Emissions of a GDI vehicle operating with different composition engine oils

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Diesel engines produce more particulate matter than their gasoline counterparts. However, the gasoline direct injection (GDI) spark ignition-type engines have been shown to emit solid particles in concentrations comparable to common direct injection compression ignition diesel engines. Metals from lubricant oil or fuel have been found to increase the particle number concentration in the below 20 nm size range and even change the soot characteristics at high metal concentrations (e.g. Gidney *et al*, 2010). Furthermore, Cheun *et el* (2010) reported that the PM-induced toxic activity of vehicular exhaust is strongly associated with tracers of lube oil emission, such as Zn, P, Ca and hopanes suggesting that incomplete combustion of lube oil plays a significant role in the exposure and health.

In this work (Pirjola *et al*, 2013), we compare the exhaust emissions of a EURO V passenger car AUDI 1.8 TFSI equipped with a three-way catalyst and used standard gasoline fuel (FSC<10 ppm) but five different synthetic engine oils (Oil1-Oil5) filling the viscosity grade requirement of SAE 5W-30. The measurements were performed at a chassis dynamometer over the New European Driving Cycle (NEDC) as well as over three steady state cycles. Exhaust sampling and dilution for particle measurements was conducted using a porous tube diluter, an ageing chamber and a secondary diluter. Number concentration and number size distribution of particles larger than 3 nm were measured by Nano-SMPS, SMPS, CPC and ELPI, and a thermodenuder was used to study particle volatility characteristics. Diluted NOx and CO_2 concentration were measured; for dilution ratio also raw CO_2 concentration was measured.

Furthermore, exhaust particle measurements were performed also on road with two of the engine oils (Oil1 and Oil4). A mobile laboratory van Sniffer (Pirjola *et al*, 2004) equipped with the same instrumentation chased AUDI at a distance of 10 m.

During the steady state tests particle size distributions were bimodal. The smaller mode was peaking at below 20 nm and the larger mode at 60-70 nm with all oils; however, the concentrations varied from oil to oil, and were inversely proportional to the engine load. Figure 1 shows that the total number concentration, measured by the ELPI, was lowest with Oil4 for all engine loads. Oil4 possessed smallest calsium and zink concentrations whereas sulphur concentration was smallest in Oil3 followed by Oil4.

During the NEDC tests the highest exhaust particle concentrations were observed in speed transients. Especially during the highest wheel speed mode and the final deceleration, high number of particles below 20 nm was measured with Oil1 and Oil2. These particles were highly volatile, indicating that their formation takes place when the exhaust aerosol was cooled in the diluter. On-road tests supported the results obtained in the laboratory for both Oil1 and Oil4.

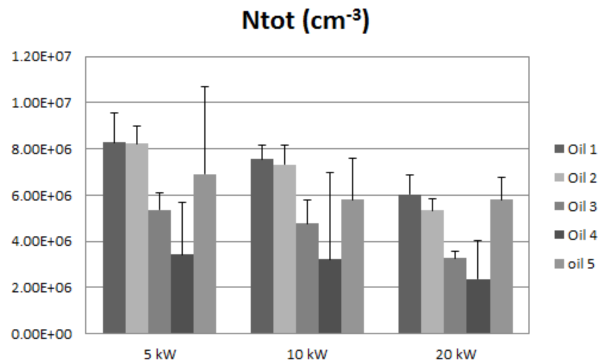

Figure 1. Averaged total particle number concentrations along with standard deviations for different lubricant oils during three steady state conditions. Concentrations have been calculated to raw exhaust concentrations.

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