

1 **SUPPLEMENTARY MATERIAL**

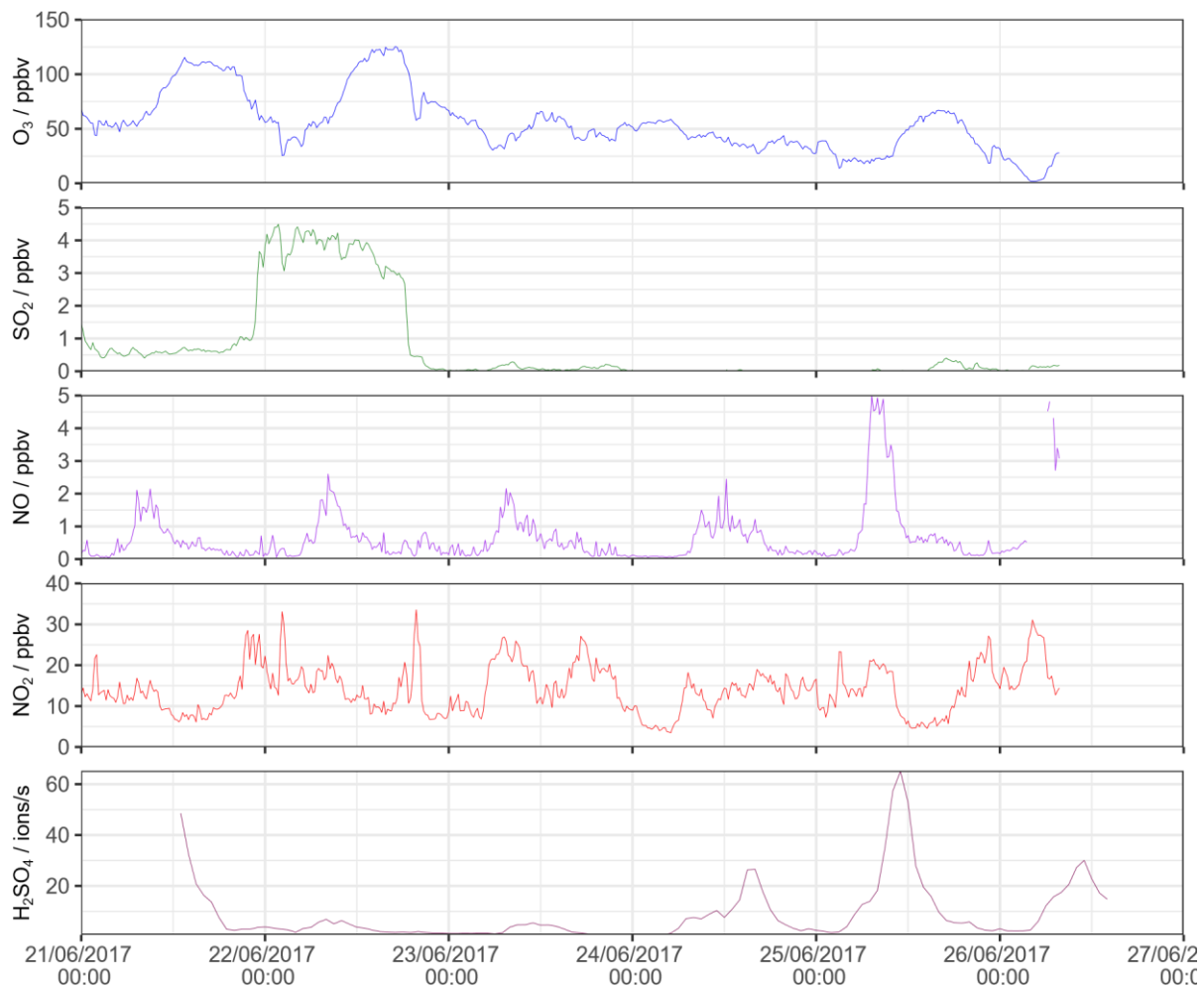
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3 **OBSERVATIONS OF HIGHLY OXIDISED**
4 **MOLECULES AND PARTICLE NUCLEATION**
5 **IN THE ATMOSPHERE OF BEIJING**

