Supplementary Materials for

Contributions of primary anthropogenic sources and rapid secondary transformations to organic aerosol pollution in Nanchang, Central China

Wei Guo[a, b], Zicong Li[a, b], Renguo Zhu[a, b], Zhongkui Zhou[a], Hongwei Xiao[c], Huayun Xiao[c]

a. School of Water Resources and environmental Engineering, East China University of Technology, Nanchang 330013, China

b. Jiangxi Province Key Laboratory of the Causes and Control of Atmospheric Pollution, East China University of Technology, Nanchang 330013, China

c. School of Agriculture and Biology, Shanghai Jiao Tong University, Shanghai 200240, China

Correspondence: Huayun Xiao (xiaohuayun@sjtu.edu.cn)

This file contains Text S1 and Text S2, Table S1 and S2, Figure S1 to S6. The detailed information is as follows:

Text S1. Meteorological conditions and air quality

During the sampling period, wind speed ranged from 0.8 to 4.4 m s^{-1}, with notable peaks in July and October. Wind patterns exhibited seasonal variability: southwest and easterly winds dominated in late spring (May) and summer (June – August), while north and north-easterly winds prevailed in other seasons (Figure S1). The annual rainfall was 3708.9 mm, predominantly concentrated in spring and summer. Atmospheric pressure fluctuated between 900–1040 hPa, displaying an inverse relationship with sunshine duration (10–14 hours). Specifically, pressure was lower in spring and summer, higher in autumn and winter, while sunshine hours showed the complementary trend. Temperature and relative humidity (RH) varied widely, ranging from −0.5 to 33.9 ℃ (mean: 19.7 ± 8.7 ℃) and 33.9%–95.9% (mean: 72.0 ± 13.9%), respectively. The CO, O_3, SO_2 and NO_2 concentrations were 0.42–1.32 mg m^{-3} (0.74 ± 0.18 mg m^{-3}), 7–187 μg m^{-3} (86.33 ± 36.81 μg m^{-3}), 3–28 μg m^{-3} (7.92 ± 4.14 μg m^{-3}), and 6–84 μg m^{-3}(27.68 ± 15.11 μg m^{-3}), respectively. Seasonal variations were particularly notable for SO_2 and NO_2. These pollutants exhibited higher concentrations during autumn and winter—coinciding with lower temperatures and reduced rainfall—and decreased levels in spring and summer when temperatures and precipitation were elevated. Conversely, O_3 concentrations demonstrated an inverse seasonal pattern.

Text S2. Instrumentation and analytical procedures

The analytical conditions employed for gas chromatography (GC) were meticulously optimized to ensure precise qualitative and quantitative assessment of target compounds. Samples were introduced in splitless mode with the injector maintained at 280 ℃. The temperature program of the GC oven commenced at an initial hold of 50 ℃ for 2 minutes, followed by a rapid ramp to 120 ℃ at a rate of 30 ℃ min^{-1}. Subsequently, the temperature was incrementally raised to 300 ℃ at a rate of 6 ℃ min^{-1}, where it was sustained for 16 minutes. This carefully calibrated thermal profile has been extensively detailed in the existing literature (Wang and Kawamura, 2005; Wang et al., 2006; Fu et al., 2008 and 2010), underscoring its efficacy in the separation of diverse organic compounds.

Qualitative analysis of the target compounds was performed by comparing retention times and ion mass spectra of the compounds in the samples against those of a standard series (see Table S1). For quantification, the average relative response factor ($\overline{\mathrm{RRF}}$) method was employed. The concentration of target compound x (ρ_x) was calculated using the following formula:

$$\rho_x = \frac{A_x \times \rho_{is}}{A_{is} \times \overline{\mathrm{RRF}}},$$

where A_x is response value (peak area) of target compound x, A_{IS} is the response value of the internal standard, ρ_{IS} denotes concentration of the internal standard. The average relative response factor ($\overline{\mathrm{RRF}}$) for the target compound is derived from the individual RRF values of authentic standards (refer to Table S1) measured at various concentrations. Since some of the target compounds' standards were difficult to obtain on the market, their RRF could be substituted with those of other standard compounds with similar properties (Fu et al., 2010 and 2014; Ding et al., 2012; Yuan et al., 2018). Specifically, the hentriacontanoic acid and dotriacontanoic acid were quantified using nonacosanoic acid and triacontanoic acid, respectively. The pentacosanol, nonacosanol, hentriacontanol, dotriacontanol were quantified using tricosanol, heptacosanol, heptacosanol, and triacontanol, respectively. The glyceric acid was quantified using glycerol. The 2-methylglyceric acid, cis-2-methy-1,3,4-trihydroxy-1-butene, 3-methyl-2,3,4-trihydroxy-1-butene, trans-2-methyl-1,3,4-trihydroxy-1-butene, 2-methylthreitol, and 2-methylerythritol were quantified using erythritol. The 2,3-dihydroxy-4-oxopentanoic acid was quantified using citric acid. The pinic acid and 3-methyl-1,2,3-butanetricarboxylic acid were quantified using pinonic acid. The β-caryophyllinic acid was quantified using octadecanoic acid (Table S1). The limits of detection (LOD) and quantification (LOQ) for the target compounds were determined based on signal-to-noise ratios of 3:1 and 10:1, respectively. In this study, the LODs ranged from 0.05 to 0.30 ng μL^{-1}, which correspond to ambient concentrations of 0.03 to 0.23 ng m^{-3}, calculated for a typical sampling volume of 1300 m^{3}.

