MUTAGENIC POTENTIAL OF PARTICLE EMISSIONS OF A VEGETABLE OIL COMPATIBLE TRACTOR

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ABSTRACT: Particulate matter emissions of plant oil compatible tractors fuelled with standard-compliant rapeseed oil fuel show lower mutagenic effects in comparison to diesel fuel. This is the result of a study conducted by the Technologie- und Förderzentrum (TFZ), Straubing. Particle samples were taken at the exhaust gas test rig of the TFZ by operating a Deutz-Fahr tractor during idle mode and at eight representative test modes according to the European particle measurement guideline. The samples were analysed for mutagenic potential with the AMES-Test by the bifa environmental institute in Augsburg.

Keywords: rapeseedoil fuel, liquid biofuels, emissions

1 INTRODUCTION AND OBJECTIVE

The use of rapeseed oil fuel in tractors adapted for vegetable oil can make a significant contribution to the climate protection. In addition, the use of rapeseed oil as fuel offers other benefits such as soil and water protection, the improvement of supply security and regional added value by on-farm production of both feed and fuel at the same time. Also since rapeseed oil used in agriculture in Germany is free of energy tax, there is the possibility to reduce fuel costs in comparison with the use of diesel. A pre-requisite for the successful use of a vegetable oil suitable engine with rapeseed oil is a high quality fuel that meets the standards set in DIN V 51605. Tractors with rapeseed oil compatible engines offered by the agricultural machinery industry are now available on the market; thus, an enhanced use of rapeseed oil is expected.

With a greater use of rapeseed oil in practice, any unanswered questions about the emissions from rapeseed oil engines gain importance. Besides limited exhaust gas emissions also mutagenic and carcinogenic effects of the engine emissions on human organism have to be considered. Media reports, referring on a study of BÜNGER et al. [1], claim that the use of rapeseed oil has an increased potential of causing cancer. This led to a feeling of uncertainty about its safety.

Therefore the purpose of this work was to investigate the mutagenicity of particle emissions from a rapeseed oil suitable tractor. To allow a more complete interpretation of the results, in addition the concentrations of polycyclic aromatic hydrocarbons (PAH) and nitrated PAH (nitro-PAH), which are known to be relevant to mutagens and carcinogens were measured.

2 APPROACH

Analyses were carried out on particle emissions collected on filters under the conditions defined for the test cycle according to EU-Directive 2000/25/EG. The particle samples (each about 30 mg) were made up from a total of 8 test points within the engine power-speed map (8-mode-test). Additionally the idle running performance was examined. A Deutz-Fahr Agrotron TTV 1160 tractor fitted with a one-tank rapeseed oil conversion system of the company Hausmann was used for the tests. The particle samples were collected at the test rig of the Technologie- und Förderzentrum (TFZ) in Straubing, while operating the tractor with standard-compliant rapeseed oil fuel (DIN V 51605) and diesel fuel (DIN EN 590). The particle sampling device and the tractor are shown in Figure 1. Altogether 7 particle samples plus an additional blank filter were taken (Figure 2).

Figure 1: Particle Sampling for Mutagenicity Analysis

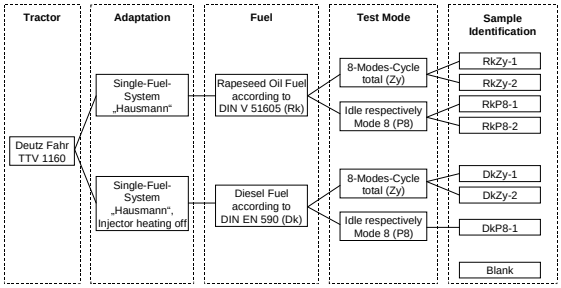

Figure 2: Samples of Exhaust Gas Particles for Mutagenicity Tests

The blank filter was not exposed to exhaust gas but - apart from that - treated the same way as the loaded filters in order to check possible contamination during the sampling procedure.

Limited exhaust gas emissions and the test conditions during sampling were monitored with a continuous data logging system.

The genotype mutation (mutagenicity) as well as the concentration of the PAH and nitro-PAH in a total of 8 samples were measured at the bifa Umweltinstitut in Augsburg by means of AMES-Tests and chemical analyses. Both, the biological and chemical tests, were carried out three times per sample.

3 RESULTS

In spite of particulate matter samples of about 30 mg, the mutagenic effects on all the test samples were at a very low level and in some cases under the detection limit.

A comparison of the results between rapeseed oil and diesel showed that the mutagenic potential of the particles derived from rapeseed oil operation was 10 to 60 % lower than from diesel fuel operation over the whole test cycle and 50 to 80 % lower in idling mode (Figure 3). Expressed in relation to exhaust gas volume, the mutagenicity of the rapeseed oil particles were 30 to 70 % lower over the full cycle and from 20 % higher to 50 % lower in idling mode. But it has to be considered that the use of a standard (instead of an adapted) engine with conventional diesel might deliver different results.

