

# FTIR Spectroscopy of Diesel and Biofuel Particles in off-road Engine Exhaust

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## Abstract

Vegetable oil based biofuels are commonly used as alternative fuels in existing engines. Rapeseed, palm, and other oils can be produced from local renewable resources. However, environmental impacts of biofuel combustion are poorly understood. Limited information exists concerning the chemical structure of particles produced by burning biodiesel and vegetable oils. This work reviews organic/inorganic composition of diesel and biofuel particles emitted from diesel locomotive and tractor engines at various operation conditions. Particles produced by burning diesel fuel and heated vegetable oils were sampled from an exhaust of a Zetor 1505 tractor engine at different engine operation conditions and from a diesel-electric locomotive. The relationship between IR bands of polar oxygen-containing groups to non-polar aliphatic C-H functional groups allow an estimate of the extent of the particle oxidation. This work allows the decreasing the uncertainties in chemical identity of original combustion nanoparticles produced by burning diesel fuel and vegetable oils and in quantification of their environmental effects.

## Organic/inorganic content by FTIR spectroscopy



- ✓ Mode: Transmission
- ✓ Resolution: 4 cm<sup>-1</sup>
- ✓ Number of scan: 100
- ✓ Background: Atmosphere

The comparative analysis of particle organic chemistry as well as the impact of different engine loads on the surface properties is carried out by Fourier Transform IR (FTIR) spectroscopy. The interpretation of bands associated with inorganic compounds is confirmed by complementary measurements of water-soluble ion species in diesel and biofuel exhausts by capillary electrophoresis.

## Tractor engine - Zetor 1505

### Fuels

- ✓ Diesel fuel (EN 590)
- ✓ Palm oil heated (HPO)
- ✓ Rapeseed oil heated (HRO)
- ✓ Rapeseed oil heated (HROe) with ethylhexylnitrate

Loads: full, ISO 8178C-1, ISO 8178C-2



## Diesel electric locomotive

### Fuel

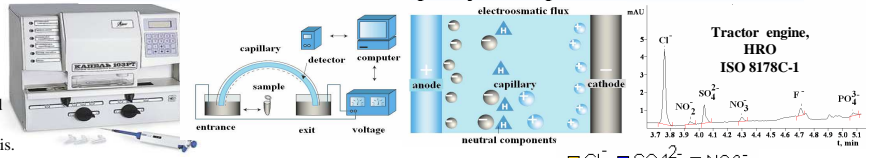
- ✓ EN 590 diesel fuel (EN 590)

Loads: full, fast idle

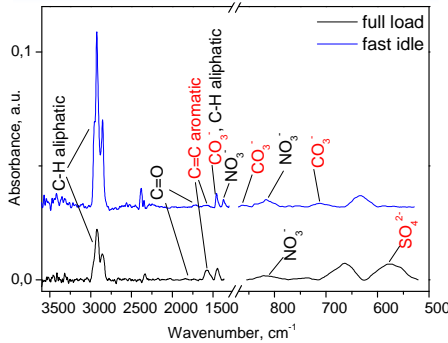


All samples were collected at PallFlex T60A20 filters

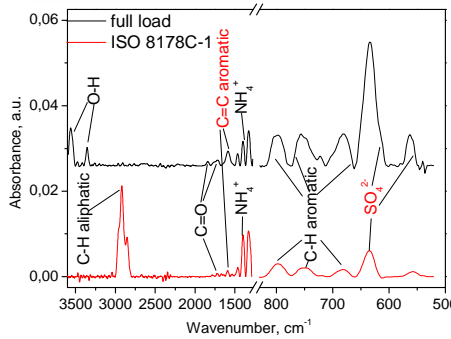
## Ion content by capillary electrophoresis



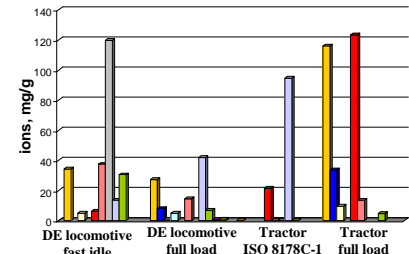
## Diesel fuel (diesel-electric locomotive)



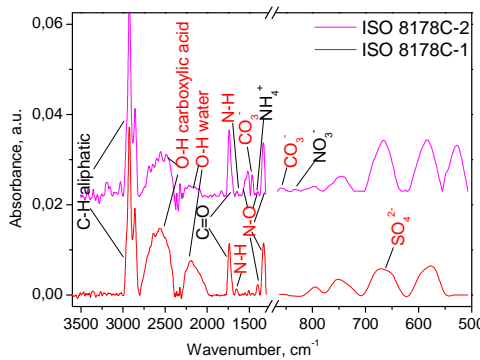
## Diesel fuel (tractor engine)



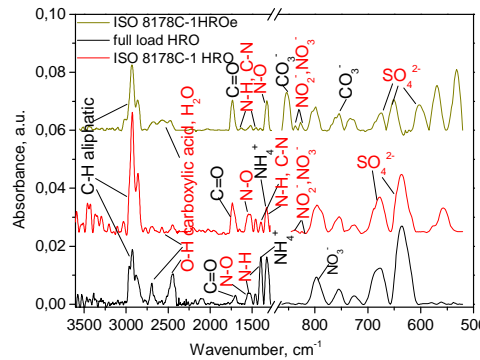
## Diesel fuel (EN 590)



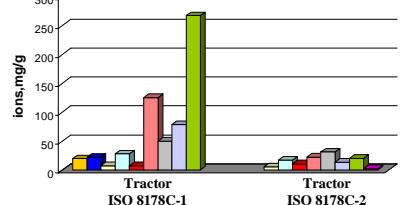
## Palm oil heated (tractor engine)



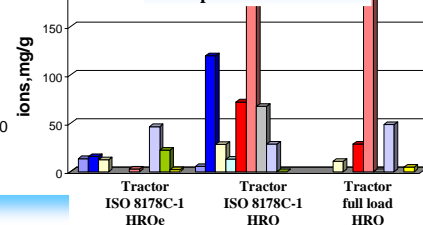
## Rapeseed oil heated (tractor engine)



## Palm oil heated



## Rapeseed oil heated



## Conclusions

- ✓ The organic/inorganic content of combustion particles from off-road engines is determined mainly by the type of the fuel used
- ✓ The main characteristic band of biodiesel particles is assigned to aromatic C-C stretching vibrations, which is absent in the spectra of particles from diesel fuel combustion
- ✓ The prominent feature of the spectra of biofuel-produced particles is significant IR bands of oxygenated functional groups - carbonyl C=O and hydroxyl O-H
- ✓ The set of bands in spectra of biofuel-produced particles could relate to N-O and N-H, C-N groups nitrogens in amines and nitrocompounds
- ✓ Small ratio of peak areas of IR bands C=O/C-H and O-H/C-H for particles produced by locomotive and tractor engines using diesel fuel indicates their hydrophobic nonoxidized surface with low relative concentration of polar oxygen containing functionalities
- ✓ Nanoparticle inorganic chemistry is revealed by absorption bands associated with nitrates, nitrites, carbonates and sulfates

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