Can scooter emissions dominate urban organic aerosol?

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In urban areas, where the health impact of pollutants increases due to higher population density, traffic is a major source of ambient organic aerosol (OA). A significant fraction of OA from traffic is secondary, produced via the reaction of exhaust precursor gases with atmospheric oxidants. Secondary OA (SOA) has not been systematically assessed for different vehicles and driving conditions and thus its relative importance compared to directly emitted, primary OA (POA) is unknown, hindering the design of effective vehicle emissions regulations.

2-stroke (2S) scooters are inexpensive and convenient and as such are a popular means of transportation globally, particularly in Asia (e.g. 6% in Thailand vs. <1% in Europe, Klaassen et al. 2005). European regulations for scooters are less stringent than for other vehicles and thus primary particulate emissions from 2S engines are estimated to be much higher. Furthermore, current estimates suggest scooters may emit more volatile organic compounds (VOCs) than all other vehicles combined in Europe by 2020 (Geivanidis et al., 2008), implying that scooters dominate SOA production from traffic emissions. Thus assessing the effects of scooters on public health requires consideration of both POA, and SOA production.

Here, we quantify POA emission factors (EF, mg kg^{-1}_{fuel}) and potential SOA EFs from 2S scooters, and the effect of using aromatic free fuel instead of standard gasoline thereon. During the tests, Euro 1 and Euro 2 2S scooters were run in idle or simulated low power conditions. Emissions from a Euro 2 2S scooter were also sampled during regulatory driving cycles (ECE47) on a chassis dynamometer.

Vehicle exhaust was introduced into smog chambers, where POA emission and SOA production were quantified using a high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS). A high resolution proton transfer time-of-flight mass spectrometer (PTR-ToF-MS) was used to investigate volatile organic compounds and a suite of instruments was utilized to quantify CO, CO_2, O_3, NO_X and total hydrocarbons.

We show that the oxidation of VOCs in the exhaust emissions of 2S scooters produce significant SOA, exceeding by up to an order of magnitude POA emissions (see Figure 1). By monitoring the decay of VOC precursors, we show that SOA formation from 2S scooter emissions essentially stems from the condensation of aromatic oxidation products. Further, we demonstrate that replacing the standard gasoline with an aromatic-free fuel mitigates SOA production (Figure 1), underlining the major role of aromatic compounds from 2S exhaust on SOA production. POA and potential SOA EFs determined here from 2S scooters will be presented and compared with EF from other vehicles, including 4-stroke scooters, gasoline cars and diesel cars to assess the contributions of 2S scooters in urban atmospheres.

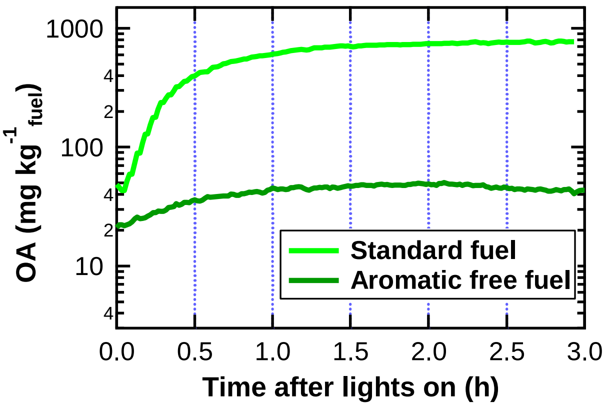

Figure 1. POA+potential SOA emission factors from a Euro 2 2-stroke scooter filled with standard gasoline and with aromatic free fuel, during the ECE47 driving cycle.

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