Biodiesel and Renewable Diesel Emissions Study VOC, Carbonyl & N_2O Emissions

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Acknowledgements

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Organic Analysis

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Engines and Fuels

Make/model/year	Emission Control Devices	Test fuels	Analyses
2000 Freightliner C15 Caterpillar		ULSD diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, A100), Renewable diesel (R20, R50, R100)	VOC Carbonyl N2O
2006 International ISM 370	EGR	ULSD diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, A100),	VOC Carbonyl
2008 Freightliner Mercedes Benz MBE 4000	DOC, DPF, EGR	ULSD diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, A100),	VOC Carbonyl

Emissions Analyses

- Speciated non-methane hydrocarbons (NMHC)
- Carbonyl compounds
- Nitrous Oxide (N2O)

Instrumentation

Analysis	Sample Container	Instrument
NMHC	Tedlar Bag	Gas Chromatograph (GC) with flame ionization detector (FID)
Carbonyls	DNPH* Cartridge	High performance liquid chromatograph (HPLC) with UV detector
N_2O	Tedlar Bag	Fourier transform infrared spectrometer (FTIR)

*** Sampling cartridge impregnated with 2,4-dinitrophenylhydrazine**

Speciated Non-Methane Hydrocarbon Analysis

- Tedlar bag samples analyzed by 2 GC/FIDs, connected in parallel
  - *Light-end GC: C1 to C5 HCs*
  - *Mid-range GC: C6 to C12 HCs*
- Liquid nitrogen trapping of sample yields FID detection limits to very low ppbC

Dual Gas Chromatograph

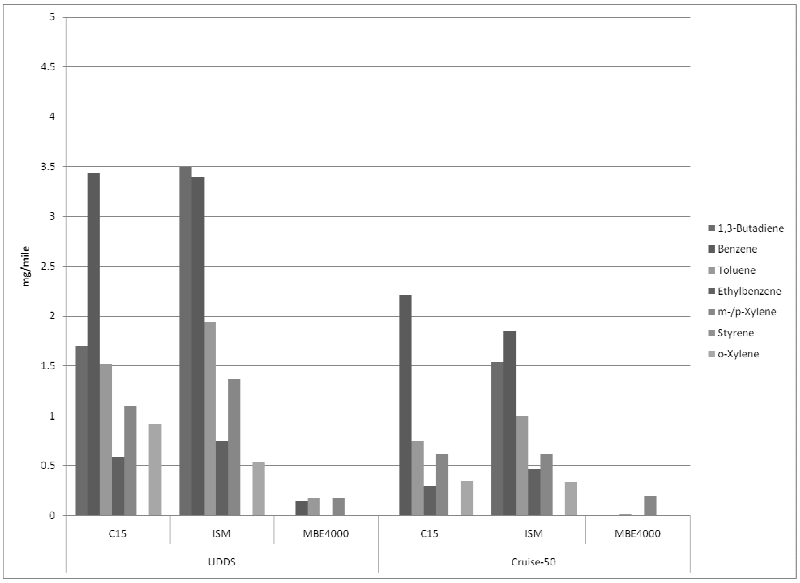
H2 Generator **Mid-range GC** **Light-end GC**

Speciated Non-Methane Hydrocarbon Analysis

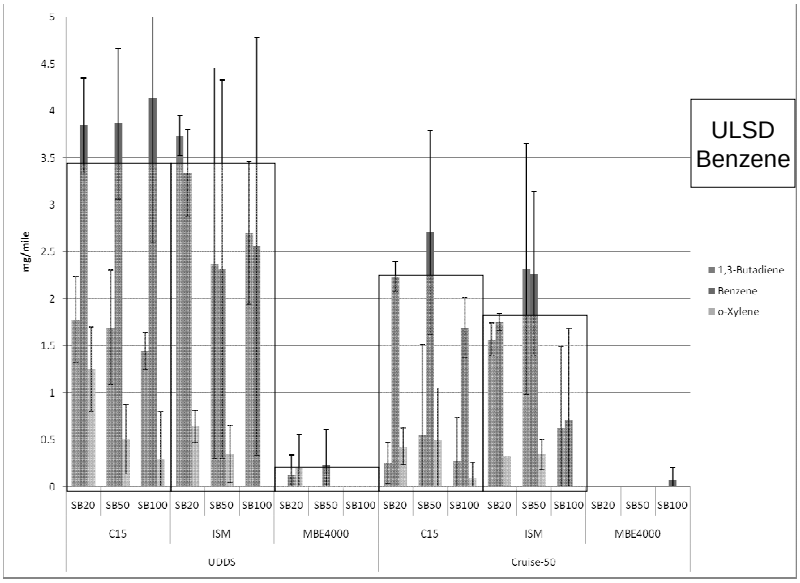
- Compounds reported for this study:

