Supplement of

Critical Role of Dust Induced Electrostatic Coagulation in the Evolution of Aerosol Size Distributions in the Atmosphere

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Supplementary Information

This file includes 13 Figures and 5 Tables:

Supplementary Figure S12. Evolution of the particle size distribution (PSD) during electrostatic coagulation in a dust-only aerosol system at 25 ℃ with an initial number concentration of 2000 #/cm^3.

Supplementary Figure S13. Evolution of the particle charge distribution during electrostatic coagulation in a dust-only aerosol system at 25 ℃ with an initial number concentration of 2000 #/cm^3.

Table S1. Soil sampling locations and soil textures.

Table S2. DMA operating electrical mobility Z_p set points for selecting dust aerosols with specific electrical mobilities.

Table S3. Ambient particles locations.

Table S4. Boltzmann equilibrium charge-state probabilities (z = −6 to +6 e).

Table S5. Size-bin edges (sorted in ascending order by column).

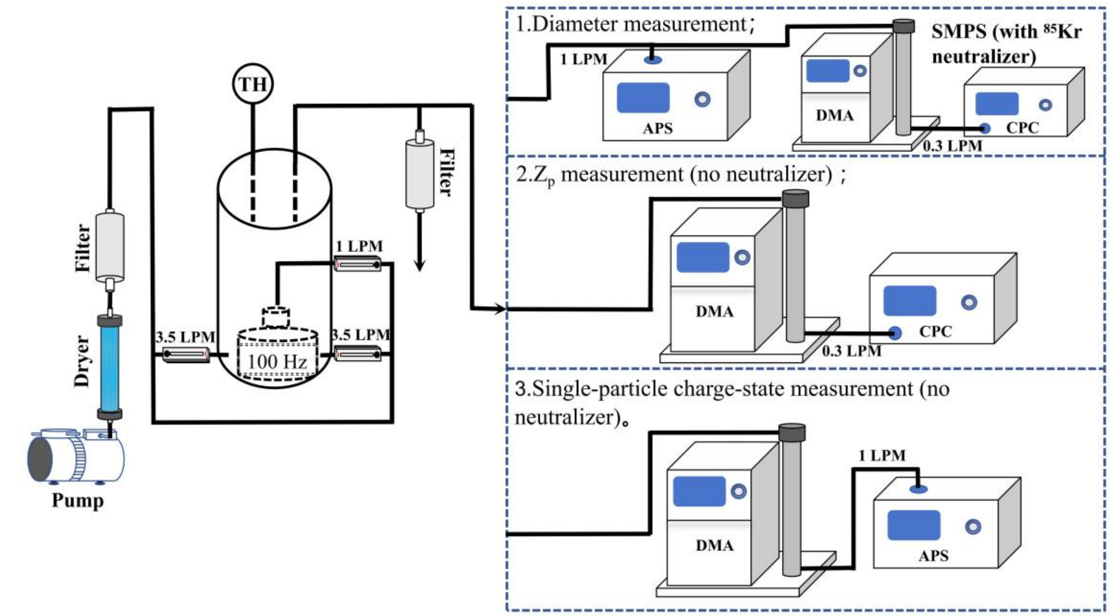

Figure S1. Schematic drawing of the experimental setup for dust aerosol measurement.

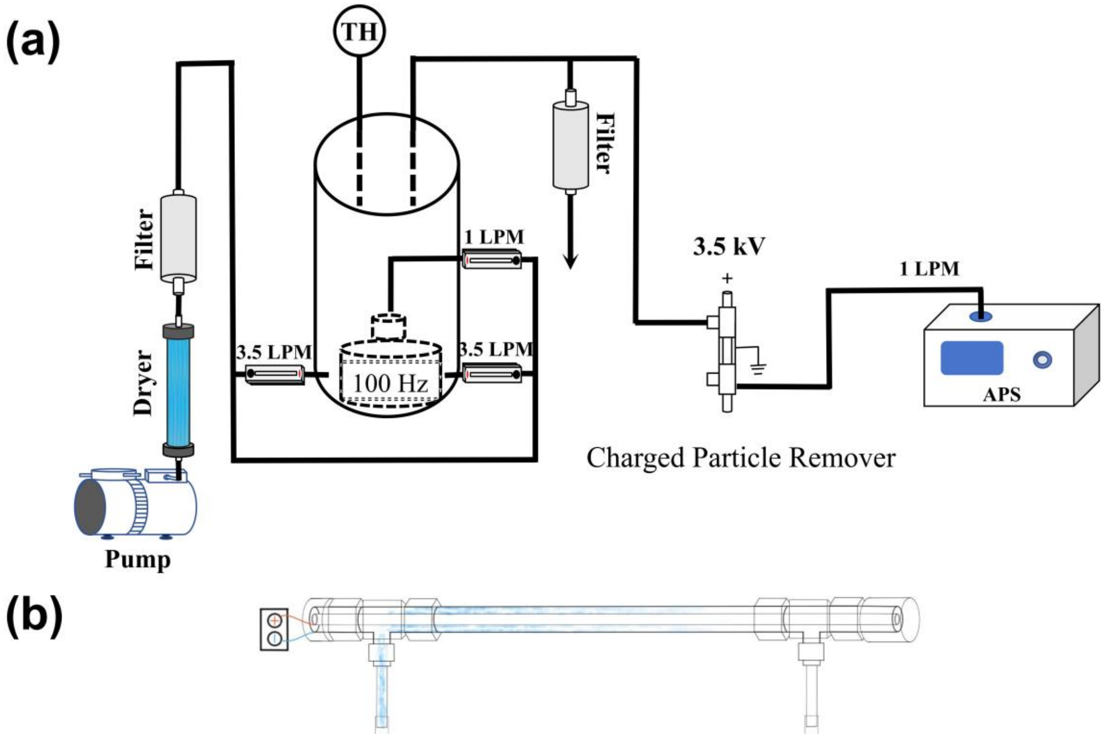

Figure S2. Experimental setup for measuring the charged fraction of dust aerosols. (a) Schematic of the setup used to measure the charged fraction of dust aerosols. (b) Geometry and operating parameters of the Charged Particle Remover (CPR), which consists of two coaxially aligned stainless-steel tubes: the inner tube has an outer diameter of 6.35 mm and the outer tube has an inner diameter of 14 mm; the length from inlet to outlet is 50 mm. The inner and outer tubes are connected to the positive and negative terminals of an adjustable high-voltage power supply, respectively.

