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Aerodynamic size-resolved composition and cloud condensation nuclei properties of aerosols in a Beijing suburban region

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S1. The instruments overview

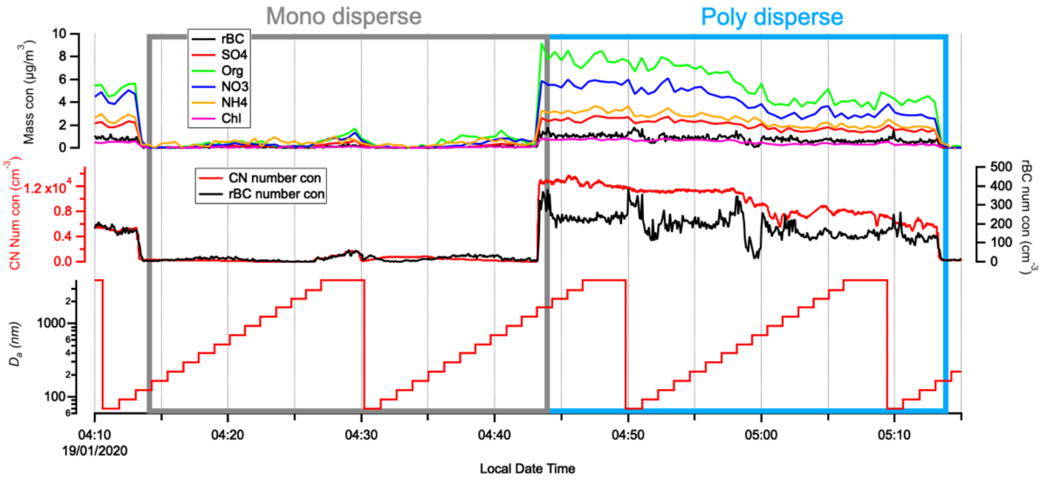

Figure S1. Example of a running cycle.

The size bins with D_a below 90 nm and above 1100 nm is excluded in this study since it is beyond the detection range of SP2 and AMS. The peak of aerosol concentrations at the end of each scan is caused by the purge and transition period of the AAC.

S2. Calculation of aerosol properties parameters

The particle density of all and non-refractory (NR) particles are calculated through:

$$\rho_{\text{all}} = \frac{M_{\text{all}}}{V_{\text{all}}} \qquad (1)$$

$$\rho_{\text{NR}} = \frac{M_{\text{NR}}}{V_{\text{NR}}} \qquad (2)$$

Where M_{all} is the mass concentration of all particles from the AMS and SP2 results, V_{all} is derived through the mass concentration of each measured composition mass concentration and the material density shown in Table S1. The calculation of ρ_{NR} is similar to the calculation of ρ_{all}, but only NR compositions from AMS are included here.

The particle density of rBCc is derived by:

$$\rho_{\mathrm{rBCc}} = \frac{M_{\mathrm{rBCc}}}{V_{\mathrm{rBCc}}} = \frac{\rho_{\mathrm{NR}} \cdot \left(\frac{1}{6}\pi D_{\mathrm{p,rBCc}}^{3} - \frac{1}{6}\pi D_{\mathrm{c}}^{3}\right) + M_{\mathrm{rBC}}}{\frac{1}{6}\pi D_{\mathrm{p,rBCc}}^{3}} \quad (3)$$

where M_{rBCc} and V_{rBCc} are the mass and volume of the rBCc respectively, the density of rBCc coating is assumed to be the same as bulk non-refractory particle density. The rBC core diameter (D_{c}) and total rBCc diameter ($D_{\mathrm{p,rBCc}}$) are derived through the SP2 LEO method.

The average single particle mass for all particles and rBCc is calculate by:

$$M_{\mathrm{single,all}} = \frac{M_{\mathrm{all}}}{N_{\mathrm{total}}} \quad (4)$$

$$M_{\mathrm{single,rBCc}} = \frac{M_{\mathrm{rBCc}}}{N_{\mathrm{rBCc}}} \quad (5)$$

Where N_{total} and N_{rBCc} is the number concentration for total CN and rBCc respectively.

