EFFECT OF OXYGENATED FUELS ON GENOTOXIC EMISSIONS OF GASOLINE DIRECT INJECTION VEHICLES

M. Muñoz[1,*], R. Haag[1], K. Zeyer[1], J. Mohn[1], P. Comte[2], J. Czerwinski[2], N. Heeb[1]
[1]EMPA, CH-8600 Dübendorf; [2]UASB, CH-2560 Nidau
Corresponding author: maria.munozfernandez@empa.ch

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BACKGROUND

Gasoline Direct Injection (GDI) engines were introduced in 2001. More power, lower consumption and lower CO_2 emission were claimed. However, large numbers of soot nanoparticles are emitted from GDI vehicles exceeding the current Euro 6 limits ($6x10^{11}$ particles/km) for diesel vehicles. It is expected that 30% of the EU fleet will be GDI vehicles in 2020 affecting air quality.

Furthermore, toxic pollutants like polycyclic aromatic hydrocarbons (PAHs) and alkyl-PAHs, many of them genotoxic, are also released from GDI vehicles. Alternative fuels with increased oxygen levels could help to lower emissions of toxic pollutants.

In 2012 Diesel exhaust was classified as a group 1 carcinogen and it is urgent to assess the genotoxic potential of GDI exhausts.

METHODOLOGY

<u>3 GDI vehicles</u>:
2 Euro 6, Golf VII and Citröen C4 and an Euro 5, Volvo V60.

<u>Sampling</u>:
Solid, condensed and gaseous fractions were collected from a CVS tunnel (see summary).
World Harmonized Light Vehicles Test Cycle (WLTC) under hot (hWLTC) and cold start (cWLTC) conditions at the chassis dynamometer of the UASB (Biel, Switzerland).

<u>Fuels:</u>
Ethanol/butanol + gasoline →E10 (10% ethanol), E85 (85% ethanol) and B15 (15% butanol).

<u>Analysis:</u>
HRGC-HRMS analyses.
Genotoxic potential of 8 genotoxic compounds (Fig. 3) (Group 1, 2A and 2B carcinogens), given in ng TEQ/m^3 :
[Concentration (ng/m^3)] x [toxic equivalency factors (TEFs)]

RESULTS

Exhaust concentrations in ng/Nm^3 of more than 30 PAHs and alkyl-PAHs were determined.
Fig. 2. shows the effect of the different fuels on PAH concentrations (ng/Nm^3), in the cWLTC (blue) and hWLTC (red) for the 3 vehicles tested.
Fig. 3. shows the cumulated genotoxic potential (ng TEQ/m^3) of the 8 genotoxic PAHs (above) and the respective normalized patterns (below). The chemical structures, color code, carcinogenic group and TEF values are shown on the right.

CONCLUSIONS

<u>Fuel effects</u>.
E10 and B15 increase emissions of the higher molecular weight PAHs (4- to 6-ring PAHs), with higher values in hWLTC in the GOLF VII. But these emissions were with the Citröen and the Volvo with E10 and E85 reduced.
Emissions of the most volatile compounds (2- and 3-ring PAHs) are lowered with the use of oxygenated fuels.

<u>Cold start emissions</u>.
A significant cold-start effect is observed for 2- and 3-ring PAHs for all vehicles. This effect is reduced for the 4-, 5- and 6-ring PAHs, being the hWLTC emissions even higher.

<u>Genotoxic Potential</u>.
The highest genotoxic potential is observed with B15 in the Golf VII in the hWLTC. Nevertheless, the use of E10, B15 and E85 seems to reduce genotoxic emissions when comparing with emissions with gasoline (E0) in the cWLTC.
<u>Patterns</u>: Benzo(a)pyrene proportions are often higher in the hWLTC and in some vehicles increase with the use of E10 and B15.

