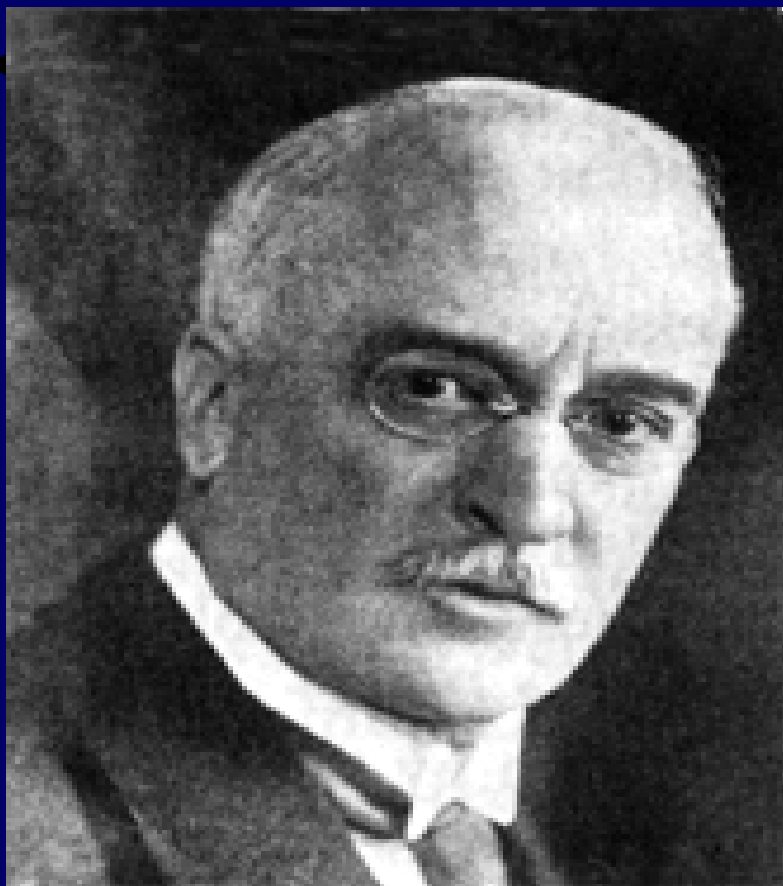


# Biodiesel: Feedstock & Technology Options



Dr. R. K. Malhotra  
Indian Oil Corporation Ltd., R&D Centre  
Faridabad, India - 121007

# FIRST USE OF PEANUT OIL IN 1895 BY DR RUDOLF DIESEL



(1858 – 1913)

- *“The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time.”*

1912

## Dr. A.P.J. ABDUL KALAM

*- At the Conference on Biodiesel: Towards Energy Independence at Rashtrapati Nilayam in Hyderabad, June 2006*

“In present scenario of dependability on fossil material based systems with its uncertainty, it is essential that an energy policy is evolved with new energy avenues.”



“Biodiesel has the potential to transform the Oil Sector.”

*Vision to produce 60 MMT Biodiesel by 2030*

# Biofuels - 2007

- World Biodiesel consumption expected to outstrip world soybean production.
- US corn for ethanol consumption will outstrip US corn exports.
- Global grain reserves have fallen from 120 days in 2000 to ~ 20 days.

# Biofuels Competitiveness

- EU commission estimates that biodiesel is competitive without subsidies at \$65/ barrel.
- On energy equivalent basis, ethanol is competitive without subsidies
  - at \$60/ barrel in US
  - at \$35/ barrel in Brazil
  - at \$115/ barrel in Europe

*\*[www.ecoworld.com](http://www.ecoworld.com)*

# POTENTIAL BIODIESEL DEMAND & AREA OF PLANTATION

Year	% Blend	Bio-diesel Requirement (Mill Tonnes)	Area of Plantation (Mill Ha)
2011-12	5.00	3.35	2.79
2011-12	20.00	13.38	11.19
2030		60	

**India's Land Area: 329 million Ha**  
**Waste Land: 60 million Ha**

# Biodiesel Value Chain

- Plantation
- Oil Extraction
- Biodiesel Production
- Blending with Diesel
- Marketing