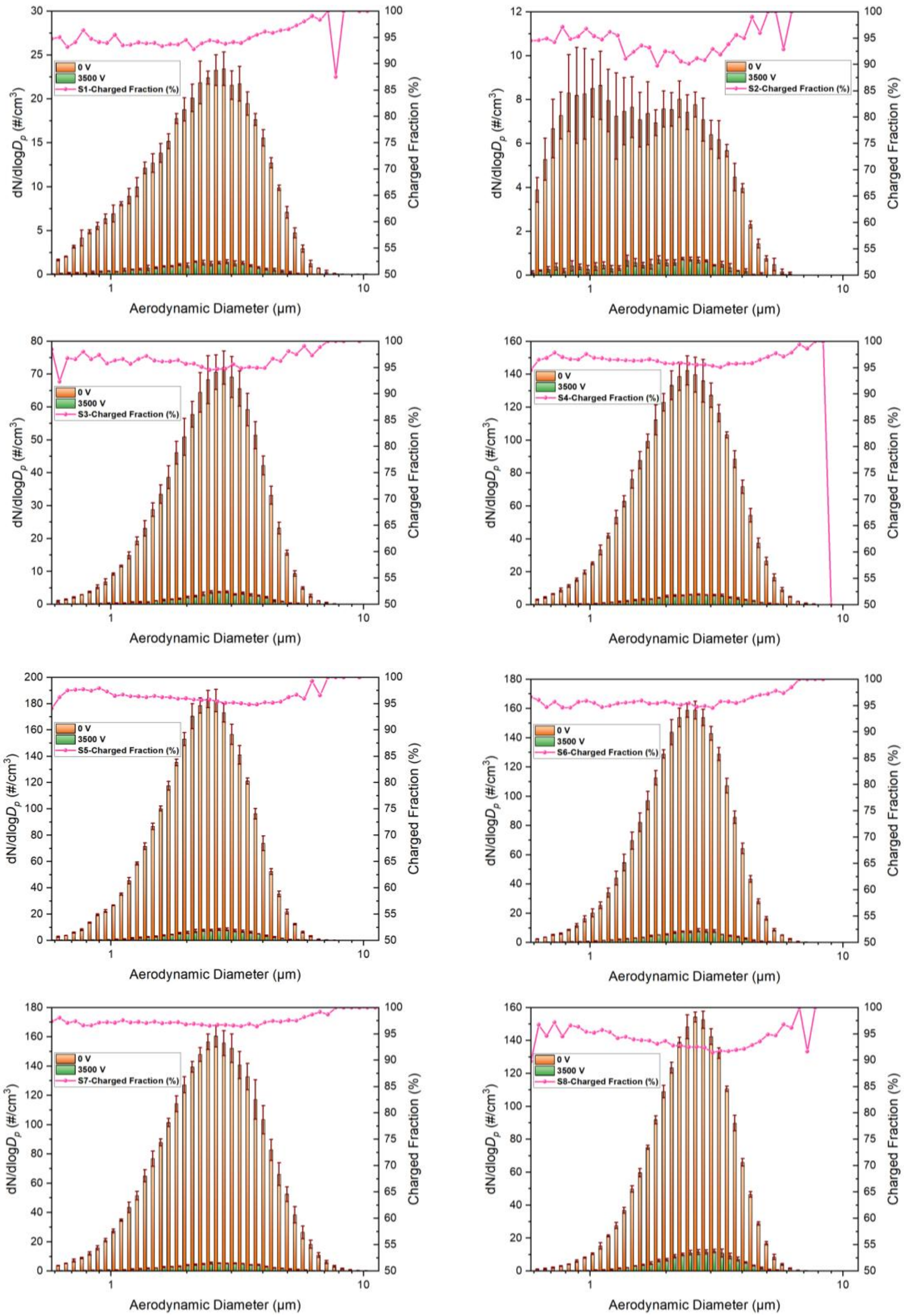

Figure S3. Charged fractions of the eight dust aerosol samples. Green and orange bars show the PSDs measured under 0 V and 3500 V, respectively. The pink line denotes the charged fraction as a function of aerodynamic diameter (0.5–10 μm). Sample IDs are indicated in the legend.

