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Supplement of

A new smog chamber system for atmospheric multiphase chemistry study: design and characterization

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Table S1. Comparison of the background species concentration in this chamber system with that in other chambers

Instrument	Thermo Scientific								TSI		
	Model 43i-TLE	Model 42i-TL		Model 49i	Model 48i-TLE	Picarro Inc.		GC-MS (Summa Canister)	CPC3772	Sensor in Chamber	
Species	**SO_2**	**NO_2**	**NO**	**O_3**	**CO**	**CO_2**	**CH_4**	**NMHC**	**Particles**	**T**	**RH**
Indoor air	~1 ppb	~3 ppb	~6 ppb	1~2 ppb	~500 ppb	~550 ppm	~2.5 ppm	111.79 ppb	~3~6*10^3 # cm^{-3}	~25 ℃	~30%~50%
Chamber_dry zero air	<1 ppb	<0.5 ppb	<0.5 ppb	<2 ppb	<50 ppb	~27 ppm	Below instrument detection limit	43.5 ppb	＜0.5 # cm^{-3}	~25 ℃	1~2%
Chamber_wet zero air_80%RH	<1 ppb	<0.5 ppb	<0.5 ppb	Below instrument detection limit	<50 ppb	~26 ppm		35.448 ppb	＜2 # cm^{-3}	~25 ℃	> 80%
24m^3 Teflon (White et al., 2018)		*<0.5 ppb*	*<0.5 ppb*					*<17 ppb*	*< 10 # cm-3*		
7m^3 Teflon (Bin Babar et al., 2016)		*<1 ppb*	*<1 ppb*	*<1 ppb*					*< 10 # cm-3*		
30m^3 Teflon (Wang et al., 2014)		*<1 ppb*	*<1 ppb*	*<1 ppb*				*<5 ppb*	*~0 # cm^{-3}*		
12m^3 Teflon (Platt et al., 2013)						*~35 ppm*			*< 0.1 # cm-3*		
90m^3 Teflon (Carter et al., 2005)		*<5 ppb*	*<5 ppb*		*<50 ppb*						
30m^3 Teflon (Chen et al., 2019)	*<1 ppb*			*<1 ppb*							

Table S2. The cleaning efficiency of common gas species and particles in this chamber system

Instrument	**Thermo Scientific**					**TSI**	**Sensor in Chamber**	
	Model 43i-TLE	**Model 42i-TL**		**Model 49i**	**Model 48i-TLE**	**CPC3772**		
Species	**SO_2**	**NO_2**	**NO**	**O_3**	**CO**	**Particles**	**T**	**RH**
Initial Abundance	151.4ppb	125ppb	1621ppb	86.1ppb	4600ppb	$6*10^3$ #·cm^{-3}	~25℃	~99%
After Cleaning_5 times of Volume	<1ppb	<0.5ppb	6.94ppb	<2ppb	291ppb	＜0.5 #·cm^{-3}	~25℃	1~2%
Background_Dry	<1ppb	<0.5ppb	<0.5ppb	<2ppb	<50ppb	＜0.5 #·cm^{-3}	~25℃	1~2%
Cleaning Efficiency	**~100%**	**~100%**	**99.60%**	**~100%**	**94.70%**	**~100%**	/	**~100%**
Volume for Completely Cleaning	**9999 L**	**9999 L**	**9999+5000 L**	**9999 L**	**9999+4500 L**	**9999 L**	/	**9999 L**

Table S3. Photolysis rate constants (s^{-1}) of some species under different light schemes (have been corrected according to the J_NO_2 value calculated by NOx and O_3 steady-state concentration)