ACKNOWLEDGEMENTS

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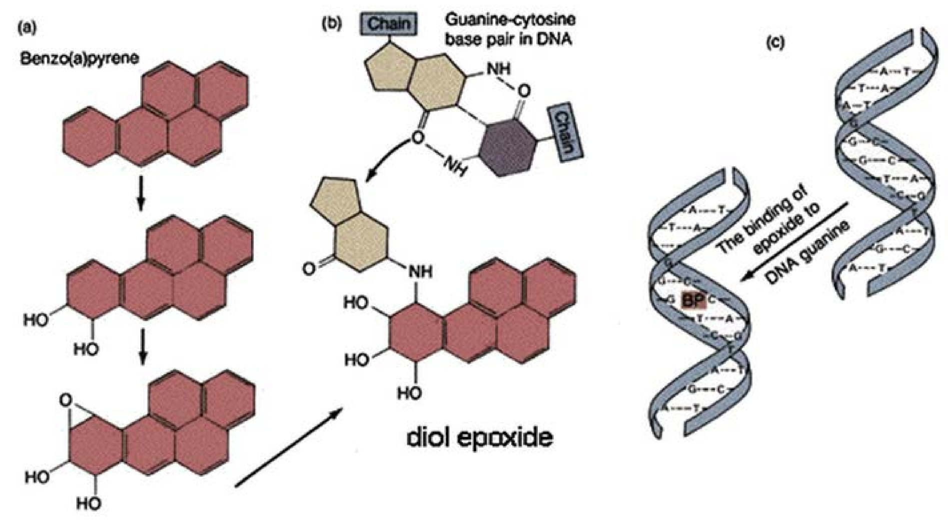
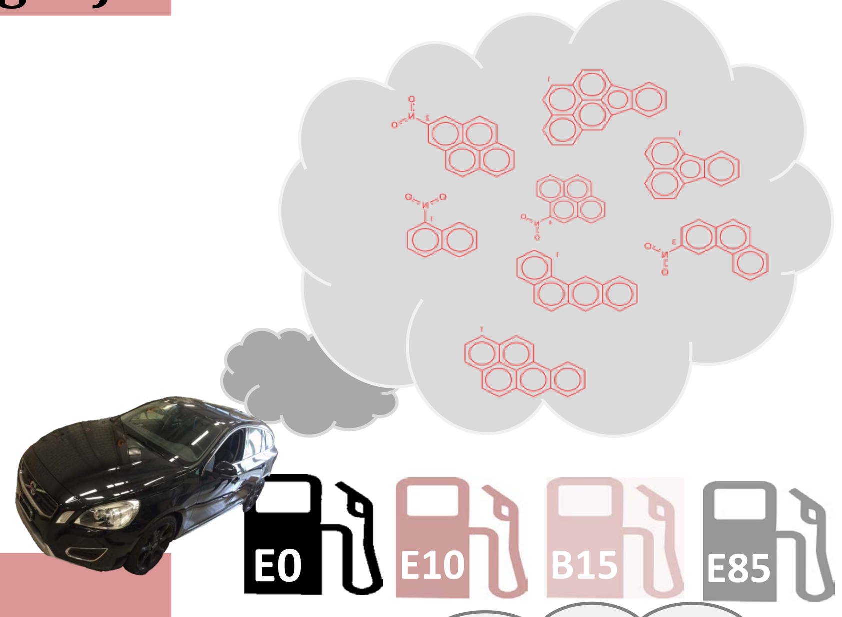
Genotoxic effect of benzo(a)pyrene (Group 1 carcinogen)