Prior to sampling, all filters were subjected to a baking process at 450 ℃ for 4 hours to eliminate residual organic contaminants. Additionally, all glassware was rinsed with methanol, dichloromethane, and hexane immediately before use to prevent potential contamination. To ensure data integrity, blank experiments and recovery tests were systematically performed during sample analysis. Field blanks were routinely collected at the end of each month and analyzed alongside the filter samples. The results indicated that background contamination was negligible, accounting for less than 3% of the concentrations found in the samples. Recovery rates for all target compounds spiked onto pre-combusted blank filters ranged from 82% to 109% (n = 3) and were treated as real samples (Table S1). Data presented herein were adjusted for field blanks but were not corrected for recoveries.

References in Texts

Ding, X., Wang, X. M., Gao, B., Fu, X. X., He, Q. F., Zhao, X. Y., Yu, J. Z., and Zheng, M.: Tracer-based estimation of secondary organic carbon in the Pearl River Delta, south China, J. Geophys. Res-Atmos., 117, https://doi.org/10.1029/2011JD016596, 2012.

Fu, P. Q., Kawamura, K., Okuzawa, K., Aggarwal, S. G., Wang, G., Kanaya, Y., and Wang, Z.: Organic molecular compositions and temporal variations of summertime mountain aerosols over Mt. Tai, North China Plain, J. Geophys. Res-Atmos., 113, https://doi.org/10.1029/2008JD009900, 2008.

Fu, P. Q., Kawamura, K., Pavuluri, C. M., Swaminathan, T., and Chen, J.: Molecular characterization of urban organic aerosol in tropical India: contributions of primary emissions and secondary photooxidation, Atmos. Chem. Phys., 10, 2663–2689, https://doi.org/10, 2663-2689, 10.5194/acp-10-2663-2010, 2010.

Fu, P. Q., Kawamura, K., Chen, J., and Miyazaki, Y.: Secondary Production of Organic Aerosols from Biogenic VOCs over Mt. Fuji, Japan, Environ. Sci. Technol., 48, 8491–8497, https://doi.org/10.1021/es500794d, 2014.

Wang, G. H., and Kawamura, K.: Molecular Characteristics of Urban Organic Aerosols from Nanjing: A Case Study of A Mega-City in China, Environ. Sci. Technol., 39, 7430–7438, https://doi.org/10.1021/es051055+, 2005.

Wang, G. H., Kawamura, K., Lee, S., Ho, K., and Cao, J. J.: Molecular, Seasonal, and Spatial Distributions of Organic Aerosols from Fourteen Chinese Cities, Environ. Sci. Technol., 40, 4619–4625, https://doi.org/10.1021/es060291x, 2006.

Yuan, Q., Lai, S. C., Song, J. W., Ding, X., Zheng, L. S., Wang, X. M., Zhao, Y., Zheng, J. Y., Yue, D. L., Zhong, L.J., Niu, X. J., and Zhang, Y. Y: Seasonal cycles of secondary organic aerosol tracers in rural Guangzhou, Southern China: The importance of atmospheric oxidants, Environ. Pollut., 240, 884–893, https://doi.org/10.1016/j.envpol.2018.05.009, 2018.

Table S1. Details of polar organic compounds identified using the GC/MS method, including limits of detection (LOD) and quantification (LOQ), selected standards and their concentrations in recovery experiments, along with recovery rates.

