

The Technology of BioHeat

New York City
2011 BioHeat Conference
Sept. 20, 2011

Tom Butcher

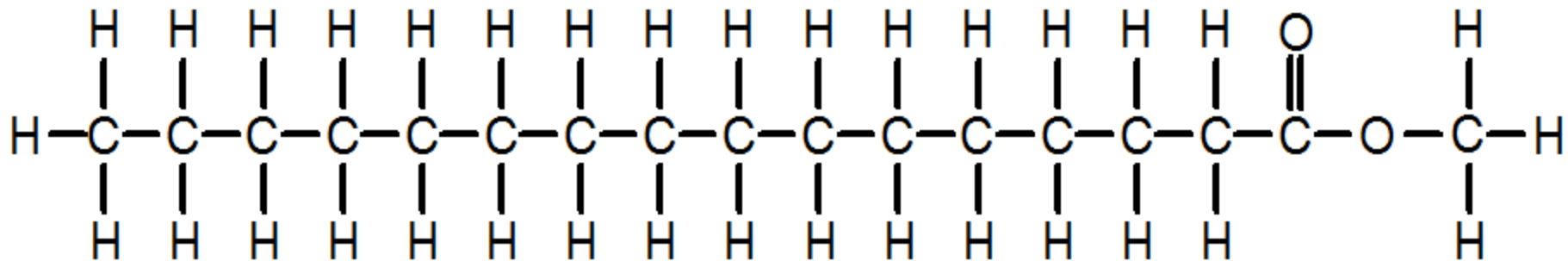
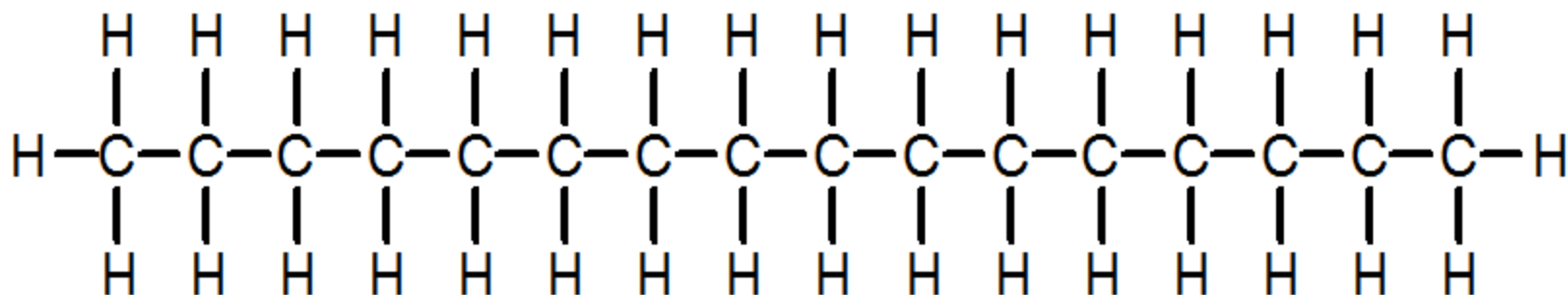
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a passion for discovery



