Measurement of late-model diesel automobile real driving emissions of reactive nitrogen compounds with on-board FTIR

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This work reports on measurement of real-world exhaust emissions (real driving emissions, RDE) of reactive nitrogen compounds (NO – nitrogen oxide and NO_2 – nitrogen dioxide, together labelled as NO_x, NH_3 – ammonia, N_2O – nitrous oxide) from diesel cars using a portable Fourier Transform Infra Red Spectrometer (FTIR).

NO_x contribute to the formation of tropospheric ozone, NO_2 is a lung irritant, N_2O is a potent greenhouse gas. The combustion process in the engines produces primarily only NO formed from atmospheric nitrogen at high combustion temperatures. Three-way catalysts used on gasoline engines produce NH_3 when run with excess fuel, and selective reduction catalysts (SCR) on diesel engine produce NO_x when overdosed with NO_x-reducing reagent (urea, sold as AdBlue). N_2O is released from some NO_x storage catalysts (LNT) during regeneration, and SCR under some conditions. Some types of oxidation catalysts intentionally produce more harmful NO_2 from NO to reduce regeneration temperature of diesel particle filters. Efforts to reduce the emissions of CO_2, NO_x and particulate matter (PM) have therefore created a concern about NO_2, NH_3 and N_2O emissions.

NO_x and other emissions have been also reported to be higher during real driving than during laboratory tests historically used for both type-approval of new vehicles and for establishment of emissions factors, based on which the total emissions of the general vehicle fleet are estimated. This is due to increasing complexity of advanced combustion and exhaust aftertreatment controls, which are – partly unintentionally, partly deliberately – tuned primarily to achieve low, compliant emissions during the type-approval test.

In this work, NO, NO_2, NH_3, N_2O and other compounds have been measured by on-board FTIR analyzers a Euro 5 diesel car with a LNT and a Euro 6 diesel car with a SCR. The LNT car was also driven at high speeds on the German autobahn, while a chassis dynamometer was used for the SCR car.

While two Euro 6 heavy vehicles had during on-road operation NO_x emissions comparable to or lower than the applicable Euro 6 limit, the NO_x emissions on the passenger cars were inconsistent. On the LNT vehicle, there were virtually no emissions of ammonia, and methane and N_2O were emitted during spikes corresponding to LNT regeneration. Such spikes were absent, and NO_x emissions were higher, during dynamic driving as shown on the graph. NO_x emissions were also generally much higher at speeds above 120-130 km/h. On the SCR vehicle, the emissions of ammonia were relatively low, while N_2O emissions were measurable.

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