Impacts of ammonia on gas-particle partition and AWC during the 2016 APHH-Beijing campaign: inducing effects of nitrate ammonium

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Atmospheric NH_3 plays a vital role not only in the environmental ecosystem but also in atmosphere chemistry. To fully understand the effects of NH_3 on the formation of haze pollution in Beijing, ambient NH_3 and related species were measured at high resolutions during the wintertime Air Pollution and Human Health-Beijing (APHH-Beijing) campaign in 2016. Simulations were made to gain insights into impacts of NH_3 on the formation of secondary inorganic aerosols (SIAs) and regional fine particle pollution. We found that the total NH_x (gaseous NH_3+particle NH_4^+) was mostly in excess of the SO_4^{2-}-NO_3^--NH_4^+-water equilibrium system during our campaign. This NH_x excess made medium aerosol acidity, with the median pH value being 3.6 and 4.5 for polluted and non-polluted conditions, respectively, and enhanced the formation of particle phase nitrate. During polluted periods, SIAs contributed most to $PM_{2.5}$ and were highly correlated with aerosol water content (AWC), indicating the importance of heterogeneous reactions in haze formation. Our analysis suggests that NH_4NO_3 is the most important factor driving the formation of AWC, with NO_3^- controlling the prior pollution stage and NH_4^+ the most polluted stage. Increased formation of NH_4NO_3 under excess NH_x, especially during the nighttime, may trigger the decreasing of aerosol DRH and hence lead to hygroscopic growth even under lower RH conditions and the wet aerosol particles become better medium for rapid heterogeneous reactions. A further increase of RH promotes the positive feedback "AWC-heterogeneous reactions" and ultimately leads to the formation of severe haze. Both our observational and modelling results suggest that the control of NH_3 may be more effective in reducing $PM_{2.5}$ under current emissions conditions in the North China Plain (NCP).

Keywords: Ammonia, partition, aerosol acidity, APHH-Beijing, PM2.5, NCP