The Fuel

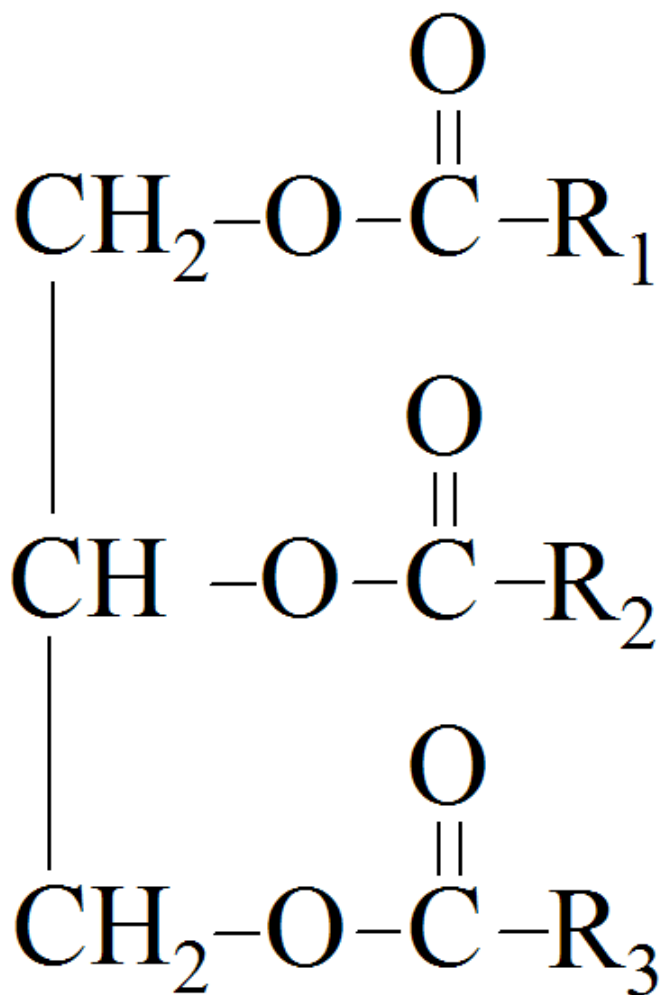
- Biodiesel is a diesel-like fuel
- Biodiesel is completely miscible with diesel or home heating oil
- Some differences from #2 or diesel:
 - Oxygenated by ~ 10% by weight
 - 8-10% higher density
 - About 10% lower heating value
 - Negligible sulfur and nitrogen content

Heating Oil

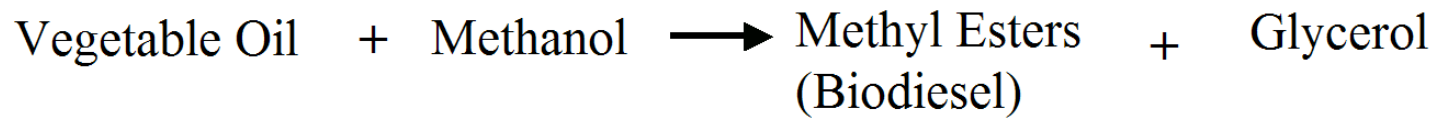
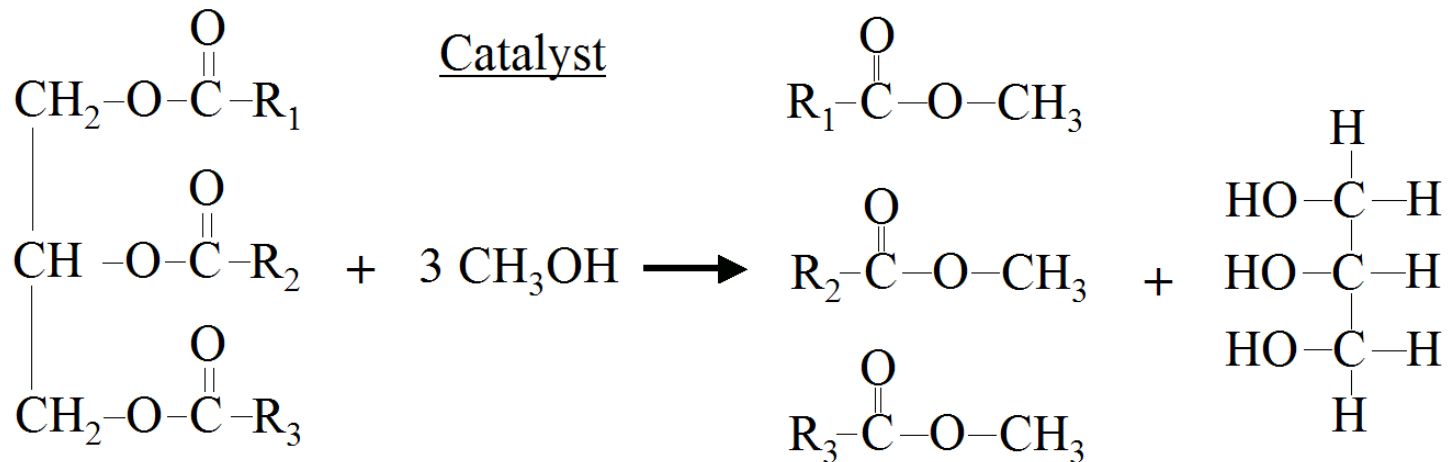


