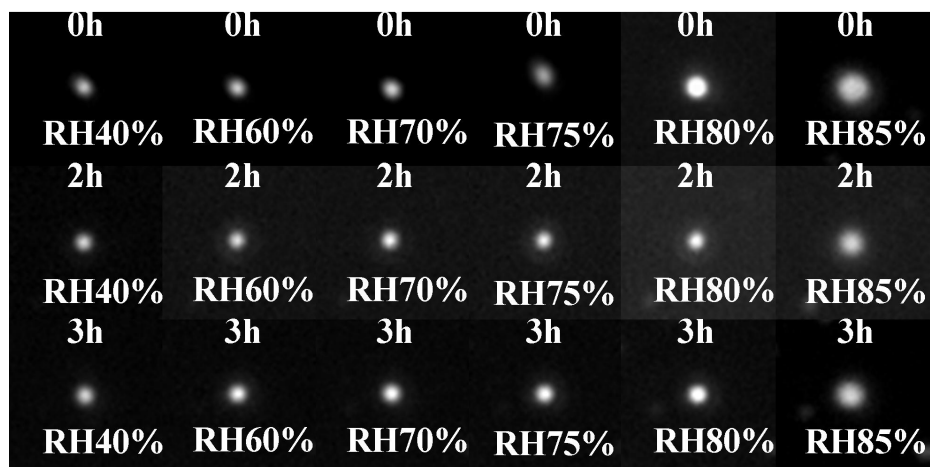


**Figure S14.** In situ dark-field images of NaCl-SOS mixed nano-particle with 10%OVF and aged for 0 h, 2 h and 3 h at humidification process.

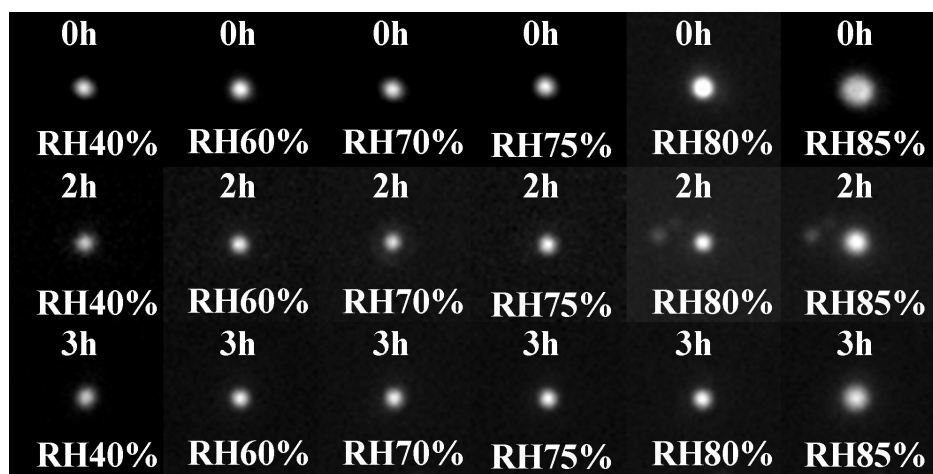
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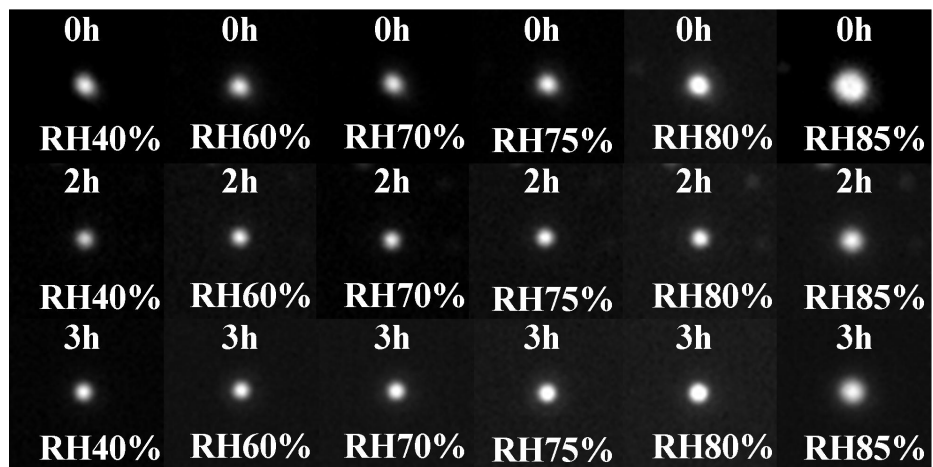
**Figure S15.** In situ dark-field images of NaCl-SOS mixed nano-particle with 18%OVF and aged for 0 h, 2 h and 3 h at humidification process.