1,3-butadiene
benzene
toluene
ethylbenzene
m-/p-xylene
styrene
o-xylene

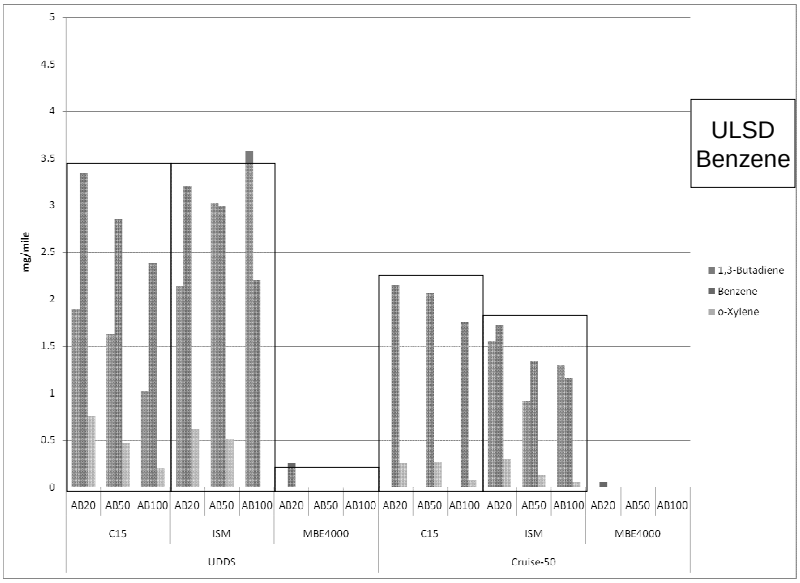
Toxic VOC - ULSD



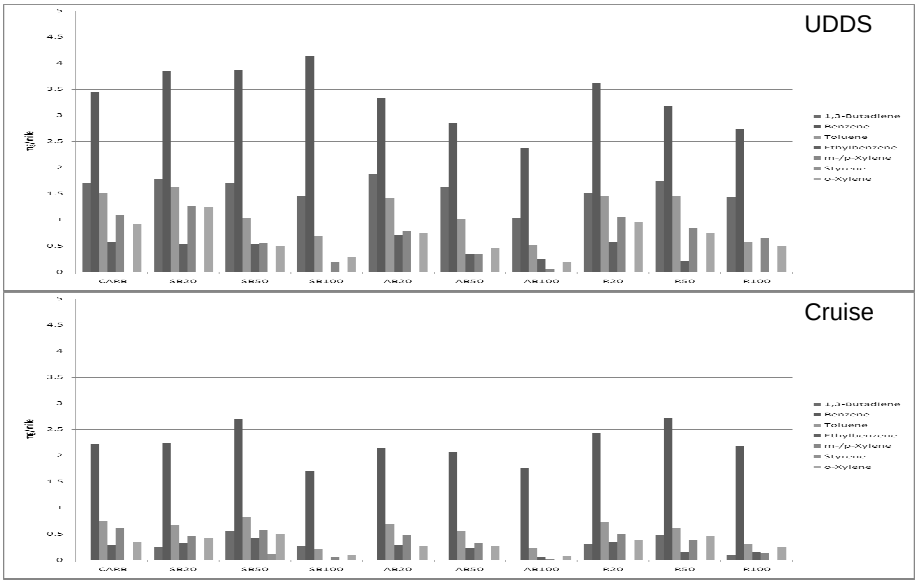
Toxic VOC - Soy Biodiesel



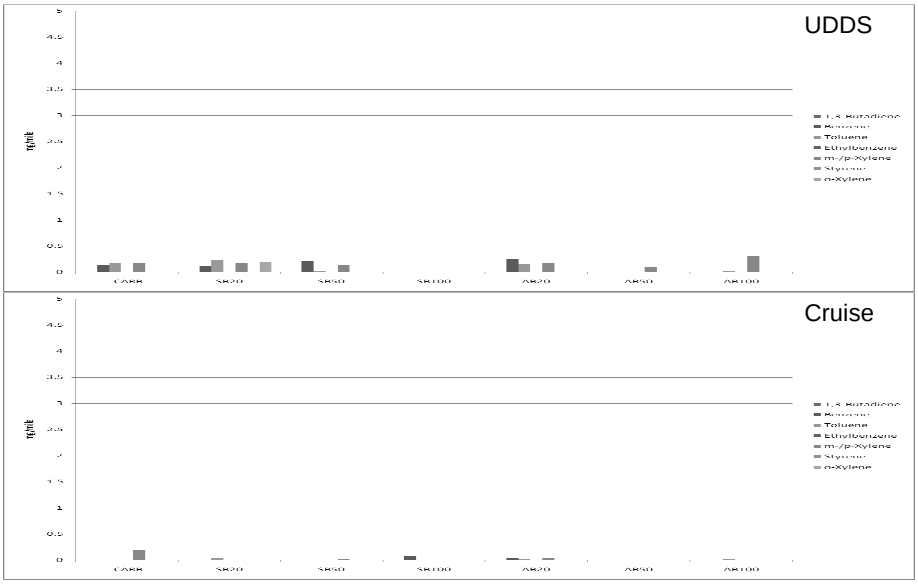
Toxic VOC - Animal Biodiesel



Toxic VOC -C15

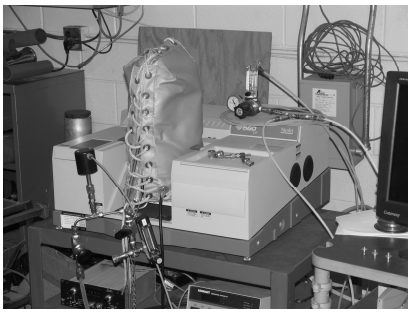


Toxic VOC -MBE4000

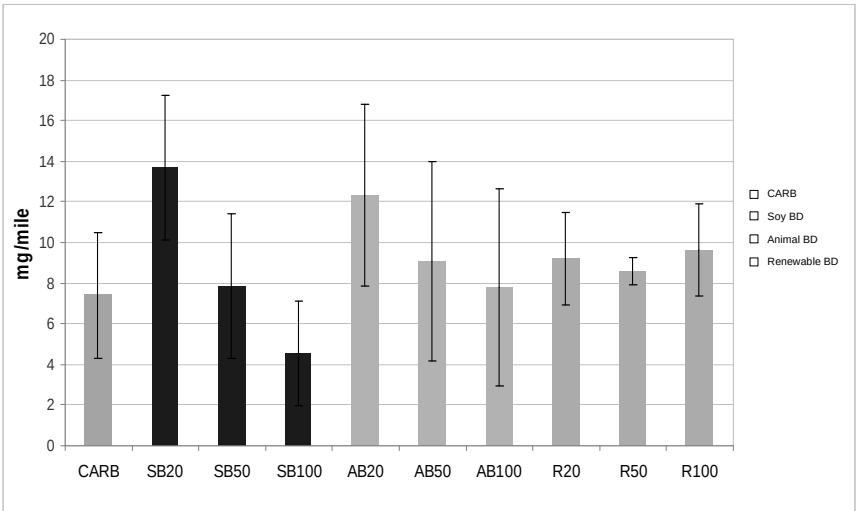


