Nitrogen containing exhaust emissions for consideration in the aerosol research

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Transformation of primary exhaust emissions into secondary products is an important aspect when traffic emissions are assessed. For example, about 30% of PM10 measured is in the form of secondary inorganic sulphate and nitrate aerosols, which are formed from the transformation of gaseous SO_2, NO_x and NH_3 emitted from various sources. These aerosols are presumably even more important as regards PM2.5. Secondary organic aerosols are formed from atmospheric oxidation and subsequent condensation of various VOCs (EEA 2012). Ammonia originates mainly from agricultural sources. However, concern of traffic sources in the production of ammonium aerosols increased as the use of urea-based SCR systems for NO_x control for diesel engimes became common. Ammonia is also formed by the three-way catalysts of the spark-ignited gasoline cars. Nitrous oxide (N_2O), a strong greenhouse gas, is also induced by catalyst chemistry under lean conditions. (Meija-Centeno 2007, EEA 2012). In this study, an extensive set of emission constituents, including ammonia emissions, were measured from two flexible-fuel cars. These results are discussed in relation with nirtogen containig emissions from other types of internal combustion engines.

Emissions from two passenger cars (VW Passat MultiFuel, DISI engine, Ford Mondeo 2.0 FlexFuel, natural aspirated MPI engine) using fuels with different alcohol content (E10, E85, and E100) were measured on chassis dynamometer using the cold-start European exhaust emissions driving cycle (NEDC) and the hot-start FTP driving cycle. Several compounds were measured on-line using Fourier transformation infrared (FTIR) equipment (Gasmet Cr-2000) from the raw exhaust gas at two-second intervals. In-depth analyses of other emissions, also secondary organic aerosols were analysed in co-operation of three research organisations.

The NO_x emissions were low for the three-way catalyst (TWC) equipped spark-ignited cars in the NEDC tests. However, surprisingly high NO_x emissions were observed for the MPI car in the hot-start FTP test (up to 228 mg/km). The highest emissions are typically observed in the beginning of the cold-start test and during accelerations, whereas here the highest NO_x concentrations occurred in the hot-start FTP test after a 10 minutes pause. This indicates engine adjustments optimised for low HC emissions leading to non-favourable conditions NO_x reduction (possibly lean air-to-fuel ratio). Nitrogen dioxide emissions were low (below 3 mg/km), as well as nitrous oxide emissions (below 5 mg/km). Both cars emitted quite similar emission levels of ammonia. The highest single emission result, close to 50 mg/km, was obtained for the the DISI car over the NEDC test cycle at -7 °C. High ammonia concentrations observed, typically over 10 ppm and substantial peaks up to 300-500 ppm. These ammonia concentrations are high when compared to limit value of 10 ppm for SCR equipped heavy-duty engines, for example. In theory, ammonia formation is enhanced in slightly rich air-to-fuel ratio at high temperatures (aggressive accelerations) when sufficiently HC and NOx emissions are present (Li et al. 2010, Mejia-Centeno 2007, Heeb et al. 2006). These results suggest that nitrogen containing emissions would deserve attention in the research of secondary aerosol formation for internal combustion engines.

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