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Bio-Fuels as Future Fuels for Automotive Vehicles – OEM's Viewpoint of Requirements & Issues

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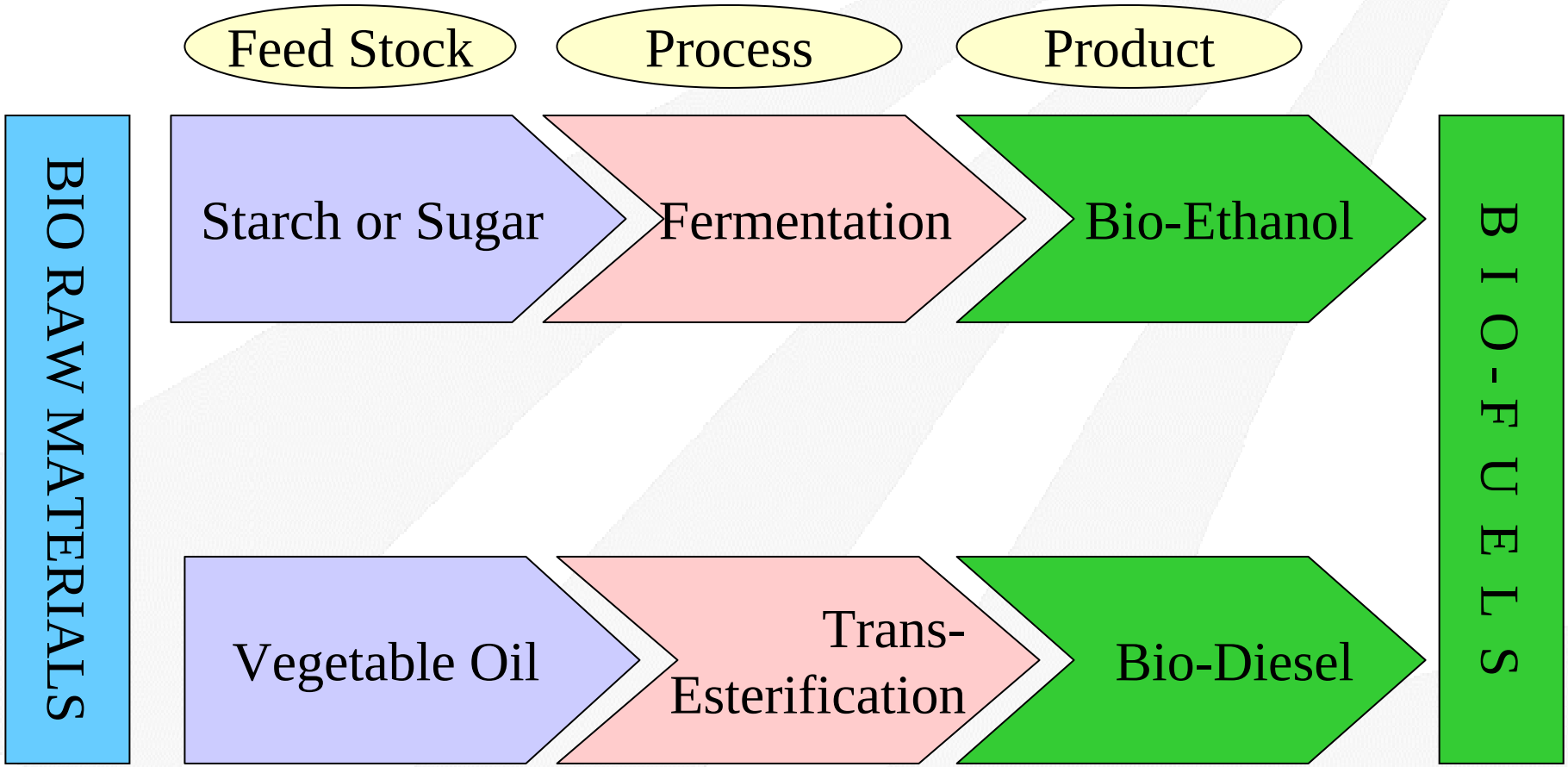
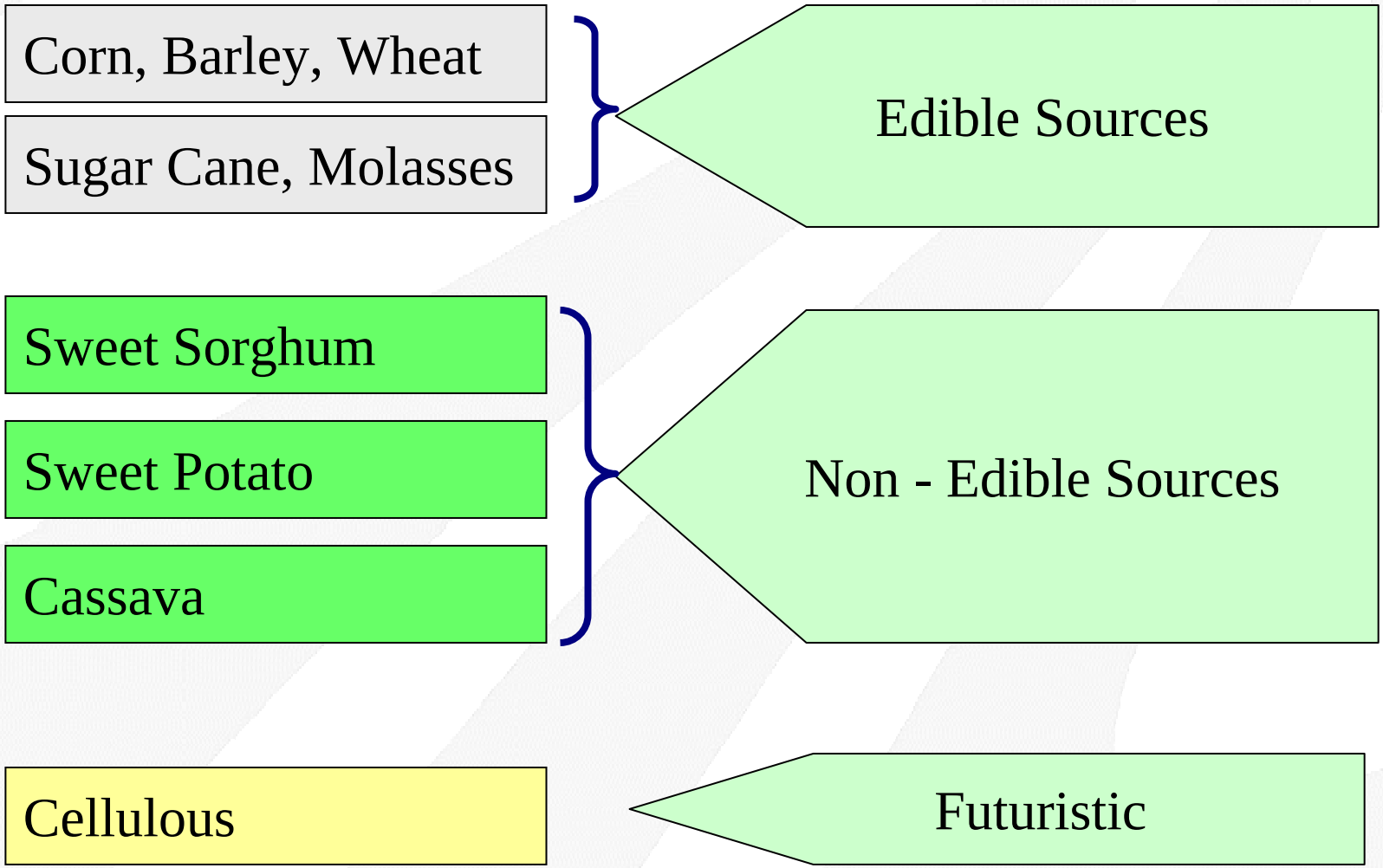
5th International Bio-Fuels Conference
New Delhi
7-8 Feb. 2008

