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Haze formation in China: Importance of secondary aerosol

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Air pollution is the world's largest single environmental hazard that causes more than a few million premature deaths in 2012 (World Health Organization, 2014), particularly in developing countries with rapid industrialization and urbanization. Rapid economic growth of China in the last three decades has resulted in serious air pollution problems on both local and regional scales. Megacities in China such as Beijing and Shanghai have suffered from haze episodes frequently with the daily mass concentrations of fine particulate matter (PM_{2.5}, fine particulates with aerodynamic diameter less than 2.5 μm) over the Chinese air pollution standard of 75 μg/m³ (China National Environmental Monitoring Centre, 2013), which is three times higher than the air quality guideline of 25 μg/m³ recommended by the World Health Organization, highlighting the urgency of urban PM mitigation in China.

Mitigation of haze formation requires fundamental knowledge of sources, transformation, transport and physical and chemical characteristics of ambient aerosol particles as well as their gaseous precursors. In addition to primary aerosol particles such as wind-blown dust and soot emitted directly from combustion sources, secondary aerosol production from physiochemical processing in the atmosphere plays a critical role in urban haze pollution in China. For instance, in the recent Journal of Environmental Science

publication, Han and co-workers clearly demonstrated that secondary inorganic aerosol (SIA, including inorganic sulphate, nitrate and ammonium) formation predominantly generated through gas-phase oxidation of anthropogenic sulphur dioxide (SO₂) and nitrogen oxides (NO_x) contributed up to 60% of the total PM₁₀ mass observed during the haze periods in Beijing summer 2006 (Han et al., 2015). More recent field measurements of PM_{2.5} also highlight the importance of SIA in haze formation in urban Beijing and other polluted regions in China (e.g., Guo et al., 2014; Huang et al., 2014).

Despite the fact that the reduction of SO₂ and NO_x emissions from coal-burning power plants and vehicles has been proposed to be effective strategies to control haze formation (Zhuang et al., 2014), there is growing evidence that secondary organic aerosol (SOA) produced through photochemical processing of volatile organic compounds (VOCs) can be a significant contributor to the observed haze episodes in China. Even though SOA only contributed about 5% of the total PM₁₀ mass in Beijing summer 2006 (Han et al., 2015), Huang et al. (2014) reported that SOA could account for 16%–30% of the PM_{2.5} mass and 40%–70% of organic aerosol mass measured at the urban sites of Beijing, Shanghai, Guangzhou and Xi'an with the daily average PM_{2.5} mass concentrations of 69–345 μg/m³ in January 2013. They also reported that the SOA-to-SIA ratios ranged from 0.6 to 1 in those polluted cities, indicating a comparable contribution of SOA and SIA to the total PM_{2.5} mass in those polluted cities.

VOCs can be largely originated from anthropogenic emissions (e.g., fossil combustion and biomass burning activities). It has been predicted that the emission of VOCs in China will increase by 49% in 2020 compared to that in 2005 (Xing et al., 2011), highlighting the importance of developing effective VOCs emissions control strategies in the near future. Unlike the sources of SIA, which are relatively well constrained as demonstrated by Han et al.

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(2015), SOA sources are still highly uncertain and their formation chemistry involves complex multiphase processing that warrants further research efforts in both field and laboratory investigations.

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