Light Scheme	$J\_H_2O_2$	J_HCHO_M	J_HCHO_R	J_HONO	J_NO_2	$J\_NO_3\_M$	$J\_NO_3\_R$	$J\_O(^1D)$
Dark (0*)	-3.26×10^{-8}	-9.48×10^{-8}	-1.29×10^{-7}	-1.53×10^{-6}	-7.29×10^{-6}	-8.63×10^{-6}	-5.84×10^{-5}	-1.11×10^{-6}
all (40*)	7.62×10^{-7}	3.63×10^{-7}	1.71×10^{-7}	9.71×10^{-4}	4.10×10^{-3}	-1.06×10^{-5}	-3.27×10^{-5}	4.16×10^{-7}
only back/top (20*)	$\mathbf{3.93\times10^{-7}}$	$\mathbf{1.85\times10^{-7}}$	$\mathbf{7.94\times10^{-8}}$	$\mathbf{5.03\times10^{-4}}$	$\mathbf{2.13\times10^{-3}}$	$\mathbf{-5.39\times10^{-6}}$	$\mathbf{-1.74\times10^{-5}}$	$\mathbf{9.11\times10^{-8}}$
only left (10*)	2.49×10^{-7}	1.24×10^{-7}	6.92×10^{-8}	3.08×10^{-4}	1.29×10^{-3}	-3.51×10^{-6}	-1.36×10^{-5}	4.14×10^{-7}
only right (10*)	1.61×10^{-7}	7.02×10^{-8}	1.79×10^{-8}	2.04×10^{-4}	8.60×10^{-4}	-3.27×10^{-6}	-1.17×10^{-5}	1.62×10^{-7}
left and right (20*)	$\mathbf{4.14\times10^{-7}}$	$\mathbf{2.07\times10^{-7}}$	$\mathbf{1.12\times10^{-7}}$	$\mathbf{5.18\times10^{-4}}$	$\mathbf{2.19\times10^{-3}}$	$\mathbf{-5.81\times10^{-6}}$	$\mathbf{-2.10\times10^{-5}}$	$\mathbf{5.10\times10^{-7}}$
odd (20*)	$\mathbf{4.16\times10^{-7}}$	$\mathbf{2.04\times10^{-7}}$	$\mathbf{1.15\times10^{-7}}$	$\mathbf{5.24\times10^{-4}}$	$\mathbf{2.21\times10^{-3}}$	$\mathbf{-5.73\times10^{-6}}$	$\mathbf{-1.80\times10^{-5}}$	$\mathbf{4.02\times10^{-7}}$
even (20*)	$\mathbf{3.90\times10^{-7}}$	$\mathbf{1.88\times10^{-7}}$	$\mathbf{7.56\times10^{-8}}$	$\mathbf{4.98\times10^{-4}}$	$\mathbf{2.10\times10^{-3}}$	$\mathbf{-5.25\times10^{-6}}$	$\mathbf{-1.65\times10^{-5}}$	$\mathbf{1.23\times10^{-7}}$

* represents the number of lights.

Table S4. Stability of temperature and RH control in this chamber system

RH_set [%]	Temp._set [°C]	Temp. [°C]	RH [%]
80	10	10.04 ± 0.05 °C	82.76 ± 0.46 %
80	20	20.00 ± 0.09 °C	81.25 ± 0.39 %
80	30	30.14 ± 0.15 °C	81.50 ± 0.74 %

Table S5. Comparison of the temperature control accuracy of this chamber system with that in other chamber studies

Parameters	Temp. Range [°C]	Temp. Accuracy [°C]	Volume [m^3]
This Study	**2.5 ~ 31**	**≤ ± 0.15**	**2**
(Wang et al., 2014)	-10 ~ 40	± 1	30
(Wu et al., 2007)	/	± 0.2	2
(Bin Babar et al., 2016)	18 ~ 33	± 0.5	7
(Ma et al., 2022)	15 ~ 30	± 1	10
(Wang et al., 2015)	-10 ~ 40	± 0.5	5

Table S6. Comparison of wall loss rate constants of common gaseous pollutants in this study with that in other chambers

Species	RH<5%	RH>80%	Wall Loss Rate Constant (10^{-4} min^{-1})_dry *[Volume (Reference)]*
NO_2_Fans Off	1.98±0.74	/	*0.42 [2m^3 Teflon; (Wu et al., 2007)]; 4~20 [5m^3 Teflon; (Wang et al., 2015)]; 1.6 [3m^3 Teflon; (Li et al., 2017)];*
NO_2	1.76±0.41	5.21±0.52	
SO_2_Fans Off	2.24±0.91	/	
SO_2	9.32±1.81	/	
NO_Fans Off	3.55±1.32	/	*0.38 [2m^3 Teflon; (Wu et al., 2007)]; 3.0~3.1 [5m^3 Teflon; (Wang et al., 2015)];*
NO	10.40±1.67	11.65±1.68	
CO_Fans Off	1.97±1.55	/	
CO	5.10±1.58	8.05±1.72	
O_3_Fans Off	2.48±1.55	/	*6.1 [2m^3 Teflon; (Wu et al., 2007)]; 3.3 [2m^3 Teflon; (Bernard et al., 2016)]; 8.99 [3m^3 Teflon; (Li et al., 2017)];*
O_3	3.39±0.48	7.68±0.68	