Bio Fuels for Automotive Use



Bio-Ethanol Fuel for Gasoline Vehicles



Global Status & Road Map for Ethanol

Country	Ethanol Blend equivalent to gasoline billon Litres	Current Blend level mandated fully or partially	Target for Blend level in future
USA	538	E2	E3
EU 27	148	E2	E3
China	68	E10	E15
Japan	61		E20
Canada	42		E15
Brazil	30	E24	E25
India	12	E5	E10
Thailand	7.5		E10
Colombia	7.5	E10	
Argentina	3.8		E5
Philippines	3.8		E5

Status of Ethanol in India

April 2001 – 3 Projects on E5 started in 3 locations – Maharastra & UP

Dee 2001 – Govt. gives Clearance for voluntarily Implementation of E5

Jan 2003 – E5 Implemented – Mandatory in 9 States & 4UTs

Programme not successful due to lack of Ethanol availability at affordable cost to oil Companies

Status of Ethanol in India

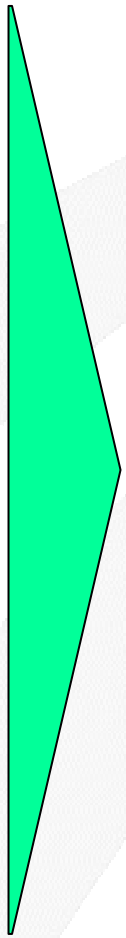
Sept 2006 – Govt. Issued Notification for E5 implementation for entire country by Nov 2006 – Yet to succeed

Oct 2008 – Govt. desires to start E10 throughout the country

OEMs Feel it to be an Aggressive Plan

Performance Issues with E10

- Low Calorific Value – 65% of Gasoline
- Inbuilt O_2 content – Stoichiometric ratio changes
- Single Boiling Point – Affect Distillation & RVP of blends



- Power Drop– Poor Driveability, Low Max. Speed
- Hot Startability – Vapour lock problems
- Leaning Effect - Lower Gradeability, Poor hot Driveability
- Lower Fuel Economy

The Severity of Problems Varies for Carbureted or MPFI Engines – More Severe for Carbureted Vehicles

Durability & Material Compatibility with E10

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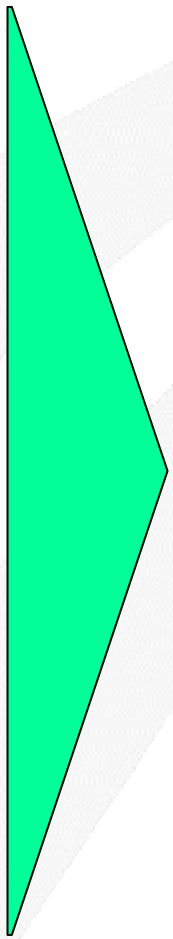
- Phase Separation
- Increased Conductivity
- Permeation
- Solvent Action



- Galvanic Corrosion of Metal parts
- Chemical Contamination of Fuel Systems
- Wear of Piston, Cylinder liner, Rings etc
- Swelling, Leaching, Plasticization of Rubber & Polymer Parts

Metal Parts Affected by Ethanol

	Metal	Engine Parts Affected
1.	Aluminum & Alloy	Carburetor, Fuel Pump Parts, Fuel Distribution Parts
2.	Magnesium Alloys	Fuel Pump Parts
3.	Copper	Tubings
4.	Zinc & Alloys	Carburetor, Engine block, Air Cleaner, Intake & Exh. Manifold
5.	Carbon Steel	Fuel Line, Fuel Pump Fitting & casing,
6.	Stainless Steel	Carburetor Needle, Springs, EGR valve
7.	Terne Coatings	Carburetor Body, Diaphragm, Fuel Tank, Fuel Line, Air Cleaner

Non-Metallic Parts affected by E10

	Non -Metal	Engine Parts Affected
1.	Nitrile	Carburetor gasket, Fuel Cap Gasket, Fuel Filter Tube, Fuel Pump Diaphragm
2.	Viton	EGR Valve, Fuel Inlet Needle Tip
3.	Neoprene	Fuel Tank vent to Carburetor cover, gas Hose Cover
4.	Epichlorohydrin	Diaphragm, Carburetor parts, fuel vapour tube, hoses
5.	Nylon 66	Carburetor Float bowl baffle, Fuel vapour storage canister
6.	Teflon	Shafting Coating, Venturi Valve
7.	Fluoroelastomers	Fuel Line hoses, Carburtor needle tips, gaskets, O rings, Fuel filter necks etc

Fuel Properties Affected by Ethanol

- Research Octane and Motor Octane Number (RON & MON)
- Density at 15^{0}C
- Distillation recovery at T_{10}, T_{50}, T_{90}, FBP.
- Vapor pressure at 38^{0}C.
- Vapour lock Index
- Oxygen Content
- Oxygenate Content
- Existent Gum content (deposit formation)
- Sulphur content.
- Water content.

