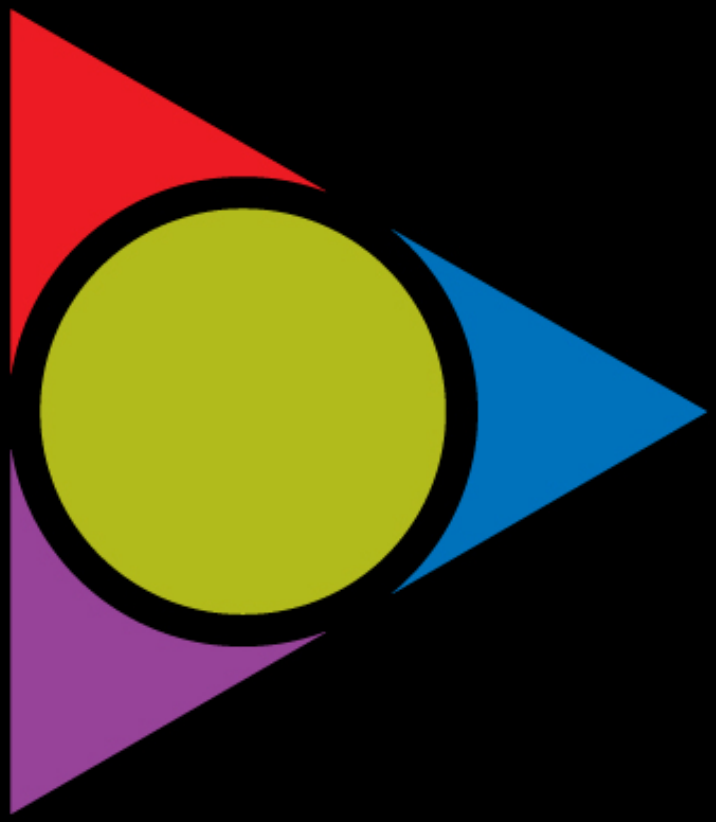

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THE EUROPEAN ALTERNATIVE FUEL MARKET AND THE ROLE OF FUEL ADDITIVES

Simon Mulqueen

Biofuels Conference

Greece 2007

Introduction

- Significant reductions made in contribution of road transport to air pollution despite continued growth in transport sector
- Focus has shifted towards climate change and limiting greenhouse gas (GHG) emissions
- Energy security has also received greater attention, with transport perceived as being particularly vulnerable given its reliance on fossil fuel reserves
- Alternative fuels are therefore gaining widespread support as a means of both substituting oil and reducing GHG emissions

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Alternative Fuel Types

- Bio-derived or alternative components considered for use in gasoline and diesel pool include;
  - Ethanol
  - Fatty Acid Methyl Ester (FAME)
  - Gas or Biomass to Liquids (GTL or BTL)
- Before such components are used, it is important to address fuel quality, handling and vehicle operability requirements
- By fulfilling these requirements it is possible to realise the potential improvements in urban air quality

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Biofuels and Fuel Standards

- The European ‘Biofuels Directive‘
- (COM(2001) 547-2001/0265 (COD))
- Increased usage of biofuels (5.75% by 2011)
- EN590 update allows up to 5% biodiesel (FAME) in road diesel
- New Biodiesel standard (EN14214)
- EN228 already allows up to 5% Ethanol (E5)
  - Recent initiative to enable E10
  - Draft Fuel Grade Ethanol Specification (prEN 15376)

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The Role of Additives – Enabling Technology

- Emissions Legislation drives the introduction of new vehicle technologies & fuels. Additives ensure that fuels remain *fit-for-use* & offer the opportunity to further enhance *performance*.
- *Fit-for-Use*
  - Reduce the Cost of Infrastructure Investment Needed to Accommodate alternative fuel component
  - Mitigate the need for separate/specialized components of distribution, engine or vehicle hardware
  - Improve Specific Alternative Fuel Properties so as to be Compatible with Conventional Fuel Distribution Systems and/or Applications
- *Performance*
  - Complement Alternative Fuel Properties to Provide Differentiated Performance

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Alternative Fuels – FAME (Bio-diesel)

- Exact nature of fatty acid depends upon the number of carbon atoms in the fatty acid chain and the presence of additional functionality i.e. double bonds