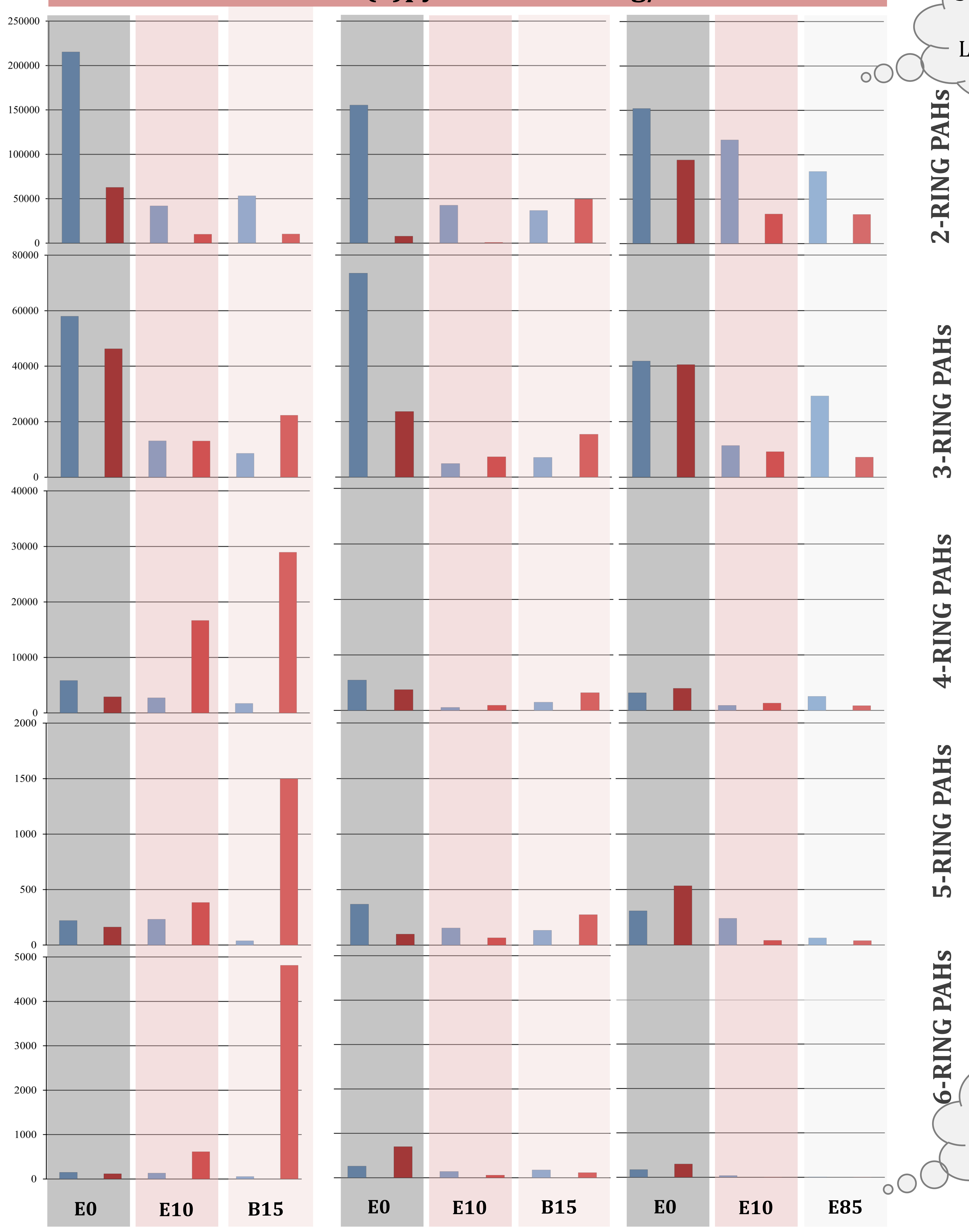
IS GDI EXHAUST GENOTOXIC?

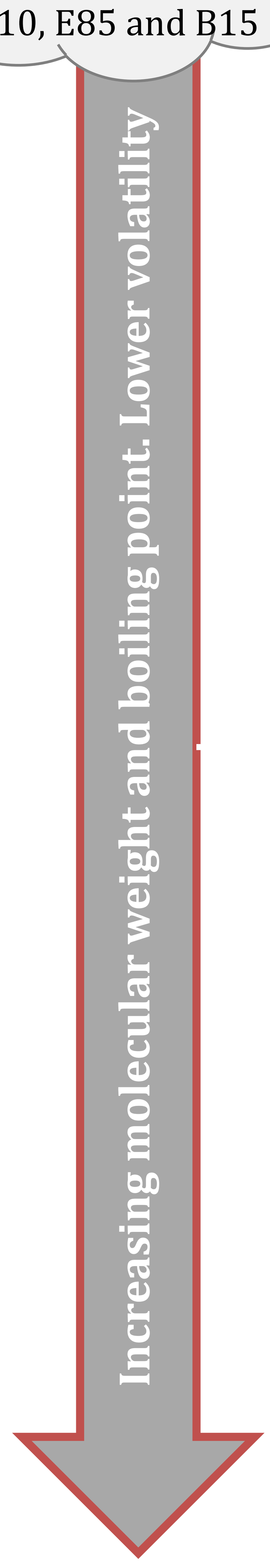


Exhaust concentration of PAHs in ng/m^3

EU Benzo(a)pyrene limit: 1 ng/m^3

Strong cold start effect of 2-,3-ring PAHs
Lower emissions with E10, E85 and B15





Higher emissions with E10 and B15 in some groups and vehicles

Fig. 2. Effect of fuels on 2-, 3-, 4-, 5- and 6-ring PAHs. Values reported in ng/Nm^3 for gasoline (E0), two ethanol/gasoline blends (E10 and E85) and a butanol/gasoline blend (B15) under the cold- (blue) and hot-start conditions (red) in the WLTC.

