

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

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TNO | Knowledge for business



**13th ETH conference on combustion generated nanoparticles
Zurich, 22-24 June 2009, Session 5B**

13th ETH nanoparticles Zurich, 22-24 June 2009



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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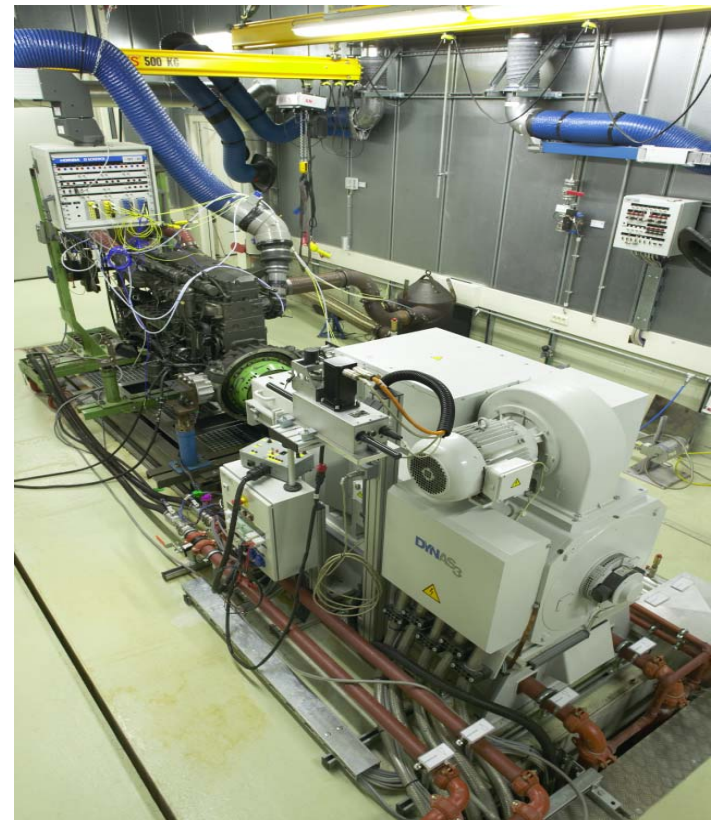
Test set-up

Engine:

- DAF XE355 HD diesel engine
- 355 kW
- Euro III emissions level
NO_x < 5, PM < 0.10 g/kWh

Test cell:

- Transient engine dyno
- CVS with full flow dilution tunnel





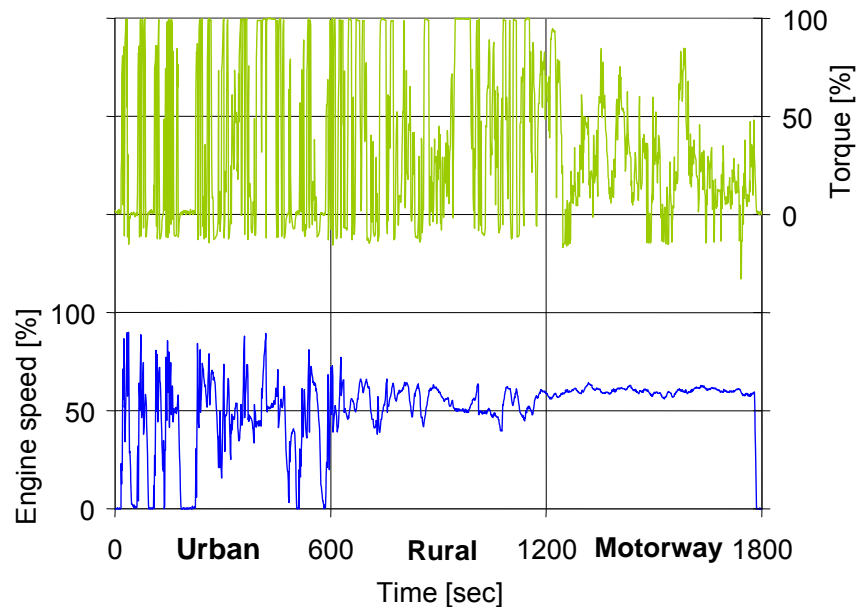
Test set-up

Fuels:

