Genotoxicity of exhaust emissions from a diesel engine during extended low-load operation on diesel and biodiesel fuels

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Background

Diesel engines are one of the principal sources of air pollution in most urban areas. Traffic in the large city is often linked with congestion. Under such conditions, diesel engines operate at very high excess air ratio. The combustion chamber surfaces are gradually cooled, the combustion efficiency decreases, and the relatively low exhaust gas temperatures (around 100 °C) effectively inhibit the functionality of virtually all catalyst surfaces.

Goals of this study were to simulate engine running under congestion condition and to assess the particulate, PAH and cPAH emissions during extended low-load operation of a conventional diesel engine and during subsequent operation at a higher load, to elucidate the contribution of the "burn-off" of the stored material to cPAH, and to assess the emissions from biodiesel under such operating conditions.

Methods

Engine

- direct-injection turbocharged after cooled engine with a mechanical fuel injection pump (Zetor 1505, 90 kW)

Exhaust sampling

-raw exhaust was diluted in 10:1 rate

-sampled by Hi-Vol sampler Ecotech 3000 set on 67.8m^3/h flow rate

-20 × 25 cm glass fiber (Emfab, TX40HI20-WW, Pall) and quartz fiber (QMA, Whatman)

Filter analysis

-QMA – EC/OC analysis

- Emfab – organic extraction by dichloromethane

->liquid chromatography (PAHs quantification),

cPAHs includes: benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenzo[a,h]anthracene, indeno[1,2,3-cd]pyrene

In vitro acellular assay, DNA adduct analysis, oxidative DNA damage

Calf-thymus DNA was incubated with extractable organic matter (EOM) corresponding to 9 dm^3 of undiluted emissions for 24 h at 37°C with and without metabolic activation by use of an S9 fraction from rat liver. DNA adducts were measured by 32P-postlabeling and 8-oxodeoxyguanosine (8-oxodG) levels were analyzed using the competitive ELISA in purified DNA to quantify oxidative damage.

Results and Conclusions

Emission and PAHs

During operation on **diesel fuel**, extended idling caused much larger **increases of c-PAH** (**Fig.1a**) than total PAH (**Fig. 1b**) or total PM mass (**Fig.1c**).

During operation on **biodiesel**, extended idling has **increased** primarily total **PM mass** (**Fig.1c**) and **total PAH** (**Fig.1b**), with the relative increase being much higher compared to diesel fuel, but the effects on c-PAH (**Fig.1a**) were relatively low.

Under all circumstances the **emissions** of B[a]P, c-PAH and total PAH were **lower on biodiesel** compared than on diesel fuel.