6

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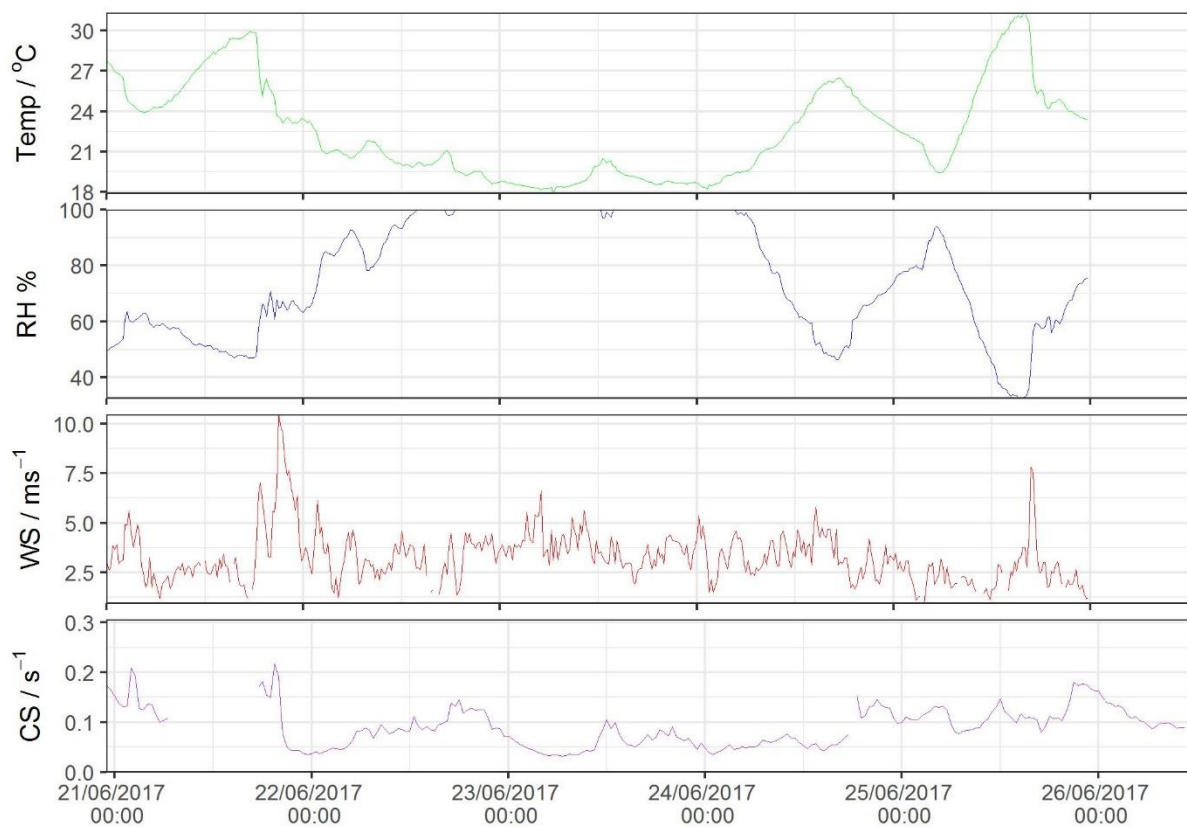
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12 **Figure S1.** Time series for (from top downwards), O₃, SO₂, NO, NO₂ and H₂SO₄.