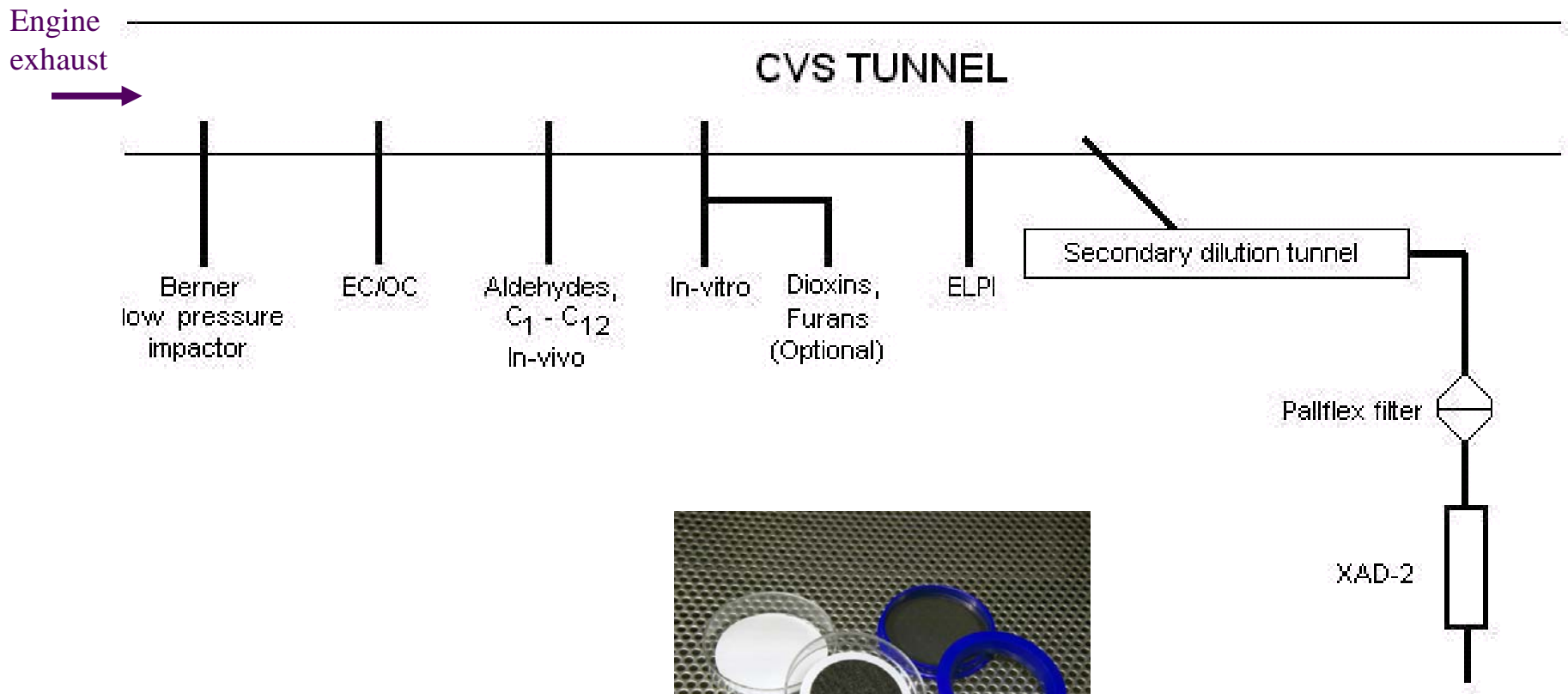
B0 (EN590)	B5	PPO
	B10	
	B20	
B0 + c-DPF	B100	

Test cycle:

European Transient Cycle
(ETC)



