Particle emissions of a heavy duty diesel engine fuelled with fossil diesel and hydrotreated vegetable oil

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Diesel exhaust emissions are a major concern for light and heavy duty vehicles due to adverse health and environmental effects. As well as increasing the air pollution components, e.g. NO_x, SO_x and PM, in the densely populated areas, diesel vehicles emit a vast amount of CO_2. One way to reduce the net CO_2 emissions is to increase the amount of bio components in the fuel. By changing the chemical and physical structure of the fuel, the exhaust emission nanoparticles and other pollution components may also change.

Hydrotreated vegetable oil (HVO) is one of renewable diesel fuels (Kuronen *et al.* 2007). The blending percentage of HVO to fossil fuel can vary between 0–100%. According to the review study of Hartikka *et al.* 2012, by using HVO (compared to fossil diesel), emissions of every regulated component were reduced on average in 14 Euro IV heavy duty vehicles. NOx, PM, CO and HC emissions were reduced by 8%, 34%, 25% and 26%, respectively, and also CO_2 emission was reduced by 4% due to larger H/C ratio in HVO compared to fossil diesel. HVO has also been observed to reduce soot particle number emissions compared to fossil fuel while the structure and oxidation properties of the particles were unaffected which indicates that similar particle filters can be used (Happonen *et al.* 2010).

In this study, particle emissions of a Euro IV truck engine were studied on an engine dynamometer. Test fuels were 100% fossil diesel fuel, complying with the EN590 standard, and 100% HVO fuel. The particle size distributions were measured with two ELPIs (Electrical low pressure impactor, Dekati), two EEPSs (Engine exhaust particle sizer, TSI), an SMPS (Scanning mobility particle sizer, TSI) and a Nano-SMPS. Particle number concentration was also measured with a UCPC (Ultrafine condensation particle counter, TSI). The exhaust sampling was conducted with two dilution systems. A double ejector dilution (DED) was used for one ELPI, while the exhaust sample for all the other instruments was diluted with a porous tube diluter (PTD). Also a thermodenuder (TD) was applied after the PTD sampling to remove the semivolatile particle fraction.

Nonvolatile particle emission factors measured with the ELPI after DED are shown in Figure 1. The emission factor is calculated from particle number and CO_2 concentrations which were measured from the same location of the sampling system. Overall, the particle number emissions are lower with HVO fuel compared to fossil fuel; differences are especially remarkable at the ESC points 7, 9 and 11 where the engine runs at low load. The particle number concentrations measured with different instruments were in very good correlation which increases the reliability of the results. Somewhat unexpectedly the nucleation mode was absent at all of the engine load conditions with both fuels. Size distributions, as well as concentrations, were similar with and without the TD consisting solely of soot particles.

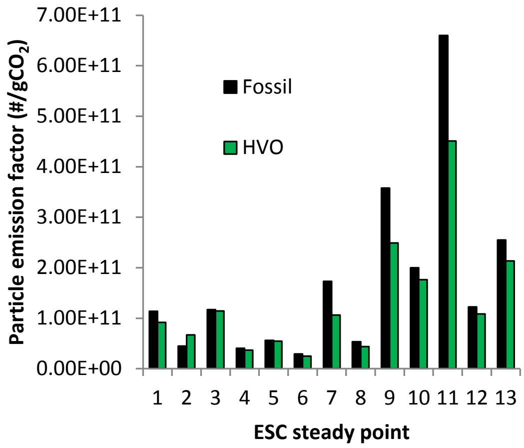

Figure 1. Solid particle engine-out number emission factors with a fossil diesel fuel and hydrotreated vegetable oil (HVO) at different ESC cycle steady test points. Particle concentrations were measured with the ELPI behind the DED sampling

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