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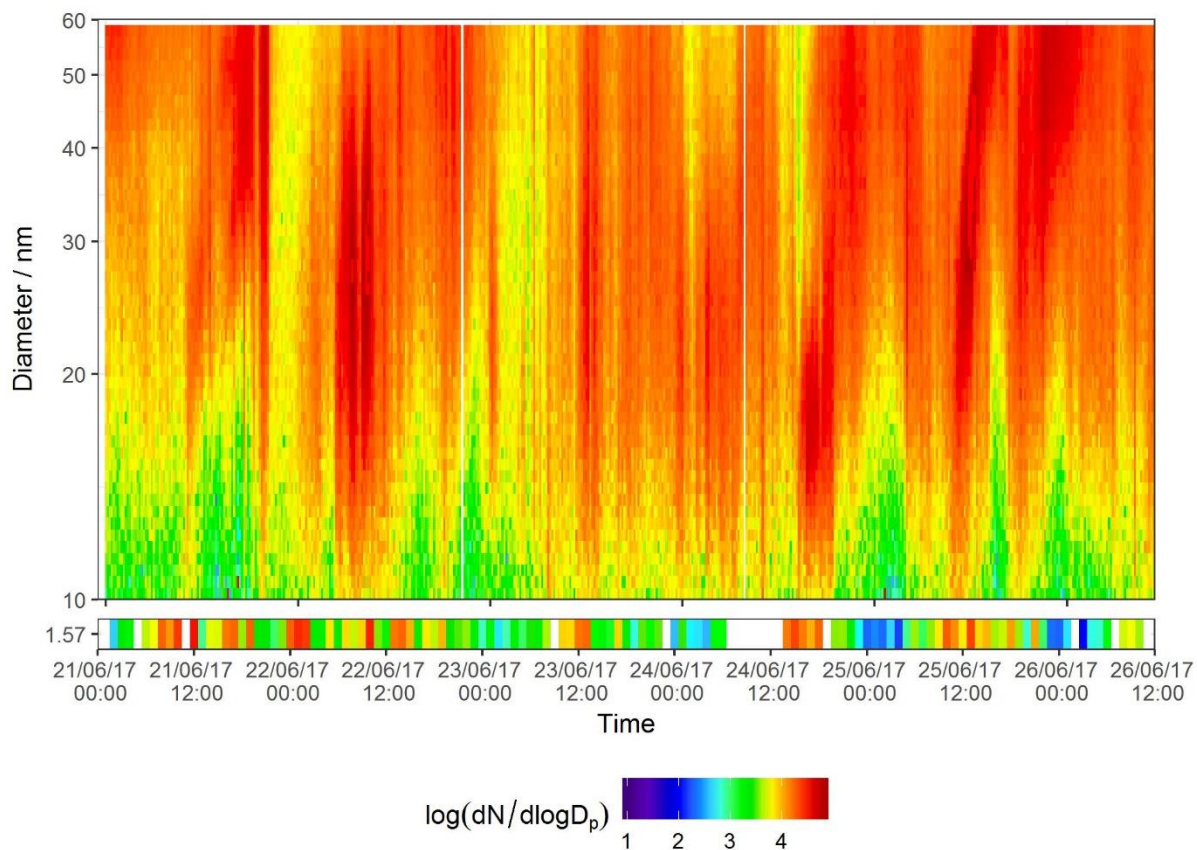


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Figure S2. MET data for the sampling period. Temperature, relative humidity and wind speed were collected at 120 M on the meteorological tower at the sampling site. Photolysis rate and particle size distribution from which condensation sink was calculated at 2 metres.

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23 **Figure S3.** SMPS + PSM contour plot for all days of sampling period. Data, from top panel to
24 bottom, from long column SMPS, nano column SMPS and PSM instruments, units in colour bar
25 are $\log_{10} (dN/d\log D_p)$ for N in cm^{-3} .

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Table S1. Relationship between molecular mass and calculated electrical mobility diameter (nm) for multiple masses up to 800 Da and densities, as calculated according to Tammet (1995), and corrected according to Larriba et al. (2011).

