Using Extractive FTIR to Measure N2O from Medium Heavy-Duty Diesel Vehicles

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Purpose

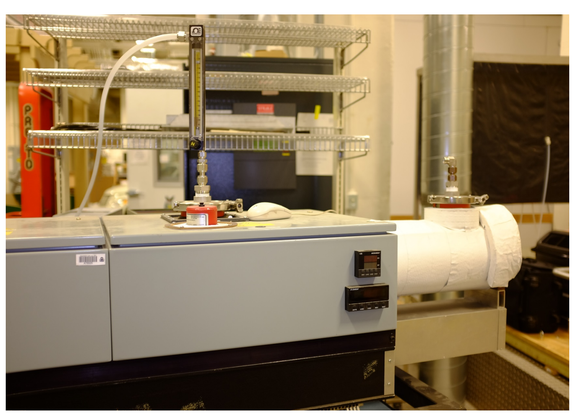
Two vehicles were tested to compare the emission effects of changing from Ultra Low Sulfur Diesel (ULSD). Two of these vehicles were tested on a chassis light-duty dynamometer because the dilution tunnel was equipped to collect samples for speciated SVOCs and VOCs.

Modal data allows emission concentrations to be compared to vehicle system parameters like air-fuel ratio (AFR), percent oxygen, exhaust temperature, and several more on real-time basis. This type of comparison makes it possible to begin to determine root causes of the analyte, a necessary step in determining potential means of controlling the emission rate. The FTIR was evaluated to whether it could produce real time modal data.

In order to verify that the FTIR was correctly time aligned and accurately measuring the diluted exhaust, comparisons were made to 40 CFR 1065 reference methods for CO_2 and NO_x. It was observed that the FTIR modes of the CO_2 and NOx data correlated to those reference methods. This suggests that when a compound such as N_2O was measured, its mode shape was correct and can be used in future studies comparing the N_2O to other vehicle parameters. The goal was not to generate emission rates but to determine when the emission rates varied so that a statistical analysis might be applied to better understand root causes for vehicular emissions.

FTIR

The FTIR system used for this study was an Industrial Monitor and Control Corporation (IMACC) (IMACC, Round Rock, TX) spectrometer equipped with a Micheleson interferometer, a zinc selenide beam splitter, a mercury cadmium telluride detector and a 12L, 1m multi-pass gas cell with gold-coated mirrors and a stainless steel coated body, with a path-length of 78 meters.



Project Approach

The emissions of two medium heavy-duty diesel trucks, equipped with Diesel Particulate Filters (DPFs), were characterized under a variety of operating conditions as well as environmental conditions. One vehicle used a NOx Adsorber Catalyst (NAC) paired with a Diesel Oxidation Catalyst (DOC) and the other vehicle used a Selective Catalytic Reduction (SCR) system for control of nitrogen oxides (NOx). Both vehicles were tested with two different fuels [ultra-low sulfur diesel (ULSD) and biodiesel (B20)] and ambient temperatures (70ºF and 20ºF).Three driving cycles provided emissions estimates under changing operating conditions: (1) a cold start with low transients (CSLT), (2) the federal heavy-duty urban dynamometer driving schedule (HD-UDDS), and (3) a warm start with low transients (WSLT).

SCR and NAC Comparisons

Figure 1 and Figure 2 present preliminary data from the study. Figure 1 presents NOx comparisons of the SCR and NAC vehicles at 20 °F using ULSD fuel under the HD-UDDS. Figure 2 presents N2O comparisons of the SCR and NAC technology for the same test. Both figures have concentration values on the y-axis and time on the x-axis. The changes in concentration values are related to changes in the speeds of the driving cycle. In Figure 1, the NOx emissions for the SCR are higher concentrations than those for the the NAC. Figure 2 illustrates that the N_2O values for the NAC were slightly higher, further parameters need to be investigated to explain these results.