Identified compounds	Molecular formula	m/z	Time (min)	LOD ng m^{-3}	LOD ng ul^{-1}	LOP ng ul^{-1}	Standards ng m^{-3}	Standards CAS	Recovery %
Fatty acids									
Decanoic acid	$C_{10}H_{20}O_2$	117, 229	15.8	0.03	0.05	0.12	10	334-48-5	103.94±3.84
Hendecanoic acid	$C_{11}H_{22}O_2$	117, 243	17.7	0.03	0.05	0.13	10	112-37-8	102.92±2.58
Lauric acid	$C_{12}H_{24}O_2$	117, 257	19.3	0.06	0.08	0.28	10	143-07-7	94.51±2.74
Tridecanoic acid	$C_{13}H_{26}O_2$	117, 271	21.3	0.03	0.05	0.14	10	638-53-9	105.59±2.04
Tetradecanoic acid	$C_{14}H_{28}O_2$	117, 285	23.5	0.05	0.07	0.23	10	544-63-8	95.66±1.74
Pentadecylic acid	$C_{15}H_{30}O_2$	117, 299	24.9	0.03	0.05	0.15	10	1002-84-2	98.18±1.65
Palmitoleic Acid	$C_{16}H_{30}O_2$	117, 313	25.5	0.05	0.06	0.21	10	373-49-9	97.92±0.63
Palmitic acid	$C_{16}H_{32}O_2$	117, 313	26.5	0.16	0.21	0.71	10	57-10-3	87.47±3.52
Heptadecanoic acid	$C_{17}H_{34}O_2$	117, 327	28.8	0.12	0.16	0.54	10	506-12-7	94.70±2.77
Oleic Acid	$C_{18}H_{34}O_2$	117, 341	30.1	0.04	0.06	0.19	10	112-80-1	90.34±5.67
Octadecanoic acid	$C_{18}H_{36}O_2$	117, 341	30.5	0.10	0.13	0.44	10	57-11-4	93.27±2.71
Nonadecanoic acid	$C_{19}H_{38}O_2$	117, 355	32.4	0.05	0.07	0.22	10	646-30-0	86.48±4.56
Icosanoic acid	$C_{20}H_{40}O_2$	117, 369	34.0	0.13	0.17	0.58	10	506-30-9	91.03±0.42
Henicosanoic acid	$C_{21}H_{42}O_2$	117, 383	35.7	0.13	0.16	0.54	10	2363-71-5	86.84±3.95
Docosanoic acid	$C_{22}H_{44}O_2$	117, 397	37.3	0.06	0.07	0.24	10	112-85-6	97.33±6.35
Tricosanoic acid	$C_{23}H_{46}O_2$	117, 411	38.8	0.08	0.11	0.36	10	2433-96-7	108.87±0.86
Tetracosanoic acid	$C_{24}H_{48}O_2$	117, 425	40.3	0.04	0.05	0.16	10	557-59-5	97.39±1.09
Pentacosanoic acid	$C_{25}H_{50}O_2$	117, 439	41.7	0.12	0.16	0.53	10	506-38-7	88.17±1.69
Hexacosanoic acid	$C_{26}H_{52}O_2$	117, 453	43.4	0.23	0.30	1.01	10	506-46-7	103.71±1.46
Heptacosanoic acid	$C_{27}H_{54}O_2$	117, 467	44.7	0.04	0.06	0.19	10	7138-40-1	105.24±3.05
Octacosanoic acid	$C_{28}H_{56}O_2$	117, 481	45.5	0.06	0.08	0.27	10	506-48-9	96.44±2.83
Nonacosanoic acid	$C_{29}H_{58}O_2$	117, 495	46.9	0.07	0.10	0.32	10	4250-38-8	100.22±2.14
Triacontanoic acid	$C_{30}H_{60}O_2$	117, 509	48.2	0.07	0.09	0.29	10	506-50-3	101.73±5.72
Hentriacontanoic acid	$C_{31}H_{62}O_2$	117, 523	50.1	0.05	0.07	0.23	10	4250-38-8 (Nonacosanoic acid)	100.22±2.14
Dotriacontanoic acid	$C_{32}H_{64}O_2$	117, 537	53.8	0.03	0.05	0.15	10	506-50-3 (Triacontanoic acid)	101.73±5.72
Fatty alcohols									
Tetradecanol	$C_{14}H_{30}O$	75, 271	18.0	0.05	0.07	0.23	10	112-72-1	101.61±0.88
Pentadecanol	$C_{15}H_{32}O$	75, 285	20.9	0.04	0.06	0.18	10	629-76-5	108.13±1.56
Hexadecanol	$C_{16}H_{34}O$	75, 299	23.6	0.12	0.16	0.53	10	36653-82-4	90.08±1.34
Heptadecanol	$C_{17}H_{36}O$	75, 313	26.1	0.03	0.05	0.14	10	1454-85-9	84.56±2.61
Octadecanol	$C_{18}H_{38}O$	75, 327	28.4	0.16	0.21	0.71	10	112-92-5	87.61±2.85
Nonadecanol	$C_{19}H_{40}O$	75, 341	30.1	0.06	0.08	0.27	10	1454-84-8	90.88±0.46
Eicosanol	$C_{20}H_{42}O$	75, 355	32.3	0.04	0.05	0.17	10	629-96-9	98.27±1.52
Heneicosanol	$C_{21}H_{44}O$	75, 369	34.5	0.05	0.07	0.23	10	15594-90-8	95.56±2.28
Docosanol	$C_{22}H_{46}O$	75, 383	36.1	0.04	0.05	0.15	10	661-19-8	108.51±0.86
Tricosanol	$C_{23}H_{48}O$	75, 397	38.6	0.03	0.05	0.13	10	3331-01-5	106.15±5.09
Tetracosanol	$C_{24}H_{50}O$	75, 411	39.1	0.08	0.10	0.34	10	506-51-4	96.03±4.57
Pentacosanol	$C_{25}H_{52}O$	75, 425	40.5	0.06	0.08	0.27	10	3331-01-5 (Tricosanol)	106.15±5.09