Biodiesel

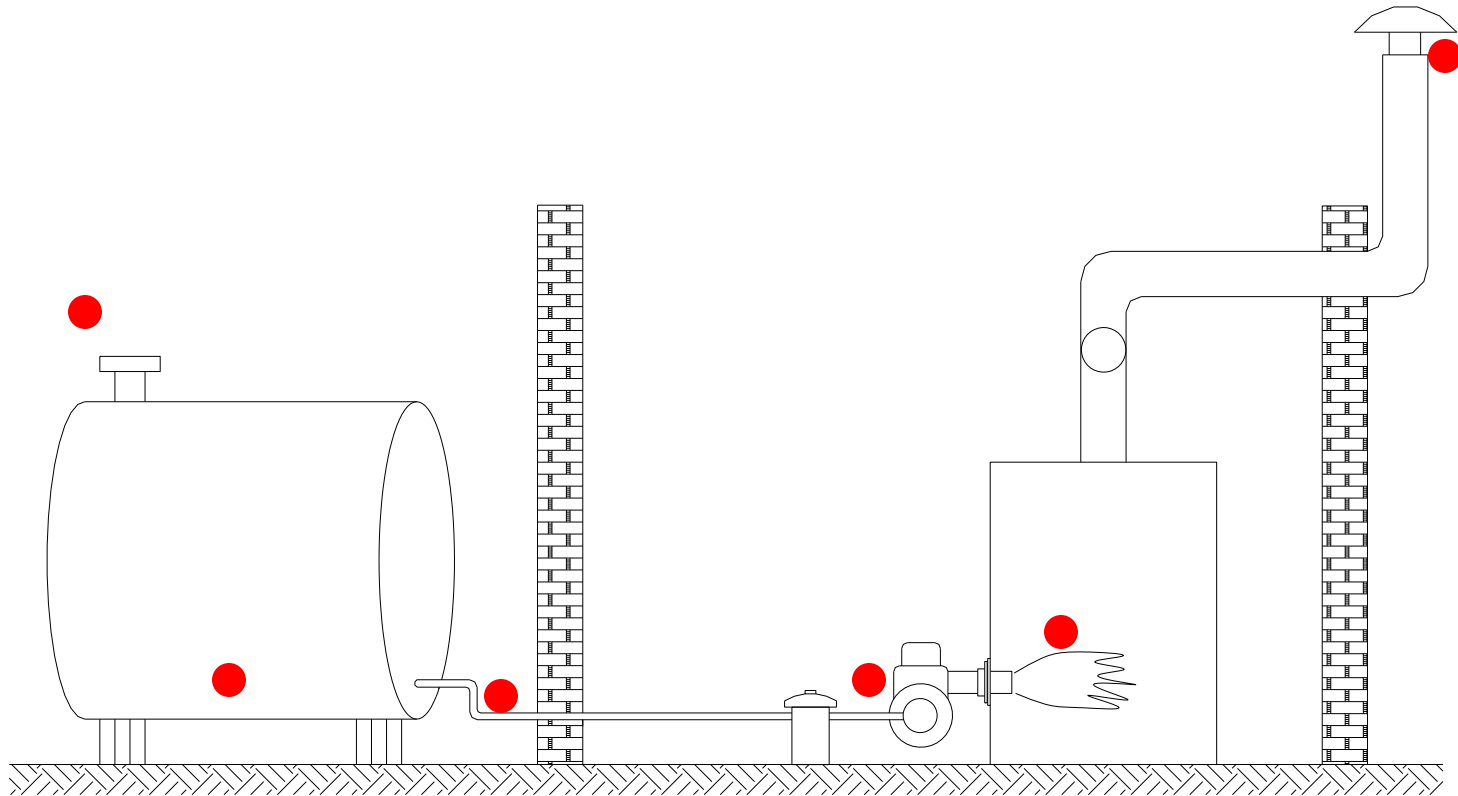
Vegetable Oil



Chemistry of Conversion



Aspects affected by the fuel



Properties

Comparison of Typical Fuel Properties, No. 2 Heating Oil and Biodiesel

Property	No. 2 Heating Oil	<u>Biodiesel</u> (B100)
Standard	ASTM D 396	ASTM D 6751
Higher Heating Value (Btu/gal)	139,200	125,000
<u>Kinematic viscosity</u> (@ 40 F)	2.7	4.0 – 6.0
<u>Specific gravity</u> (kg/liter @ 60 F)	0.86	0.88
Density (lb/gal)	7.1	7.25
<u>Water and Sediment</u> (vol%)	0.001	0.05
Carbon (wt%)	86.6	77.0
Hydrogen (wt%)	13.6	12.0
Oxygen (wt%)	0.1	11.0
Sulfur (wt%)	0.1	0.0 to 0.0024
Flash Point (F)	120 to 210	210 to 350
Cloud Point (F)	-9 to 5	26 to 54
Pour Point (F)	-9 to 16	5 to 50

Key conclusions – lab tests in boilers and furnaces with No. 2 oil

- Combustion stability is good to B-100
- NOx emissions are somewhat lower
- Particulate emissions are lower, in proportion to fuel sulfur content
- Flame luminosity somewhat lower at higher blend ratios, particularly during startup transients

Field Studies – Warwick

- 2001-2002 in two phases
- 32,285 gallons blend burned
- NOx emissions reduced by 19%
- No combustion performance impacts
- Fuel storage temperatures to 50 F

Field Studies – Abbott and Mills

- In cooperation with Brookhaven, NYSERDA sponsored
- 2001-2005, Upstate New York
- B-20, 100 homes
- Furnaces, boilers, water heaters
- Indoor, outdoor, buried tanks
- Winter design temperature 0 F
- No increase in service resulting from biodiesel use

Field Studies – Sagamore Hill

