Fine Particulate Matter from a Flex-Fuel Engine: NEDC and High Speed

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Since 2005, new limit values for fine particulate matter hold in areas of Germany which are predominantly affected by heavy traffic or urban centres, called low-emission zones (LEZ). In those LEZ, the fine dust air pollution is expected to declining. However, as one of very few countries in the world (New Zealand and the US state of Oregon), in Germany it is still allowed to drive without speed restriction on motorways. In addition to that, it is well-known that petrol engine start to leave stoichiometric combustion at speed higher than approximately 130 km/h towards fuel excess, consequently leading to higher fuel consumption and particulate emissions.

A flex-fuel engine was operated on petrol with 10 vol-% (E10) and 85 vol-% (E85) to investigate possible reductions in particulate carbonaceous emissions by using higher amounts of ethanol. Firstly, the engine was started (cold start) and performed 11 times the "New European Driving Cycle" (NEDC) with both fuels. Secondly, and a self-designed "High-Speed Driving Cycle" (HSDC) with speeds from 80 km/h up to 180 km/h was applied to examine particulate emissions from high speed. On-line measurements were carried out with a 7-wavelengths aethalometer and ABB gas analysers. Furthermore, the exhaust was diluted 1:40 or 1:10 to sample PM2.5 on quartz fibre filters for thermal/optical carbon analysis (TOCA) hyphenated to photoionisation time-of-flight mass spectrometry (PI-TOFMS). The TOCA-PI-TOFMS enables the investigation of the molecular composition of thermal fractions during carbon analysis (Grabowsky 2011). According to *ImproveA* protocol, four fractions of organic carbon are defined by the slope of the flame ionisation detector (Chow 2007). While resonance-enhanced multi-photon ionisation (REMPI) refers to a selective technique for aromatic compounds, single-photon ionisation (SPI) is a more universal technique which ionises analytes with lower ionisation energies than photon energies (Hanley & Zimmermann 2009). In the first two OC fractions, mainly thermodesorption of semi-volatile compounds occurs whereas in OC3 and OC4 decomposition of larger molecules takes place

Switching from E10 to E85, organic carbon (OC) was reduced by about 83 % for both driving cycles, whereas elemental carbon (EC) even declined by 98 % due to a improved combustion by additional oxygen in the fuel. Surprisingly, higher OC and EC emission factors (EF) were obtained for NEDC. Although the self-defined HSDC features high speeds, accelerations and brake appear less frequently than in NEDC. Thus, it can be concluded that typical start-and-stop in urban areas produces higher emissions than constantly fast driving on motorways. However, only E10 showed significance in this observation while no distinct difference could be identify for E85. Due to one to two orders of magnitude lower EFs of OC and EC for E85, the relative variance to the mean value increases that more experiments have to be carried out for a reliable prediction (Figure 1).

In the REMPI spectra, the majority of aromatic species contained no alkylation indicating a dominant formation mechanism by radical reactions rather than unburned fuel. Finally, a strong relation between OC-to-EC ratio and Ångström exponents could be observed, indicating that particle-bound organic matter from the flex-fuel engine contains light-absorbing carbon in the lower visible UV range, i.e. brown carbon.

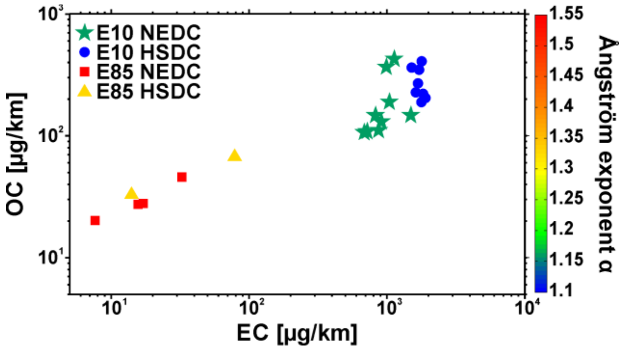

Figure 1. Logarithmic scatter plot of OC and EC emission factors together with Ångström exponents.

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