Benzo(a)pyrene toxic emissions predominant and higher in hWLTC and with the use of biofuels

Genotoxic potential in ng TEQ/m^3 and patterns

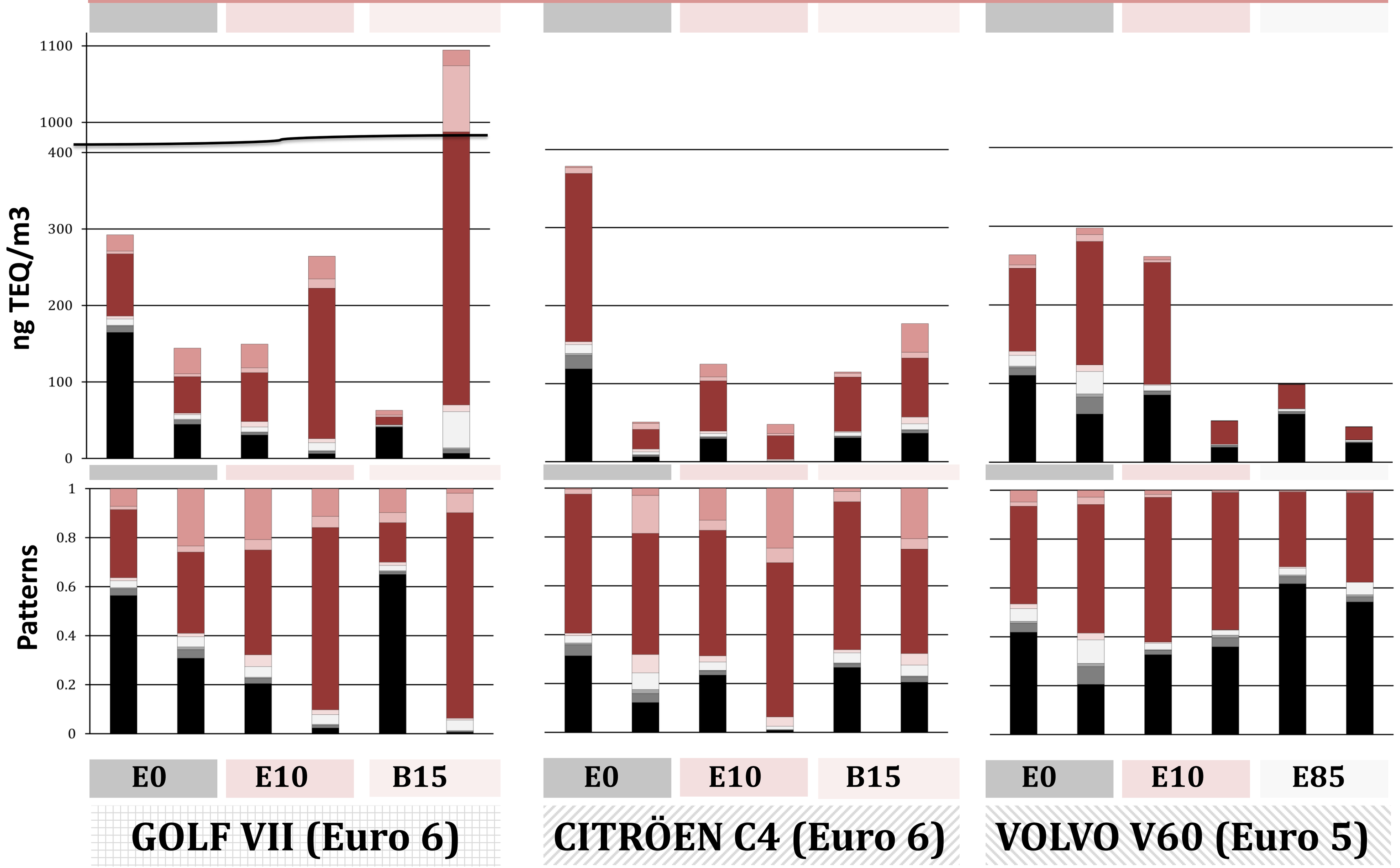


Fig. 3. Cumulated genotoxic potential of the genotoxic PAHs in ng TEQ/Nm3 (above) and individual patterns (below) in the cWLTC and hWLTC (left and right column respectively) for the 3 vehicles tested and the 4 fuels used. Chemical structures, carcinogenic group and TEF values of the genotoxic PAHs on the right.