Above Properties Lead to Performance Problems. Hence Specs Need to be Controlled Within Acceptable Limits

Other Fuel Properties Change with E10

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- Inorganic Elements - Fe, Na, K, Ca, Zn, Cu, Pb.
- Sulphates and Chlorides contents
- Phase separation
- Copper and silver strip corrosion
- PIONA (Paraffin, Iso-paraffins, Olefins, Naphthenes, Aromatics).
- Oxygenates and Oxygen contents
- Biodegradation (micro organism growth) test.
- Oxidation stability.

These Properties Contribute to Corrosion & Material Incompatibility with Ethanol Higher Blends

Issues for E10 Implementation

OEMs appreciate the need for E10 as an Emission reduction Mode for Automotive Vehicles. To ensure this:

- Rational Taxation, duties needed for Ethanol to ensure Affordable Cost to the Oil Companies

- Procurement & Distribution Policy to be laid out to Ensure Uninterrupted Ethanol Supply

- Oil Companies must create Facilities to Blend Ethanol & Store it at Depot Level

- Material Compatibility of Fuel Distribution & Supply Lines – There Should not be any Degradation of Fuel Quality During Distribution

Issues for E10 Implementation

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- Fuel Standards For Ethanol for Blending & E10 Should be in Place Before hand to Ensure Clarity of Fuel Quality

- Should Have Sufficient Lead Time for OEMs to Carry Out Necessary Trial and Vehicle / Engine must be Modified to meet E10 Requirements

- Detailed Fleet Studies & Pilot Project Should be Done to Assess Performance Deterioration on New & In-Use Vehicles

- Supply of E5 should be Continued along with E10 after introductions Till All Issues are Sorted out on In-Use Vehicles.

- Once Implemented, OEMs will not like to have irregular supply & switching back & forth between B10 to gasoline

BIO - DIESEL

What is Biodiesel ?

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Biodiesel is monoalkyl ester of long chain fatty acids produced from the Trans-esterification reaction of vegetable oil with alcohol in the presence of catalyst & can be used as fuel

What is Biodiesel ? Contd…..

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- **Bio-Diesel may be in the form of :**

Fatty Acid Methyl Ester or Fatty Acid Ethyl Ester

- Main Characteristics:

  - Better lubricity
  - High Flash Point
  - Comparable Heating Value content
  - Readily mixes with diesel
  - Ready to use in diesel run engines

Raw materials for Biodiesel

Soyabean oil	USA, Canada
Rape seed oil	Europe
Palm oil	South East Asian Countries
Waste Cooking oil	USA, Canada
Jatropha oil	India, China,
Karanje oil	India
Sunflower oil	Europe
Cotton Seed oil	Greece
Beef Tallow oil	Ireland

Status of Biodiesel in Automotives

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- **B2 (2% Biodiesel)** : being used at some places as a fuel additive / lubricity enhancer

- **B5 (5% Biodiesel)** :Already approved by FIE manufacturers & running very successfully in some parts of world without any problems.