Mass / Da	ρ g/cm ³					
	1.0	1.2	1.4	1.6	1.8	2.0
200	1.159	1.109	1.068	1.035	1.006	0.982
300	1.284	1.226	1.179	1.141	1.109	1.081
400	1.383	1.319	1.268	1.226	1.19	1.159
500	1.466	1.397	1.342	1.297	1.259	1.226
600	1.539	1.466	1.408	1.359	1.319	1.284
700	1.605	1.528	1.466	1.415	1.372	1.335
800	1.664	1.583	1.519	1.466	1.421	1.383

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32 **Table S2.** All peaks identified by NO₃- CIMS

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Ion	Mass
C ₂ HO ₃ O ⁻	88.988
C ₃ H ₅ O ₂ O ⁻	89.025
HSO ₄ ⁻	96.96
C ₄ H ₃ O ₂ O ⁻	99.009
C ₄ H ₅ O ₂ O ⁻	101.024
C ₃ H ₃ O ₃ O ⁻	103.004
SO ₄ O ⁻	111.947
C ₆ H ₄ NO ₃ ⁻	138.019
SO ₃ NO ₃ ⁻	141.945
C ₂ H ₇ N HSO ₄ ⁻	142.018
C ₅ H ₉ O ₄ O ⁻	149.046
H ₂ SO ₄ NO ₃ ⁻	159.956
C ₃ H ₅ NO ₃ NO ₃ ⁻	165.015
C ₃ H ₄ O ₄ NO ₃ ⁻	165.999
C ₈ H ₁₁ O ₃ O ⁻	171.066
C ₇ H ₁₀ NO ₃ O ⁻	172.062
IO ₃ ⁻	174.89
C ₄ H ₆ O ₄ NO ₃ ⁻	180.015
C ₃ H ₆ NO ₄ NO ₃ ⁻	182.018
C ₄ H ₆ O ₂ HSO ₄ ⁻	182.997
C ₃ H ₆ O ₅ NO ₃ ⁻	184.01
C ₃ H ₅ O ₃ HSO ₄ ⁻	185.984
C ₅ H ₆ NO ₃ NO ₃ ⁻	191.031
C ₅ H ₈ O ₄ NO ₃ ⁻	194.031
H ₂ SO ₄ HSO ₄ ⁻	194.926

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35 **Table S2** continued

Ion	Mass
$C_4H_8O_5NO_3^-$	198.026
$C_5H_{10}O_2HSO_4^-$	199.028
$C_6H_5NO_3NO_3^-$	201.015
$HNO_3 SO_3 NO_3^-$	204.941
$C_6H_{12}NO_3NO_3^-$	208.07
$C_5H_9NO_4NO_3^-$	209.042
$C_5H_8O_5NO_3^-$	210.026
$C_4H_7NO_5NO_3^-$	211.021
$C_5H_{10}O_5NO_3^-$	212.041
$C_4H_8O_6NO_3^-$	214.02
$C_7H_7NO_3NO_3^-$	215.031
$C_4H_{10}O_6NO_3^-$	216.036
$C_7H_8O_4NO_3^-$	218.031
$C_6H_7NO_4NO_3^-$	219.026
$C_7H_{10}O_4NO_3^-$	220.046
$C_6H_9NO_4NO_3^-$	221.042
$C_5H_7NO_5NO_3^-$	223.021
$C_9H_9NO_2NO_3^-$	225.052
$C_{10}H_{13}NONO_3^-$	225.088
$C_4H_7NO_6NO_3^-$	227.016
$C_8H_9NO_3NO_3^-$	229.047
$C_5H_{12}O_6NO_3^-$	230.052
$C_7H_7NO_4NO_3^-$	231.026

Ion	Mass
$C_8H_{10}O_4NO_3^-$	232.046
$C_7H_9NO_4NO_3^-$	233.042
$C_7H_8O_5NO_3^-$	234.026
$C_7H_{10}O_5NO_3^-$	236.041
$C_5H_5NO_6NO_3^-$	237.000
$C_6H_9NO_5NO_3^-$	237.036
$C_6H_8O_6NO_3^-$	238.020
$C_7H_{12}O_5NO_3^-$	238.057
$C_5H_7NO_6NO_3^-$	239.016
$C_{10}H_{11}NO_2NO_3^-$	239.067
$C_6H_{10}O_6NO_3^-$	240.036
$C_5H_9NO_6NO_3^-$	241.031
$C_5H_{11}NO_6NO_3^-$	243.047
$C_5H_{10}O_7NO_3^-$	244.031
$C_{10}H_{14}O_3NO_3^-$	244.083
$(H_2SO_4)_3NH_3HSO_4^-$	246.007
$C_3H_7NO_8NO_3^-$	247.006
$C_8H_{10}O_5NO_3^-$	248.041
$C_7H_9NO_5NO_3^-$	249.036
$C_8H_{12}O_5NO_3^-$	250.057
$C_6H_9NO_6NO_3^-$	253.031
$C_5H_8N_2O_6NO_3^-$	254.027