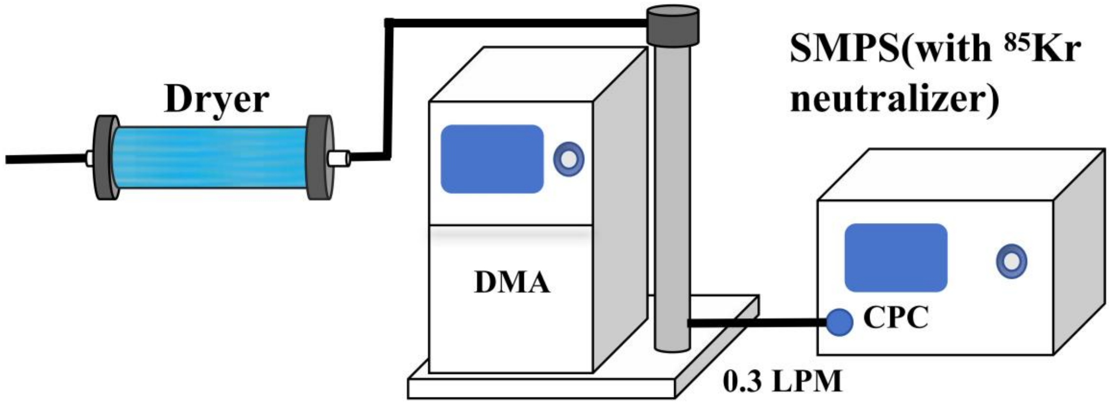

Figure S4. Experimental setup for measuring the electrical mobility diameter of ambient aerosols.

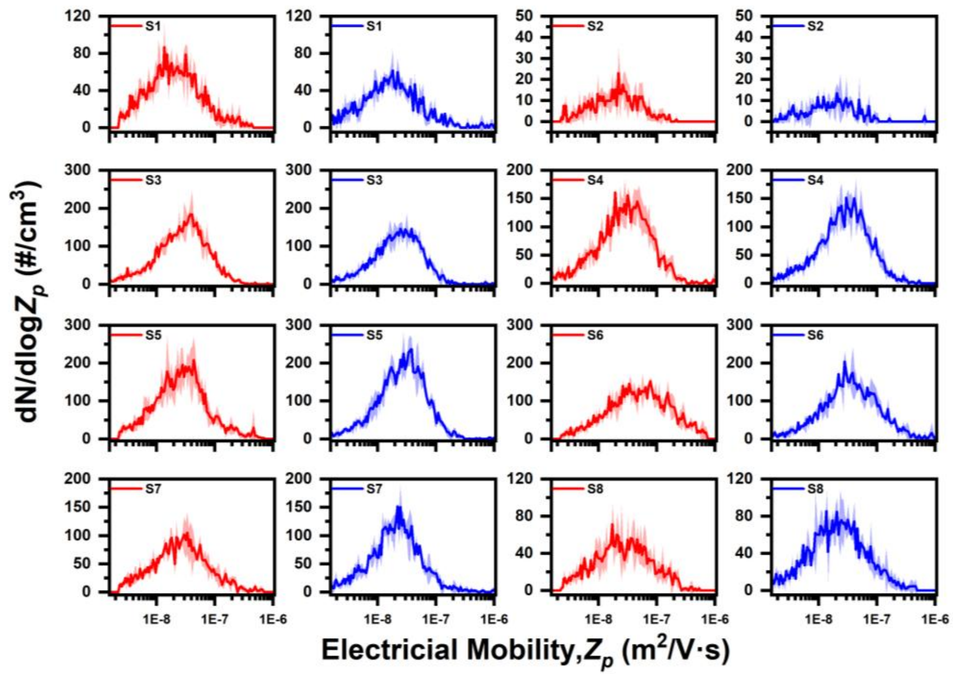

Figure S5. Electrical mobility data for the eight dust aerosol samples. Red indicates positively charged particles, and blue indicates negatively charged particles.

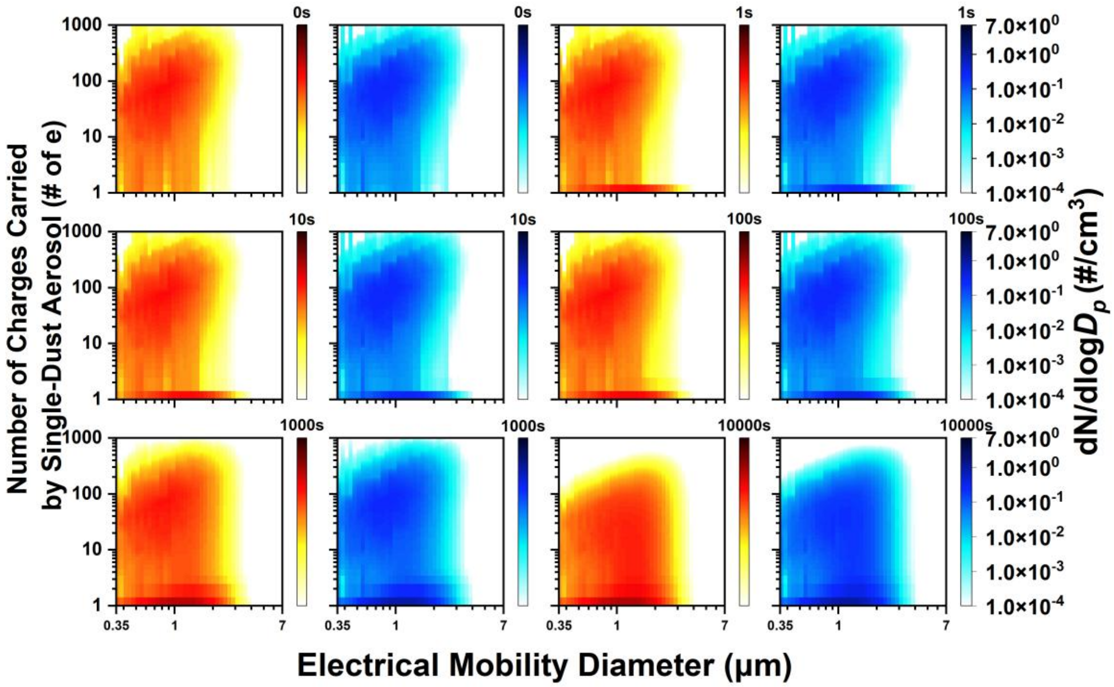

Figure S6. Evolution of the particle charge distribution during electrostatic coagulation in a dust-only aerosol system at 25 ℃ with an initial number concentration of 50 #/cm^3.