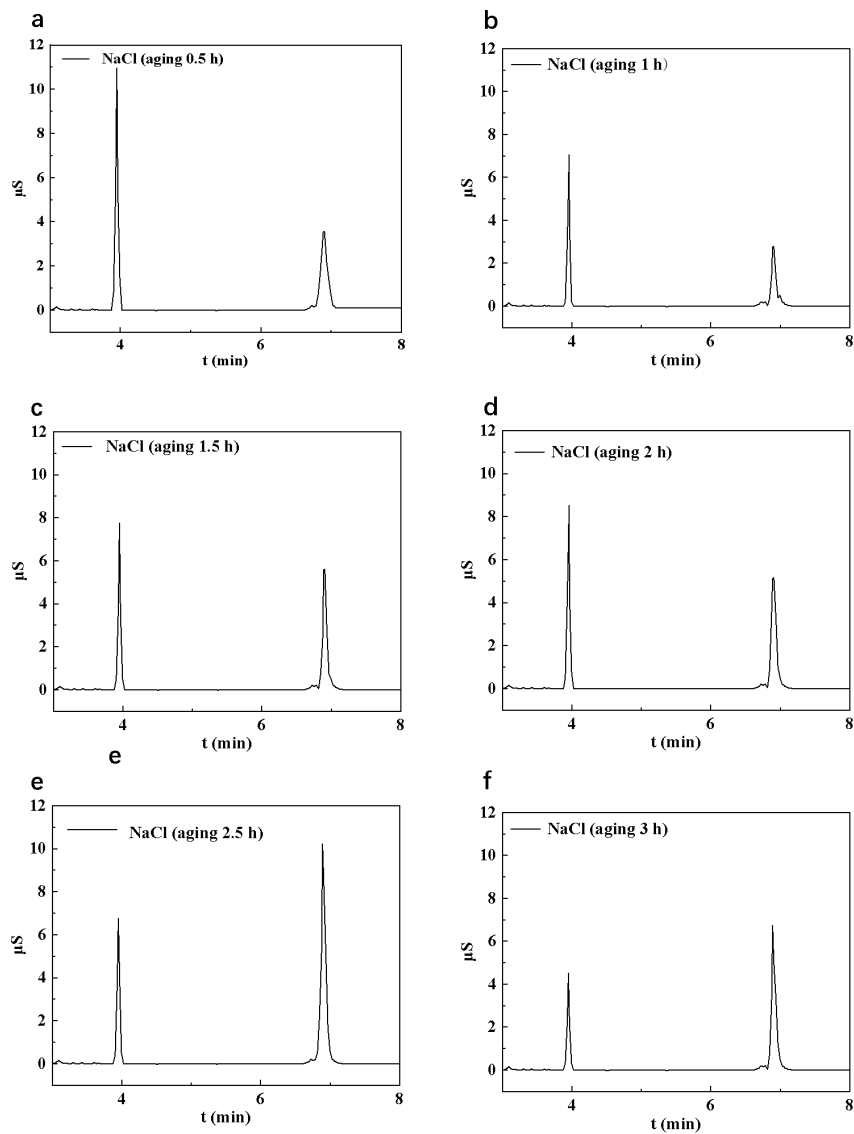
**Figure S16.** In situ dark-field images of NaCl-SOS mixed nano-particle with 33% OVF and aged for 0 h, 2 h and 3 h at humidification process.



**Figure S17.** In situ dark-field images of NaCl-SOS mixed nano-particle with 50% OVF and aged for 0 h, 2 h and 3 h at humidification process.



**Figure S18.** In situ dark-field images of NaCl-SOS mixed nano-particle with 70% OVF and aged for 0 h, 2 h and 3 h at humidification process.



**Figure S19.** ion chromatography test of NaCl nano single particles (100 nm) aged for 0.5 h, 1 h, 1.5 h, 2 h, 2.5 h, 3 h.