NITROUS OXIDE ANALYSIS

- Tedlar bag samples analyzed by Fourier transform infrared spectroscopy (FTIR)
  - 10-Meter, folded path IR cell



N_2O – C15 Engine



Carbonyl Analysis (Aldehydes and Ketones)

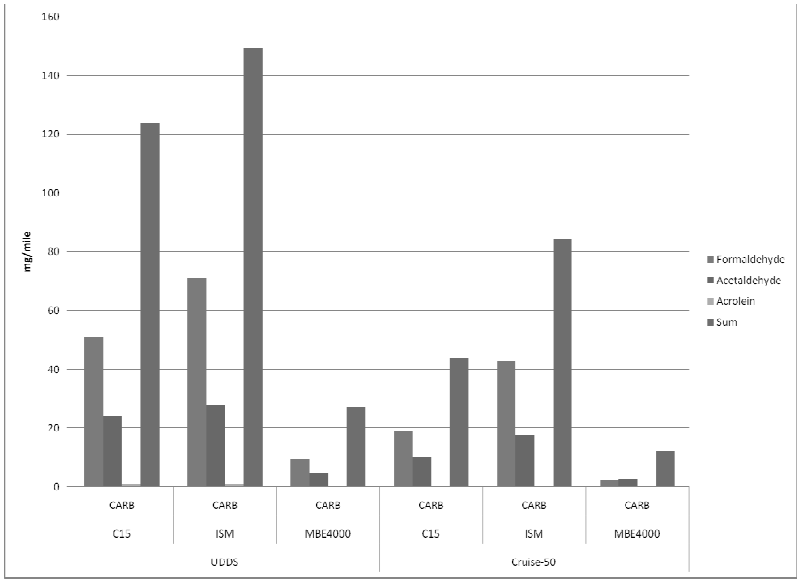
- Carbonyl group derivatized by DNPH in sampling cartridge*
- Cartridges flushed with solvent to extract carbonyl compounds