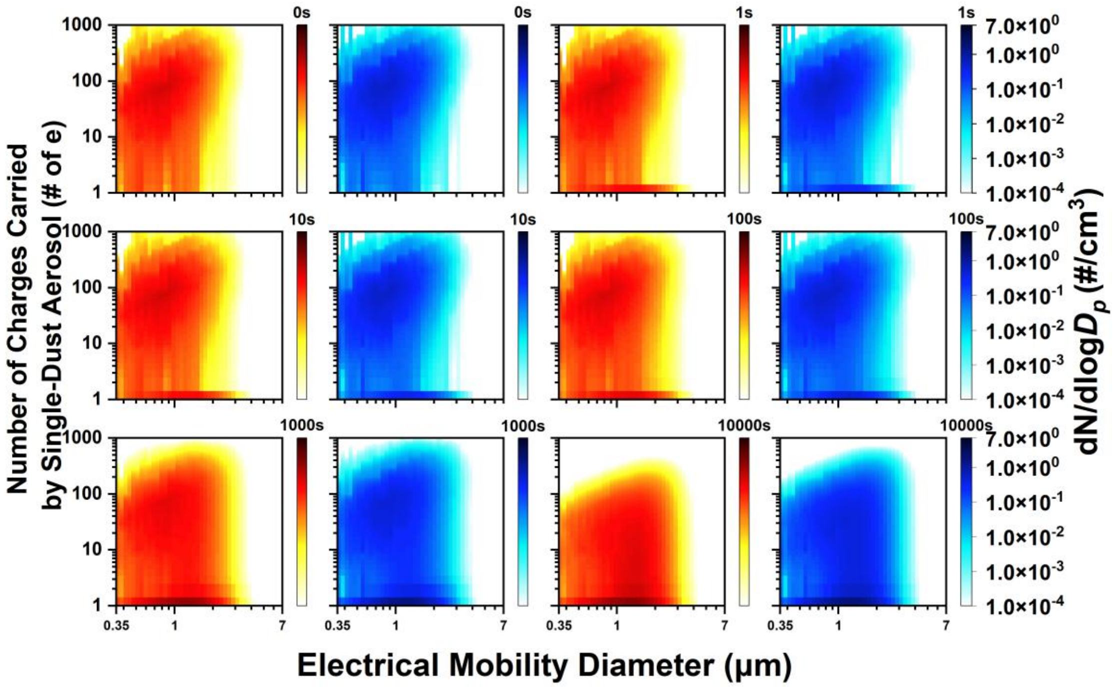

Figure S7. Evolution of the particle charge distribution during electrostatic coagulation in a dust-only aerosol system at 25 °C with an initial number concentration of 100 #/cm^3.

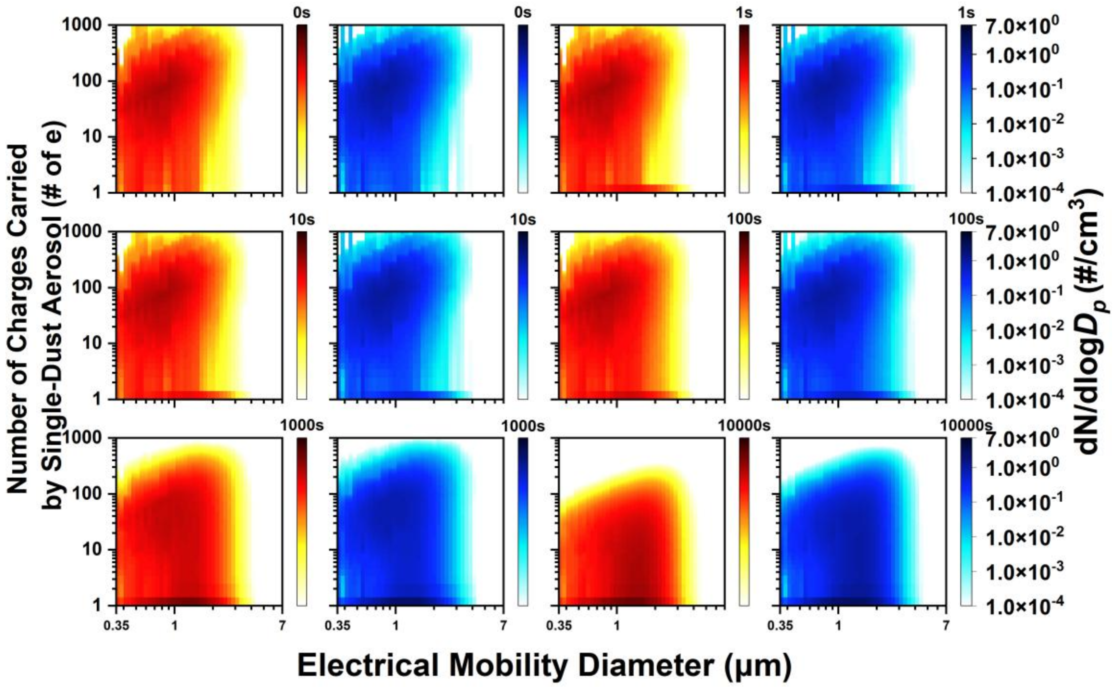

Figure S8. Evolution of the particle charge distribution during electrostatic coagulation in a dust-only aerosol system at 25 ℃ with an initial number concentration of 200 #/cm^3.