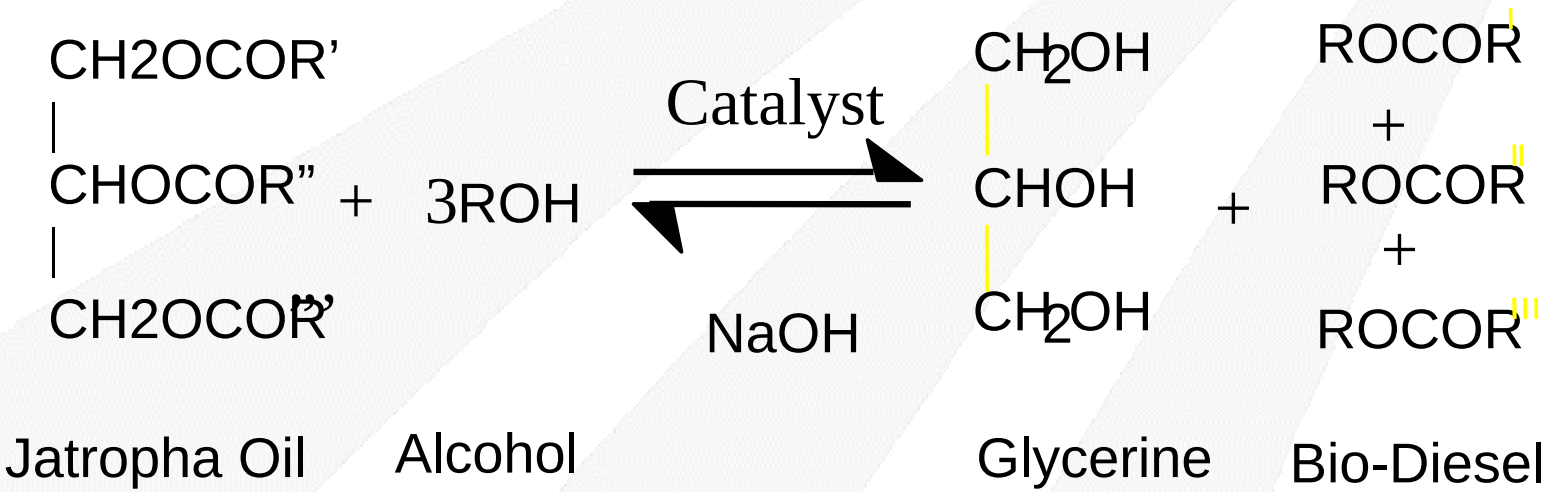
- **B10-B20 (10-20% Biodiesel)** under assessment

- **100 (100% Biodiesel)** : future option

- **2nd Generation biofuels (BtL/GtL)**: techno-economic studies being done world-wide. Cost effective process still a Challenge.

- ✓ **USA uses B20 blends popularly**
- ✓ **EU – 5-15%**
- ✓ **Blending Targets of EU is 5.75% by 2010 and 20% by 2020**
- ✓ **India planning 5% blending mandatory.**

Trans-esterification Process



Bio Diesel Process & Product Quality

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- Bio-Diesel Quality Depends on :
  - *Rawmaterial or Source of oil
  - *Trans-esterification Process

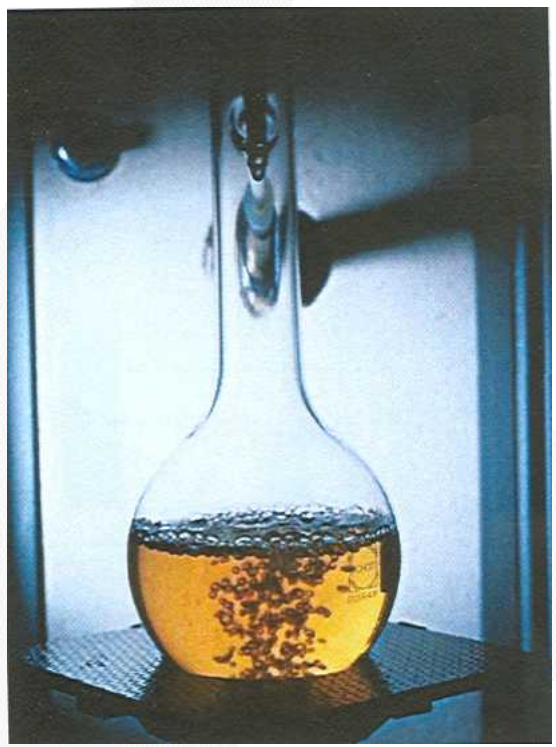
Process Factors	Impact on Product	
•Alcohol Selection •Alcohol to Oil Ratio •Catalyst Used •Process Control	•Product Quality •Cost •Yield •Process Speed	Optimum & Stable Bio-Diesel