- Detailed examination of acid structure reveals significant differences which can result in an observed difference in the property of the resulting FAME

Fuel Property	Unsaturated	Saturated
Cold Flow	Better	Worse
Stability	Worse	Better
Cetane	Worse	Better

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FAME – Oxidation Stability

- The Rancimat test has been adopted in many FAME specifications to determine oxidation stability behaviour
- It has been determined that the Rancimat Induction period of FAME can be extended by treatment with a suitable stability improver (S.I.) additives

Fuel	Induction Time (hours)
RME Base	7.8
RME + S.I. A @ 250 mg/kg	8.3
RME + S.I. A @ 500 mg/kg	8.8
RME + S.I. A @ 1000 mg/kg	9.4

Fuel	Induction Time (hours)
SME Base 1	1.4
SME 1 + S.I. B @1000 mg/l	4.8
SME Base 2	2.8
SME + S.I. B @1000 mg/l	5.1

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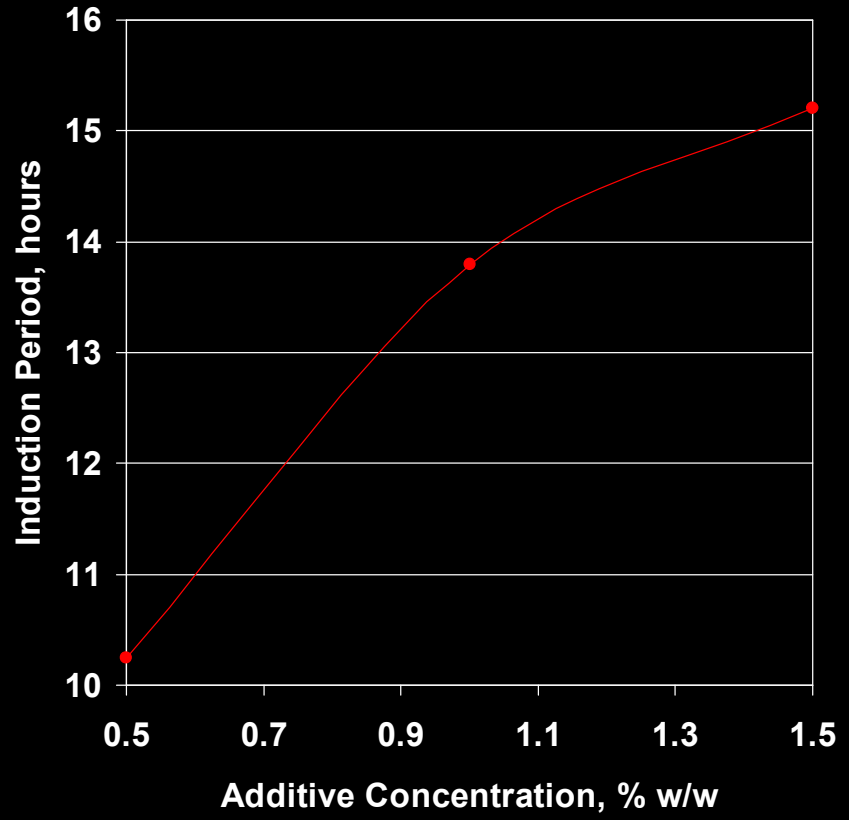
FAME – Long Term Storage Stability

- Impact of long term storage on FAME induction period assessed
- Data concluded that after 20 days storage RME shows a fall in induction period
- Same material treated with a stability improver stayed on specification for 84 days



