Effect of Biodiesel Fuels on Emissions from EURO 4 Passenger Cars

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Transport & Air Quality Unit
Institute for Environment and Sustainability (IES)
EC-DG-JRC Ispra, Italy
## Collaboration agreement EBB & JRC-Transport & Air Quality Unit

### Experimental Fuel test Program:

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Ref. Fuel</th>
<th>BLEND 10%</th>
<th>BLEND 20%</th>
<th>B100</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Reference Fuel</td>
<td>X</td>
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<td></td>
<td>Reference Test (10ppms S)</td>
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<tr>
<td>RME</td>
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<td>X</td>
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<td>EN14214 Reference</td>
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<tr>
<td>Mix 3</td>
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<td>X</td>
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<td>50% soy – 50% sunflower</td>
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<tr>
<td>MIX1</td>
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<td></td>
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<td></td>
<td>70% RME – 10% palmolein 20% soy</td>
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<tr>
<td>MIX2</td>
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<td></td>
<td></td>
<td></td>
<td>70% RME – 15% sunflower 15% hoso</td>
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<tr>
<td>PALM</td>
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<td></td>
<td></td>
<td>X</td>
<td>Palmolein Methyl Ester</td>
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</tbody>
</table>
El plan contra el CO₂ rebaja los impuestos a un millón de coches por contaminar menos

El Gobierno aprueba 80 medidas pero admite que no bastarán para cumplir los objetivos de Kioto

Las petroleras tendrán que mezclar la gasolina con biocarburantes a partir de septiembre

"...Petrol companies will have to mix Fossil fuels with biofuels from September on..."
Some good reasons for the promotion of biofuels in the EU

- Increase security of energy supply

- To reduce gas emissions from road transport, in order to comply with targets of Kyoto protocol

- Support development of rural communities
EU Legislation

Challenges arising from TWO main Directives Regarding Biodiesel

2003/30/EC
On the promotion of the use of biofuels or other renewable fuels for transport

2003/96/EC
Restructuring the community framework for the taxation of energy products and electricity
Article 3

“...Member States should ensure that a minimum proportion of biofuels and other renewable fuels is placed on their markets, and, to that effect, shall set national indicative targets.”

REFERENCE VALUES FOR THESE TARGETS:

2% Before 31 Dec 2005

5.75% Before 31 Dec 2010
Proposal for a

DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and the introduction of a mechanism to monitor and reduce greenhouse gas emissions from the use of road transport fuels and amending Council Directive 1999/32/EC, as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC

(presented by the Commission)
EUROPEAN COUNCIL 8/9 March 2007
Presidency conclusions:

“... a 10% binding minimum target to be achieved by all Member States for the share of biofuels in overall EU transport petrol and diesel consumption by 2020, to be introduced in a cost-efficient way...”
• Impact of biofuel quality on emissions,

• Compatibility between biofuels and conventional fuels and engines
Experimental program: emissions tests on a LD passenger car diesel vehicles

- Climatic Chamber – 10°C/+30°C with controlled humidity
- Emissions analyzers for HC, CO, CO₂ & NOx
- 4 x 4 chassis
  Dynamometer for: Passenger cars 2WD / 4WD, Small Trucks, Minivans, Tractors
Vehicle used for the test (provided by the EBB):

• CITROEN C4 HDi 1560 cc - 66 Kw
• Euro 4 emission level
• Common Rail System Car (without FAP)

• 3000 Km being refueled with 100%. RME
Pollutants considered in the research programme

**EURO 4 Regulated emissions**
- HC
- CO
- NOx
- PM (particle matter)

**Non Regulated emissions:**
- Speciation of VOC for ozone formation
- Carbonyl compounds
- Particles
  - Chemical composition (PAH)
  - Mass size distribution and Number of particles
- OC/EC and Metals

Directive 70/220/EEC and subsequent amendments
### Collaboration agreement EBB & JRC-Transport & Air Quality Unit

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**Legend:**
- **X**: Present

**Notes:**
- EN14214 Reference

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Influence of RME on regulated emissions

* Ref. Fuel: diesel with <10 ppm S
Mass size distributions for NEDC cycles for RME

<table>
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<tr>
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<th>RME B10</th>
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<th>RME B100</th>
</tr>
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<tr>
<td>NEDC</td>
<td>Mass impactor</td>
<td>B10</td>
<td>B100</td>
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</table>

Aerodynamic Diameter [nm]

Mass Emissions dm/dlogDp [mg/km]
Particle number size distributions at 120 km/h for RME
Influence of RME % content on regulated emissions

• Results consistent with data already available for older technologies: effects on emissions clearly depends on the biodiesel content

• The higher the biodiesel content, the greater the reduction of PM emissions

• Increased HC and CO emissions for 30% blends and neat biodiesel due to the cold start effect
Influence of 10% Biodiesel Blends on regulated emissions

* diesel with <10 ppm S

- CO: EURO 4 limit = 0.50 g/km
- NOx: EURO 4 limit = 4.0 mg/km
- PM: EURO 4 limit = 25 mg/km
Mass size distributions for NEDC cycles for 10% Biodiesel blends
Particle number size distributions at 120 km/h for 10% Biodiesel blends
Influence of biodiesel quality on regulated emissions

- No significant emission variation has been noticed using a 10% biodiesel blend when compared with the base diesel fuel

- No significant difference, in terms of effects on emissions, among the different biodiesels tested
Regulated and Non-regulated Emissions

PART 1
Regulated emissions:
HC, CO, NOx, PM

PART 2
Non regulated emissions
VOC & Potential O₃ Formation & Carbonyls (H-CHO; CH₃-CHO)
Up-to-date information on ozone conditions across Europe – EEA - Mozilla

European Environment Agency

Welcome | Map | Comparison | About ozone | Ozone and health | Ozone and legislation | What can I do? | Find out more

Up-to-date information on ozone conditions across Europe

>> Click on the picture to go to the map

Ozone today - European status

Find out the level of ozone pollution in your area or in any other place in Europe.

