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# Chemical and physical characterization of diesel emissions from EURO 2, 3 and 4 vehicles fuelled by reference diesel and a 20% biofuel blend.

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## INTRODUCTION

It is well known, that diesel fuelled vehicles emit high amounts of sub-micrometer aerosol, which in turn is expected to cause adverse health effects. It is envisaged that future regulations will control particulate emissions also in terms of size (Tsolakis, 2006). This work presents a study on diesel exhaust emissions covering different engine types (EURO norm 2-4) operated with a blend (20% w/w biodiesel) and a reference fossil diesel. The study aims at identifying differences in emissions for engines representative for the present car population in Denmark.

## METHODS

Gas-phase and particle-phase emissions were measured in different operation modes, that is mode 1 (idle), mode 2 (max torque; 25% load), mode 3 (max torque; 50% load), mode 4 (max torque; 100% load), and mode 5 (max power; 100% load). The raw exhaust from the engine was mixed with particle-free air (1:10) in a dilution tunnel.

NO, $NO_2$, CO, $CO_2$, and Total Volatile Organic Compounds (TVOC) were measured in the raw gas exhaust. Carbonyls and filter samples for chemical analysis (EC/OC, PAH, hopanes and steranes) were obtained from the dilution tunnel.

A rotating disc diluter (Matter Engineering, Switzerland) provided variable dilution (15-300 times) and connected the raw gas and a Differential Mobility Particle Sizer (DMPS with size range between 10 – 700nm), which measured the sub-micrometer particle number size distribution (PNSD).

Table 1. Overview of experiment runs and determined parameters (3 replicate measurements).

| Type of engine | EURO Norm | Particles | Particle phase | Gas phase |
|---|---|---|---|---|
| Audi 1,9 TDI | EURO 2 | PNSD | PAH, steranes, hopanes | NO, NO2, CO, CO2, TVOC, carbonyls |
| Peugeot 1,6 HDI | EURO 3 | PNSD | steranes, hopanes | NO, NO2, CO, CO2, TVOC |
| Peugeot 1,6 HDI (Particle Filter) | EURO 4 | PNSD | PAH, EC/OC, steranes, hopanes | NO, NO2, CO, CO2, TVOC |

The chemical measurements were conducted in mode 4, which is representative for driving on a country road (80 km/hour for Danish conditions).

## RESULTS

The particle volume and thereby particle mass of sub-micrometer particles was two orders of magnitude lower for the EURO 4 engine (with particle filter) compared to the EURO 2 and 3 engines. Also, substantial differences in particle number size distribution were observed when using different fuels, but the same engine. In Figure 1, the particle number size distribution of a mode mix (18% mode 1, 25% mode 2, 16% mode 3, 16% mode 4, 25% mode 5) representative for typical driving conditions is presented.

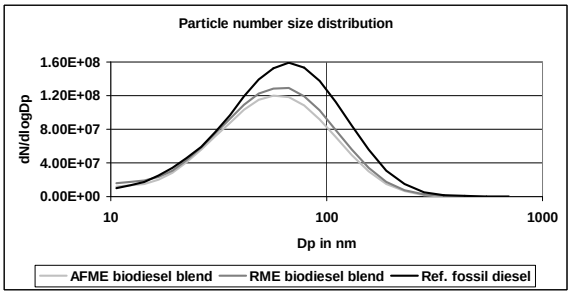


Figure 1. Particle number size distribution (mode mix, EURO 3) for different fuels.

Operating the EURO 3 engine with either of the biodiesel blends resulted in a decrease of emitted sub-micrometer particle volume of about 56% compared to the reference fossil diesel.

For the EURO 2 engine, emission of the individual PAH's were 11-56 % lower when fuelled by the biodiesel blend relative to operation with the reference fossil diesel. For example, the emission of benzo[a]pyrene was 18% lower. Similar and in some cases larger differences were measured for gas-phase carbonyls, e.g. formaldehyde, acetaldehyde and methacrolein were 25, 19 and 30% lower when biodiesel was added to the fuel.

## ACKNOWLEDGEMENT

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## REFERENCES

Tsolakis, A. (2006). Effects on particle size distribution from diesel engine operating on RME biodiesel with EGR. *Energy and Fuels*, 20, 1418-1424.