- Solution analyzed by high performance liquid chromatograph (HPLC) with UV detection

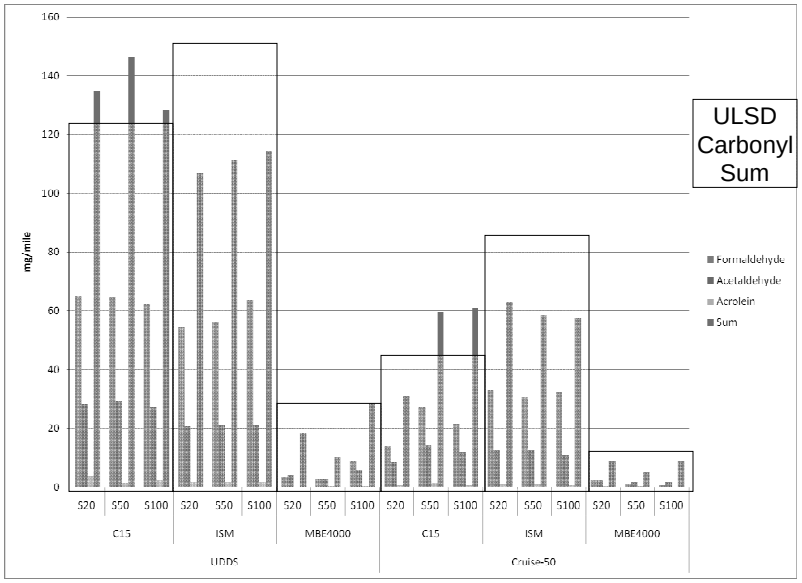
Carbonyl Analysis (Aldehydes and Ketones)

- This method measures:
  - formaldehyde
  - acetaldehyde
  - acrolein*
  - 10 Other carbonyls (to C_6)