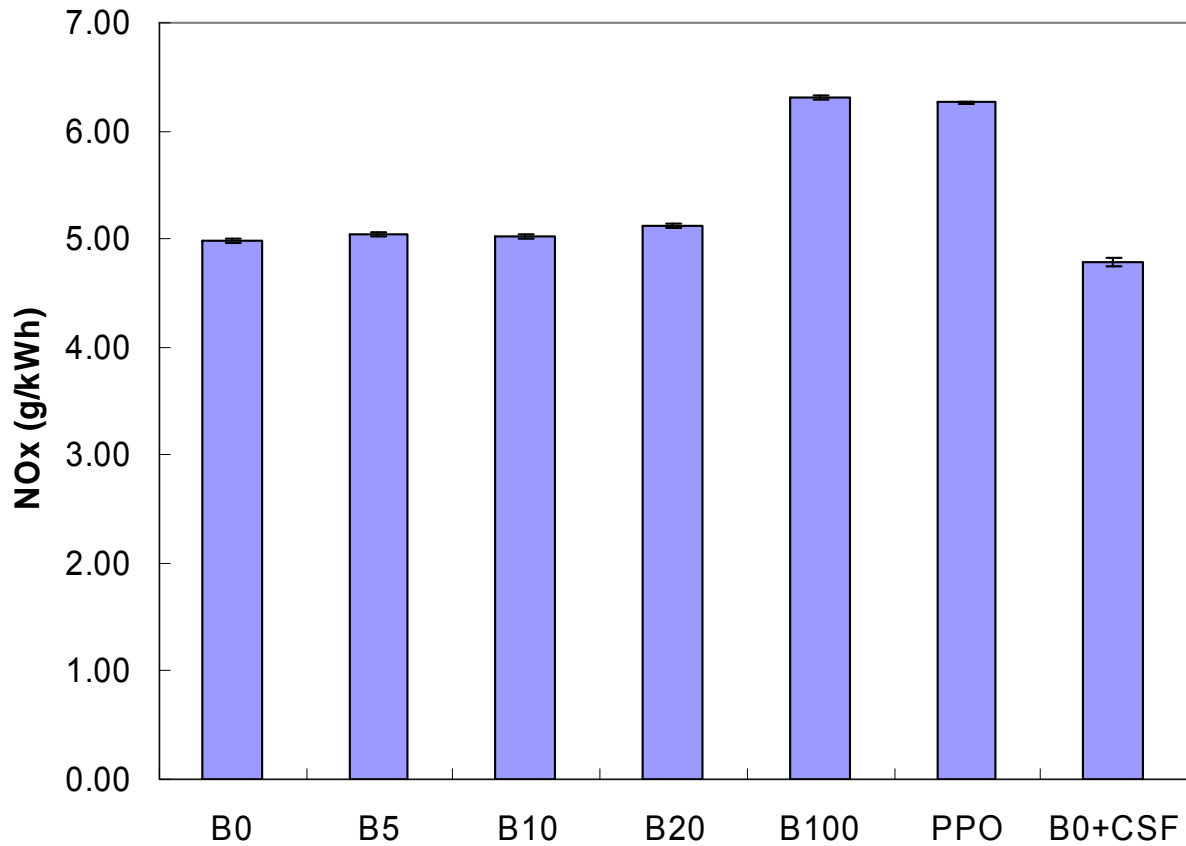
Test set up - sample collection



Content

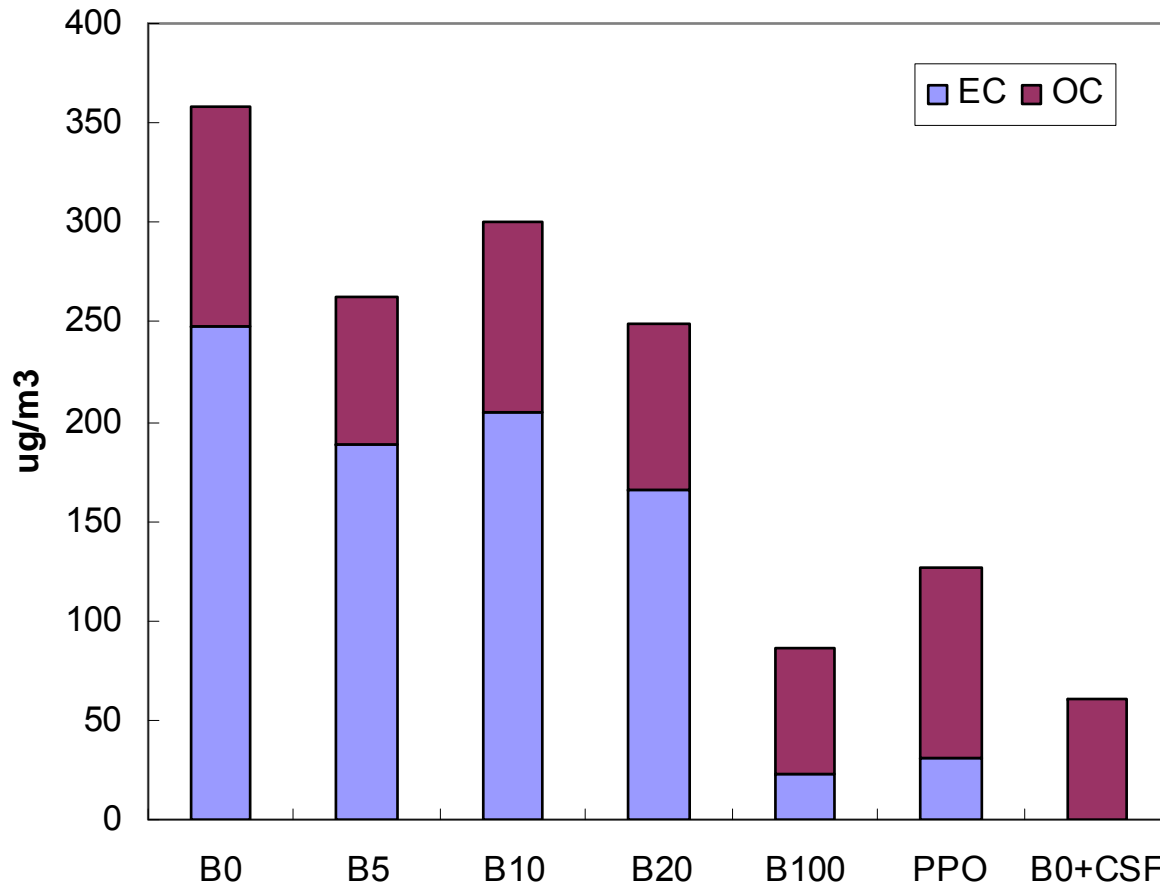
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Results - NOx



