The significant role of vehicle ammonia emissions in urban secondary aerosol formation for Chinese megacities

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Tailpipe aftertreatment devices of on-road vehicles are effective to control emissions of regulated pollutants but would result in ammonia (NH_3) emissions as unwanted side product. For example, three-way catalyst (TWC) converters used by gasoline vehicles generate NH_3 emissions. For diesel vehicles, NH_3 emissions are in general related to urea injection for selective catalyst reduction converters (SCR). Based on recent tailpipe emission measurements for gasoline [1] and diesel [2] vehicles in China, we update the vehicle NH_3 emission inventory for on-road vehicles in China [3]. The results indicate that, at the national level, on-road vehicles currently are responsible for a minor fraction (~90 kt, 0.8%) of total anthropogenic NH_3 emissions in China. The contribution fractions vary from below 0.5% in remote provinces (e.g., Tibet, Xinjiang, Inner Mongolia) to more than 5% in populated municipalities (e.g., Beijing, Shanghai). Of note, supported by detailed street-level traffic data, a high-resolution emission inventory [4] for the urban area of Beijing (note: the urban area of Beijing is about 1000 km^2 and denotes the area within the Fifth Ring Road and. By comparison, the total area of the municipality of Beijing is about 16,000 km^2) suggest that on-road vehicles are the leading source (approximately 80%) of anthropogenic NH_3 emissions, of which gasoline cars are estimated to contribute more than 70%.

We further apply an atmospheric chemical transport model (WRF/CMAQ 5.3; 3 km-and-1 km simulation resolutions) to quantify the role of vehicle NH_3 emissions in the formation of secondary inorganic aerosol, in particular focusing on the impact of the spatial heterogeneity of vehicle NH_3 emissions. With the Brute-Force method by closing all vehicle NH_3 emissions, we find that total $PM_{2.5}$ concentrations in the urban area of Beijing are lowered by 1 $\mu g/m^3$ (3%) in the summer. The wintertime reduction of $PM_{2.5}$ is quite significant, which is up to 10 $\mu g/m^3$ (9%). The changes in two seasons are both predominantly caused by the reduction in ammonium nitrate. This study, by implication, suggest that vehicle emissions are an important source of NH_3 emissions in traffic-dense urban areas of megacities in China, and contribute significantly to urban $PM_{2.5}$ pollution (particularly in winter). Further source apportionment studies by using atmospheric models should carefully consider the high concentration of vehicle NH_3 emissions in urban areas.

References

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