Hexacosanol	$C_{26}H_{54}O$	75, 439	42.3	0.06	0.08	0.25	10	506-52-5	85.91±4.75
Heptacosanol	$C_{27}H_{56}O$	75, 453	43.5	0.08	0.10	0.33	10	2004-39-9	98.48±4.80
Octacosanol	$C_{28}H_{58}O$	75, 467	45.0	0.10	0.13	0.44	10	557-61-9	92.88±4.34
Nonacosanol	$C_{29}H_{60}O$	75, 481	46.3	0.11	0.15	0.49	10	2004-39-9 (Heptacosanol)	98.48±4.80
Triacontanol	$C_{30}H_{62}O$	75, 495	48.3	0.13	0.17	0.57	10	593-50-0	89.50±3.81
Hentriacontanol	$C_{31}H_{64}O$	75, 509	50.2	0.09	0.11	0.37	n.a.	2004-39-9 (Heptacosanol)	98.48±4.80
Dotriacontanol	$C_{32}H_{66}O$	75, 523	52.7	0.06	0.08	0.27	n.a.	593-50-0 (Triacontanol)	89.50±3.81
Cholesterol	$C_{27}H_{46}O$	129, 458	45.1	0.10	0.13	0.45	10	57-88-5	87.23±1.51
Stigmasterol	$C_{29}H_{48}O$	129, 484	46.5	0.08	0.11	0.36	10	83-48-7	98.71±0.85
β-sitosterol	$C_{29}H_{50}O$	129, 486	46.8	0.11	0.15	0.49	10	83-46-5	88.32±4.07
Saccharides									
Ribose	$C_5H_{10}O_5$	191, 204, 217	19.5	0.12	0.16	0.53	20	50-69-1	90.34±2.8
Galactosan	$C_6H_{10}O_5$	204, 217, 333	19.8	0.13	0.16	0.55	20	644-76-8	90.29±0.15
Mannosan	$C_6H_{10}O_5$	204, 217, 333	20.1	0.10	0.13	0.44	20	14168-65-1	88.92±2.04
Levoglucosan	$C_6H_{10}O_5$	204, 217, 333	21.2	0.16	0.20	0.68	20	498-07-7	111.28±5.07
Arabitol	$C_5H_{12}O_5$	217, 307, 319	22.3	0.09	0.11	0.37	20	488-82-4	93.33±3.25
Fructose	$C_6H_{12}O_6$	191, 204, 217	22.5	0.09	0.12	0.41	20	57-48-7	89.89±9.50
Pinitol	$C_7H_{14}O_6$	217, 260, 318	22.8	0.06	0.07	0.24	20	10284-63-6	103.43±0.88
Galactose	$C_6H_{12}O_6$	204, 191, 217	23.1	0.07	0.10	0.32	20	59-23-4	88.91±6.66
Glucose	$C_6H_{12}O_6$	191, 204, 217	23.8	0.11	0.15	0.49	20	50-99-7	97.50±2.46
Mannitol	$C_6H_{14}O_6$	205, 217, 319	24.3	0.13	0.16	0.55	20	69-65-8	102.68±3.08
Inositol	$C_6H_{12}O_6$	217, 305, 318	27.1	0.06	0.08	0.27	20	87-89-8	97.82±6.98
Sucrose	$C_{12}H_{22}O_{11}$	217, 361, 437	35.3	0.05	0.06	0.21	20	57-50-1	93.08±2.96
Lactose	$C_{12}H_{22}O_{11}$	191, 217, 361	36.2	0.04	0.05	0.16	20	63-42-3	96.02±3.06
Maltose	$C_{12}H_{22}O_{11}$	204, 217, 361	38.1	0.09	0.11	0.37	20	69-79-4	91.13±4.13
Turanose	$C_{12}H_{22}O_{11}$	147, 217, 361	38.5	0.07	0.09	0.29	20	547-25-1	94.45±1.10
Trehalose	$C_{12}H_{22}O_{11}$	147, 217, 361	39.0	0.08	0.10	0.34	20	99-20-7	96.47±6.23
Others (Monoacids, diacids, polyacids, and polyols)									
Benzoic acid	$C_7H_6O_2$	77, 105, 179	10.5	0.06	0.07	0.24	5	65-85-0	81.66±4.79
Glycerol	$C_3H_8O_3$	73, 171, 308	11.7	0.06	0.08	0.28	5	56-81-5	84.73±1.75
Glyceric acid	$C_3H_6O_4$	73, 247, 292	12.2	0.10	0.13	0.45	5	56-81-5 (Glycerol)	84.73±1.75
2-Methylglyceric acid	$C_4H_8O_4$	203, 219, 306	13.3	0.09	0.11	0.37	5	149-32-6 (Erythritol)	87.19±3.53
Cis-2-methy-1,3,4-trihydroxy-1-butene	$C_5H_{10}O_3$	73, 147, 231	14.2	0.08	0.10	0.33	5	149-32-6 (Erythritol)	87.19±3.53
3-methyl-2,3,4-trihydroxy-1-butene	$C_5H_{10}O_3$	147, 215, 231	15.1	0.10	0.13	0.44	5	149-32-6 (Erythritol)	87.19±3.53
Trans-2-methyl-1,3,4-trihydroxy-1-butene	$C_5H_{10}O_3$	73, 147, 231	15.6	0.06	0.07	0.25	5	149-32-6 (Erythritol)	87.19±3.53
Malic acid	$C_4H_6O_5$	73, 245, 287	16.0	0.11	0.15	0.50	5	636-61-3	84.61±6.92
2,3-Dihydroxy-4-oxopentanoic acid (DHOPA)	$C_5H_8O_5$	189, 247, 350	16.1	0.10	0.13	0.44	5	77-92-9 (Citric acid)	83.88±1.72
Citric acid	$C_6H_8O_7$	73, 89, 357	16.5	0.19	0.24	0.81	5	77-92-9	83.88±1.72
Pinonic acid	$C_{10}H_{16}O_3$	125, 171, 257	16.8	0.13	0.16	0.54	5	61826-55-9	97.31±6.29
2-Methylthreitol	$C_5H_{12}O_4$	129, 219, 277	17.8	0.08	0.11	0.35	5	149-32-6 (Erythritol)	87.19±3.53
2-Methylerythritol	$C_5H_{12}O_4$	129, 219, 277	18.0	0.07	0.09	0.30	5	149-32-6 (Erythritol)	87.19±3.53