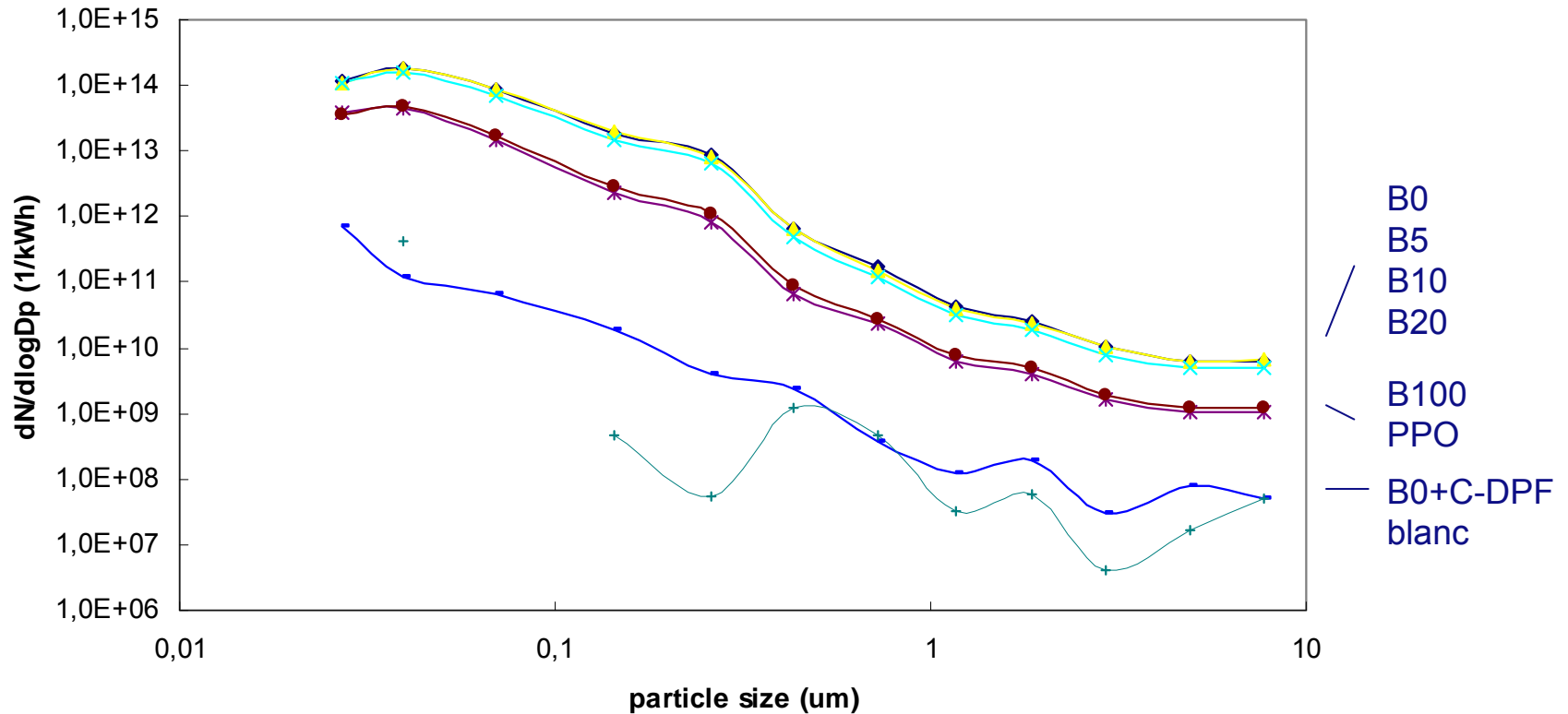
- B100 and PPO: 30% increase

Results - Particles



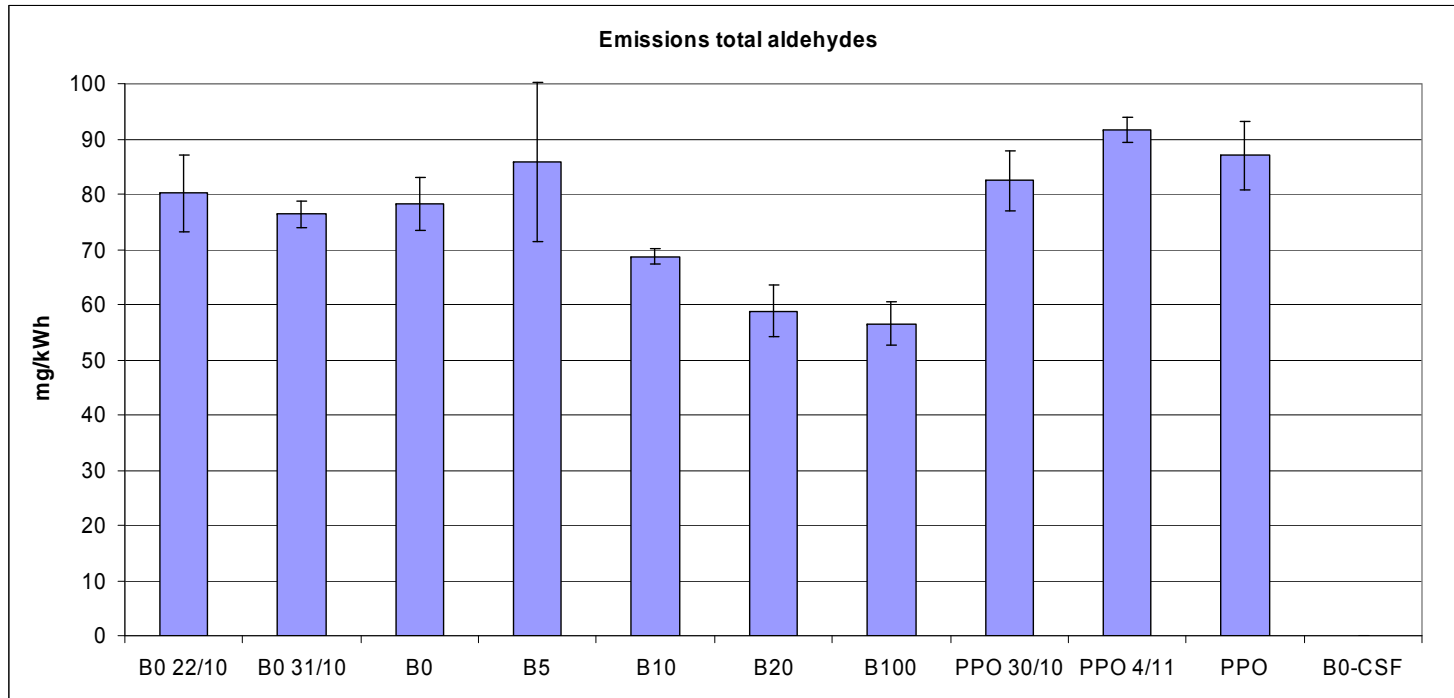
- Particulate mass reduction due to reduction Elementary Carbon