Fuel Quality Aspects

- Several Countries have developed national specifications for Biodiesel

- Bio-diesel Specs worldwide:

Country /Area	Specifications
EU	EN 14214
US	ASTM D 6751
Germany	DIN E 51601
India	IS 15607:2005
Brazil	ANP42
Japan	JASO M360



Comparison of EU, BIS & ASTM Standards

Property	Unit	EN 14214:2003	IS 15607:2005	ASTM D6751-02
Ester content	% m/m,min	96.50	96.50	NA
Density at 15°C	Kg/m^3	860-900	860-900	NA
Kin. Viscosity at 40°C	mm^2/sec	3.5-5.0	2.5-6.0	1.9-6.0
Flash Point	°C ,min	120	120	130
Sulpher Content	mg/kg,max	10	50	15 max
Cetane No.		51 min	51 min	47 min
Water Content	mg/kg,max	500	500	0.05 %vol (water & Sediments
Copper Strip Corrosion 3 h at 50°C	Rating	Class 1	Class 1	No. 3 max
Oxidation Stability	hours ,min (at 110°C)	6.00	6.00	NA

Comparison of EU, BIS & ASTM Standards

Property	Unit	EN 14214:2003	IS 15607:2005	ASTM D6751:02
Acid Value	**mg KOH /g**	**0.50**	**0.50**	**0.80**
Iodine Value	g Iodine/ 100g max	**120**	**to report**	**NA**
Methanol or Ethanol	**% m/m,max**	**0.20**	**0.20**	**NA**
Free Glycerol	% m/m,max	**0.02**	**0.02**	**0.02**
Total Glycerol	% m/m,max	**0.25**	**0.25**	**0.25**
Group I Metal (Na+K)	mg/Kg,max	**5**	**5***	**5**
Group II Metal (Ca+Mg)	**mg/Kg,max**	**5**	**5***	**NA**
Phosphorus Content	mg/Kg,max	**10**	**10**	**0.001 %mass**
Distillation Temp. (90% recovery ,T90) ^{o}C ,max	**^{o}C ,max**	**NA**	**NA**	**360**

* **Amended in the 2007 revision which is under release**

Impact of Process Quality on Bio-diesel Property

Effectiveness of Trans Est. process	Free Methyl Ester
Completeness of Trans Est. process	Free Glycerin
Unsaturated Fatty Acid	Oxidation Stability
Effective Catalyst Removal	Gr. I & II Metals
Effective Methanol Removal	Free Methanol
Feedstock Property	Acid, Oxidation Stab.
Contamination on process	Sulphur level
Insufficient Water Removal	Water Content

Potential FIE /Engine Problems

Fuel Characteristics	Effect	Failure Mode
•Fatty acid methyl esters	•Causes some Elastomers including nitrile rubbers to soften, Swell	•Fuel Leakage
•Free Methanol in Biodiesel	•Corrodes Aluminums & Zinc •Low Flash point	•Corrosion of FIE
•Biodiesel process chemicals	•Potassium & Sodium compounds , Solid particles	•Blocked nozzles
•Dissolved water in Biodiesel	•Reversion of Biodiesel to fatty acid	•Filter plugging
•Free water in mixtures	•Corrosion, sustains bacteria •Increase conductivity of fuel	•Corrosion of FIE • Sludging
•Free glycerin, mono- & di-Glyceride	•Corrodes non ferrous metals, •Soaks cellulose filters,Sediments on moving parts & lacquering	•Filter clogging •Injector coking

Potential FIE /Engine Problems

Free fatty acid	•Provides an electrolyte & hastens corrosion of Zinc •Salts of Organic acids compounds formed	•Corrosion of FIE •Filter plugging •Sediments on parts
High Viscosity at low Temperature	•Generates excessive heat locally in rotary pumps •higher stress on components	•Pump seizures •Early life failures •Peer nozzle spray
Solid Impurities	•Potential lubricity Problems	•Reduced service life
Acids (Formic,acetic)	•Corrodes metallic parts	•Corrosion of FIE
Higher molecular org. acids	•Similar to fatty acid	
Polymerization products	•Deposits especially from fuel mixes	•Filter plugging •Lacquering formation in hot areas