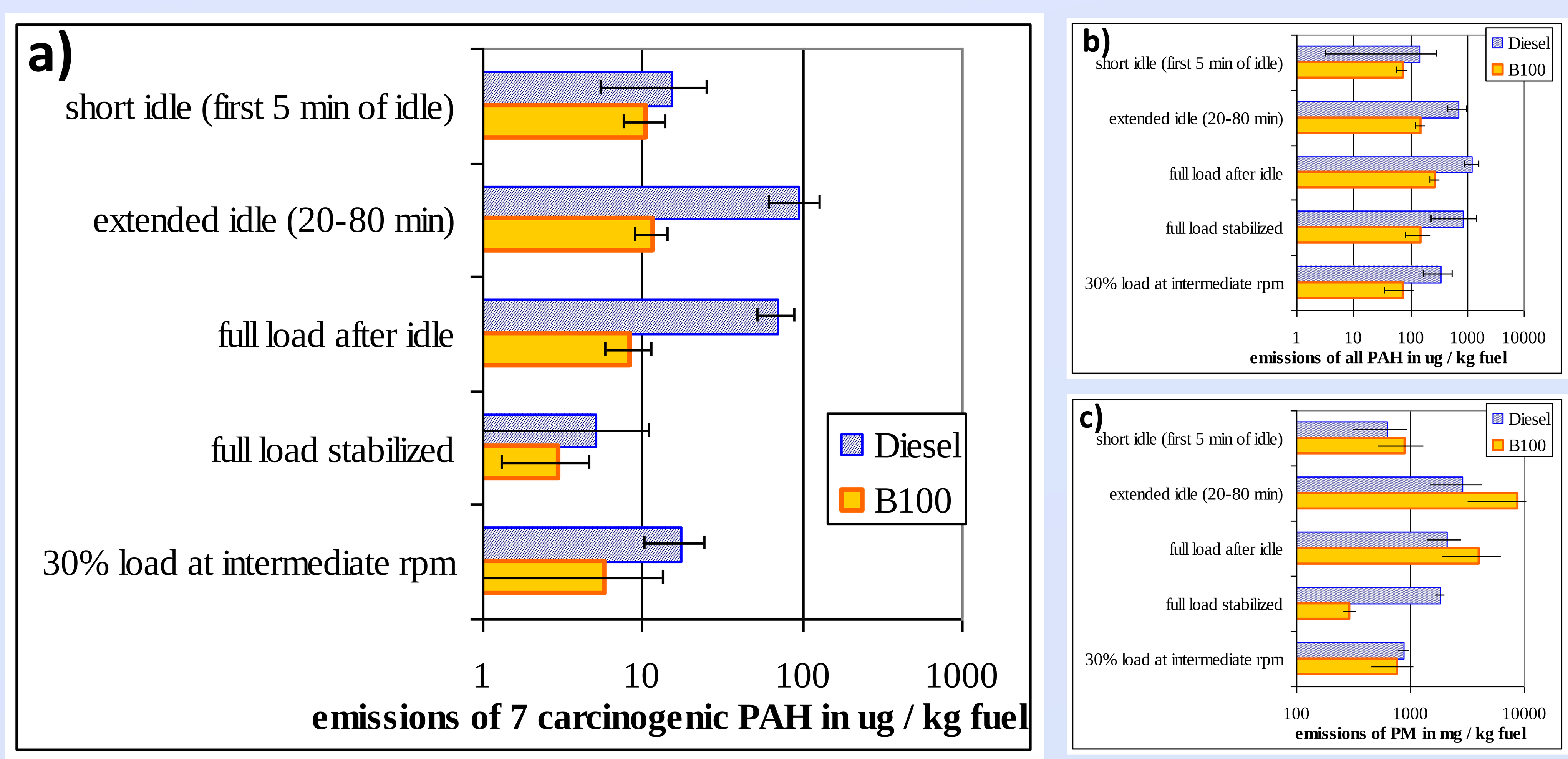

Fig 1 Comparison of fuel-specific emissions of a) cPAH, b) all PAH c) total PM mass

Genotoxicity and oxidative DNA damage

The results normalized per 9 dm^3 of undiluted exhaust suggest that highest **genotoxicity** is induced by EOM sample collected during **first 5 min at 100% load after extended idle**, i.e. deposit "burn-off" (**Fig. 2a**). For this operational mode are DNA adduct levels 3- to 6-fold higher for diesel than for biodiesel exhaust. With exception of the full load stabilized, **genotoxicity of diesel exhaust is higher than that of biodiesel**. EOM samples represented operational modes "**full load after idle**" and "**extended idle**" induced comparable genotoxicity even without cPAH activation (-S9) (**Fig. 2b**) suggesting strong effects of directly acting genotoxic compounds such as nitro- and oxy-PAH derivatives.