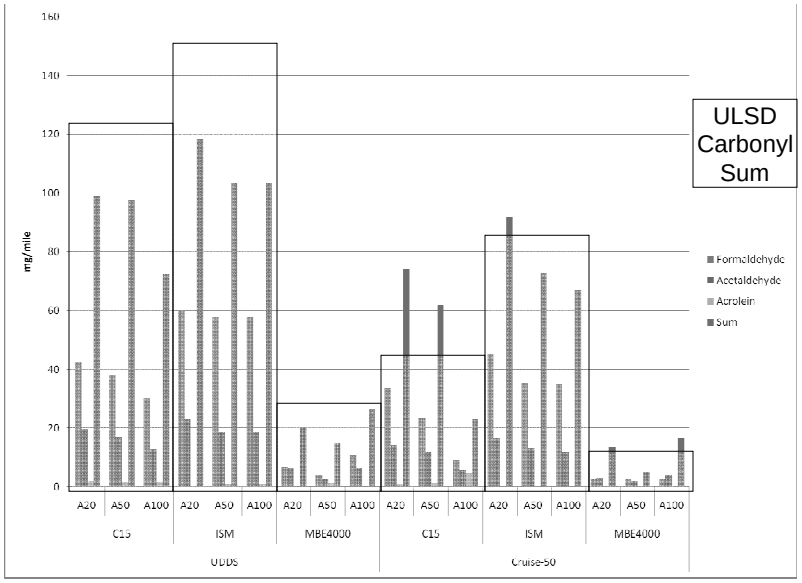
Carbonyl - ULSD



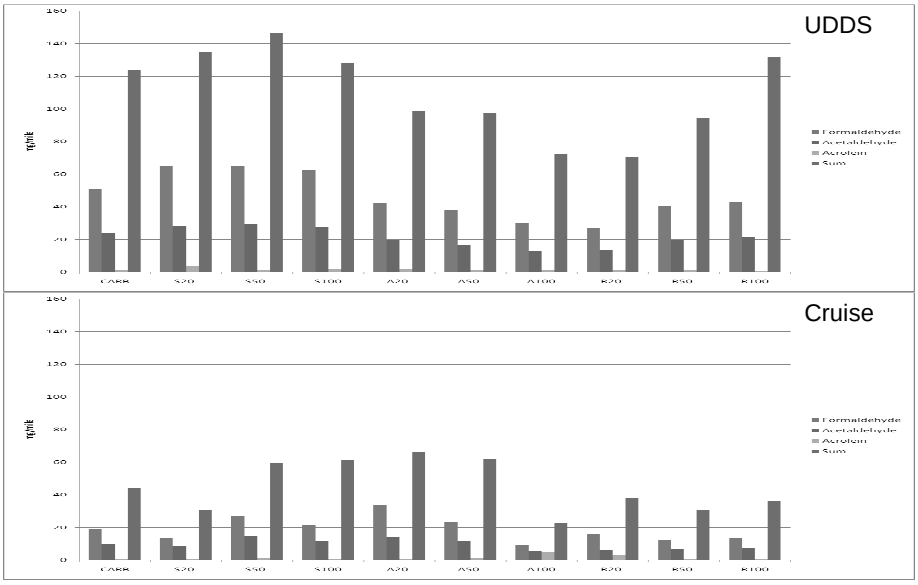
Carbonyl - Soy Biodiesel



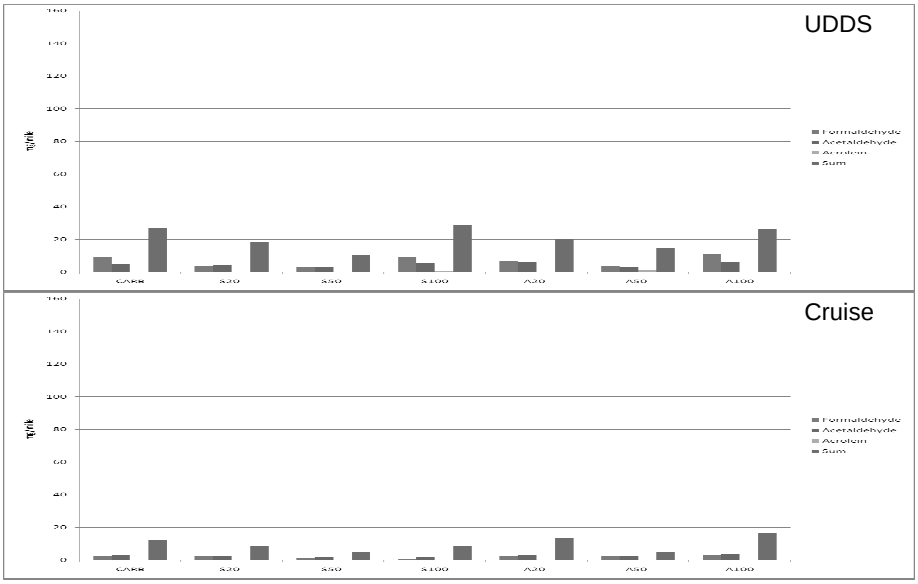
Carbonyl - Animal Biodiesel



Carbonyl-C15



Carbonyl-MBE4000



Summary - VOC

- Soy Biodiesel
  - No significant VOC increase versus ULSD Fuel
  - No trend with regard to increasing Biodiesel fractions
- Animal Biodiesel
  - Modest VOC decrease versus ULSD Fuel
  - VOC reduced with increasing Biodiesel fractions
- Renewable Biodiesel
  - Modest VOC decrease in UDDS cycle versus ULSD fuel but not in cruise
  - VOC reduced with increasing Biodiesel fraction in UDDS but not in cruise

Summary – N2O

- No significant change in N2O emissions is observed for any fuel blend

Summary - Carbonyl

- Soy Biodiesel
  - No significant changes versus ULSD Fuel
  - No trend with regards to increasing Biodiesel fractions
- Animal Biodiesel
  - Modest decrease versus USLD Fuel in UDDS Cycle only
  - emissions reduced with increasing Biodiesel fractions.
- Renewable Biodiesel
  - No significant changes versus ULSD

Summary - Engines

- VOC
  - C15 and ISM engines perform similarly to each other under all fuel scenarios
  - MBE4000 emits ~ <1/10th of the average of C15 and ISM engines
- Carbonyls
  - C15 and ISM engines perform similarly to each other under all fuel scenarios
  - MBE4000 emits ~ <1/6th of the average of C15 and ISM engines