110 **Table S1.** The measured values of the growth factors for NaCl single nano-particles at different relative humidities after aging.

| D(nm) | RH(%) | GF(0.5h)  | GF(1h)    | GF(1.5h)   | GF(2h)     | GF(2.5h)  | GF(3h)    | GF(3.5h)  |
|-------|-------|-----------|-----------|------------|------------|-----------|-----------|-----------|
| 50    | 40    | 1.05±0.01 | 1.08±0.01 | 1.10±0.02  | 1.13±0.02  | 1.16±0.02 | 1.18±0.02 | 1.18±0.02 |
|       | 60    | 1.10±0.02 | 1.16±0.01 | 1.17±0.02  | 1.23 ±0.01 | 1.28±0.02 | 1.31±0.01 | 1.32±0.02 |
|       | 70    | 1.13±0.03 | 1.20±0.01 | 1.23 ±0.04 | 1.33±0.01  | 1.40±0.01 | 1.44±0.02 | 1.47±0.02 |
|       | 75    | 1.16±0.03 | 1.25±0.01 | 1.27±0.02  | 1.38±0.03  | 1.47±0.02 | 1.50±0.02 | 1.52±0.02 |

|     |    |           |           |            |           |            |            |            |
|-----|----|-----------|-----------|------------|-----------|------------|------------|------------|
|     | 80 | 1.92±0.01 | 1.87±0.03 | 1.84±0.02  | 1.79±0.02 | 1.73±0.02  | 1.71 ±0.01 | 1.70 ±0.01 |
|     | 85 | 2.06±0.01 | 2.01±0.03 | 2.00±0.02  | 1.92±0.03 | 1.88 ±0.04 | 1.84±0.03  | 1.83±0.03  |
| 150 | 40 | 1.13±0.01 | 1.13±0.01 | 1.16 ±0.01 | 1.18±0.01 | 1.19±0.01  | 1.19±0.01  | 1.19±0.01  |
|     | 60 | 1.22±0.02 | 1.23±0.01 | 1.27±0.01  | 1.31±0.02 | 1.34±0.01  | 1.34±0.01  | 1.34±0.01  |
|     | 70 | 1.31±0.02 | 1.33±0.02 | 1.39±0.02  | 1.46±0.02 | 1.48±0.02  | 1.49±0.02  | 1.50±0.02  |
|     | 75 | 1.37±0.02 | 1.38±0.02 | 1.46±0.02  | 1.52±0.02 | 1.55±0.03  | 1.56±0.02  | 1.53±0.03  |
|     | 80 | 1.80±0.02 | 1.77±0.02 | 1.74±0.03  | 1.71±0.03 | 1.69±0.02  | 1.68±0.02  | 1.67±0.02  |
|     | 85 | 1.94±0.03 | 1.95±0.05 | 1.88±0.03  | 1.85±0.02 | 1.82±0.05  | 1.83±0.02  | 1.81±0.02  |
| 200 | 40 | 1.13±0.01 | 1.16±0.02 | 1.18±0.02  | 1.19±0.02 | 1.20±0.00  | 1.20±0.02  | 1.20±0.02  |
|     | 60 | 1.24±0.01 | 1.28±0.02 | 1.31±0.02  | 1.34±0.02 | 1.34±0.01  | 1.34±0.02  | 1.35±0.02  |
|     | 70 | 1.33±0.02 | 1.41±0.02 | 1.45±0.04  | 1.49±0.01 | 1.50±0.02  | 1.50±0.02  | 1.50±0.02  |
|     | 75 | 1.39±0.02 | 1.48±0.02 | 1.50±0.02  | 1.56±0.02 | 1.57±0.02  | 1.56±0.02  | 1.57±0.02  |
|     | 80 | 1.78±0.02 | 1.73±0.03 | 1.71±0.03  | 1.68±0.03 | 1.68±0.03  | 1.67±0.02  | 1.68±0.02  |
|     | 85 | 1.91±0.04 | 1.87±0.02 | 1.83±0.03  | 1.81±0.03 | 1.81±0.02  | 1.80±0.02  | 1.81±0.02  |
| 250 | 40 | 1.12±0.01 | 1.14±0.02 | 1.17±0.03  | 1.18±0.02 | 1.20±0.02  | 1.20±0.01  | 1.20±0.01  |