Table S7. Total particle volume wall loss rate constants under different RHs in this study

RH [%]	Temp. [°C]	Total volume wall loss constant [10^{-3} min^{-1}]
< 5	20±0.1	4.96±0.57
30	20±0.1	5.05±0.11
60	20±0.1	4.97±0.71
90	20±0.1	3.71±0.34

Table S8. Summary of experimental conditions and results for α-pinene ozonolysis experiments

Exp	Exp Condition	RH [%]	Temp. [K]	Initial VOC [ppb]	Initial O3 [ppb]	Δmo [μg/m3]	SOA Yield
1	No Seeds	＜5	293.15±0.1	61.17	248	137.69	0.406
2	No Seeds	＜5	293.15±0.1	31.5	414	7.939	0.045
3	No Seeds	＜5	293.15±0.1	41.6693	255	75.046	0.327
4	No Seeds	＜5	293.15±0.1	41.275	152.7	60.57	0.276
5	No Seeds	＜5	293.15±0.1	73.861	73.4	64.958	0.289
6	Solid Seeds	＜5	293.15±0.1	61.635	324	112.782	0.329
7	Metastable Seeds	~60	293.15±0.1	68.8524	298	83.769	0.262
8	Liquid Seeds	~80	293.15±0.1	70.2095	309	84.215	0.216

Table S9. Comparison of the fitting parameters of SOA two-product model for seed-absent experiments in this study with that in other chamber studies

α1	α2	K1	K2	Reference
0.62479	0.0326791	0.0121589	0.0121596	This Study
0.4626	0.04287	0.0134	0.01124	(Ma et al., 2022)
0.200563	0.13575	1.0024	0.001	(Bin Babar et al., 2016) (*Fitting in this study*)
0.189	0.486	0.0958	0.0022	(Wang et al., 2014)
0.11	0.29	0.40	0.004	(Wang et al., 2011)
0.239	0.169	0.042	0.001	(Cocker Iii et al., 2001)

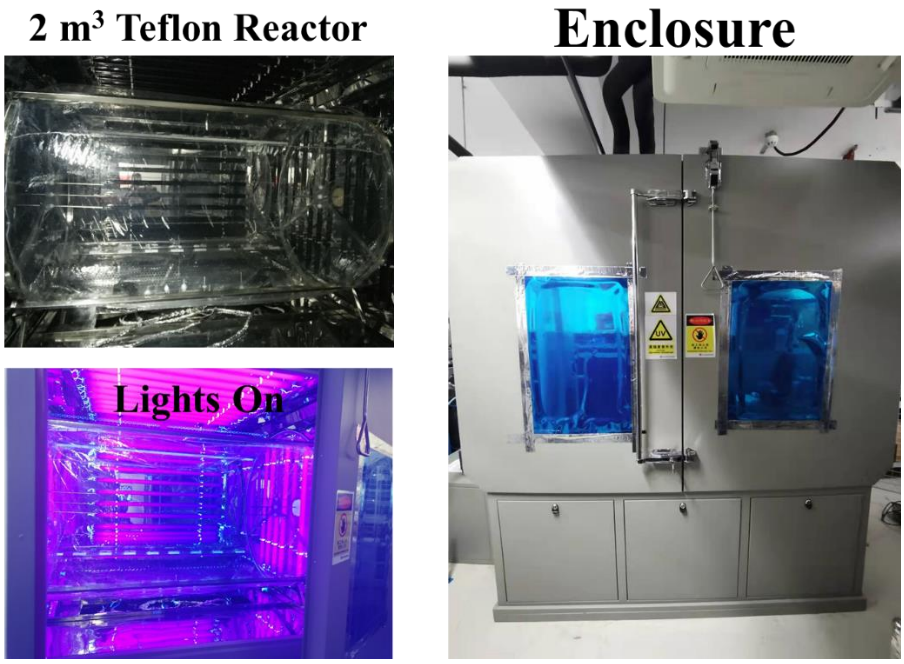

Figure S1. Pictures of this AIR Teflon chamber (reactor and its enclosure)

