

(19.8%), 汽油车尾气源 (18.2%), 溶剂使用源 (17.6%)、天然气及燃烧源 (16.3%)、生物排放源 (15.4%) 和液化石油气使用源 (12.7%)。因此, 呼和浩特市防治 VOCs 污染应该重点管控机动车尾气源 (汽油车尾气源, 柴油车尾气源)、溶剂使用源、天然气及燃烧源。

(3) 通过相对增量反应性和 EKMA 曲线分析表明, 呼和浩特市夏季 O₃ 超标日的敏感性以 VOCs 控制为主; 烯烃和芳香烃是 RIR 值最大的 VOCs 组分。

(4) 通过模拟不同前体物削减情景下的 O₃ 生成速率显示, 液化石油气使用源削减 50% 后臭氧浓度下降最为明显, 其次对汽油车尾气源和溶剂使用源的消减也可使得臭氧浓度出现不同程度的下降; 而针对柴油车尾气源和天然气及燃烧源的削减效果相对较差, 针对呼和浩特夏季 O₃ 污染的防控应重点关注液化石油气使用源, 溶剂使用源及汽油车尾气源。

参考文献(References)

Chen T, Zhang P, Chu B, et al. 2022. Secondary organic aerosol formation from mixed volatile organic compounds: Effect of RO₂ chemistry and precursor concentration [J]. npj

Climate and Atmospheric Science, 5: 95. doi:10.1038/s41612-022-00321-y

Gu Y X, Li K, Xu J M, et al. 2020. Observed dependence of surface ozone on increasing temperature in Shanghai, China [J]. Atmospheric Environment, 221:117108. doi:10.1016/j.atmosenv.2019.117108

Li Q, Su G, Li C, et al. 2020. An investigation into the role of VOCs in SOA and ozone production in Beijing, China [J]. Sci. Total Environ, doi: 10.1016/j.scitotenv.2020.137536

Lyu X P, Chen N, Guo H, et al. 2016. Ambient volatile organic compounds and their effect on ozone production in Wuhan, central China [J]. Science of the Total Environment, 541:200-209. doi:10.1016/j.scitotenv.2015.09.093

Wang H L, Chen C H, Wang Q, et al. 2013. Chemical loss of volatile organic compounds and its impact on the source analysis through a two-year continuous measurement [J]. Atmospheric Environment, 80: 488-498. doi:10.1016/J.ATMSENV.2013.08.040

Wei W, Li Y, Ren Y T, et al. 2019. Sensitivity of summer ozone to precursor emission change over

- Beijing during 2010-2015: A WRF-Chem modeling study [J]. *Atmospheric Environment*, 218:11698-11702. doi: 10.1016/j.atmosenv.2019.116984
- Wolfe G M, Marvin M R, Roberts S J, et al. 2016. The framework for 0-D atmospheric modeling (F0AM) v3.1 [J]. *Geosci Model Dev*, 9:3309-3319. doi:10.5194/gmd-9-3309-2016
- Zhang Q, Zheng Y X, Tong D, et al. 2019. Drivers of improved PM_{2.5} air quality in China from 2013 to 2017 [J]. *Proceedings of the National Academy of Sciences*, 116(49):24463-24469. doi:10.1073/pnas.1907956116
- Zhao Y Y, Chen L H, Li K W, et al. 2020. Atmospheric ozone chemistry and control strategies in Hangzhou, China: Application of a 0-D box model [J]. *Atmospheric Research*, 246:105109. doi:10.1016/j.atmosres.2020.105109
- 侯墨, 蒋小梅, 赵文鹏, 等. 2023. 2021年夏季新乡市城区臭氧超标日污染特征及敏感性 [J]. *环境科学*, 44(05): 2472-2480. Hou Mo, Jiang Xiaomei, Zhao Wenpeng, et al. 2023. Ozone pollution characteristics and sensitivity during the ozone pollution days in summer 2021 of Xinxiang city [J]. *Environmental Science*, 44(05): 2472-2480. doi:10.13227/j.hjkx.202205229
- 李圳, 黄志炯, 王肖丽, 等. 2022. 前体物排放变化对珠江三角洲地区秋季臭氧污染演变的影响研究 [J]. *环境科学学报*, 42(10): 36-48. Li Zhen, Huang Zhijiong, Wang Xiaoli, et al. 2022. Effects of changes in precursor emissions on the evolution of ozone pollution in the Pearl River Delta region in autumn [J]. *Acta Scientiae Circumstantiae*, 42(10): 36-48. doi:10.13671/j.hjkxxb.2022.0113
- 林燕芬, 段玉森, 高宗江, 等. 2019. 基于VOCs 加密监测的上海典型臭氧污染过程特征及成因分析 [J]. *环境科学学报* 39(01): 126-133. Lin Yanfen, Duan Yusen, Gao Zongjiang, et al. 2019. Typical ozone pollution process and source identification in Shanghai based on VOCs intense measurement [J]. *Acta Scientiae Circumstantiae*, 39(1) : 126-133. doi:10.13671/j.hjkxxb.2018.0242
- 陆克定, 张远航, 苏杭, 等. 2010. 珠江三角洲夏季臭氧区域污染及其控制因素分析[J]. *中国科学: 化学*, 40(04): 407-420. Lu Keding, Zhang Yuanhang, Su Hang, et al. 2010.