Emission Advantage with Bio-Diesel

Pollutants (g / km)	Percentage Improvement for each Fuel		
	B10	B20	B100
HC	18	24	40
NOx	0.0	-2.6	-4
CO	0	0	0
CO2	0.4	-0.3	-1.6
PM	12	20	36

Emission Test results on SUV with CRDi meeting Euro III emission

Performance Study - Some Highlights

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Test Description		Effect Bio-diesel over Diesel		
		B10	B20	B100*
Fuel Economy (kmpl)		No change	No change	No change
Power @ Wheel (kw)		No change	1-2% ↓	10-12% ↓
Acc^{n}	speedwise	No change	No change	10% ↓
	distancewise	No change	No change	2% ↓
Max Speed (kmph)		No change	No change	5% ↓
Gradability (angle deg.)		No change	No change	-----
Engine Noise (db)		No change	No change	5% ↓

* Engine tested as it is without modification over normal Diesel settings

Finding of Engine Durability studies

If the Acid value, Moisture content & Oxidation Stability parameters of the fuel exceeds the prescribed limits, ageing starts & Bio Diesel degrades to the point where it is out of specifications

The Effects of fuel ageing on the Engine and FIP :

Ageing Product	Consequences for the FIE
Polymers, Insoluble (gum, sludge)	•Filter clogging •Deposit formation inside the entire FIE •Sticking moving parts •Injector coking
Polymers, Soluble	•Resin forming inside the entire FIE
Ageing acids	•Corrosion of metal parts •Soap formation with metal ions deriving from wear or corrosion (deposits)
Peroxides	•Embitterment of elastomers

Material Compatibility Results

Components / Test Desc.	Observations / Results
Fuel tank	Same as diesel till B10
Fuel Line / Hoses	Natural Rubber needs to be changed to Polymer
Fuel Filter	OK for B5 & B10 Material review required beyond B10
FIP	Natural rubber O-Rings, Seals and Gaskets to be replaced with Viton Material

Engine Durability Aspects

- Ensuring Fuel Quality: OEMs are concerned that Biodiesel which is not of adequate purity & quality affects engine & fuel system component durability.

- Ensuring Fuel Stability: Biodiesel may undergo oxidation during storage, handling & use, causing fuel system deposits. These deposits could cause plugging & damage engine fuel system components.

Key Benefits Reported from Studies

Benefits:

- **Reduction in HC, PM, CO emission – % gain depends on Blend ratio, vehicle type, Emission level etc**
- **No deterioration in performance of the vehicle in terms of Fuel economy, Drivability up to B10 blends**
- **The cold temperature Startability & Performance good**
- **No Adverse effect on the engine durability**
- **Engine & FIP Wear within the prescribed limits**
- **Lube oil analysis results shows satisfactory results**
- **Fuel Filter life with B10 comparable to Neat Diesel**

Issues for Bio-Diesel Implementation

- OEMs recognize environmental & sustainability benefit of Bio-Diesel & encourage its implementation in phases

- Sufficient Infra structure Facilities Should be Ensured for Continuous Supply of Bio-diesel to Oil Companies for a Sustained Mixing of Blends

- Govt policies & tax structure to encourage the rural sector farmers to grow Jatropha or Kranje plantations. Encourage private-public partnerships to work out viable model for Bio-plant farming. Farmers need incentives to get over the gestation period- 3 years for Jatropha & 5 years for Karanje

- B5 can be implemented in India in the near future

Issues for Bio-Diesel Implementation

- Ensure Fuel Quality is big Challenge & needs Specific Attention. Moisture, Oxi. stability & Acid value require Control.

- Ensure Bio-diesel Meets the specification IS 15607 & Be Mandatory for Any Supplier of Bio-Diesel in India. Need for Quality Bio-diesel is Still not Appreciated by Bio-diesel manufacturers in India

- Durability issues with higher Blends have to sorted out before considering it. Increase Deposit Forming Tendencies on FIE Parts May Hamper Blends Above B10.

- Sufficient Lead Time Must be There Before Bio-Diesel Implementation for Pilot Field Studies.

Thank You !!