Ion	Mass
$C_{10}H_{11}NO_2NO_3^-$	239.067
$C_6H_{10}O_6NO_3^-$	240.036
$C_5H_9NO_6NO_3^-$	241.031
$C_5H_{11}NO_6NO_3^-$	243.047
$C_5H_{10}O_7NO_3^-$	244.031
$C_{10}H_{14}O_3NO_3^-$	244.083
$(H_2SO_4)_3NH_3HSO_4^-$	246.007
$C_3H_7NO_8NO_3^-$	247.006
$C_8H_{10}O_5NO_3^-$	248.041
$C_7H_9NO_5NO_3^-$	249.036
$C_8H_{12}O_5NO_3^-$	250.057
$C_6H_9NO_6NO_3^-$	253.031
$C_5H_{10}O_9NO_3^-$	276.021
$C_{10}H_{14}O_5NO_3^-$	276.072
$C_7H_7NO_3HNO_3NO_3^-$	278.027
$C_8H_{12}O_7NO_3^-$	282.047
$C_6H_{10}N_2O_7NO_3^-$	284.037
$C_{10}H_9NO_5NO_3^-$	285.036
$C_{10}H_8O_6NO_3^-$	286.02
$C_5H_{10}N_2O_8NO_3^-$	288.032
$C_{10}H_{15}NO_5NO_3^-$	291.083
$C_{10}H_{14}O_6NO_3^-$	292.067
$C_9H_{13}NO_6NO_3^-$	293.063
$C_{10}H_{16}O_6NO_3^-$	294.083
$C_9H_{15}NO_6NO_3^-$	295.078
$C_2H_7NHNO_3NO_3^-$	296.033
$C_{12}H_{13}NO_4NO_3^-$	297.073
$C_6H_{10}N_2O_8NO_3^-$	300.032
$C_7H_{13}NO_8NO_3^-$	301.052

41 **Table S2** continued

Ion	Mass
$C_7H_{12}O_9NO_3^-$	302.036
$C_5H_{10}N_2O_9NO_3^-$	304.027
$C_{11}H_{17}NO_5NO_3^-$	305.099
$C_{10}H_{15}NO_6NO_3^-$	307.078
$HSO_5H_2SO_4HSO_4^-$	307.882
$C_{10}H_{14}O_7NO_3^-$	308.062
$C_{13}H_{13}NO_4NO_3^-$	309.073
$C_{13}H_{14}NO_4NO_3^-$	310.081
$C_9H_{15}NO_7NO_3^-$	311.073
$C_9H_{14}O_8NO_3^-$	312.057
$C_7H_{12}N_2O_8NO_3^-$	314.048
$C_{10}H_9NO_7NO_3^-$	317.026
$C_{11}H_{12}O_7NO_3^-$	318.047
$C_{10}H_{15}N_2O_6NO_3^-$	321.081
$HNO_3HSO_5(NH_3)_3$	323.99
HSO_4^-	
$C_{10}H_{14}O_8NO_3^-$	324.057
$C_{10}H_{17}NO_7NO_3^-$	325.089
$C_{10}H_{16}O_8NO_3^-$	326.073
$C_9H_{15}NO_8NO_3^-$	327.068
$C_{13}H_{14}O_6NO_3^-$	328.067
$C_{12}H_{13}NO_6NO_3^-$	329.063
$C_{11}H_{12}N_2O_6NO_3^-$	330.058
$(C_2H_7N)_3H_2SO_4HSO_4^-$	330.101
$C_{10}H_9NO_8NO_3^-$	333.021