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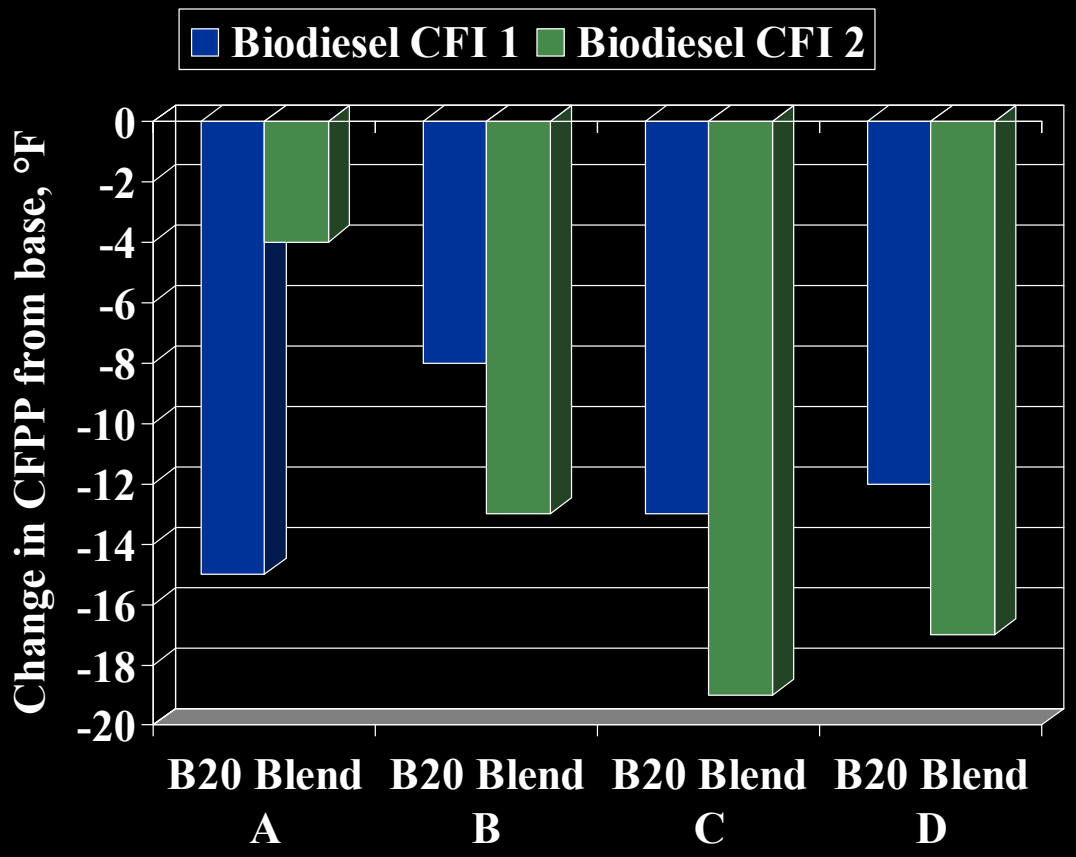
FAME – Cold Flow

- Blends higher than B5 may require re-optimised treatment regimes
- CFI additive efficacy can vary with different FAME / diesel fuel compositions



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FAME - Conductivity

- The use of static dissipators in conventional ULSD becoming more commonplace
- FAME has a high natural conductivity
- However at typical blending proportions, conductivity levels fall short of predicted values
- For B20 and below, fuel should be treated in the manner as conventional ULSD for conductivity purposes
- Additive treatment remains the most flexible and feasible method of adjusting fuel conductivity

FAME Content, % v/v	0	5	20	100
Conductivity, pS/m	2	3	13	497

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Alternative Fuels – Ethanol in Gasoline

- Ethanol high octane number (111 RON, 82 MON) oxygenated fuel either for use directly in dedicated vehicles or as a blending component
- Maximum level often determined by factors such as materials compatibility and whether the engine has been modified to allow for lower energy content
- Other factors such as potential for water ingress and impact on fuel volatility require consideration

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Ethanol in Gasoline – Operability Concerns

- General Motors (GM) observed increased fuel pump wear in sections of the US vehicle fleet operating on E10
- Field studies performed investigating quality of ethanol in the gasoline pool
- GM proposed changes to the specification for fuel grade ethanol
  - Development of acid detection method
  - Control of Ethanol pHe in ethanol manufacture
  - Incorporation of pHe into ASTM D4806 and ASTM D 5798 specification
  - pHe also incorporated into draft prEN 15376 Standard