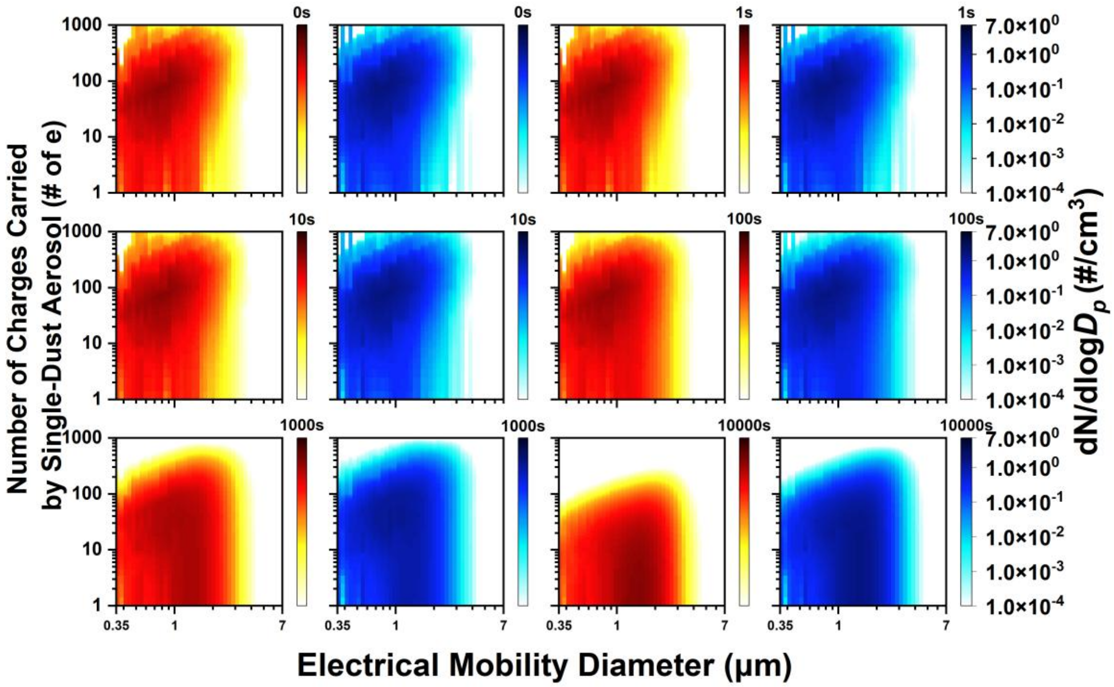

Figure S9. Evolution of the particle charge distribution during electrostatic coagulation in a dust-only aerosol system at 25 °C with an initial number concentration of 300 #/cm^3.

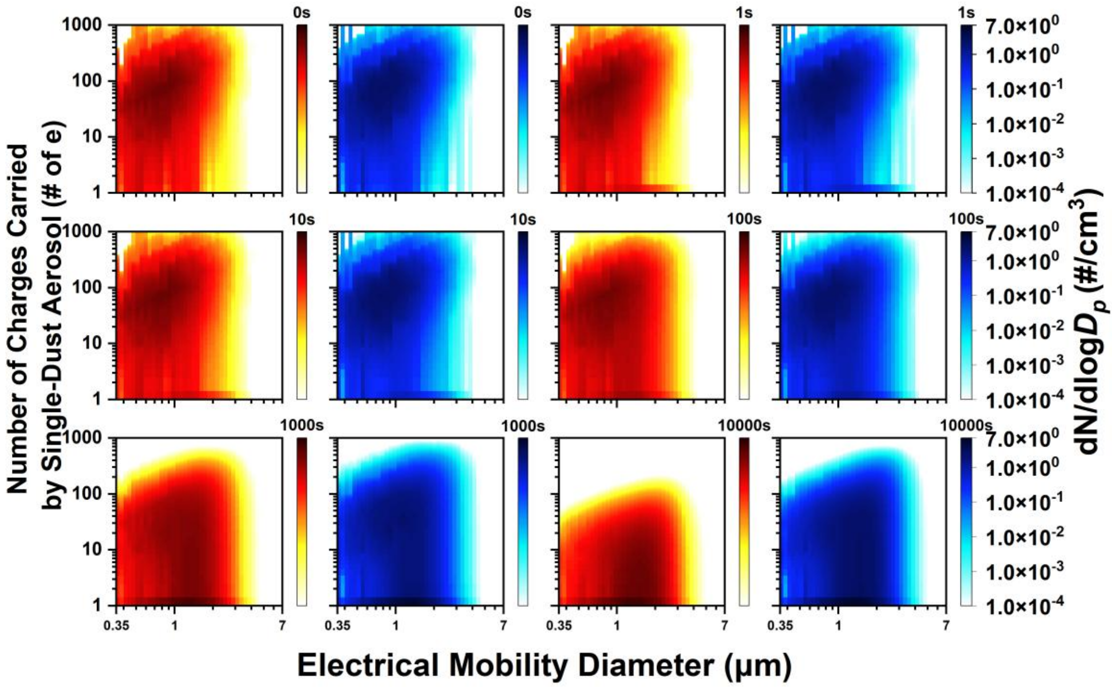

Figure S10. Evolution of the particle charge distribution during electrostatic coagulation in a dust-only aerosol system at 25 ℃ with an initial number concentration of 500 #/cm^3.

