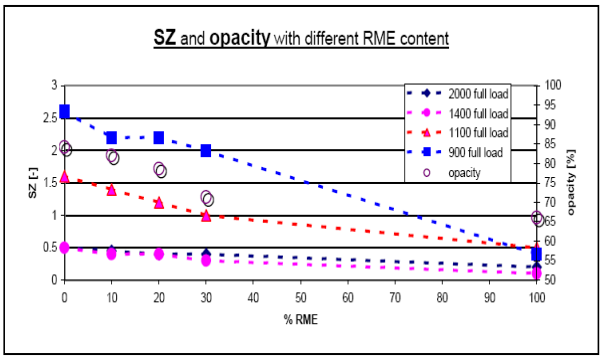
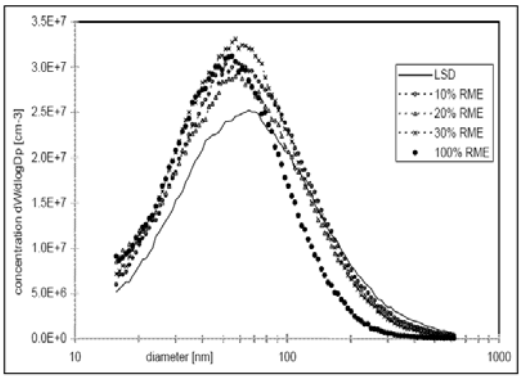
Mayer A. / TTM Switzerland

Nanoparticle Emissions from HD-Diesels operated with Biofuel-blends

HDV-Diesel engines have been investigated with respect to their emissions of toxic air contaminants including nanoparticles and PAH when using blends of RME and standard ULSDiesel fuel with and without passively regenerated Diesel particle filters. Blends of 10, 20 and 30 % of RME were compared to 100 % ULSD and 100 % RME. Smoke emission SZ and opacity during free acceleration was reduced when RME was mixed into ULSF, about proportional to the RME-content.



This was explained by coulometric analysis which showed a reduction of elemental carbon EC when increasing the RME content. Size distribution analysis proved that the number concentration of particles above 60 nm mobility size was reduced, the number concentration of particles smaller than 60 nm however was rather increased.



Filtration efficiency was about equal for all blends (> 99 % for all size classes 20 – 300 nm) and regeneration characteristics did not show any significant difference with the different fuels. With respect to other pollutants their was again now significant influence neither for NOx, CO and HC nor for particle bound PAH.

The investigation concluded that in case of RME-blends the same particle filters should be used as for standard Diesel fuel and no different certification protocol needs to be applied .

Impact of RME/Diesel Blends on Particle Formation, Particle Filtration and PAH Emissions

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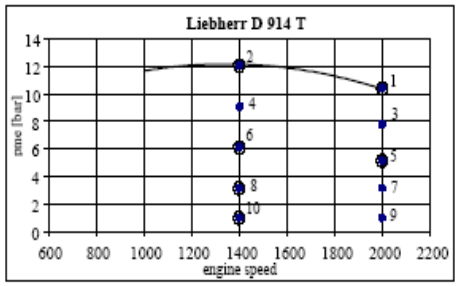
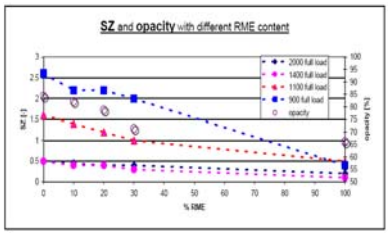
Rudolf Diesel wrote 1912 “today the use of vegetable oils as fuels might be insignificant, in future however such products might become as important as fossil fuels today” [2] Renewable bio fuels are finally becoming popular.The political argument is independence from imported and finite resources. The environmental argument is the CO_2 balance to restrain global warming. Also cited are the expected lower pollutant emissions in particular lower PAH-emissions and less smoke.

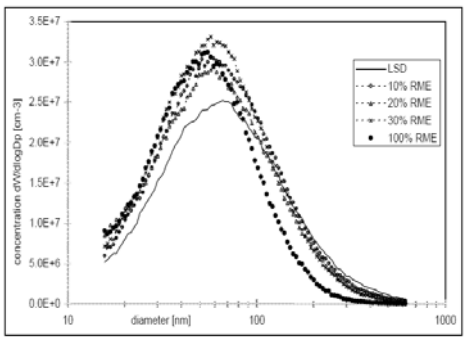
		Diesel	RME
Density at 15 °C	g/ml	0.820-0.845	0.880
Sulfur	ppm	< 50	< 25
Cetane Number		> 51	53
Calorific value	MJ/kg	42.5	37.3
C fraction	in %	86.7	77.5
H fraction	in %	13.3	11.8
O fraction	in %	0	10.7
Minimum air	kg/kg	14.5	12.5
Boiling range 10-90% °C		180 – 330 [4]	350 – 360