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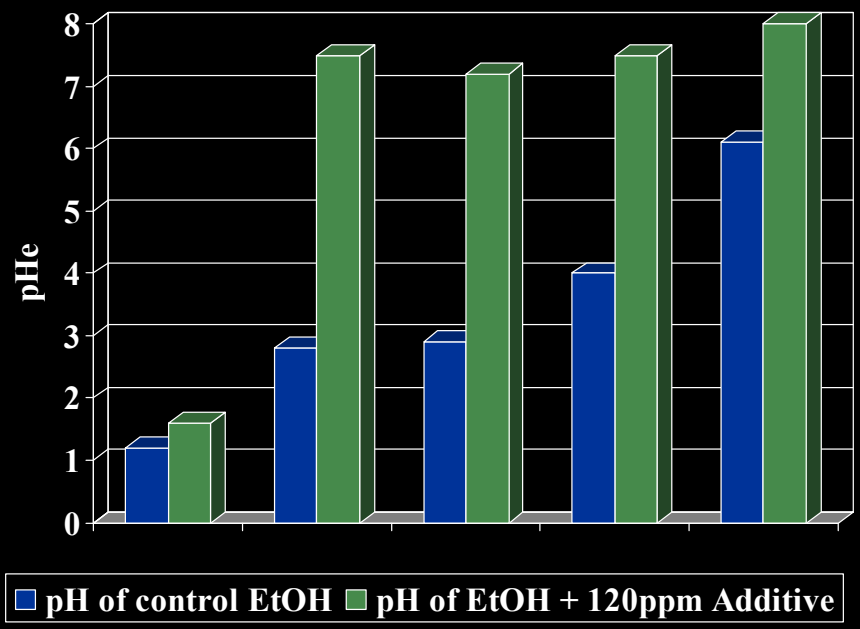
Ethanol in gasoline – Operability Concerns

- Study concluded that a significant fraction of the US ethanol pool had low pHe and during long term storage pHe decreased due to acid formation

- Low pHe strongly correlates with increased corrosivity shown by poor performance in NACE TM-01-72 Corrosion test

- For all ethanol with a base pHe > 2.5, it is possible, through additive use, to increase pHe to meet ASTM specification of 6.5 to 9.0



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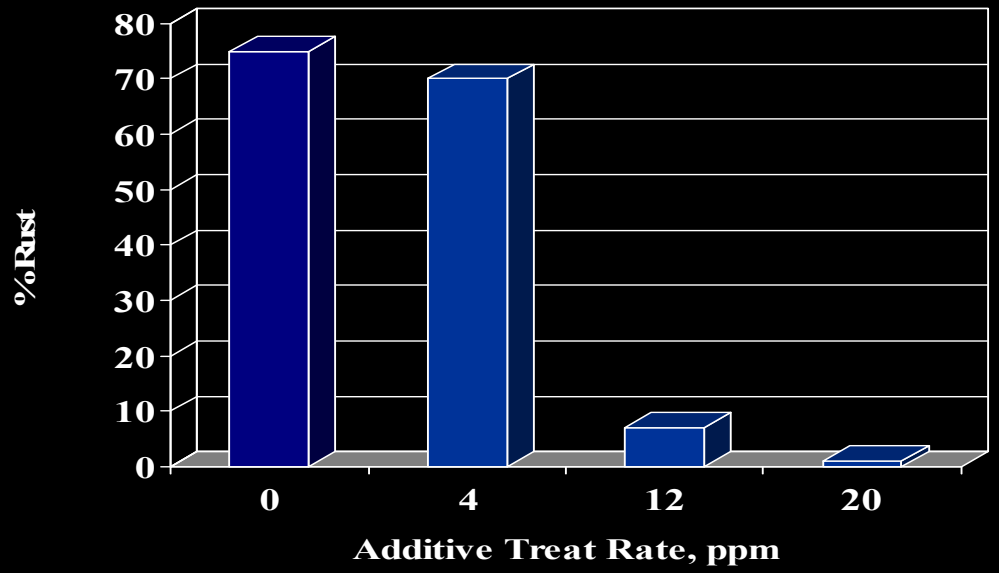
Ethanol in Gasoline – Corrosion Inhibition

- In extreme cases, vessel ruptures have occurred in carbon steel tanks where untreated ethanol has been stored for extended periods
- Additive treatment to control pHe and corrosion can prevent such occurrences
- prEN 15376 states “For distribution purposes, it is recommended that ethanol producers and downstream distributors and petrol blenders consider the need to add anti-corrosion additives to fuel grade ethanol…”



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Alternative Fuels - GTL

- GTL – Natural gas (or coal) derived fuel
- Low temperature Fischer-Tropsch GTL process produces a highly paraffinic middle distillate material low in sulphur and aromatics
- When used in a diesel engine, GTL typically gives reduced emissions of PM and NOx relative to conventional diesel fuel
- As with conventional ultra low sulphur diesel fuels additive treatment may be required to comply with finished fuel specifications