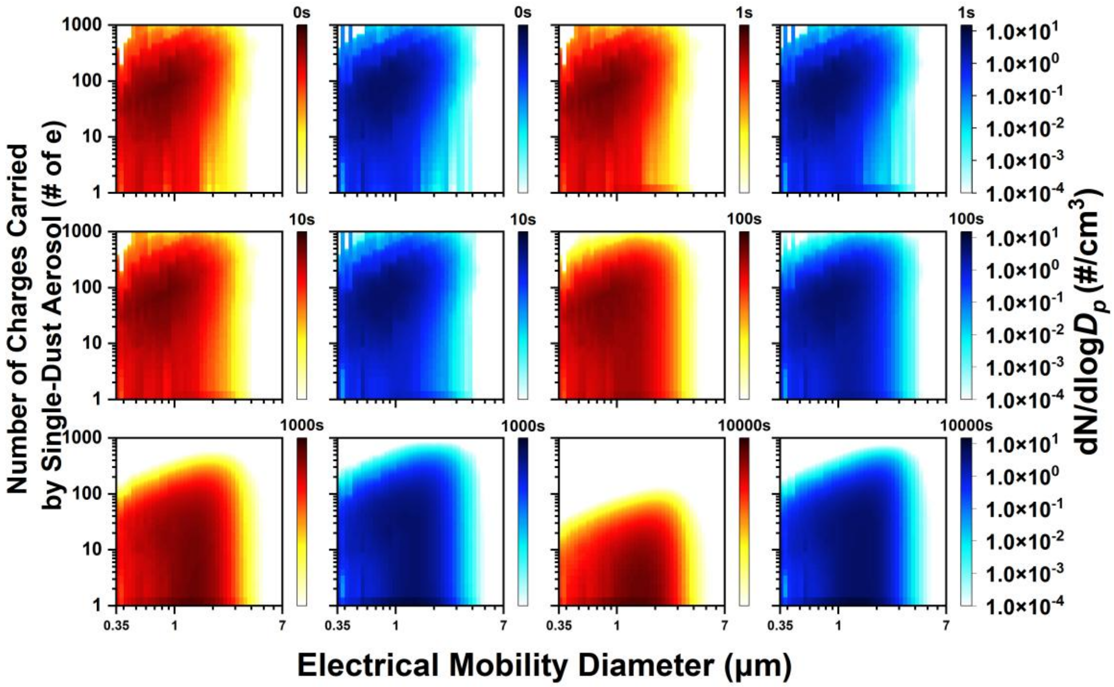

Figure S11. Evolution of the particle charge distribution during electrostatic coagulation in a dust-only aerosol system at 25 ℃ with an initial number concentration of 1000 $\#/cm^3$. The color bar indicates number concentration ($dN/dlogD_p$, $\#/cm^3$) and is capped at 15 $\#/cm^3$.

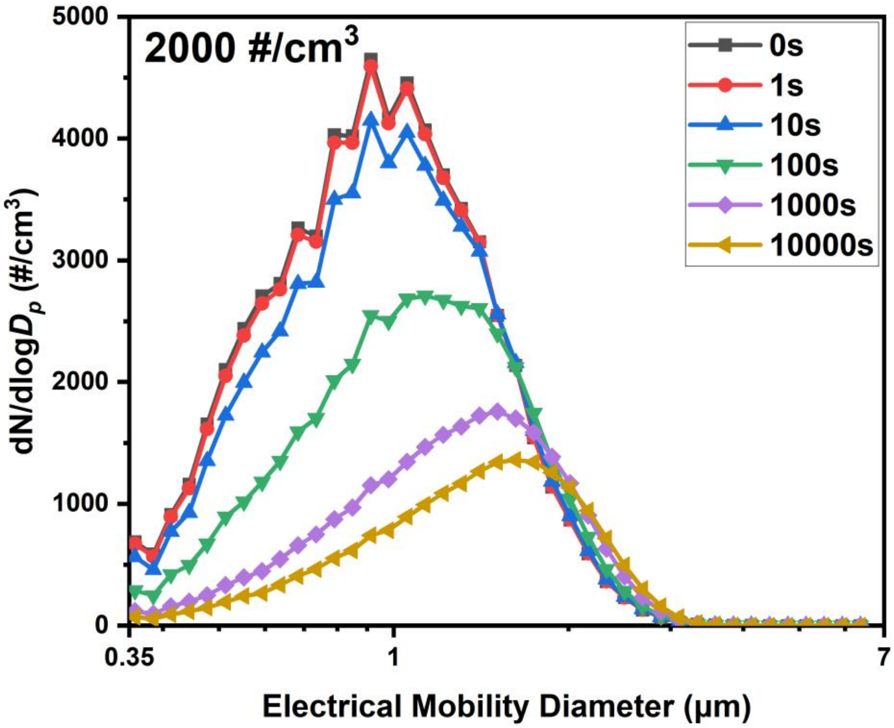

Figure S12. Evolution of the PSD during electrostatic coagulation in a dust-only aerosol system at 25 °C with an initial number concentration of 2000 #/cm^3.