- In cooperation with Brookhaven, National Park Service, NYSERDA sponsored
- Theodore Roosevelt home and museum
- B-20, 2 years
- No problems in appliances or storage
- B-100 tests done, pump seals changed to viton

B-5 ASTM Effort

Sponsors:

National Biodiesel Board

National Oilheat Research Alliance

Main Performer:

Underwriters Laboratories Inc.

Supporting Organizations:

R.W. Beckett Corp.

Carlin Combustion Technologies

Riello Burners

Brookhaven National Laboratory

Tasks:

Basic combustion performance verification under normal and extreme conditions

Materials compatibility as required for any burner or component approval

Gaseous and Liquid Fuel Green House Gas Emissions in NY/NJ/PA Region IPCC AR4 20 Year Analysis Assuming Sustainable Biofuels



Beyond B-5

- What is the “Legacy-safe” level?
- What level of technical data is required to definitively show legacy-safe?
- Above the legacy-safe level new seal materials will be required. Are current tests adequate to qualify these materials?
- Above legacy-safe focus on B-100

Stability

- General conclusion so far is that stability of biodiesel blends is lower but acceptable
- Do we need to go beyond 6751 for heating applications where storage times are longer?
- Great deal of work has been done and is on-going – this question is not unique to this market application

Sediment and biodiesel

- Most tanks have water and sediment on bottom
- Product of years of biological and oxidative degradation
- What is solvency impact of biodiesel blends?