- Regional ozone pollution and its control factors in the Pearl River Delta in summer [J]. *Scientia Sinica Chimica*, 40(04): 407-420.
- 田俊杰,丁祥,安静宇,等. 2023. 长三角区域人为源活性挥发性有机物高分辨率排放清单 [J]. *环境科学*, 44(01): 58-65. Tian Junjie, Ding Xiang, An Jingyu, et al. 2023. High-resolution emission inventory of reactive volatile organic compounds from anthropogenic sources in the Yangtze River Delta Region[J]. *Environmental Science*, 44(01): 58-65. doi:10.13227/j.hjcx.202201100.
- 王淑娟,刘新军,周冰,等. 2021. 夏季石家庄高新区 VOCs 污染特征及来源解析 [J].*河北大学学报(自然科学版)*, 41(06): 690-697. Wang Shujuan, Liu Xinjun, Zhou Bing, et al. 2021. Characteristics and source apportionment of VOCs in Shijiazhuang high-tech industrial development zone in summer [J]. *Journal of Hebei University (Natural Science Edition)*, 41(06): 690-697. doi:10.3969/j.jssn.1000-1565.2021.06.009
- 王文美,高璟赟,肖致美,等. 2021. 天津市夏季不同臭氧浓度级别 VOCs 特征及来源 [J]. *环境科学*, 42(8) : 3585-3594. Wang Wenmei, Gao Jingyun, Xiao Zhimei, et al. 2021. Characteristics and sources of VOCs at different ozone concentration levels in Tianjin [J]. *Environmental Science*, 42(8): 3585-3594. doi:10.13227/j.hjcx.202101129
- 肖建军,汪太明,王业耀,等. 2022. 中国自然背景地区臭氧浓度时空变化特征分析[J]. *环境科学研究*, 35(9): 2128-2135. Xiao Jianjun, Wang Taiming, Wang Yeyao, et al. 2022. Analysis of ozone time series variation in atmospheric background area in China [J]. *Research of Environmental Sciences*, 35(9): 2128-2135. doi:10.13198/j.issn.1001-6929.2022.06.02
- 张敬巧,吴亚君,李慧,等. 2019. 廊坊开发区秋季 VOCs 污染特征及来源解析 [J]. *中国环境科学*, 39(8): 3186-3192. Zhang Jingqiao, Wu yajun, Lihui, et al. 2019. Characteristics and source apportionment of ambient volatile compounds in autumn in Langfang development zones [J]. *China Environmental Science*, 39(8): 3186-3192. doi:10.19674/j.cnki.issn1000-6923.2019.0376