3-hydroxyglutaric acid	$C_5H_8O_5$	185, 275, 349	18.2	0.09	0.11	0.37	5	638-18-6	88.78 ±5.36
4-Hydroxybenzoic acid	$C_7H_6O_3$	73, 225, 283	18.4	0.06	0.08	0.28	5	99-96-7	92.58 ±5.37
Pinic acid	$C_9H_{14}O_4$	129, 171, 241	20.5	0.09	0.11	0.37	5	61826-55-9 (Pinonic acid)	97.31 ±6.29
Phthalic acid	$C_8H_6O_4$	221, 295	20.9	0.07	0.09	0.31	5	88-99-3	92.45 ±7.45
Isophthalic acid	$C_8H_6O_4$	221, 295	21.5	0.06	0.08	0.28	5	121-91-5	94.27 ±3.05
Terephthalic acid	$C_8H_6O_4$	221, 295	22.1	0.09	0.11	0.37	5	100-21-0	95.04 ±6.27
3-methyl-1,2,3-butanetricarboxylic acid (MBTCA)	$C_8H_{12}O_6$	204, 245, 405	22.4	0.09	0.12	0.39	5	61826-55-9 (Pinonic acid)	97.31 ±6.29
Vanillic acid	$C_8H_8O_4$	73, 223, 267	23.3	0.10	0.13	0.45	5	121-34-6	85.73 ±4.65
Syringic acid	$C_9H_{10}O_5$	73, 233, 297	23.6	0.09	0.11	0.37	5	530-57-4	82.66 ±1.89
β-caryophyllinic acid	$C_{14}H_{22}O_4$	117, 309, 383	25.1	0.12	0.16	0.54	10	57-11-4 (Octadecanoic acid)	93.27 ±2.71
Dehydroabietic acid	$C_{20}H_{28}O_2$	73, 239, 250	32.2	0.08	0.10	0.33	5	1740-19-8	97.10 ±1.32

Table S2. Representative compounds from various emission sources and their mass fractions in OC and OA. The aerosol mass fractions refer specifically to those present in PM$_{2.5}$.

The mass fraction of tracers in POC and POA							
Sources	Representative compounds	Hydrocarbon class	f_{POC}	SD	f_{POA}	SD	References
Biomass burning	Levoglucosan	Saccharides	0.1186	0.0941	0.0629	0.0678	Andreae and Metlet, 2001; Andreae, 2019
Coal burning	C27α[a] and C29αβ[b]	Hopanes	0.0010	0.0010	0.0004	0.0004	Zhang et al., 2008
Vehicle exhaust	benzo(g,h,i)perylene (BghiP)	PAHs	0.0014	0.0020	0.0009	0.0013	Oros and Simoneit, 2000
Cooking	C16:0, C18:0, Stigmasterol, and β-sitosterol	Fatty acid and Sterols	0.1783	0.1233	0.1153	0.0858	He et al., 2004; Zhao et al., 2007
Plant debris	Glucose	Primary sugars	0.0516	n.d.	0.0267	n.d.	Puxbaum and Tenze-Kunit, 2003
Fungal spores	Mannitol	Sugar alcohols	0.1308	n.d.	0.0678	n.d.	Bauer et al., 2002 and 2008

The mass fraction of tracers in SOC and SOA							
Sources	Representative compounds	Precursor	f_{SOC}	SD	f_{SOA}	SD	References
Biogenic	2-MGA[c], C5-alkene triols[d], and MTLs[e]	Hemiterpenes	0.1550	0.0390	0.0630	0.0160	Kleindienst, 2007
Biogenic	PNA[f], PA[g], MBTCA[h], and 3-HGA[i]	Monoterpene	0.2300	0.1110	0.1680	0.0810	Kleindienst, 2007
Biogenic	β-caryophyllinic acid	Sesquiterpene	0.0230	0.0050	0.0109	0.0022	Kleindienst, 2007
Anthropogenic	DHOPA[j]	Toluene	0.0079	0.0027	0.0040	0.0011	Kleindienst, 2007
Anthropogenic	Phthalic acid	PAHs (Naphthalene)	0.0390	0.0084	0.0200	0.0084	Kleindienst, 2012

[a] C27α and [b] C29αβ: 17α(H)-22,29,30-Trisnorhopane and 17(H),21(H)-30-Norhopane.

[c] 2-MGA: 2-methylglyceric acid.

[d] C5-alkene triols: Cis-2-methy-1,3,4-trihydroxy-1-butene, 3-methyl-2,3,4-trihydroxy-1-butene, and Trans-2-methyl-1,3,4-trihydroxy-1-butene.

[e] MTLs: 2-methylthreitol and 2-methylerythritol

[f] PNA: Pinonic acid.

[g] PA: Pinic acid

[h] MBTCA: 3-Methyl-1,2,3-butanetricarboxylic acid

[i] 3-HGA: 3-Hydroxyglutaric acid

[j] DHOPA: 2,3-Dihydroxy-4-oxopentanoic acid

References in Table S2

Andreae, M. O., and Merlet, P.: Emission of trace gases and aerosols from biomass burning, Global Biogeochem. Cy., 15, 955–966, https://doi.org/10.1029/2000GB001382, 2001.

Andreae, M. O.: Emission of trace gases and aerosols from biomass burning–an updated assessment, Atmos. Chem. Phys., 19, 8523–8546, https://doi.org/10.5194/acp-19-8523-2019, 2019.

Bauer, H., Kasper-Giebl, A., Zibuschka, F., Hitzenberger, R., Kraus, G. F., and Puxbaum, H.: Determination of the Carbon Content of Airborne Fungal Spores, Anal. Chem., 74, 91–95, https://doi.org/10.1021/ac010331+, 2002.

Bauer, H., Claeys, M., Vermeylen, R., Schueller, E., Weinke, G., Berger, A., and Puxbaum, H.: Arabitol and mannitol as tracers for the quantification of airborne fungal spores, Atmos. Environ., 42, 588–593, https://doi.org/10.1016/j.atmosenv.2007.10.013, 2008.