Results - Particle numbers



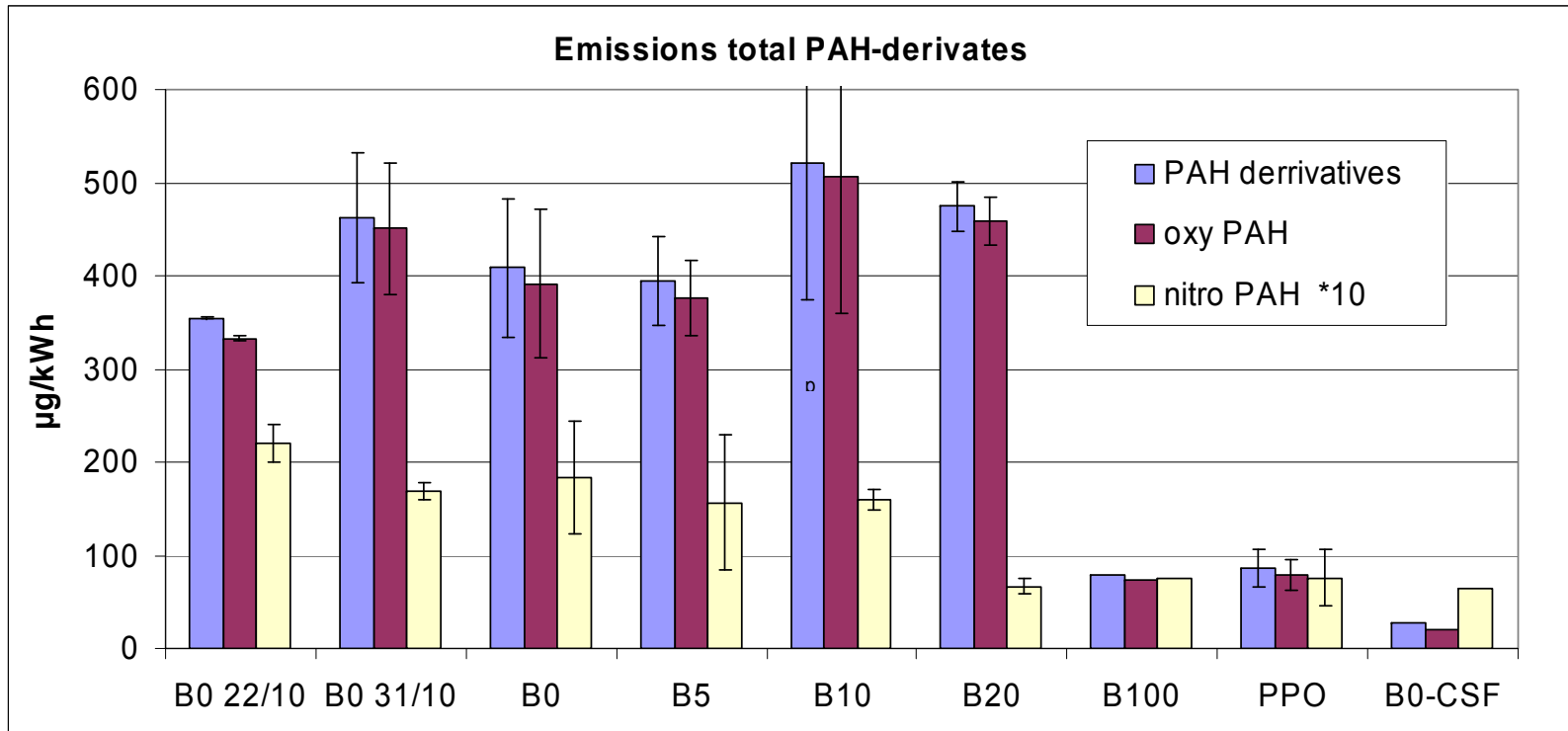
- B100 and PPO: reduction of 80% } compared to baseline B0
- DPF: reduction >99%