Figure 1: NOx Comparison SCR and NAC Technology at 20 °F (ULSD Fuel)

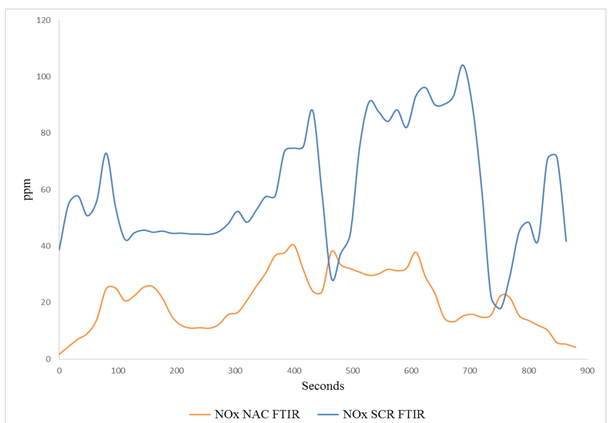
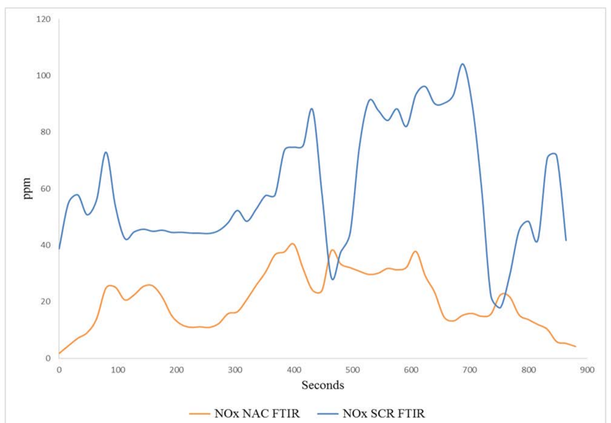
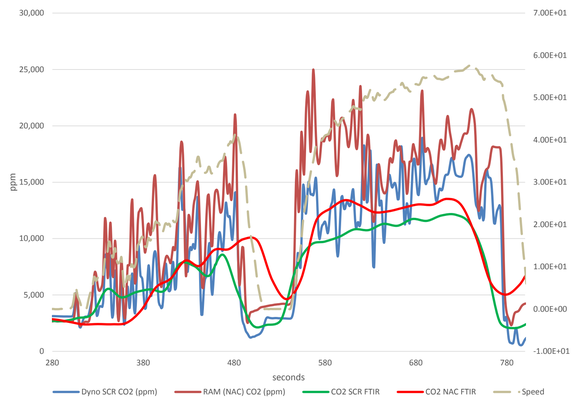


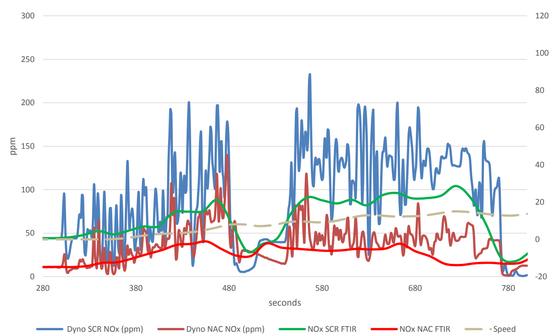
Figure 2: N2O Comparison of SCR and NAC Technology at 20 °F (ULSD Fuel)



Modal Comparisons

The modal data from the FTIR measurements of the CO_2 and NO_x show that the FTIR had sufficient time resolution to suggest which portions of the driving cycle resulted in the highest emissions. That being the case, the FTIR provides valuable insight into the conditions that result in nitrous oxide.





References: 1. U.S. Department of State (2007). Projected Greenhouse Gas Emissions. In: Fourth Climate Action Report to the UN Framework Convention on Climate Change . U.S. Department of State, Washington, DC, USA..
2. Title 40 Protection of the Environment Subchapter U Air Pollution Controls Part 1037 Control of Emissions from New Heavy-Duty Motor Vehicles