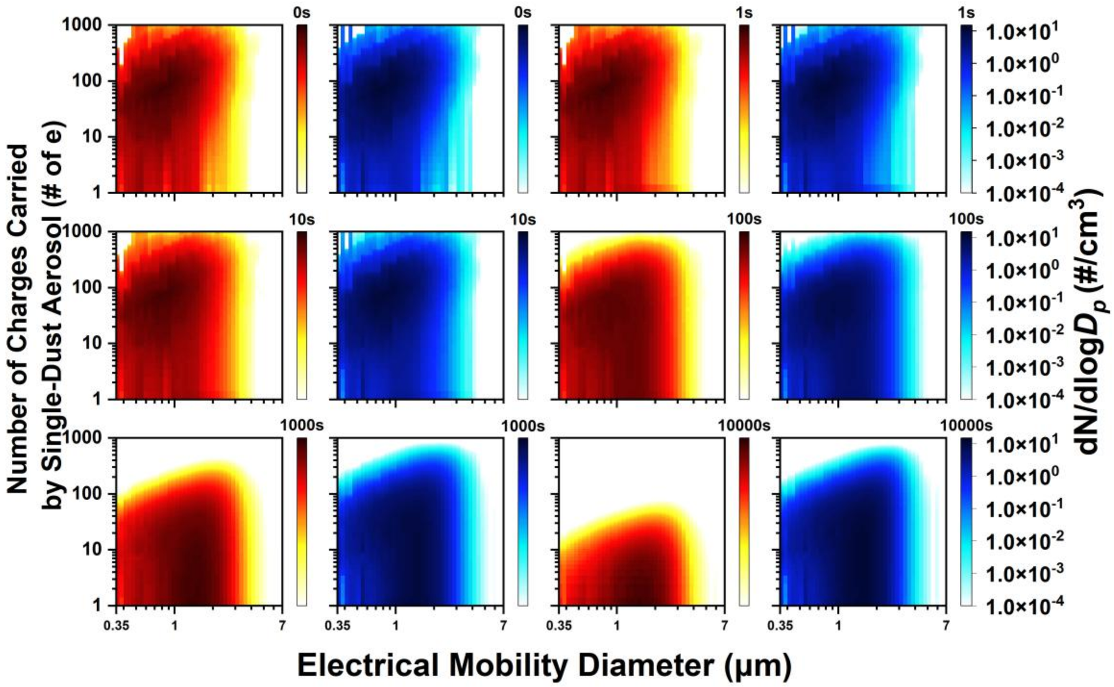

Figure S13. Evolution of the particle charge distribution during electrostatic coagulation in a dust-only aerosol system at 25 ℃ with an initial number concentration of 2000 #/cm^3. The color bar indicates number concentration (dN/dlogD$_p$, #/cm^3) and is capped at 15 #/cm^3.

Table S1. Soil sampling locations and soil textures.

Soils	Location	Soil Texture
S1	E 93.8641° N 40.3535°	sand
S2	E 94.6694° N 40.0875°	sand
S3	E 113.2347° N 41.0082°	loamy sand
S4	E 113.2245° N 41.0020°	silt loam
S5	E 111.7782° N 40.9207°	silt loam
S6	E 120.9210° N 31.0780°	silt loam
S7	E 121.5277° N 31.3361°	loam
S8	E 105.2029º N 30.4996º	silty clay loam

Table S2. DMA operating electrical mobility Z_p set points for selecting dust aerosols with specific electrical mobilities.

No.	Z_p ($m^2/v \cdot s$)
1	4.67886×10^{-9}
2	7.8278×10^{-9}
3	1.36459×10^{-8}
4	2.47569×10^{-8}
5	4.63801×10^{-8}
6	8.94994×10^{-8}
7	1.75627×10^{-7}
8	3.51371×10^{-7}
9	7.02561×10^{-7}

Table S3. Ambient particles locations. The sampling inlet was located on the seventh floor, approximately 20 m above ground level.

Fine Particulate Matter	Location
FuDan University	E 121.5210° N 31.3260°

Table S4. Boltzmann equilibrium charge-state probabilities (z = −6 to +6 e).

		Fraction of Total Particle Concentration That Carries This Number (-6 to +6) of Charges												
particle Diameter Midpoint, (nm)	Mobility Midpoint $m^2/v \cdot s$	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6
14.33	1.03E-02	0	0	0	0	0	0.07740	0.86198	0.06060	0	0	0	0	0
16.55	7.77E-03	0	0	0	0	0	0.09030	0.83938	0.07030	0	0	0	0	0
19.11	5.86E-03	0	0	0	0	0	0.10470	0.81425	0.08100	0	0	0	0	0
22.07	4.43E-03	0	0	0	0	0.00040	0.12050	0.78618	0.09280	0.00020	0	0	0	0
25.48	3.35E-03	0	0	0	0	0.00080	0.13750	0.75588	0.10540	0.00040	0	0	0	0
29.43	2.54E-03	0	0	0	0	0.00150	0.15540	0.72334	0.11880	0.00090	0	0	0	0
33.98	1.93E-03	0	0	0	0	0.00290	0.17390	0.68883	0.13270	0.00170	0	0	0	0
39.24	1.47E-03	0	0	0	0	0.00510	0.19260	0.65272	0.14670	0.00290	0	0	0	0
45.32	1.12E-03	0	0	0	0	0.00840	0.21090	0.61545	0.16050	0.00480	0	0	0	0
52.33	8.53E-04	0	0	0	0	0.01310	0.22820	0.57755	0.17370	0.00750	0	0	0	0
60.43	6.54E-04	0	0	0	0	0.01950	0.24400	0.53969	0.18570	0.01110	0	0	0	0
69.78	5.03E-04	0	0	0	0	0.02780	0.25760	0.50260	0.19630	0.01570	0	0	0	0
80.58	3.89E-04	0	0	0	0.00120	0.03790	0.26860	0.46539	0.20500	0.02130	0.00050	0	0	0
93.06	3.01E-04	0	0	0	0.00260	0.04970	0.27660	0.43040	0.21150	0.02800	0.00120	0	0	0
107.46	2.35E-04	0	0	0.00010	0.00510	0.06280	0.28120	0.39728	0.21550	0.03560	0.00230	0	0	0
124.09	1.84E-04	0	0	0.00040	0.00910	0.07670	0.28250	0.36632	0.21690	0.04390	0.00410	0.00010	0	0
143.3	1.45E-04	0	0	0.00100	0.01460	0.09090	0.28040	0.33774	0.21580	0.05250	0.00660	0.00040	0	0
165.48	1.15E-04	0	0.00010	0.00230	0.02200	0.10470	0.27510	0.31172	0.21220	0.06120	0.00990	0.00080	0	0
191.1	9.23E-05	0	0.00030	0.00440	0.03090	0.11740	0.26710	0.28841	0.20650	0.06940	0.01390	0.00150	0.00010	0
220.67	7.43E-05	0.00010	0.00090	0.00770	0.04110	0.12850	0.25680	0.26786	0.19890	0.07680	0.01850	0.00260	0.00020	0
254.83	6.02E-05	0.00020	0.00190	0.01250	0.05220	0.13760	0.24480	0.25006	0.18980	0.08290	0.02340	0.00430	0.00050	0
294.27	4.91E-05	0.00050	0.00370	0.01870	0.06340	0.14430	0.23160	0.23483	0.17970	0.08730	0.02840	0.00640	0.00100	0.00010
339.82	4.04E-05	0.00120	0.00660	0.02620	0.07420	0.14860	0.21780	0.22184	0.16900	0.09010	0.03330	0.00900	0.00170	0.00020
392.42	3.34E-05	0.00250	0.01080	0.03480	0.08420	0.15050	0.20390	0.21058	0.15810	0.09100	0.03780	0.01200	0.00280	0.00050
453.16	2.77E-05	0.00460	0.01620	0.04400	0.09290	0.15030	0.19040	0.20035	0.14740	0.09030	0.04170	0.01510	0.00430	0.00090
523.3	2.32E-05	0.00790	0.02290	0.05340	0.10010	0.14810	0.17770	0.19035	0.13720	0.08830	0.04490	0.01830	0.00600	0.00160
604.3	1.94E-05	0.01230	0.03050	0.06230	0.10560	0.14450	0.16610	0.17970	0.12780	0.08540	0.04740	0.02140	0.00800	0.00250
697.83	1.63E-05	0.01800	0.03860	0.07050	0.10930	0.13980	0.15600	0.16748	0.11940	0.08210	0.04900	0.02420	0.01020	0.00360
805.84	1.38E-05	0.02460	0.04690	0.07750	0.11130	0.13450	0.14750	0.15282	0.11210	0.07890	0.04990	0.02660	0.01230	0.00500