Then the volume equivalent diameter of all particle is assumed to equal to the mass equivalent diameter:

$$D_{v,\mathrm{all}} = D_{m,\mathrm{all}} = \sqrt[3]{\frac{6M_{\mathrm{single,all}}}{\rho_{\mathrm{all}} \cdot \pi}} \quad (6)$$

The shape factor is derived from:

$$\chi = \frac{\rho_{\mathrm{p}} {D_{\mathrm{v}}}^{2} C_{c}(D_{v})}{{D_{\mathrm{a}}}^{2} C_{c}(D_{\mathrm{a}})} \quad (7)$$

S3. The size-resolved aerosol composition volume fractions

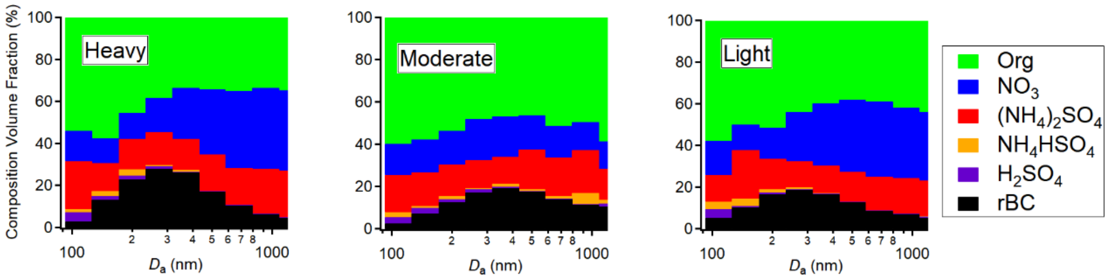

Figure S2 Composition volume fractions under different pollution level

S4. The simplified ion pairing scheme

Details about this ion pairing scheme is discussed in Gysel et al(Gysel et al., 2007), the solutions are expressed as below:

$$n_{\mathrm{NH_4NO_3}} = n_{\mathrm{NO_3^-}}$$

$$n_{\mathrm{H_2SO_4}} = \max\left(0, n_{\mathrm{SO_4^{2-}}} - n_{\mathrm{NH_4^+}} + n_{\mathrm{NO_3^-}}\right)$$

$$n_{\mathrm{NH_4HSO_4}} = \min\left(2n_{\mathrm{SO_4^{2-}}} - n_{\mathrm{NH_4^+}} + n_{\mathrm{NO_3^-}}, n_{\mathrm{NH_4^+}} - n_{\mathrm{NO_3^-}}\right)$$

$$n_{\mathrm{(NH_4)_2SO_4}} = \max\left(n_{\mathrm{NH_4^+}} - n_{\mathrm{NO_3^-}} - n_{\mathrm{SO_4^{2-}}}, 0\right)$$

$$n_{\mathrm{HNO_3}} = 0$$

where n represents the number of moles for each component.

S5. Density and hygroscopicity parameter for each composition

	Density (kg/m^3)	κ
NH_4NO_3	1720	0.67 (Petters and Kreidenweis, 2007)
$(NH_4)_2SO_4$	1769	0.61 (Petters and Kreidenweis, 2007)
$(NH_4)HSO_4$	1780	0.65 (Petters and Kreidenweis, 2007)
H_2SO_4	1830	0.90 (Petters and Kreidenweis, 2007)
Organics (Org)	1400	0.29*(O:C ratio) (Chang et al., 2010)
Black Carbon (BC)	1800	0

Table S1. The material density and hygroscopicity parameter (κ) used for calculation.

S6. Mass absorption coefficient calculation

The mass absorption coefficient of rBCc at 880 nm (MAC$_{880}$) and at 550 nm (MAC$_{550}$) is calculated by using the core-shell Mie theory approach(Bohren and Huffman, 2008). The refractive index of coating material is assumed to be $1.5 - 0i$, and the refractive index of rBC core is assumed to be $2.26 - 1.26i$ (Taylor et al., 2020). The coating material of rBCc is assumed to be non-absorbing. Both coated and uncoated cases are calculated to present the absorption enhancement from lensing effect of coatings at different size.