|     | 60 | 1.21±0.01 | 1.25±0.02 | 1.30±0.01  | 1.33±0.01 | 1.34±0.02  | 1.35±0.02  | 1.35±0.02  |
|     | 70 | 1.31±0.02 | 1.35±0.02 | 1.44±0.01  | 1.46±0.01 | 1.49±0.01  | 1.50±0.02  | 1.51±0.02  |
|     | 75 | 1.35±0.02 | 1.41±0.01 | 1.49±0.02  | 1.53±0.02 | 1.55±0.02  | 1.56±0.01  | 1.57±0.02  |
|     | 80 | 1.81±0.02 | 1.78±0.02 | 1.72±0.03  | 1.70±0.02 | 1.68±0.02  | 1.67±0.03  | 1.68±0.02  |
|     | 85 | 1.96±0.02 | 1.91±0.03 | 1.84±0.06  | 1.83±0.02 | 1.81±0.03  | 1.81±0.02  | 1.79±0.06  |
| 300 | 40 | 1.10±0.01 | 1.14±0.00 | 1.17±0.01  | 1.18±0.01 | 1.19±0.01  | 1.20±0.02  | 1.20±0.01  |
|     | 60 | 1.18±0.02 | 1.26±0.01 | 1.29±0.02  | 1.32±0.03 | 1.33±0.01  | 1.33±0.02  | 1.34±0.02  |
|     | 70 | 1.26±0.01 | 1.37±0.03 | 1.43±0.02  | 1.47±0.02 | 1.49±0.03  | 1.49±0.01  | 1.51±0.02  |
|     | 75 | 1.30±0.02 | 1.42±0.02 | 1.50±0.03  | 1.53±0.02 | 1.55±0.02  | 1.57±0.01  | 1.56±0.02  |
|     | 80 | 1.84±0.02 | 1.77±0.03 | 1.72±0.02  | 1.70±0.02 | 1.69±0.02  | 1.69±0.03  | 1.68±0.03  |
|     | 85 | 1.98±0.03 | 1.89±0.02 | 1.85±0.05  | 1.84±0.02 | 1.81±0.02  | 1.82±0.03  | 1.81±0.03  |
| 350 | 40 | 1.09±0.01 | 1.12±0.01 | 1.15±0.01  | 1.18±0.01 | 1.18±0.05  | 1.19±0.01  | 1.20±0.01  |
|     | 60 | 1.17±0.02 | 1.19±0.01 | 1.26±0.01  | 1.31±0.00 | 1.32±0.01  | 1.34±0.02  | 1.34±0.01  |
|     | 70 | 1.23±0.02 | 1.29±0.02 | 1.36±0.02  | 1.44±0.01 | 1.45±0.04  | 1.48±0.02  | 1.49±0.02  |
|     | 75 | 1.26±0.02 | 1.33±0.01 | 1.41±0.01  | 1.50±0.02 | 1.53±0.04  | 1.56±0.02  | 1.56±0.02  |
|     | 80 | 1.86±0.03 | 1.82±0.03 | 1.77±0.02  | 1.73±0.03 | 1.71±0.03  | 1.68±0.02  | 1.67±0.02  |
|     | 85 | 1.99±0.05 | 1.97±0.03 | 1.89±0.03  | 1.84±0.03 | 1.82±0.03  | 1.81±0.02  | 1.81±0.02  |
| 400 | 40 | 1.08±0.01 | 1.12±0.02 | 1.16±0.01  | 1.17±0.01 | 1.17±0.00  | 1.18±0.01  | 1.19±0.03  |
|     | 60 | 1.16±0.01 | 1.21±0.01 | 1.28±0.02  | 1.30±0.02 | 1.31±0.02  | 1.33±0.03  | 1.34±0.01  |
|     | 70 | 1.23±0.02 | 1.31±0.01 | 1.39±0.02  | 1.43±0.02 | 1.45±0.03  | 1.47±0.01  | 1.49±0.01  |
|     | 75 | 1.24±0.01 | 1.33±0.01 | 1.45±0.02  | 1.48±0.01 | 1.52±0.02  | 1.54±0.02  | 1.56±0.02  |

|    |           |           |           |           |           |           |           |
|----|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 80 | 1.87±0.01 | 1.81±0.03 | 1.75±0.03 | 1.72±0.03 | 1.71±0.01 | 1.69±0.01 | 1.69±0.04 |
| 85 | 2.01±0.01 | 1.94±0.01 | 1.86±0.03 | 1.84±0.01 | 1.84±0.05 | 1.84±0.01 | 1.82±0.02 |