The equation is as follows:

$$f(N)=10^{[\sum_{i=0}^{5} a_i(N)(\log\frac{D_p}{nm})^i]} \tag{1}$$

Applicable aerosols size range:

$$1\ \text{nm} \le D_p \le 1000\ \text{nm for N} = -1, 0, 1$$

$$20\ \text{nm} \le D_p \le 1000\ \text{nm for } N = -2, 2$$

$a_i(N)$	N=-2	N=-1	N=0	N=1	N=2
a_0	-26.3328	-2.3197	-0.0003	-2.3484	-44.4756
a_1	35.9044	0.6175	-0.1014	0.6044	79.3772
a_2	-21.4608	0.6201	0.3073	0.4800	-62.8900
a_3	7.0867	-0.1105	-0.3372	0.0013	26.4492
a_4	-1.3088	-0.1260	0.1023	-0.1553	-5.7480
a_5	0.1051	0.0297	-0.0105	0.0320	0.5049

For the fraction of particles carrying three or more charges, use Equation which is based on a derivation by Gunn from 1956:

$$f(N) = \frac{e}{\sqrt{4\pi^2 \varepsilon_0 D_p k T}} \exp \frac{-\left[N - \frac{2\pi\varepsilon_0 D_p kT}{e^2} \ln\left(\frac{Z_{i+}}{Z_{i-}}\right)\right]^2}{2\frac{2\pi\varepsilon_0 D_p kT}{e^2}} \qquad (2)$$

Where e ($1.60217733 \times 10^{-19}$ C) is elementary charge, ε_0 ($8.854187817 \times 10^{-12}$ F/m) is dielectric constant, D_p (m) is electrical mobility diameter, T (K) is Temperature, N is number of elementary charge units, $\frac{Z_{i+}}{Z_{i-}}$ (0.875,Wiedensohler, A. 1988) is ion mobility ratio.

Table S5. Size-bin edges (sorted in ascending order by column)

Background (non-dust) ambient aerosol size-bin edges (14.1–346 nm; 90 edges)								
14.1		31.1		68.5		151.2		333.8
14.6		32.2		71		156.8		346
15.1		33.4		73.7		162.5		
15.7		34.6		76.4		168.5		
16.3		35.9		79.1		174.7		
16.8		37.2		82		181.1		
17.5		38.5		85.1		187.7		
18.1		40		88.2		194.6		
18.8		41.4		91.4		201.7		
19.5		42.9		94.7		209.1		
20.2		44.5		98.2		216.7		
20.9		46.1		101.8		224.7		
21.7		47.8		105.5		232.9		
22.5		49.6		109.4		241.4		
23.3		51.4		113.4		250.3		
24.1		53.3		117.6		259.5		
25		55.2		121.9		269		
25.9		57.3		126.3		278.8		
26.9		59.4		131		289		
27.9		61.5		135.8		299.6		
28.9		63.8		140.7		310.6		
30		66.1		145.9		322		

Dust aerosol size-bin edges (0.358–6.37 µm; 41 edges).								
0.358		0.684		1.308		2.499		4.776
0.385		0.735		1.406		2.685		5.132
0.413		0.79		1.51		2.886		5.515
0.444		0.849		1.623		3.101		5.926
0.477		0.913		1.744		3.333		6.37
0.513		0.98		1.874		3.581		
0.552		1.054		2.014		3.848		
0.593		1.132		2.164		4.135		
0.637		1.217		2.326		4.444		