S7. Correlation between measured and modelled rBCc activation

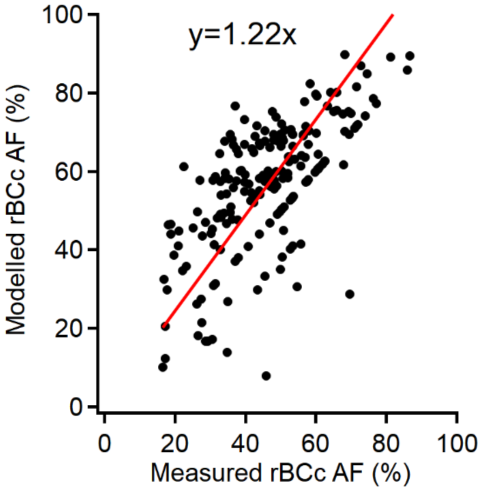

Figure S3 Correlation between measured and modelled rBCc activation fraction (AF) using Orthogonal Distance Regression (ODR) fitting method.

S8. PM_1 frequency distribution

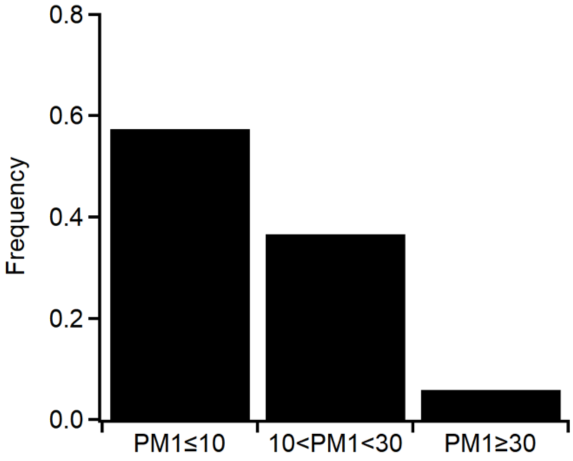

Figure S4 Frequency distribution of PM_1 concentrations

References

Bohren, C. F., and Huffman, D. R.: Absorption and scattering of light by small particles, John Wiley & Sons, 2008.

Chang, R. Y. W., Slowik, J. G., Shantz, N. C., Vlasenko, A., Liggio, J., Sjostedt, S. J., Leaitch, W. R., and Abbatt, J. P. D.: The hygroscopicity parameter (κ) of ambient organic aerosol at a field site subject to biogenic and anthropogenic influences: relationship to degree of aerosol oxidation, Atmos. Chem. Phys., 10, 5047-5064, 10.5194/acp-10-5047-2010, 2010.

Gysel, M., Crosier, J., Topping, D. O., Whitehead, J. D., Bower, K. N., Cubison, M. J., Williams, P. I., Flynn, M. J., McFiggans, G. B., and Coe, H.: Closure study between chemical composition and hygroscopic growth of aerosol particles during TORCH2, Atmos. Chem. Phys., 7, 6131-6144, 10.5194/acp-7-6131-2007, 2007.

Petters, M. D., and Kreidenweis, S. M.: A single parameter representation of hygroscopic growth and cloud condensation nucleus activity, Atmos. Chem. Phys., 7, 1961-1971, 10.5194/acp-7-1961-2007, 2007.

Taylor, J. W., Wu, H., Szpek, K., Bower, K., Crawford, I., Flynn, M. J., Williams, P. I., Dorsey, J., Langridge, J. M., Cotterell, M. I., Fox, C., Davies, N. W., Haywood, J. M., and Coe, H.: Absorption closure in highly aged biomass burning smoke, Atmos. Chem. Phys., 20, 11201-11221, 10.5194/acp-20-11201-2020, 2020.