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Health Effects of Emissions from Biofuel Combustion

EFAEP Biofuels Seminar

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Health implications from biofuel combustion

- ✓Fossil fuel engine emissions contain known mutagenic substances
- ✓Concern about the use of biofuels and the related emissions
- ✓Bio is not equal to healthy and good for the environment
- ✓Engines are currently not always designed to have an optimized combustion of these fuels

How do these changes affect health?

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Mutagenic potency of combustion products Biodiesel

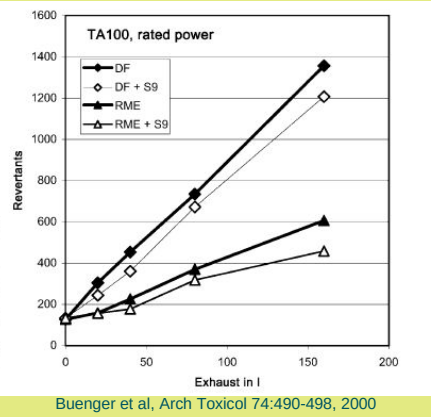
Table 7. Mutagenic potency values for test fuels - hot start conditions

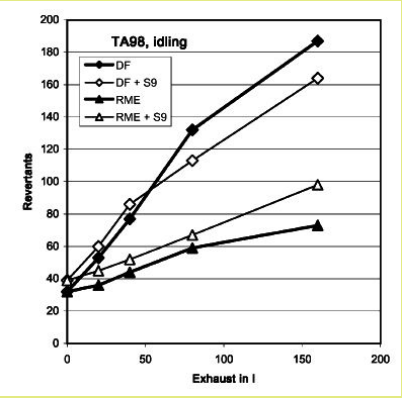
	Test Fuel	UC Davis Sample ID	CSM Run #	Mean TA98 Mutagenic Potency (Rev/µg Eq)[a] (+S9)	Std. Dev.	(-S9)	Std. Dev.
Petrol	D 2-1[b]	CbioD.6-8	4518-20	0.99	(± 0.31)	1.32	(± 0.04)
Soy	S M E	CbioD.10-12	4525-27	2.03	(± 0.45)	3.69	(± 0.18)
Canola	C M E	CbioD.14-16	4533-35	1.72	(± 0.25)	2.99	(± 0.13)
Pork	P L M E[c]	CbioD.18-20	4540-42	3.66	(± 0.33)	3.83	(± 0.32)
Beef	B T M E	CbioD.22-24	4570-72	2.23	(± 0.22)	2.29	(± 0.17)
Yellow grease	Y G M E LFFA	CbioD.26-28	4586-88	2.59	(± 0.32)	2.61	(± 0.12)
Petrol	D 2-2[d]	CbioD.29	4546-7, 4560	1.16	(± 0.14)	1.15	(± 0.41)

Kado & Kuzmicky NREL/SR-510-31463, 2003

✓More mutagenicity for biodiesel per mass, but less per mile

Mutagenic potency of combustion products Biodiesel





Buenger et al, Arch Toxicol 74:490-498, 2000

✓Higher soluble organic fraction (SOF) with biodiesel

✓Lower mutagenicity with biodiesel (low S and aromatic compounds)

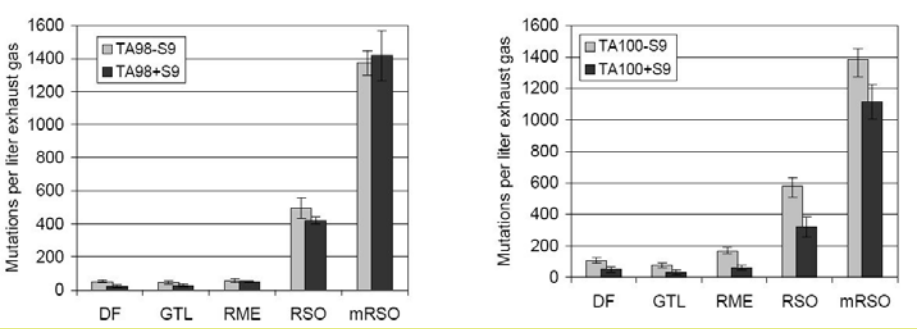
✓More mutagenicity with high vs lower loads

Mutagenic potency of combustion products Biodiesel

- ✓In vitro study evaluation mutagenicity
- ✓Mammalian cell model (rat hepatocytes) and Ames assay
- ✓ Ames assay – higher mutagenic potential for diesel exhaust
- ✓Results are less dramatic in rat hepatocyte model due to differences in metabolic capacities

Eckl et al, 1997

Mutagenic potency of combustion products Pure Plant Oil (PPO)



Krahl et al, SAE 2007-01-4042

DF – common diesel fuel

GTL – gas to liquid diesel fuel

RME – rapeseed oil derived biodiesel

RSO – cold pressed crude rapeseed oil

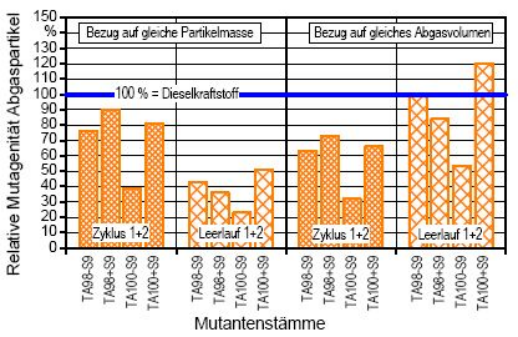
mRSO – modified rapeseed oil with lowered viscosity

- ✓Heating resulted in emission reduction
- ✓However, heating resulted in an even higher mutagenicity

Conflicting results with respect to mutagenicity?