Why should you be concerned about ozone?

Too much ozone in the air can affect your health. It can irritate your breathing, reduce lung function and trigger asthma. Ozone can also damage the environment.

Ground-level ozone is formed from pollutants emitted from vehicle exhausts and industrial production. It is one of the air pollutants of most concern in Europe today.

Learn more

What is ozone?

How can I protect my health?

How can I help reduce air pollution?

Note: The map is based on preliminary data
EMISSIONS OF AIR POLLUTION BY SECTOR IN 2003 EU-25
(Source: EEA)

Note: 'Other' includes energy-related emissions from households, services and agriculture.
Source: EEA.

- First Daughter Directive (1999/30/EC) relating to limit values for NOx, SO₂, Pb and PM10. in ambient air
- Second Daughter Directive (2000/69/EC) relating to limit values for benzene and carbon monoxide in ambient air
- Fourth Daughter Directive relating to As, Cd, Ni, Hg and PAH in ambient air (2004/107/EC)
The 31 ozone precursors VOCs recommended for measurements in the Ozone Directive:

*Ethanetrans-2-Butenen-Hexanem+p-XyleneEthene cis-2-Butenei-Hexaneo-XyleneEthyne1,3-Butadienen-Heptane1,2,4-TrimethylbenzenePropanen-Pentanen-Octane1,2,3-TrimethylbenzenePropenei-Pentanei-Octane1,3,5-Trimethylbenzenen-Butane1-PenteneBenzenei-Butane2-PenteneTolueneFormaldehyde1-ButeneIsopreneEthylbenzeneNMHC*
Influence of biodiesel (10%) on VOCs emissions

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>1,2,4-tri-methyl benzene</th>
<th>1,3,5-tri-methyl benzene</th>
<th>o-xylene</th>
<th>m-xylene</th>
<th>ethyl-benzene</th>
<th>toluene</th>
<th>benzene</th>
<th>n-heptane</th>
<th>n-hexane</th>
<th>isoprene</th>
<th>cyclo-hexane+3-methyl-pentane</th>
<th>2-methylpentane</th>
<th>cis-2-pentene</th>
<th>trans-2-pentene</th>
<th>n-pentane</th>
<th>1,3-butadiene</th>
<th>iso-pentane (2-methyl-butane)</th>
<th>propyne</th>
<th>cis-2-butene</th>
<th>isobutene</th>
<th>isobutene</th>
<th>1-butene</th>
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<th>n-butane</th>
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<th>iso-butane</th>
<th>iso-butane</th>
<th>acetylene</th>
<th>propene</th>
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Influence of RME perceptual on VOCs emissions

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Maximum Incremental Reactivity (MIR) approach

\[
\text{MIR}_i = \max \left\{ \frac{d[O_3]_p}{dE_i} \right\}
\]

Where \([O_3]_p\) is the peak ozone formation and "Ei" is the emission of the VOCi

Potential ozone formation

\[
PO_3(g/km) = \sum_i \{\text{MIR}_i \ (g \ O_3/g \ VOC) \ E_i(g/km)\}
\]

W.P.L. Carl et al.
O₃ Potential Formation for emitted VOCs during the NEDC

- 1,2,4-tri-methyl benzene
- 1,3,5-tri-methyl benzene
- o-xylene
- m-xylene
- ethyl-benzene
- toluene
- benzene
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- cis-2-butene
- isobutene
- 1-butene
- trans-2-butene
- n-butane
- iso-butane
- acetylene
- propene
- propane
- ethene
- ethane
Carbonyl compounds in Biodiesel emissions

Carbonyls emissions [mg/km]

- Formaldehyde
- Acetaldehyde
- Acrolein + Acetone
- Propionaldehyde
Carbonyls emissions [mg/km]

- Formaldehyde
- Acetaldehyde
- Acrolein+Acetone
- Propionaldehyde
Conclusions

• 10% of biodiesel added to a reference fuel for Light duty applications did not show any significant difference for the regulated emissions (HC, CO, NOx) and are able to largely reduce particulate emissions over the NEDC cycle.
• No significant difference was detected either for VOCs and Carbonyls.

• All emissions from biodiesel blends and or neat biodiesel tested showed very low levels and they were always below the Euro 4 emission standards
The work showed here has been performed at the VELA Laboratory

Transport & Air Quality Unit,

Institute for Environment and Sustainability

EC-DG JRC, Ispra (IT)

with the contributions from:

A. Farfaletti, L. Montero, G. Martini,
Krasenbrink, and G. de Santi