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44 **Table S2** continued

Ion	Mass
$C_9H_8N_2O_8NO_3^-$	334.016
$C_{10}H_{11}NO_8NO_3^-$	335.037
$H_2OHSO_5NH_3(HNO_3)_2NO_3^-$	335.971
$C_{11}H_{17}NO_7NO_3^-$	337.089
$C_{11}H_{16}O_8NO_3^-$	338.073
$C_{10}H_{15}NO_8NO_3^-$	339.068
$C_{14}H_{14}O_6NO_3^-$	340.067
$C_{10}H_{16}O_9NO_3^-$	342.068
$(H_2SO_4)_2(NH_3)_3HSO_4^-$	343.975
$C_{13}H_{17}NO_6NO_3^-$	345.094
$C_2H_7NHNO_3_2HSO_5NO_3^-$	345.992
$C_{11}H_{11}NO_8NO_3^-$	347.037
$C_{10}H_{14}N_2O_8NO_3^-$	352.063
$C_{11}H_{17}NO_8NO_3^-$	353.084
$C_{14}H_{14}NO_6NO_3^-$	354.07
$C_{10}H_{15}NO_9NO_3^-$	355.063
$C_{11}H_{18}O_9NO_3^-$	356.083
$C_{12}H_{12}N_2O_7NO_3^-$	358.053
$C_{14}H_{19}NO_6NO_3^-$	359.11
$H_2O(NH_3)_2HSO_5H_2SO_4HSO_4^-$	359.946
$H_2O(NH_3)_3(H_2SO_4)_2HSO_4^-$	361.985
$(H_2O)_2(NH_3)_2(H_2SO_4)_2HSO_4^-$	362.969
$C_{13}H_{19}NO_7NO_3^-$	363.105
$C_{13}H_{18}O_8NO_3^-$	364.089
$C_{13}H_{20}O_8NO_3^-$	366.104
$C_{12}H_{19}NO_8NO_3^-$	367.099

46 **Table S2** continued

Ion	Mass
$C_{11}H_{16}O_{10}NO_3^-$	370.063
$C_{14}H_{15}NO_7NO_3^-$	371.073
$C_{14}H_{14}O_8NO_3^-$	372.057
$C_{13}H_{13}NO_8NO_3^-$	373.052
$(H_2O)_2NH_3(H_2SO_4)_2$	373.966
$HNO_3NO_3^-$	
$C_{10}H_{16}O_{11}NO_3^-$	374.058
$(C_2H_7N)_2(H_2SO_4)_2HSO_4^-$	383.011
$C_{13}H_{15}NO_8NO_3^-$	375.068
$H_2O(NH_3)_3HSO_5$	376.972
$H_2SO_4HSO_4^-$	
$(H_2O)_2(NH_3)_2HSO_5$	377.956
$H_2SO_4HSO_4^-$	
$C_{14}H_{23}NO_7NO_3^-$	379.136
$C_{13}H_{21}NO_8NO_3^-$	381.115
$C_{16}H_{18}NO_6NO_3^-$	382.102
$C_{16}H_{19}NO_6NO_3^-$	383.11
$C_{14}H_{15}NO_8NO_3^-$	387.068
$C_{10}H_{17}NO_{11}NO_3^-$	389.069
$C_{15}H_{23}NO_7NO_3^-$	391.136
$C_{14}H_{21}NO_8NO_3^-$	393.115
$C_{17}H_{21}NO_6NO_3^-$	397.125