Effects of Pure Plant Oil (PPO) – Rapeseed

- ✓ TFZ/Bifa Euro V heavy duty truck
- ✓ No increased mutagenicity compared to fossil fuel
- ✓ Dilution of engine exhaust before Ames test one of the differences with other experiment



Formation of multinucleate cells and apoptosis - Biodiesel

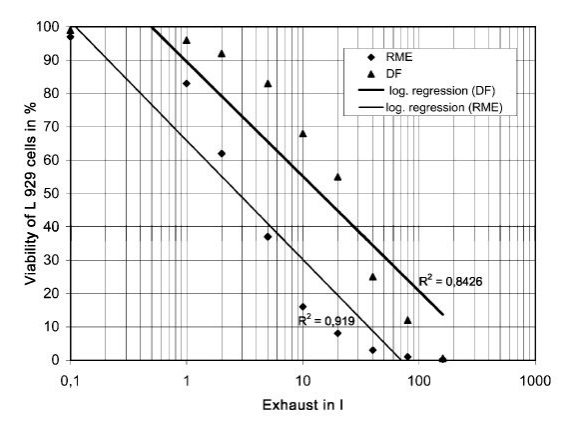
Table 1 A549 cells were treated with different ratios of diesel:biodiesel exhaust particulate matter (PDEP and BDEP) for 5 days and assayed for multinuclearity

Proportion of PDEP%	*Proportion of BDEP%*	*% Multinucleated cells*
0	0	7±1
80	20	52±4
60	40	48±4
40	60	47±5
20	80	16±2
0	100	12±2

Ackland et al, Immunol Cell Biol 1-6, 2007

- ✓More biodiesel less multinucleate cells
- ✓Diesel exhaust much stronger inducer of cellular death through apoptosis than biodiesel

Cytotoxicity of combustion products Biodiesel



Buenger et al, Arch Toxicol 74:490-498, 2000

- ✓Cytotoxicity of biodiesel (RME) under idling conditions 4x more potent than petroleum diesel fuel

Health effects of combustion products Biodiesel – Rodent exposure

- ✓Fischer 344 rats male & female
- ✓Subchronic inhalation – 6 h/day, 5 days/wk, 13 wk
- ✓3 dilutions of emission (soybean) – 40, 200, 500 ug/m^3
- ✓Only modest health effects limited to the lung primarily at the highest exposure level
- ✓Dose-related increase in lung MØ and particle uptake

Finch et al, Inhal Tox 14: 1017-1048, 2002

Health effects of combustion products Biodiesel (B20) – Modeling approach

- ✓Study employed inventory and air quality modeling
- ✓Analyze the impacts of biodiesel (B20) use in heavy duty on road vehicles on human health
- ✓100% penetration of B20 in HDDV is estimated to reduce risk for premature death by ~5-6%

Morris et al, 2003
www.nrel.gov/vehiclesandfuels/npbf/pubs_biodiesel.html

Health effects of combustion products E85 – Modeling approach

- ✓Modeling to examine effect of converting from conventional gasoline (CG) to E85
- ✓Cancer, mortality, and hospitalization in USA and particular LA
- ✓E85 – less benzene and butadiene but more acetaldehyde and formaldehyde production
- ✓Possible increase in ozone-related mortality, hospitalization and astma (9% LA and 4% USA)
- ✓Cancer rates would be similar for gasoline and E85

Jacobson Environ Sci Technol 41:4150-4157, 2007

Health effects of combustion products E85 – Modeling approach

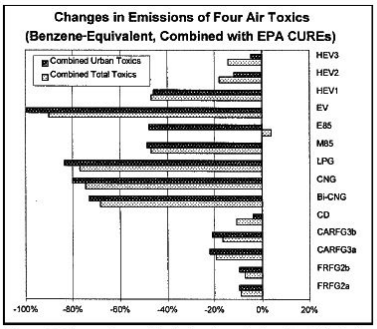


Figure 8. Changes in combined air toxics emissions for AFVs relative to CG vehicles (benzene-equivalent using EPA's CURE).

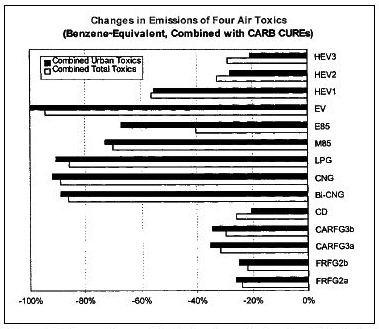


Figure 9. Changes in combined air toxics emissions for AFVs relative to CG vehicles (benzene-equivalent using CARB's CURE).

Winebrake et al, J Air Waste Manage Assoc, 2001

- ✓All fuels less toxic than CG (urban emissions)
- ✓E85 increase relative to CG for "total" emissions (EPA's CURE)

Final remarks

- ✓Rapid developments in biofuel area, and toxicology may not be able to provide good risk assessment data in time
- ✓Importance of each individual pollutant toxicity in assessing the overall air toxic effects of each fuel
- ✓What test system, conditions and endpoints
- ✓How are the results expressed?
- ✓Both environmental issues and health aspects needs to be considered

Thank you for your attention