Health Effects of Biofuels and Diesel Particulate Filter with a Euro III truck engine

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Content

• Objective

• Test program

• Results
  • Regulated and non-regulated emissions
  • Particulate mass and numbers
  • Toxicology

• Conclusions
Objective

Characterisation of exhaust emissions with biodiesel and Diesel Particulate Filter on a HD Euro III engine:

• Transient tests
• Regulated and non-regulated emissions
• Particulate mass and numbers
• Toxicology
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Test set-up

Engine:
• DAF XE355 HD diesel engine
• 355 kW
• Euro III emissions level
  NOx < 5, PM < 0.10 g/kWh

Test cell:
• Transient engine dyno
• CVS with full flow dilution tunnel
Test set-up

Fuels:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>B0</td>
<td>B5</td>
<td>PPO</td>
</tr>
<tr>
<td>(EN590)</td>
<td>B10</td>
<td></td>
</tr>
<tr>
<td>B0 + c-DPF</td>
<td>B20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B100</td>
<td></td>
</tr>
</tbody>
</table>

Test cycle:

European Transient Cycle (ETC)
Test set up - sample collection

Engine exhaust

Berner low pressure impactor
EC/OC
Aldehydes, C₁ - C₁₂
In-vivo
In-vitro
Dioxins, Furans (Optional)
ELPI

CVS TUNNEL

Secondary dilution tunnel

Pallflex filter

XAD-2
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Results - NOx

- B100 and PPO: 30% increase
Results - Particles

- Particulate mass reduction due to reduction Elementary Carbon
Results - Particle numbers

- B100 and PPO: reduction of 80%
- DPF: reduction >99%

compared to baseline B0
Results – aldehydes

• Up to about 25% reduction with B100
Results - PAH, oxy-PAH, nitro-PAH

DPF or B100, PPO compared to B0 (no DPF):
- PAH, oxy-PAH decrease proportional with PM mass
- nitro-PAH: smaller reduction
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Results - Toxicology

From PM filter extract:

- Cytotoxicity
  - LDH

- Oxidative stress
  - Oxidative potential
  - HO-1 expression

- Mutagenicity/genotoxicity
  - Ames; TA98, YG1024
  - Comet
  - Micronucleus

Preliminary results with exposure chamber (not included)
Cytotoxicity - LDH

- Raw 264.7 mice macrophage cells
- Max conc.: 1%
- 24 hours exposure

Only B100 gives a significance increase
Micronucleus test

- Proliferation as a measure for cytotoxicity
- B100: increase in cytotoxicity, only -S9
- Raw 264.7 mice macrophage cells
- 4 hours exposure
Oxidative stress

Oxidative potential
DTT assay

B100, PPO, DPF compared to B0:
• > 95% decrease with DTT assay

Hemeoxygenase (HO-1) expression

• Dose response for HO-1
• No difference in response for different fuels and DPF
Mutagenicity/genotoxicity

Ames – TA98, YG1024

TA98, -S9

YG1024, -S9

- Significant effect for YG1024 with B100 and PPO
- Micronucleus test and Comet assay are negative
## Summary

Effects per m³ exhaust or kWh compared to B0

<table>
<thead>
<tr>
<th></th>
<th>B100</th>
<th>PPO</th>
<th>B0+C-DPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM number</td>
<td>↓ 80%</td>
<td>↓ 80%</td>
<td>↓ &gt;99%</td>
</tr>
<tr>
<td>PM mass</td>
<td>↓ 80%</td>
<td>↓ 60%</td>
<td>↓ &gt;99%</td>
</tr>
<tr>
<td>NOx</td>
<td>↑ 30%</td>
<td>↑ 30%</td>
<td>~</td>
</tr>
<tr>
<td>PAH, oxy-PAH</td>
<td>↓ 70%</td>
<td>↓ 70%</td>
<td>↓ 90%</td>
</tr>
<tr>
<td>nitro-PAH</td>
<td>↓ 50%</td>
<td>↓ 50%</td>
<td>↓ 50%</td>
</tr>
<tr>
<td>Cytotoxicity (LDH, prolif.)</td>
<td>↑ 200%</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td>Oxidative potential (DTT)</td>
<td>↓ 95%</td>
<td>↓ 95%</td>
<td>↓ 95%</td>
</tr>
<tr>
<td>HO-1 Hemeoxygenase</td>
<td>~</td>
<td>~</td>
<td>~</td>
</tr>
<tr>
<td>Mutagenicity: Ames – YG1024</td>
<td>↑ 60%</td>
<td>↑ 60%</td>
<td>~</td>
</tr>
</tbody>
</table>
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With Euro III heavy-duty engine:

<table>
<thead>
<tr>
<th></th>
<th>B100 and PPO</th>
<th>Wall-flow DPF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PM mass and number, PAH and oxy-PAH, nitro-PAH, NOx</strong></td>
<td>•60% - 80% lower</td>
<td>•&gt;90% lower</td>
</tr>
<tr>
<td></td>
<td>•~50% lower</td>
<td>•~50% lower</td>
</tr>
<tr>
<td></td>
<td>•30% higher</td>
<td>•equal (higher NO₂)</td>
</tr>
<tr>
<td><strong>PM fraction</strong></td>
<td>•increased or equal</td>
<td>•equal</td>
</tr>
<tr>
<td>•Ames toxicity (mutagenicity)</td>
<td>•equal or lower</td>
<td>•equal or lower</td>
</tr>
<tr>
<td>•oxidative stress</td>
<td>•increased (B100)</td>
<td></td>
</tr>
<tr>
<td>•cytotoxicity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

⇒ Evaluated biofuels show toxic effects in vitro
   Further investigation recommended on chemical compounds that cause toxic effects

⇒ PM mass might not adequately reflect health effects of engine particulates

⇒ Recommendation to carry out more biological tests on engine exhaust (both gas and particulate phase)
Thank you for your attention

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