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49 **Table S2** continued

Ion	Mass
$\text{C}_{16}\text{H}_{20}\text{N}_2\text{O}_6\text{NO}_3^-$	398.121
$\text{C}_{16}\text{H}_{19}\text{NO}_7\text{NO}_3^-$	399.105
$\text{C}_{16}\text{H}_{18}\text{O}_8\text{NO}_3^-$	400.089
$\text{C}_{15}\text{H}_{17}\text{NO}_8\text{NO}_3^-$	401.084
$\text{C}_{15}\text{H}_{16}\text{O}_9\text{NO}_3^-$	402.068
$\text{C}_{14}\text{H}_{15}\text{NO}_9\text{NO}_3^-$	403.063
$\text{C}_{17}\text{H}_{28}\text{O}_7\text{NO}_3^-$	406.172
$\text{C}_{17}\text{H}_{18}\text{N}_2\text{O}_6\text{NO}_3^-$	408.105
$\text{C}_{18}\text{H}_{21}\text{NO}_6\text{NO}_3^-$	409.125
$\text{C}_{17}\text{H}_{19}\text{NO}_7\text{NO}_3^-$	411.105
$\text{C}_{17}\text{H}_{20}\text{O}_8\text{NO}_3^-$	414.104
$\text{C}_{16}\text{H}_{19}\text{NO}_8\text{NO}_3^-$	415.099
$\text{C}_{16}\text{H}_{21}\text{NO}_8\text{NO}_3^-$	417.115
$\text{C}_{14}\text{H}_{14}\text{O}_{11}\text{NO}_3^-$	420.042
$(\text{NH}_3)_2(\text{H}_2\text{SO}_4)_3 \text{HSO}_4^-$	424.915
$\text{C}_{18}\text{H}_{21}\text{NO}_7\text{NO}_3^-$	425.12
$\text{C}_{15}\text{H}_{24}\text{O}_{10}\text{NO}_3^-$	426.125
$\text{C}_{18}\text{H}_{22}\text{O}_8\text{NO}_3^-$	428.12
$\text{C}_{17}\text{H}_{21}\text{NO}_8\text{NO}_3^-$	429.115
$\text{C}_{16}\text{H}_{23}\text{NO}_9\text{NO}_3^-$	435.126

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51 **Table S2** continued

Ion	Mass
$C_{15}H_{23}NO_{10}NO_3^-$	439.121
$(H_2SO_4)_3(NH_3)_3HSO_4^-$	441.942
$C_{18}H_{23}NO_8NO_3^-$	443.131
$C_{12}H_{16}O_{14}NO_3^-$	446.042
$C_{17}H_{27}NO_9NO_3^-$	451.157
$C_{16}H_{25}NO_{10}NO_3^-$	453.136
$C_{17}H_{28}O_{10}NO_3^-$	454.157
$C_{16}H_{27}NO_{10}NO_3^-$	455.152
$C_{19}H_{22}O_9NO_3^-$	456.115
$(NH_3)_3HSO_5(H_2SO_4)_2HSO_4^-$	456.929
$C_{15}H_{25}NO_{11}NO_3^-$	457.131
$H_2O(NH_3)_2HSO_5(H_2SO_4)_2HSO_4^-$	457.913
$C_{20}H_{32}NO_7NO_3^-$	460.206
$C_{17}H_{25}NO_{10}NO_3^-$	465.136
$C_{17}H_{29}NO_{10}NO_3^-$	469.168
$C_{16}H_{24}O_{12}NO_3^-$	470.115
$C_{16}H_{27}NO_{11}NO_3^-$	471.147
$C_{16}H_{26}O_{12}NO_3^-$	472.131
$(C_2H_7N)_4(H_2SO_4)_2HSO_4^-$	473.126
$C_{15}H_{27}NO_{12}NO_3^-$	475.142
$(H_2O)_2(NH_3)_3(H_2SO_4)_3HSO_4^-$	477.963

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53 **Table S2** continued

Ion	Mass
$C_{17}H_{25}NO_{11}NO_3^-$	481.131
$C_{18}H_{28}O_{11}NO_3^-$	482.152
$C_{17}H_{27}NO_{11}NO_3^-$	483.147
$C_{20}H_{26}N_2O_8NO_3^-$	484.157
$C_{20}H_{27}NO_9NO_3^-$	487.157
$(H_2SO_4)_4(NH_3)_2$	487.911
NO_3^-	
$C_{20}H_{29}NO_9NO_3^-$	489.173

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