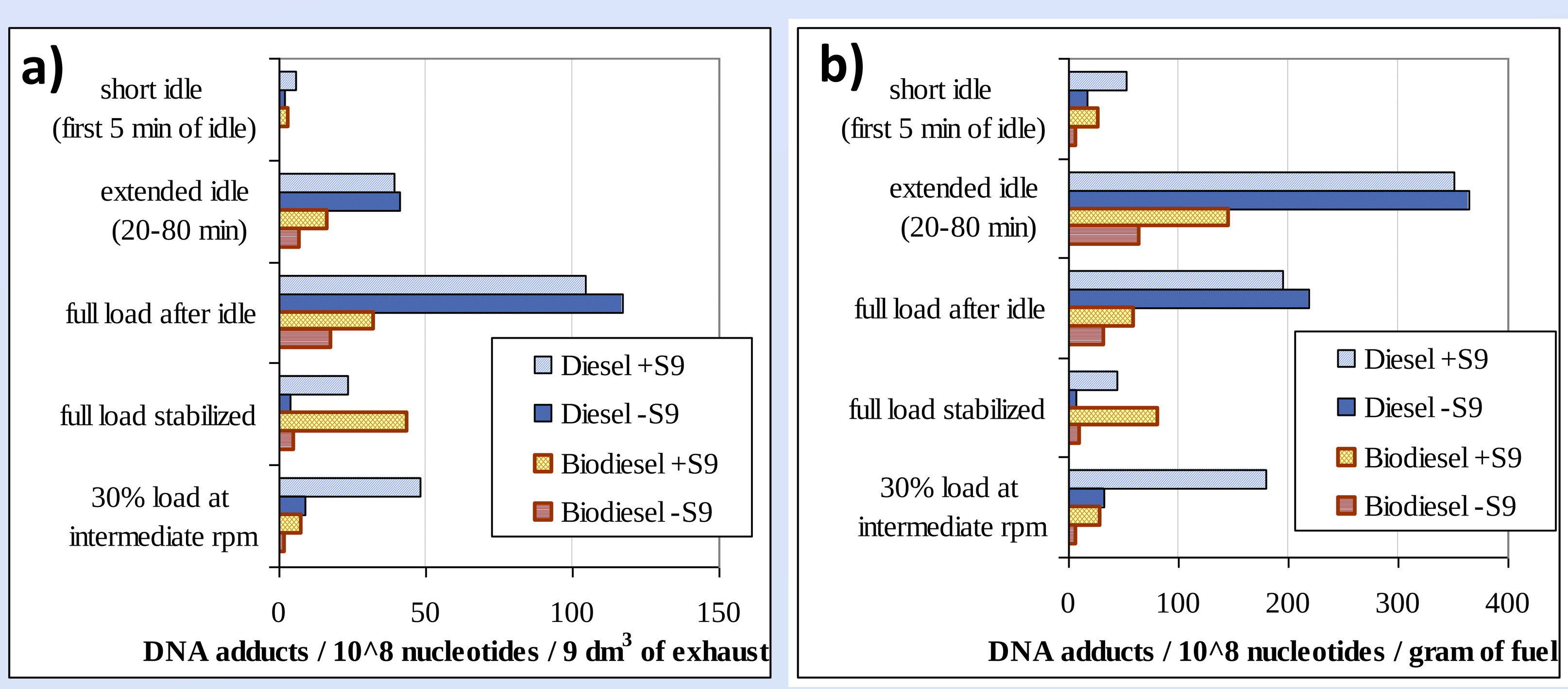

Fig. 2 DNA adduct levels per volume of undiluted exhaust (a) and gram of fuel (b)

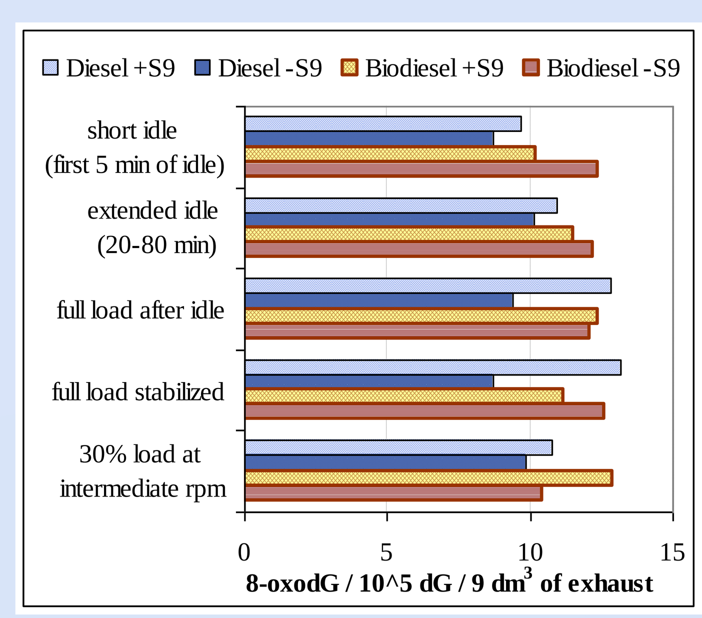

Fig. 3 DNA oxidative damage per volume of undiluted exhaust

In our study, very low induction of oxidative damage to DNA by all the EOM was observed (**Fig. 3**)

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