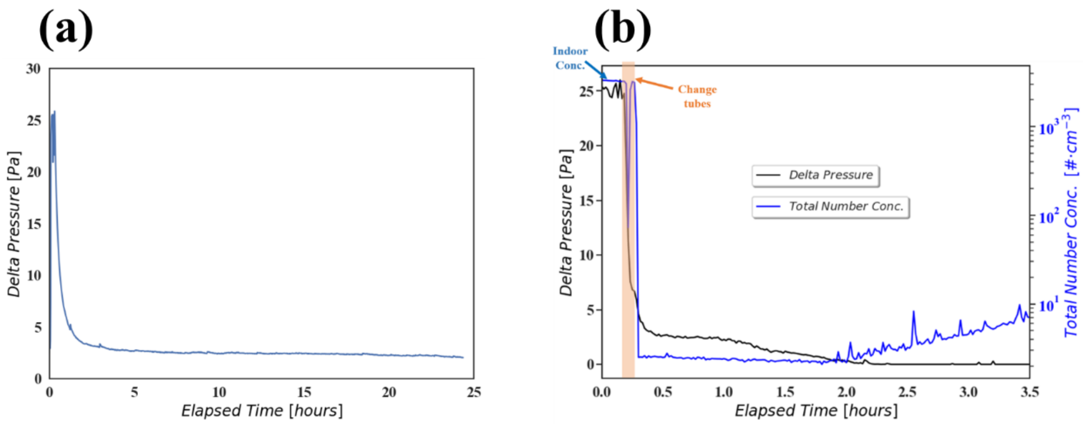

Figure S2. Description of leakproofness for the reactor

Figure S3. Pictures of the shrinked volumes with the amount of gas lost

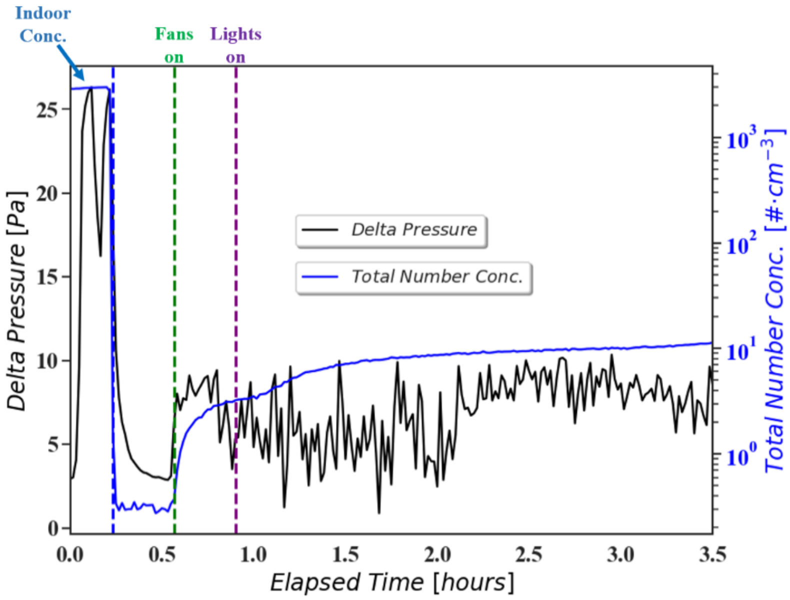

Figure S4. Interference test of lights and fans working on the background particle number concentration