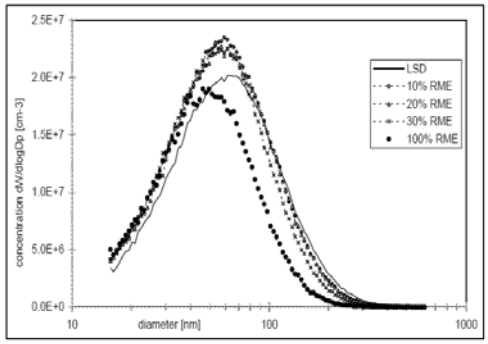


The Swiss city of Basel is planning to fuel its DPF fitted bus fleet with a RME (Rapeseed Methyl Ester) blend. They wanted evaluated both the emission characteristics of this fuel and its compatibility with CRT particle filters. EV financed the research.

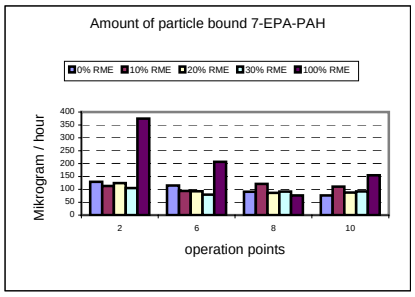


Due to its favorable O_2/C ratio, RME the share of EC. The smoke metric (SZ) and the opacity during free acceleration confirm this very distinctive trend.

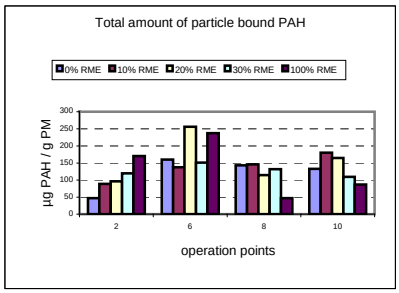




The size distributions in the size range 15 – 600 nm (mobility diameter) were analyzed for all blending ratios and at all operating points. The examples show the size distribution for full-load and 25% load at medium RPM. The data confirms the published effect [1] The blending of RME noticeably diminishes, and pure 100% RME clearly curtails the number of the large particles. However, all tests reveal that RME blended fuel tend to increase the count of finer particles.



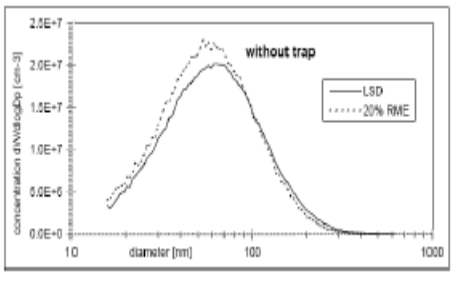
PAH-emissions show now clear trend

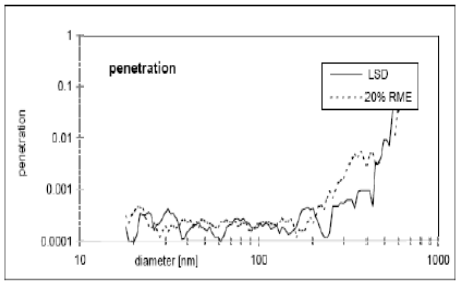


Specific PAH-content of PM – no trend

µg PAH/g PM	Diesel + DPF		20% RME + DPF	
	MP2	MP8	MP2	MP8
Total PAH	56.4	86.7	24.6	66.5
7-EPA-PAH	9.9	22.6	6.6	18.7
WHO-PAH	4.8	10.0	2.3	10.1

With DPF sampling time was much longer than without filter in order to collect sufficient mass on the test filter. The result is interesting: the few particles, that exit the DPF, carry substantially less carcinogenic PAH, particularly at full-load, which means that the reduction rate for PAH is better than the filtration rate for solid particles.





B_e/B_e Diesel			Diesel + DPF	Diesel + 20% RME + DPF
Test-point	RPM	Torque Nm		
MP2	1400	600	0.99	1.01
MP6	1400	297	1.01	1.03
MP8	1400	149	1.03	1.04
MP10	1400	59	0.96	0.98
MP5	2000	252	1.01	1.04
MP1	2000	500	1.01	1.03
Average			1.00	1.02

The penetration exhibits very low values. Unexpectedly, there is a slight increase of large particles. More important is however the favorable response to fine particles, which are > 99.8 % intercepted. There is no discernable difference between the fuel variants. These tests were also an opportunity to measure the effect of DPF on fuel consumption of the two fuel variants – see Table

[1] SAE 2005-01-1728 *Impact of RME on emissions* [2] MTZ 53 1992 11 O.Syassen *Chances and problems of renewable bio fuels*