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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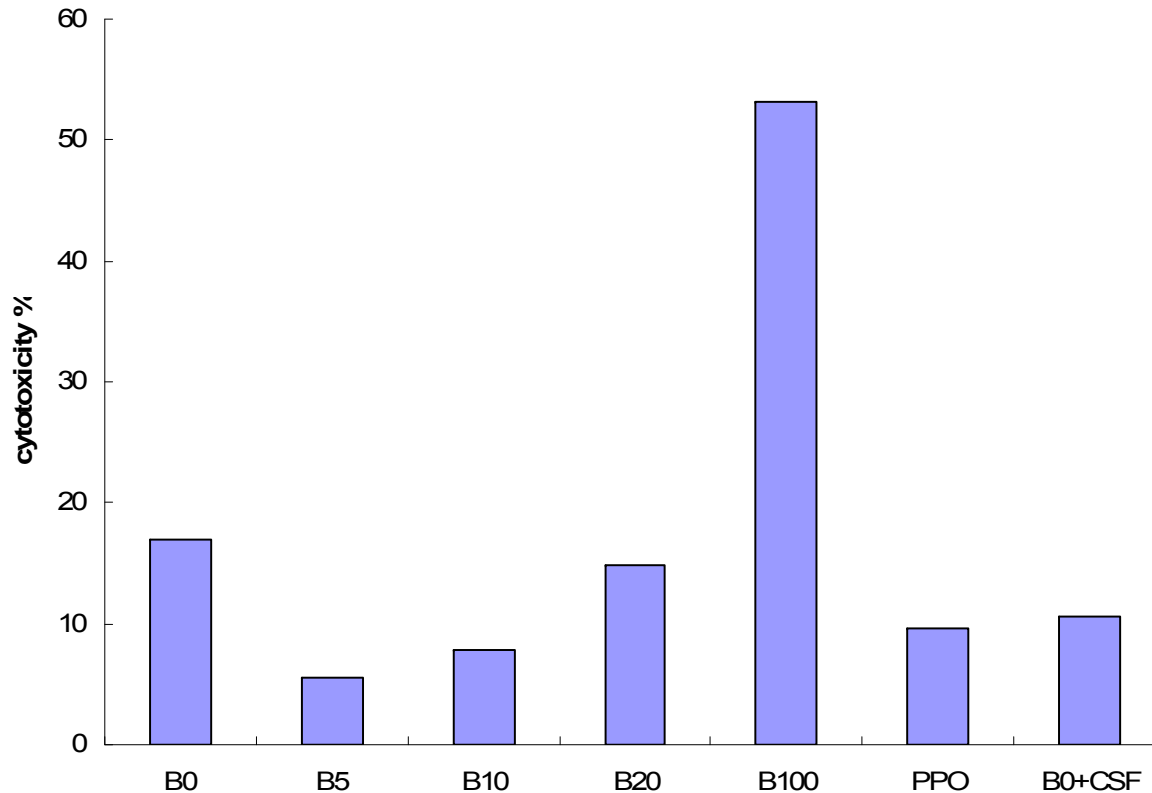
Results - Toxicology