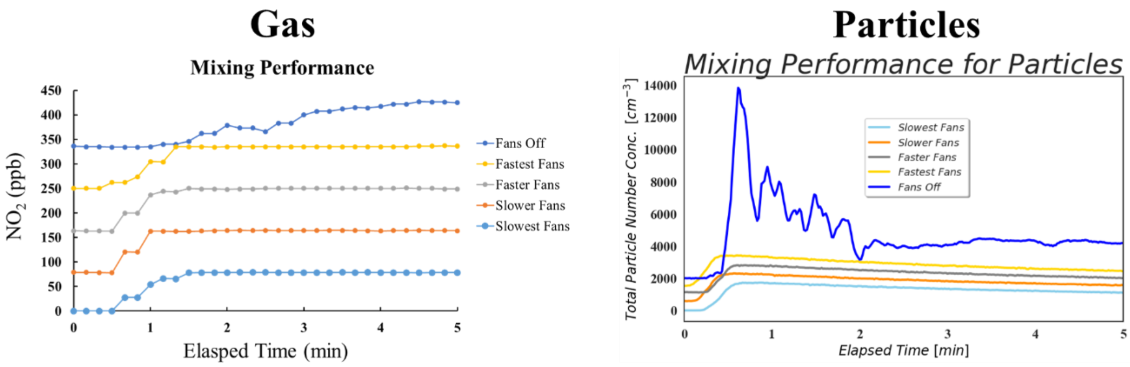

Figure S5. Mixing performance of gases and particles

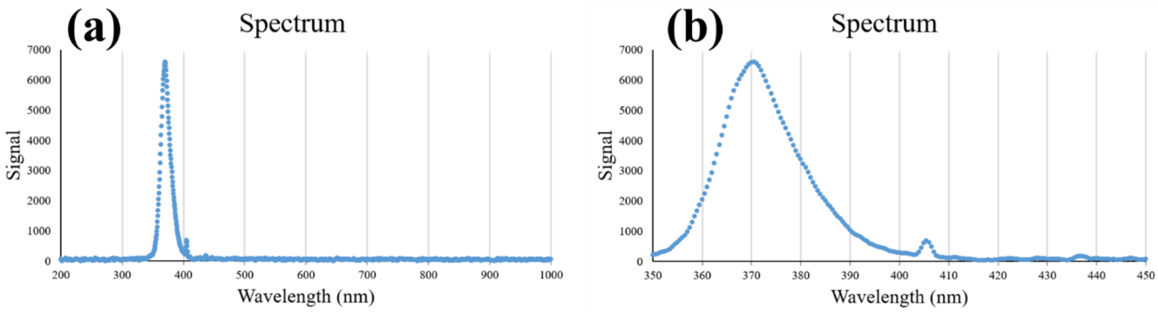

Figure S6. Radiation spectral distribution characteristics of the current artificial lights

