Supplementary of

Carbonyl compounds from typical combustion sources: emission characteristics, influencing factors, and their contribution to ozone formation

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Text S1 Quality assurance/ quality control (QA/QC)

Before sampling, the entire combustion system and combustion setup were inspected, and the flow rate was measured before each sample collection to ensure that the system was airtight. Additionally, 3 to 5 laboratory blanks were prepared for each batch of sample tubes. During sampling, a field blank group was included, which was identical to the sample tubes in all conditions except for not being connected to the sampler, and it was analyzed together with the samples. Each group of samples included 2 to 4 replicate samples to eliminate randomness. To prevent breakthrough, two identical sampling tubes were connected in series to the sampler. After processing and analysis, if the detected substance in the rear tube exceeded 3% of the total amount in both tubes, it was considered a breakthrough, and the results were deemed unusable. Moreover, the linear regression coefficient R^2 of the standard curve for sample analysis was greater than 0.999. To ensure the stability of the instrument, a known concentration standard sample was inserted every 10 samples to ensure that the instrument deviation was within 10%.

Table S1 Volatile content values of six raw coals.

Coal type	LL	GJ	DT	SH	NM	PX
Vdaf（%）	20	25	26~27	30	32	35

Table S2 Basic information of on-road gasoline vehicles (ethanol gasoline).

Vehicle model	Emission standard	Model year	Engine model	Engine size (L)
Gasoline vehicles	China V	2016	DAM15R1	1.5
	China V	2017	TNN4G115B	1.5
	China V	2020	LZW1028SP6	1.5
	China V	2014	LQG5029XXYBF	1.2
	China VI	2017	LZW1029PY	1.5
	China VI	2021	LZW5028CCYPWV	1.5

Table S3 Basic information of on-road diesel vehicles.

Vehicle model	Emission standard	Model year	Mileage	Engine model	Engine size (L)
	China V	2019	40068	UK12030066	1.5
	China V	2018	69000	LJ4A15Q	1.5
Diesel vehicles	China V	2018	100700	H2116228	1.5
	China VI	2021	13634	LJ469Q-AEC	1.3
	China VI	2021	39000	DAM16KL	1.6
	China VI	2021	98122	LJ4A18Q6	1.8

Table S4 Basic information of agricultural machinery sampling vehicles.

Machinery type	Emission standard	Model year	Engine power(kW)	Tail gas treatment
Small Tractor	China II	2015/2	11(＜22.1)	
Medium Tractor	China II	2014/2	73.5（22.1＜73.6）	
Medium Tractor	China III	2022/4	118（＞73.6）	ECU、Intercooler、Supercharger
Small Harvester	China III	2015/8	46	
Medium Harvester	China III	2021/11	92	ECU、EGR、Intercooler、Supercharger

Table S5 The MIR value of carbonyl compounds(Zhang et al., 2021) .

Carbonyl compounds	MIR
Formaldehyde	6.71
Acetaldehyde	4.10
Acetone	0.22
Acrolein	3.01
Propionaldehyde	2.60
Crotonaldehyde	3.97
Butyraldehyde	4.54
Benzaldehyde	-1.02
Cyclohexanone	0.97
Isovaleraldehyde	3.75
Valeraldehyde	6.27
o-Tolualdehyde	-1.19
m-Tolualdehyde	-1.16
p-Tolualdehyde	-0.65
Hexaldehyde	5.72
2,5-Dimethylbenzaldehyde	0
Heptaldehyde	4.63

References

1.Zhang, Y., Xue, L., Carter, W. P. L., Pei, C., Chen, T., Mu, J., Wang, Y., Zhang, Q., and Wang, W.: Development of ozone reactivity scales for volatile organic compounds in a Chinese megacity, Atmos. Chem. Phys., 21, 11053–11068, https://doi.org/10.5194/acp-21-11053-2021, 2021.