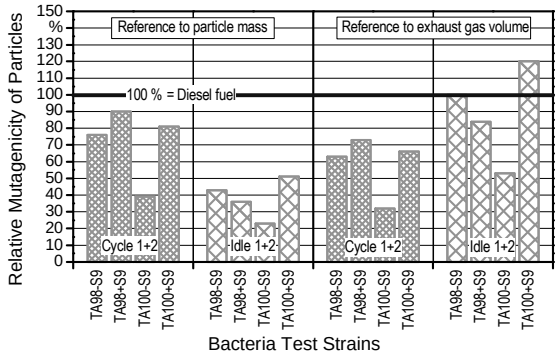

Figure 3: Mutagenicity of Exhaust Gas Particles from a Deutz-Fahr Tractor, Operated with Rapeseed Oil and Diesel Fuel at the 8-Mode-Cycle according to 2000/25/EC and at Idle

The presented results are verified by three further autonomous studies of the year 2007 [2, 3, 4, 6] (Table). In contrast to the above results, BÜNGER et al. (2007) [1] obtained in an unadapted engine of another manufacturer and a different test cycle with unspecified, "viscosity improved" rapeseed oil significantly higher mutagenicity with rapeseed oil than with diesel fuel. The difference between results is possible due to the various test conditions.

Table: Overview about Studies on Mutagenicity of Exhaust Gas Particles of Rapeseed Oil Fuelled Engines

Source	Bünger et al. (2007) [1]	Bioltec and Bifa (2007) [4]	Univ. of Rostock and BSL (2007) [3]	bifa / TUM by order of Airport Munich (2007) [2]	TFZ and Bifa (2007) [5]
Test Cycle for Sampling	13-mode-cycle	13-mode-cycle	8-mode-cycle (single modes)	13-mode-cycle	8-mode-cycle and idle
Machine Engine Engine type Exhaust stage	Truck Mercedes-Benz OM 906 LA Euro III	Truck DAF Euro V	Tractor John Deere John Deere 6068 HL stage IIIa	Mercedes Benz OM 602.900 Euro I	Tractor Deutz-Fahr Deutz BF6M 1013EC stage II
Engine Adaptation	Fuel pre-heating in tank (70 °C)	Dual fuel system "bioltec"	Single fuel system "John Deere/VWP"	Single fuel system "VWP"	Single fuel system "Hausmann"
Fuel	Rapeseed oil (RO) viscosity improved, diesel fuel (DF)	Rapeseed oil - diesel mixture; diesel fuel (DF)	Rapeseed oil fuel DIN V 51605 and diesel DIN EN 590	Rapeseed oil fuel DIN V 51605 and diesel DIN EN 590	Rapeseed oil fuel DIN V 51605 and diesel DIN EN 590
Mutagenicity referring to Particle Mass	--	**0,4 - 0,6** x DF	--	**0,4 - 1,1** x diesel	8-Mode-Cycle: **0,4 - 0,9** x DF Idle: **0,2 - 0,5** x DF
Mutagenicity referring to Exhaust Gas Volume/Mass	No fuel heating: **5 - 18** x DF With RO heating: **13 - 59** x DF	--	Mode 1-6 and idle: **0,1 - 0,9** x DF Mode 7: **0,9 - 2** x DF	--	8-Mode-Cycle: **0,3 - 0,7** x DF Idle: **0,5 - 1,2** x DF

The results of the chemical analysis showed that the concentration of total nitro-PAH of the particles were much higher with diesel fuel than with rapeseed oil fuel (Figure 4). In particular the strongly mutagenic components 2-nitropyren and 3-nitrofluoranthen are to be found in greater amount in the diesel fuel samples. The higher mutagenicity with the diesel fuel could be at least partly due to this higher concentration of nitro-PAH.

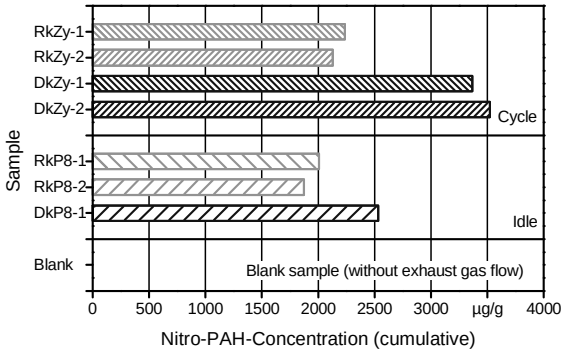

Figure 4: Concentration of Particle Bound Nitro-PAH from a Deutz-Fahr Tractor, Operated with Rapeseed Oil and Diesel Fuel at the 8-Mode-Cycle according to 2000/25/EC and at Idle

4 CONCLUSIONS AND OUTLOOK

The results of this research show a reduced mutagenicity of particle emissions with the use of standard-compliant rapeseed oil fuel in suitably adapted engines when compared with diesel fuel. This can be verified by three further studies, however one study shows opposite results.

The concentrations of particle bound nitro-PAH, which are known to be strongly mutagenic are lower for rapeseed oil fuel operation, which might partly explain the results.

In future works influences of engine and exhaust gas aftertreatment systems, engine operation mode and fuel quality on mutagenic effects of emissions need to be examined. Finally different methodologies of particle sampling and AMES-Test analyses have to be tested.

The entire report, „Bericht 14" of the series „Berichte aus dem TFZ", is available as download at www.tfz.bayern.de.

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