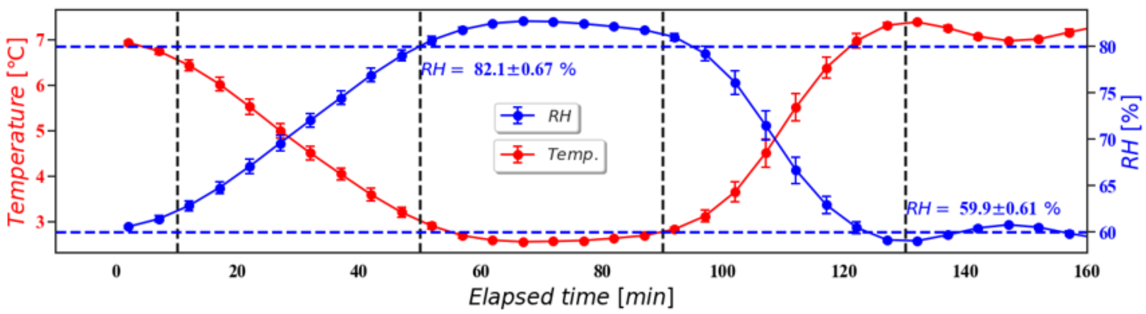

Figure S7. Control performance for RH cycle change in this chamber system

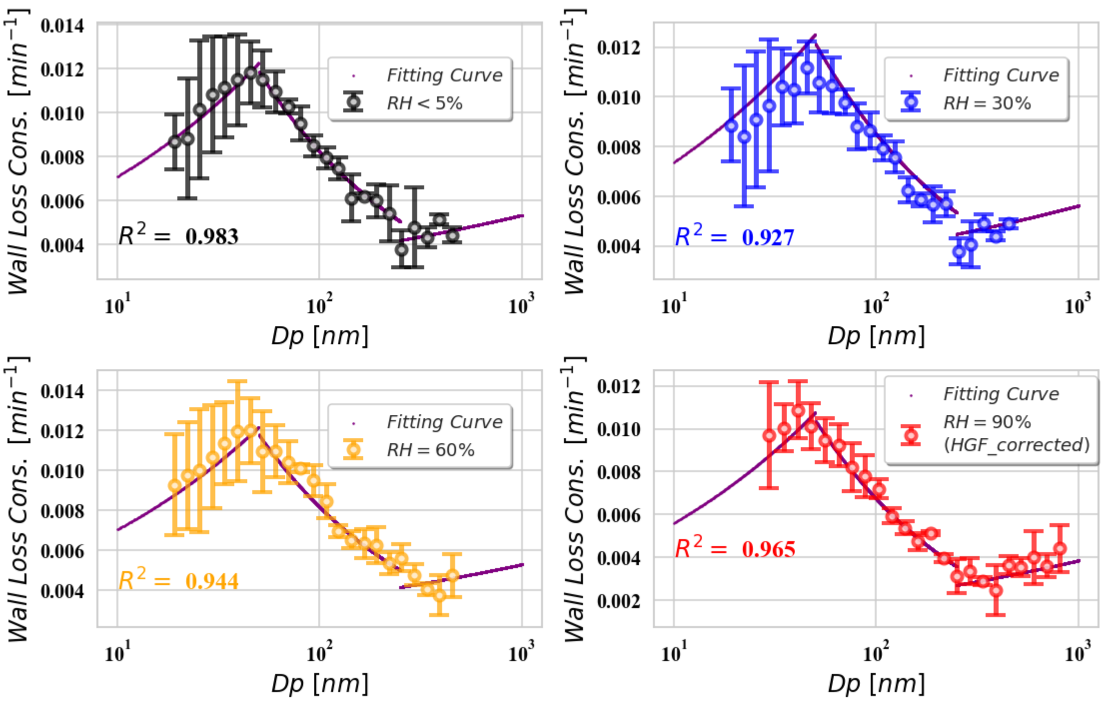

Figure S8. Wall loss rate constants of ammonium sulfates particles under different RH as a function of particle size