4Tests

Sediment dispersion and refiltering

Settling rate comparison

Particle size distribution of dispersed sediment

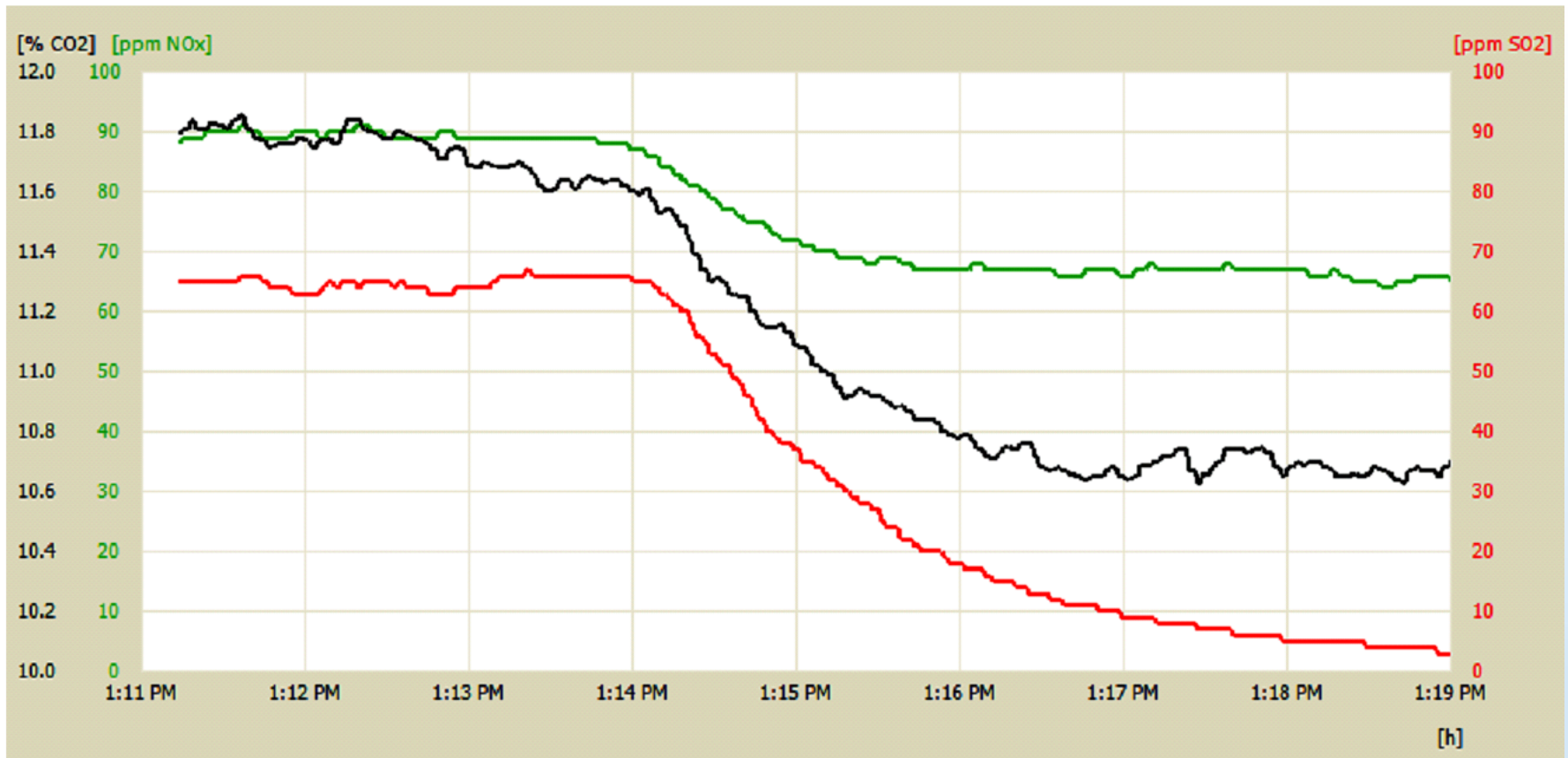
FTIR analysis of biodiesel in which sediment has been dispersed