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

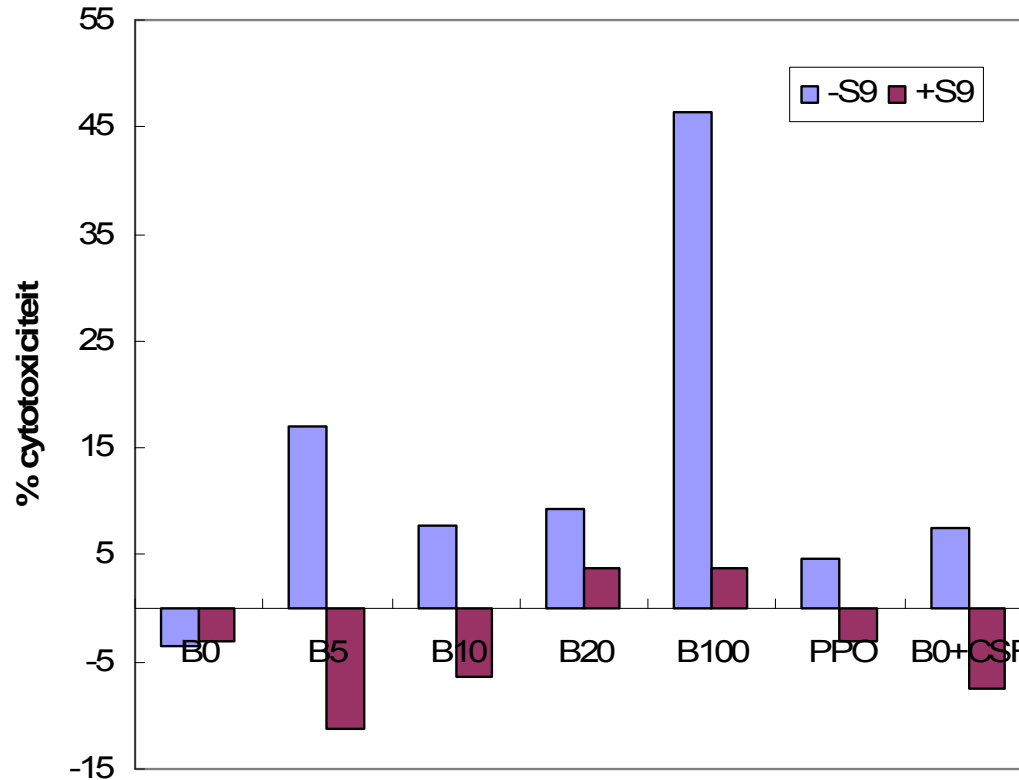


- Raw 264.7 mice macrophage cells
- Max conc.: 1%
- 24 hours exposure

- Only B100 gives a significance increase



Micronucleus test



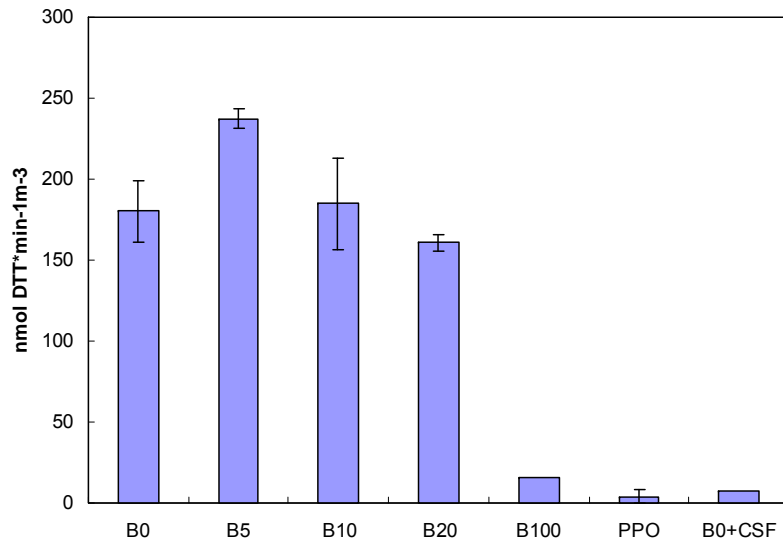
- Raw 264.7 mice macrophage cells
- 4 hours exposure

- Proliferation as a measure for cytotoxicity
- B100: increase in cytotoxicity, only -S9



Oxidative stress

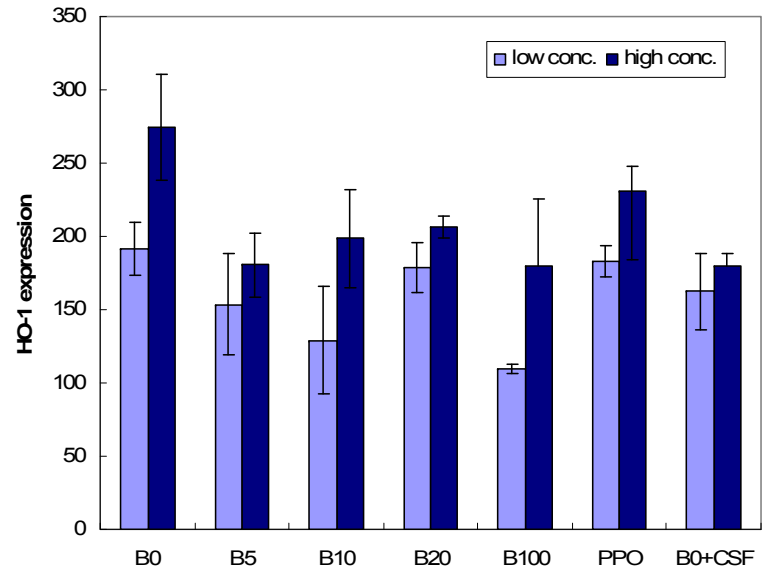
Oxidative potential DTT assay



B100, PPO, DPF compared to B0:

- > 95% decrease with DTT assay

Hemeoxygenase (HO-1) expression

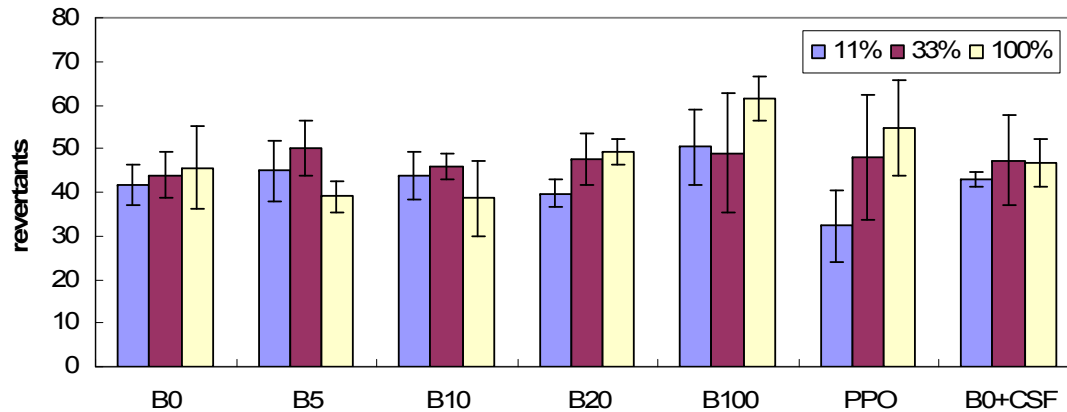


- Dose response for HO-1
- No difference in response for different fuels and DPF

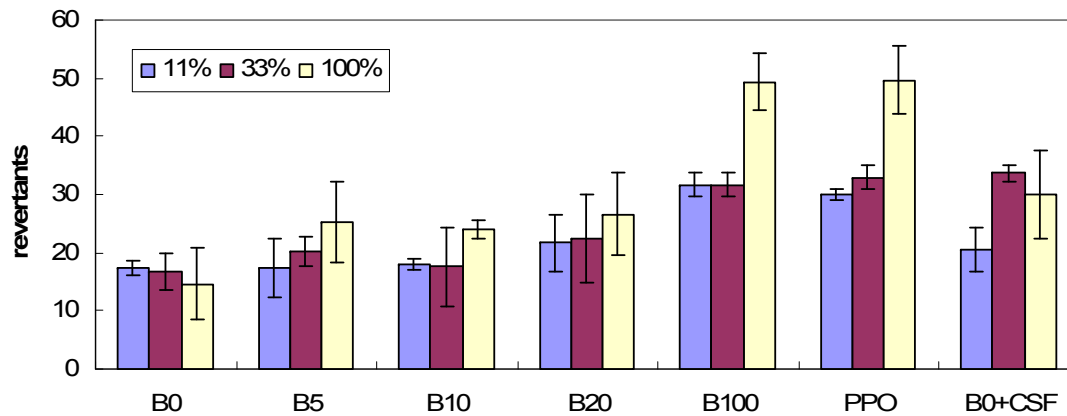


Mutagenicity/genotoxicity

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

	B100	PPO	B0+C-DPF
PM number	↓ 80%	↓ 80%	↓ >99%
PM mass	↓ 80%	↓ 60%	↓ >99%
NO_x	↑ 30%	↑ 30%	~
PAH, oxy-PAH	↓ 70%	↓ 70%	↓ 90%
nitro-PAH	↓ 50%	↓ 50%	↓ 50%
Cytotoxicity (LDH, prolif.)	↑ 200%	~	~
Oxidative potential (DTT)	↓ 95%	↓ 95%	↓ 95%
HO-1 Hemeoxygenase	~	~	~
Mutagenicity: Ames – YG1024	↑ 60%	↑ 60%	~



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Conclusions

(1)

With Euro III heavy-duty engine:

	B100 and PPO	Wall-flow DPF
<ul style="list-style-type: none">•PM mass and number, PAH and oxy-PAH•nitro-PAH•NOx	<ul style="list-style-type: none">•60% - 80% lower•~50% lower• 30% higher	<ul style="list-style-type: none">•>90% lower•~50% lower•equal (higher NO₂)
<u>PM fraction</u> <ul style="list-style-type: none">•Ames toxicity (mutagenicity)•oxidative stress•cytotoxicity	<ul style="list-style-type: none">•increased or equal•equal or lower•increased (B100)	<ul style="list-style-type: none">•equal•equal or lower

Conclusions

(2)

- ⇒ 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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