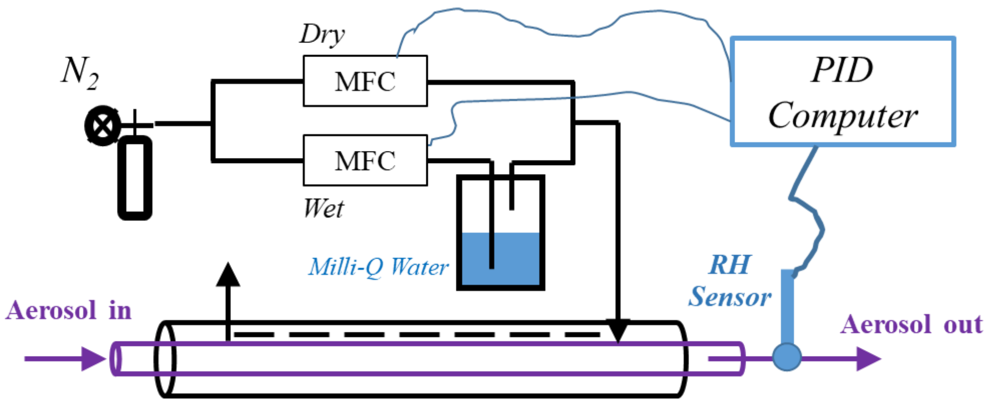

Figure S9. Diagram of the pre-RH-control device for seed particles

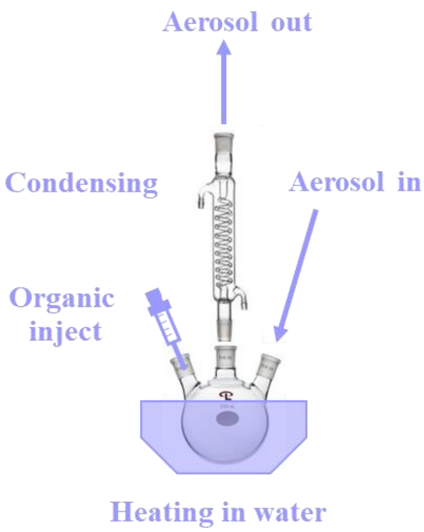

Figure S10. Diagram of the coating device for seed particles

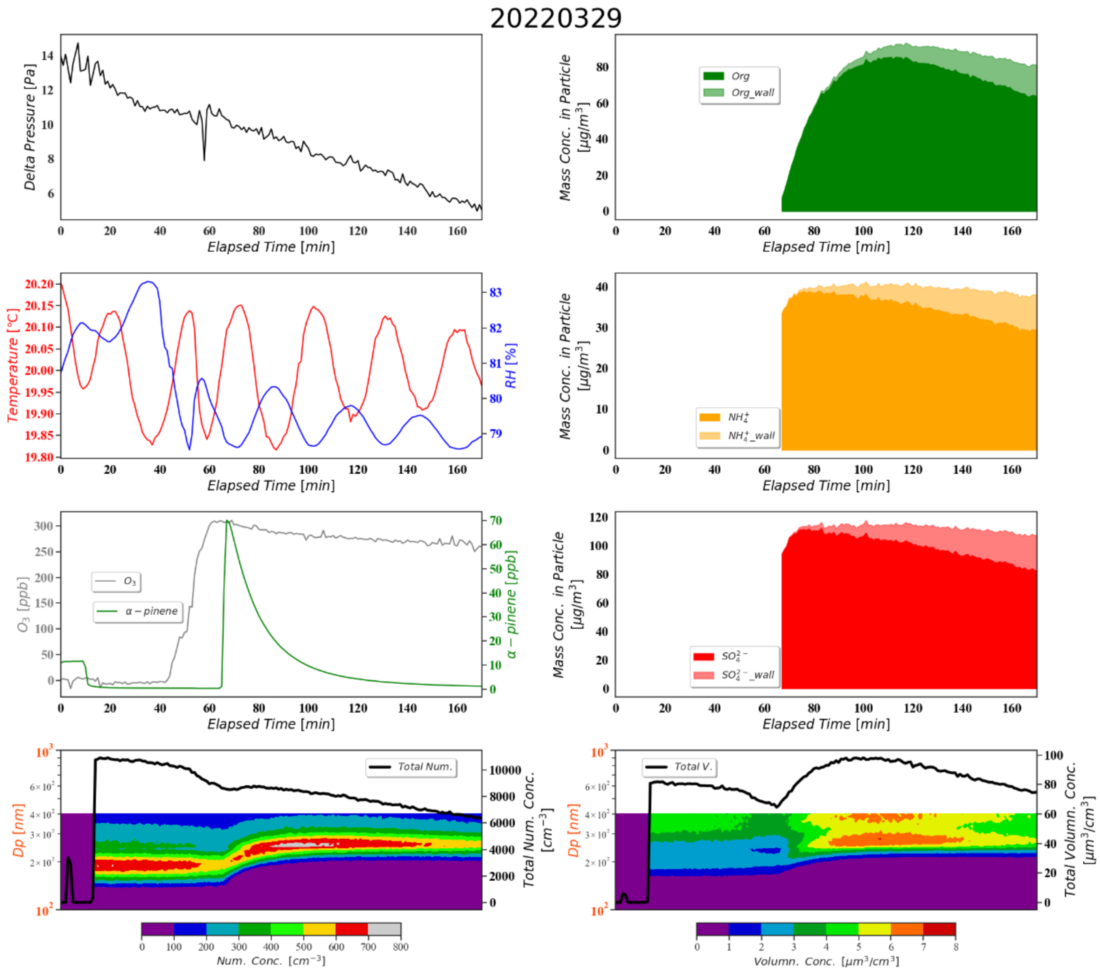

Figure S11. Example data from an α-pinene ozonolysis experiment (deliquescent ammonium sulfate seeds, 80% RH)

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