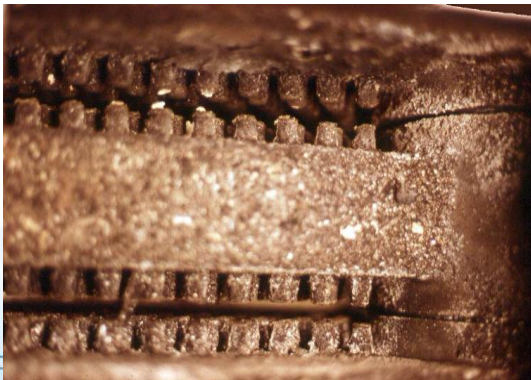
Conclusions from sediment tests

- No significant change in size distribution of dispersed particles.
- No quantitative impact of solubility of sludge
- No measurable change in biodiesel following mixing with sludge based on FTIR
- Slower settling rate which may be due to viscosity and density differences.

Transition - #2 to B100

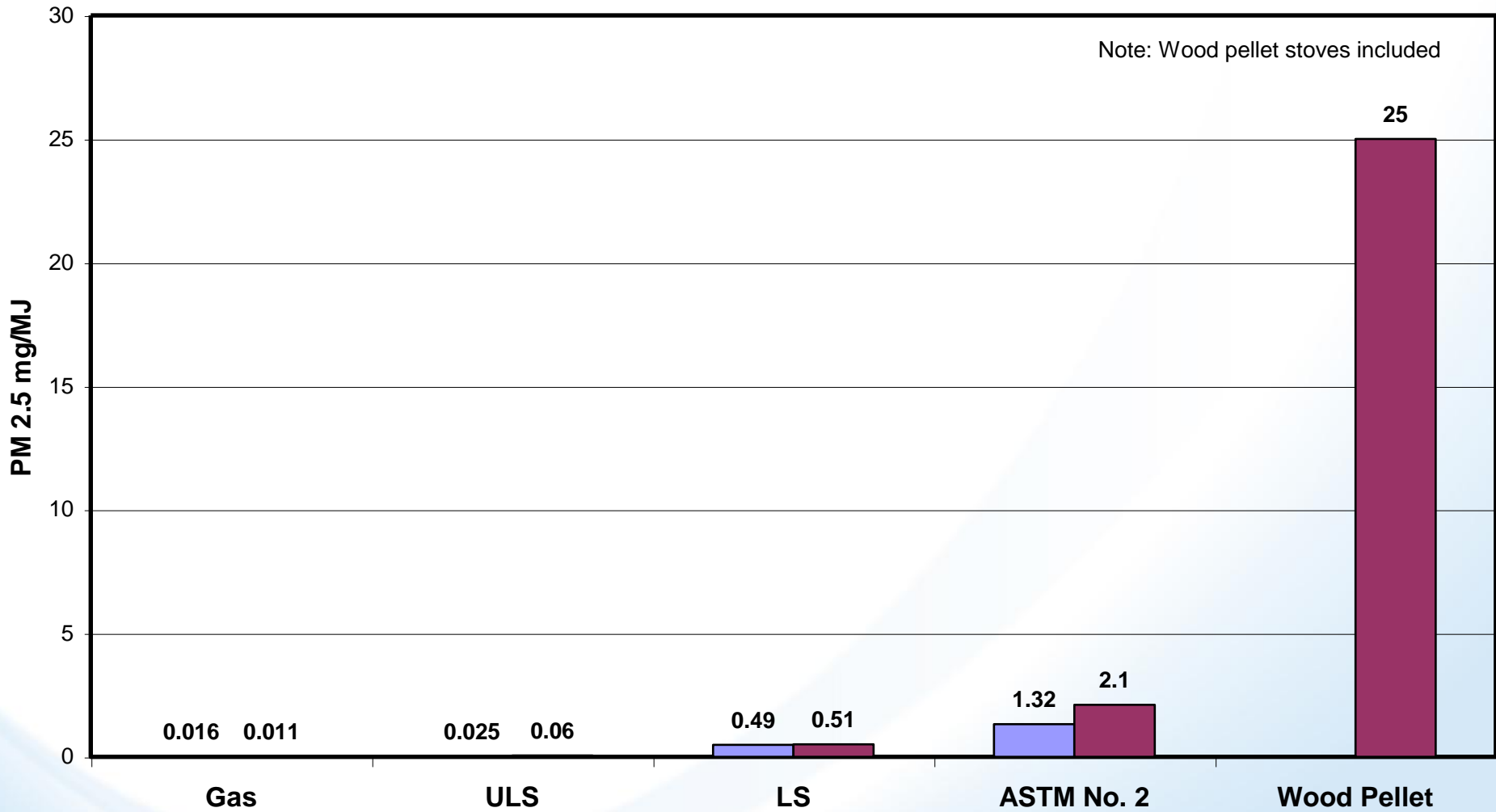


Low sulfur is an attribute that can reduce boiler corrosion and enable low cost, high efficiency, condensing operation



Boiler Furnace

Note: Wood pellet stoves included



B-100 studies at BNL

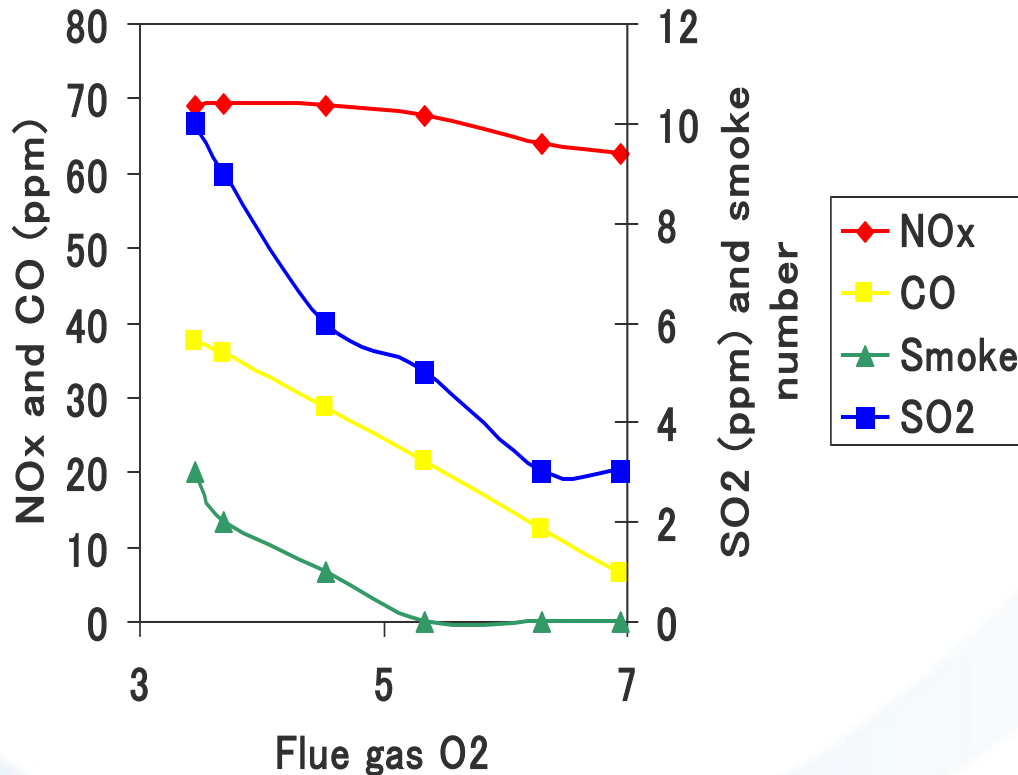
- Full scale boiler tests conducted with tallow- and soy-based biodiesels
- Burner equipped with a bio conversion kit by manufacturer
- Flawless performance during cold ignition and steady state
- Fulton moving to commercial status
- Efficiency to 94%



Brookhaven Science Associates



B-100, listed burner now available



Conclusions

- B-5 BioHeat blends are technically very compatible with existing applications
- Existing field experience with much higher blend ratios provides a rich source of confirming data
- Fuel quality is critical to success.
- B-100 may offer an interesting future opportunity to go well beyond legacy-safe for the population of heating equipment on average.

Thank You!

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