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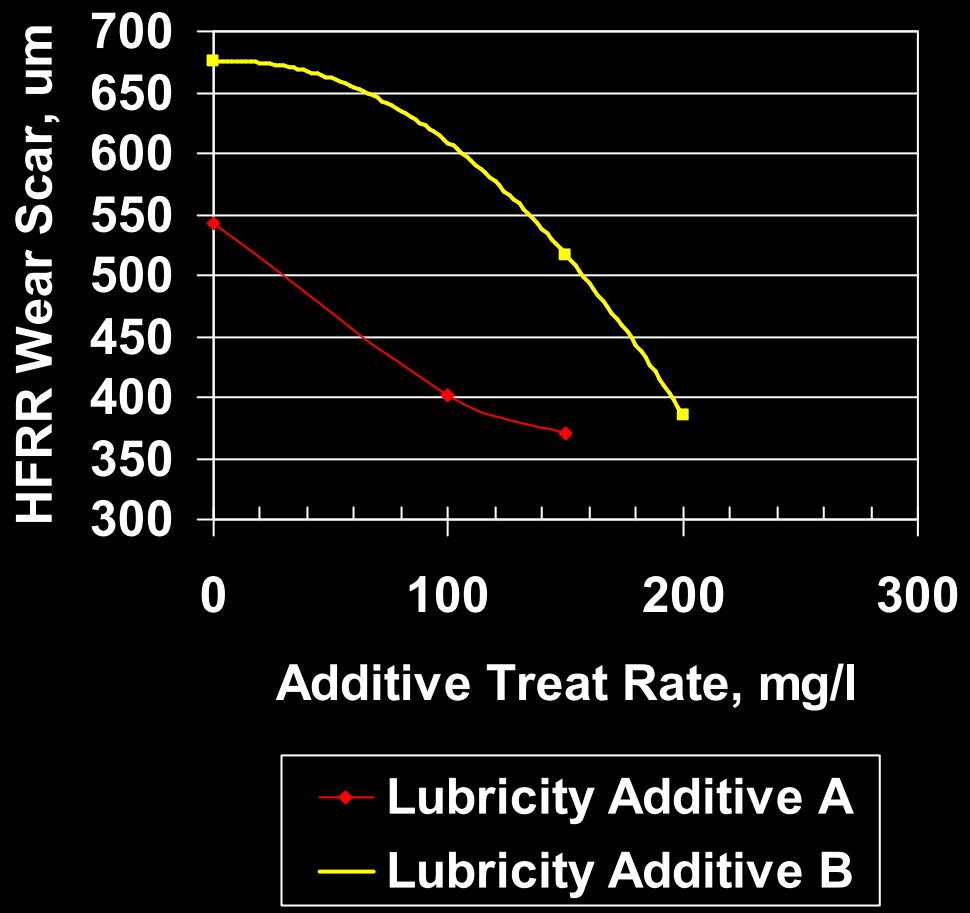
GTL - Lubricity

- GTL diesel is low in sulphur and presents similar concerns as ULSD
- The potential for wear on critical components of fuel injection pumps is one such concern
- Lubricity additive types successfully used in conventional ULSD can be employed in GTL



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GTL - Conductivity

- Middle distillate ground fuels often contain static dissipator owing to low basefuel conductivity at temperature of handling
- Middle distillate fuels produced through GTL synthesis do not contain natural conducting species
- GTL diesel can benefit from addition of static dissipator

Conductivity Additive Treat Rate, mg/l	GTL Fuel 1	GTL Fuel 2
0.0	0	0
0.5	51	55
1.0	103	107
1.5	140	218

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Conclusions

- Alternative fuel use increasingly mandated in an attempt to minimise the negative contribution of road transport fuels to air quality
- It is of critical importance to establish and meet technical standards to ensure quality of pure or blended bio-derived fuels
- Bio-derived and alternative fuels can offer a reduced reliance on crude imports, provides new options for meeting emissions requirements and help reduce the contribution of road transport fuels to greenhouse gas emissions.
- The use of additive systems can play a valuable role in enabling the incorporation of alternative fuel sources into the general gasoline and diesel pool

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