He, L. Y., Hu, M., Huang, X. F., Yu, B. D., Zhang, Y. H., and Liu, D. Q.: Measurement of emissions of fine particulate organic matter from Chinese cooking, Atmos. Environ., 38, 6557–6564, https://doi.org/10.1016/j.atmosenv.2004.08.034, 2004.

Kleindienst, T. E., Jaoui, M., Lewandowski, M., Offenberg, J. H., Lewis, C. W., Bhave, P. V., and Edney, E. O.: Estimates of the contributions of biogenic and anthropogenic hydrocarbons to secondary organic aerosol at a southeastern US location, Atmos. Environ., 41, 8288–8300, https://doi.org/10.1016/j.atmosenv.2007.06.045, 2007.

Kleindienst, T. E., Jaoui, M., Lewandowski, M., Offenberg, J. H., and Docherty, K. S.: The formation of SOA and chemical tracer compounds from the photooxidation of naphthalene and its methyl analogs in the presence and absence of nitrogen oxides, Atmos. Chem. Phys., 12, 8711–8726 https://doi.org/10.5194/acp-12-8711-2012, 2012.

Oros, D. R., and Simoneit, B. R. T.: Identification and emission rates of molecular tracers in coal smoke particulate matter, Fuel, 79, 515–536, https://doi.org/10.1016/S0016-2361(99)00153-2, 2000.

Puxbaum, H., and Tenze-Kunit, M.: Size distribution and seasonal variation of atmospheric cellulose, Atmos. Environ., 37, 3693–3699, https://doi.org/10.1016/S1352-2310(03)00451-5, 2003.

Zhang, Y., Schauer, J. J., Zhang, Y., Zeng, L., Wei, Y., Liu, Y., and Shao, M.: Characteristics of Particulate Carbon Emissions from Real-World Chinese Coal Combustion, Environ. Sci. Technol., 42, 5068-5073, https://doi.org/10.1021/es7022576, 2008.

Zhao, Y. L., Hu, M., Slanina, S., and Zhang, Y. H.: Chemical Compositions of Fine Particulate Organic Matter Emitted from Chinese Cooking, Environ. Sci. Technol, 41, 99–105, https://doi.org/10.1021/es0614518, 2007.

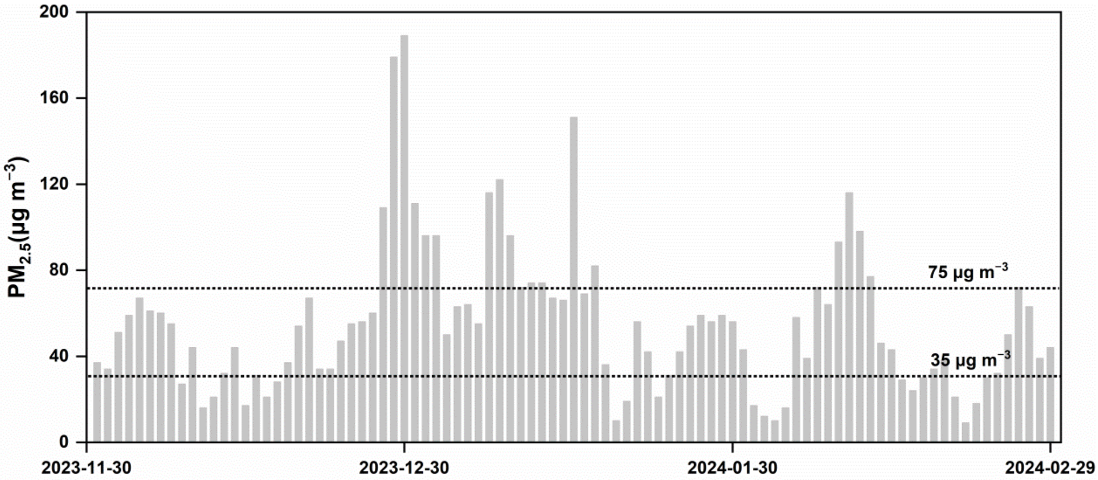

Figure S1. Daily variation of $PM_{2.5}$ concentrations in Nanchang during the winter of 2023–2024. Data are sourced from the China Air Quality Online Monitoring and Analysis Platform (https://www.aqistudy.cn/historydata/).