**Table S2.** The measured values of the growth factors for NaCl-SOS single nano-particles of different organic volume fractions at different relative humidities after aging.

| OVF(%) | RH(%) | GF(0h)    | GF(2h)    | GF(3h)    |
|--------|-------|-----------|-----------|-----------|
| 5      | 40    | 1.01±0.02 | 1.15±0.02 | 1.17±0.01 |
|        | 60    | 1.01±0.01 | 1.28±0.02 | 1.33±0.02 |
|        | 70    | 1.01±0.01 | 1.39±0.01 | 1.45±0.02 |
|        | 75    | 0.99±0.01 | 1.46±0.02 | 1.54±0.02 |
|        | 80    | 2.01±0.04 | 1.73±0.01 | 1.71±0.02 |
|        | 85    | 2.15±0.03 | 1.89±0.03 | 1.82±0.03 |
| 10     | 40    | 1.02±0.02 | 1.15±0.01 | 1.17±0.02 |
|        | 60    | 1.04±0.03 | 1.28±0.01 | 1.32±0.02 |
|        | 70    | 1.00±0.02 | 1.40±0.02 | 1.47±0.03 |
|        | 75    | 1.00±0.02 | 1.43±0.02 | 1.51±0.03 |
|        | 80    | 2.01±0.02 | 1.75±0.02 | 1.71±0.02 |
|        | 85    | 2.16±0.02 | 1.88±0.03 | 1.84±0.02 |
| 18     | 40    | 1.02±0.02 | 1.14±0.01 | 1.18±0.01 |
|        | 60    | 1.02±0.02 | 1.28±0.03 | 1.32±0.02 |
|        | 70    | 1.00±0.03 | 1.38±0.02 | 1.45±0.01 |
|        | 75    | 1.01±0.02 | 1.44±0.02 | 1.50±0.02 |
|        | 80    | 2.00±0.02 | 1.76±0.03 | 1.71±0.02 |
|        | 85    | 2.15±0.01 | 1.86±0.01 | 1.84±0.05 |
| 33     | 40    | 1.01±0.01 | 1.14±0.02 | 1.18±0.02 |
|        | 60    | 1.02±0.01 | 1.23±0.03 | 1.31±0.02 |
|        | 70    | 1.02±0.01 | 1.36±0.02 | 1.42±0.02 |
|        | 75    | 1.00±0.02 | 1.42±0.04 | 1.51±0.02 |
|        | 80    | 2.02±0.02 | 1.76±0.02 | 1.73±0.02 |
|        | 85    | 2.14±0.03 | 1.93±0.01 | 1.84±0.03 |
| 50     | 40    | 1.02±0.01 | 1.12±0.02 | 1.16±0.01 |
|        | 60    | 1.01±0.01 | 1.23±0.02 | 1.26±0.03 |
|        | 70    | 0.99±0.03 | 1.33±0.01 | 1.40±0.02 |
|        | 75    | 1.02±0.01 | 1.37±0.01 | 1.44±0.02 |
|        | 80    | 2.02±0.01 | 1.78±0.02 | 1.74±0.01 |
|        | 85    | 2.16±0.02 | 1.91±0.04 | 1.89±0.01 |
| 70     | 40    | 1.02±0.02 | 1.07±0.01 | 1.12±0.02 |

|    |               |               |               |
|----|---------------|---------------|---------------|
| 60 | $1.00\pm0.01$ | $1.11\pm0.02$ | $1.20\pm0.01$ |
| 70 | $0.99\pm0.03$ | $1.13\pm0.02$ | $1.27\pm0.02$ |
| 75 | $1.00\pm0.02$ | $1.17\pm0.01$ | $1.31\pm0.02$ |
| 80 | $2.02\pm0.03$ | $1.92\pm0.01$ | $1.81\pm0.01$ |
| 85 | $2.15\pm0.01$ | $2.04\pm0.03$ | $1.97\pm0.01$ |