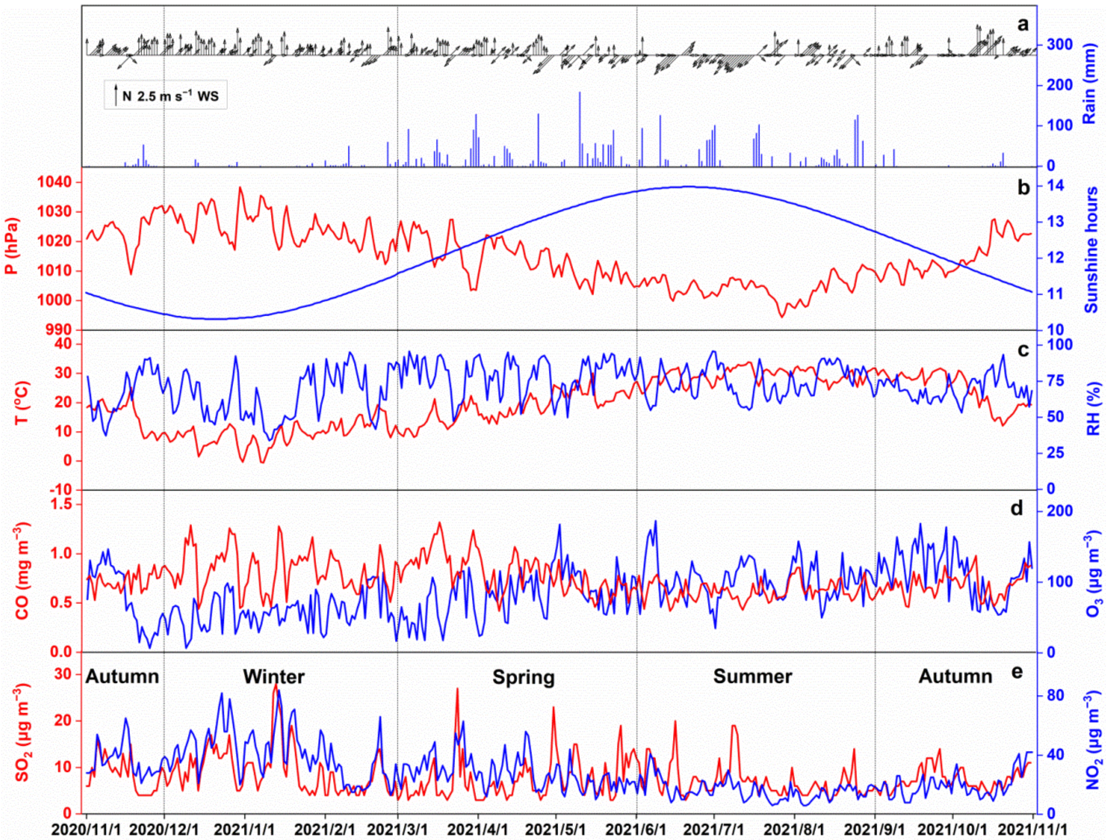

Figure S2. Time series of meteorological parameters and gaseous pollutant concentrations during sampling periods.

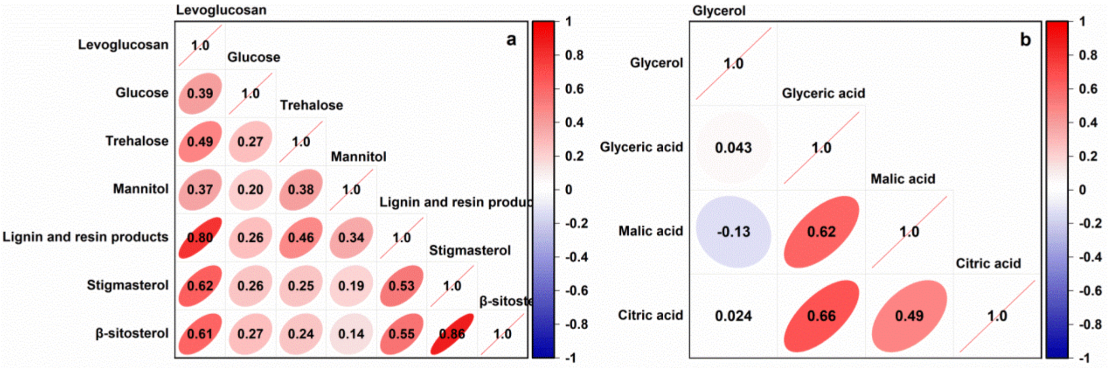

Figure S3. (a) Correlation between levoglucosan and some primary sugars, sugar alcohols, lignin, resin products, and sterols. (b) Correlation between glycerol and hydroxy acids.

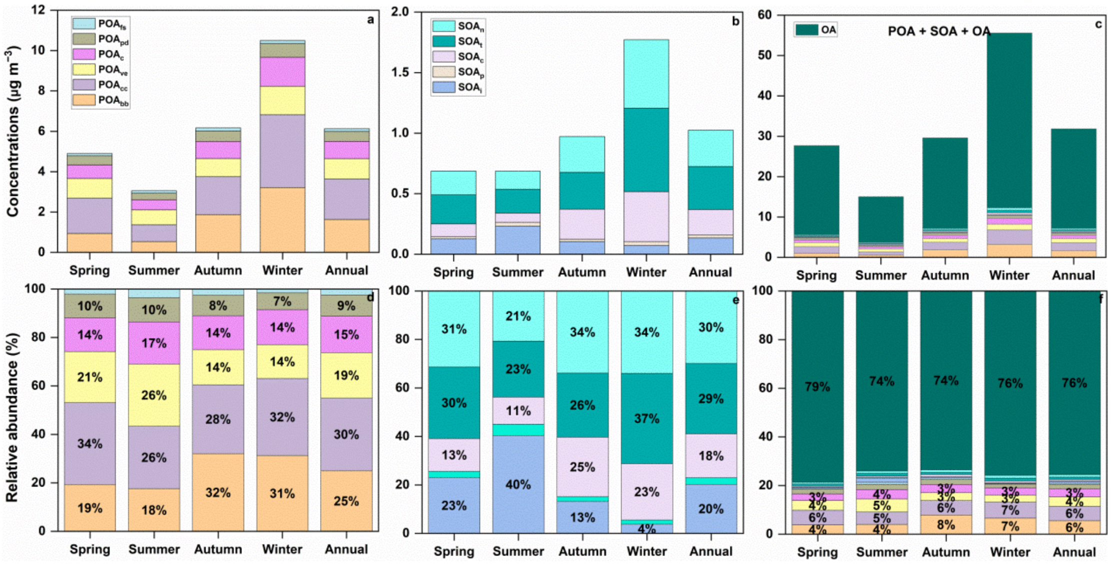

Figure S4. Concentrations and relative abundances of primary organic aerosol (POA) from biomass burning (POA_{bb}), coal combustion (POA_{cc}), vehicle exhaust (POA_{ve}), cooking (POA_c), plant debris (POA_{pd}), and fungal spores (POA_{fs}), alongside secondary organic aerosol (SOA) from isoprene (SOA_i), α/β-pinene (SOA_p), β-caryophyllene (SOA_c), toluene (SOA_t), and naphthalene (SOA_n).

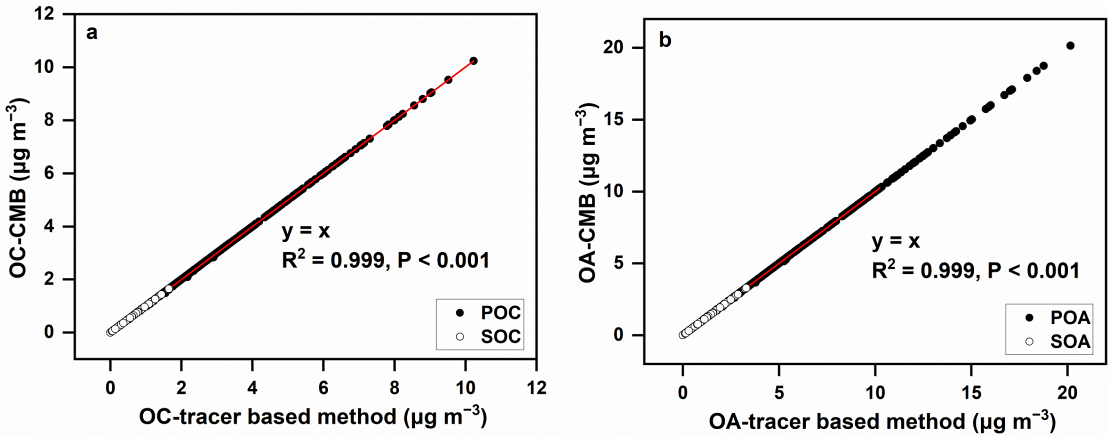

Figure S5. Comparison of OC and OA concentrations calculated by CMB model with those calculated by tracer-based method.

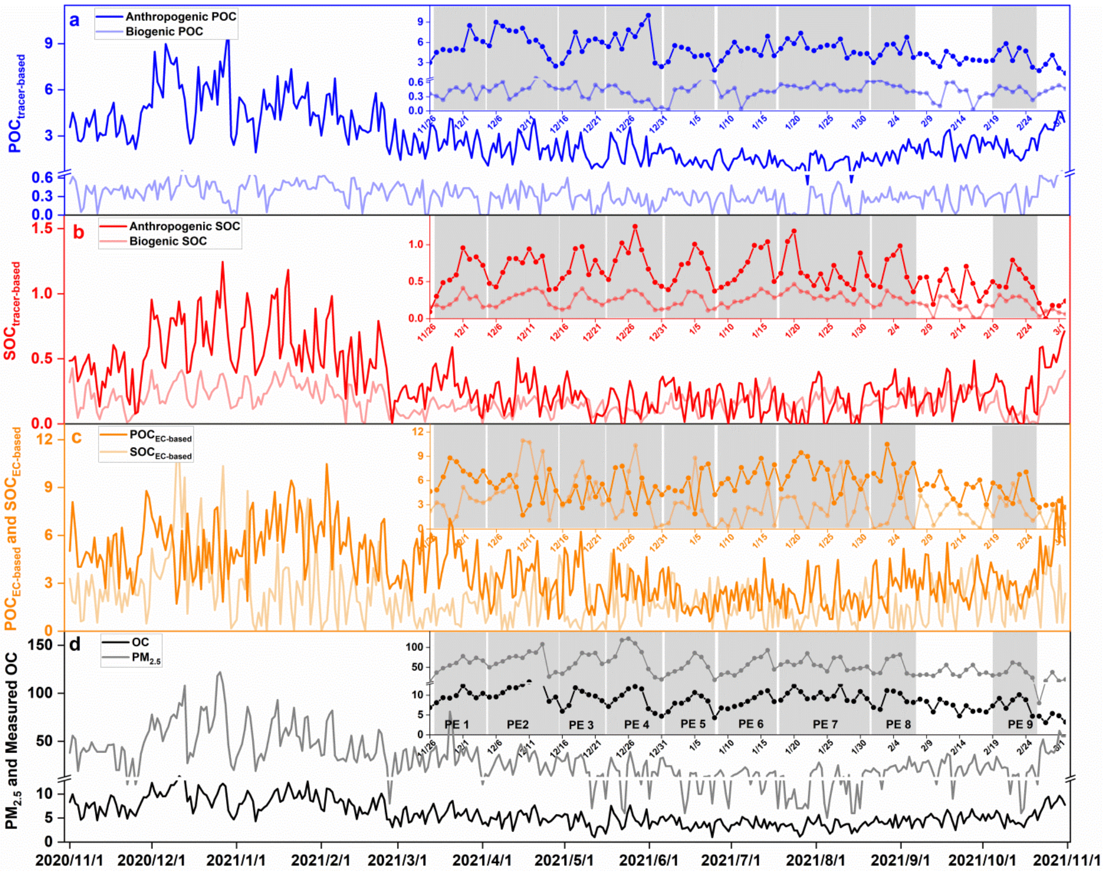

Figure S6. Time series of POC and SOC concentrations calculated using the tracer-based method, alongside POC and SOC concentrations derived from the EC-based method, as well as $PM_{2.5}$ and measured OC concentrations during the sampling period