# BIODIESEL – Initiatives of IOC



- Study of complete value chain of Biodiesel
- Initiating from Jatropha Plantation to Field Trials
- Plantation of 150,000 Jatropha saplings on 200 acres
- Analysis of Jatropha Fatty Acid composition vs other oils
- Setting up of quality control lab
- Development / Patenting of Process for Biodiesel Synthesis
- Oxidative Stability / Material compatibility / Lubricity Studies
- Studies on Blends with Palm Oil
- Rig / Engine / Emission Studies
- Field trials on cars / buses / trains

# RAW MATERIALS FOR BIODIESEL PRODUCTION



- Rapeseed (Europe)
- Sunflower oil (Italy , France and Thailand)
- Soybean oil (USA & Brazil)
- Palm oil (Malaysia)
- Linseed & Olive oil (Spain)
- Cottonseed oil (Greece)
- Pongamia Pinnata & Jatropha Curcas
- Tallow and Used frying oils

*Jatropha, Palm, Pongamia & Indian Mustard  
are potential feedstocks for India*

# Plantation

- Land Procurement
  - Waste Land identified
- Selection of Feedstock
  - Genotypes / Oil Content / Plant Life
- Nursery Preparation
- Maintenance
  - Mortality / Irrigation / Climate
- Inter Cropping
- Harvesting
  - manual / mechanical
- Storage / Transportation

# Oil Extraction

- Oil Expellers
  - Dedicated expellers for Jatropha
- Solvent Extraction
- De-Oiled Cake
  - Toxicity
  - Uses of Cake – Fertilizer, Biomass etc.



# Jatropha Curcas

- Jatropha is a hardy plant, well adopted to arid, semi-arid conditions.
- Low fertility and moisture demand.
- Grow on stony, shallow or even calcareous soil.
- Propagated through seed or cuttings.
- Different parts of plant are useful for medicines preparation
- Bark of plant is used as raw material for dye
- Seed cake after oil expelling is used as fertilizer for soil enrichment
- Seeds and leaves are used as insecticide / pesticide



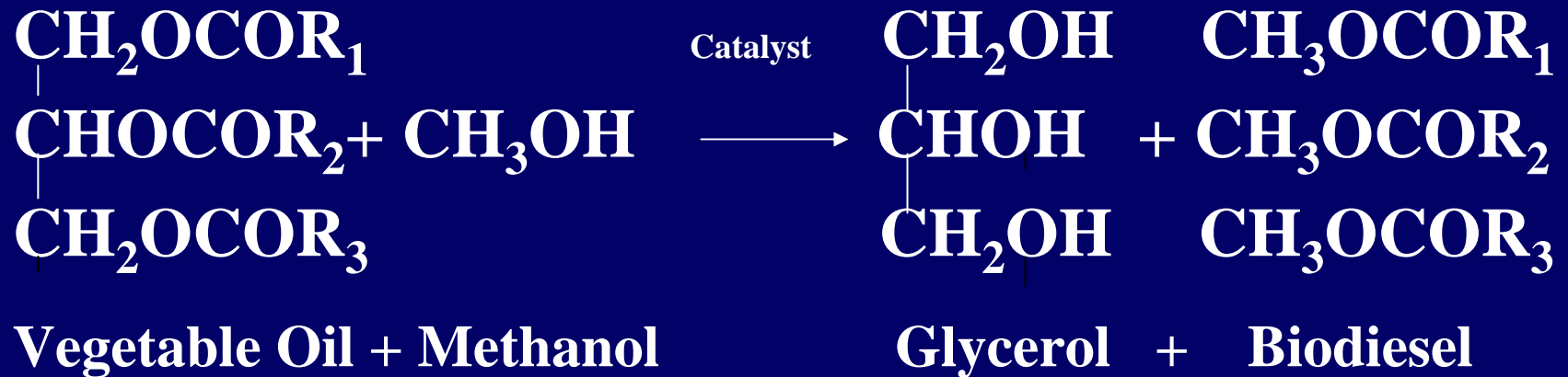
# Indian Mustard

- Botanical Name : Brassica Juncea
- Botanical Family: Brassicaceae
- RapeSeed & Canola Oil belong to same family
- A Rabi (Winter) Crop
- Sowing in Oct -Nov
- Flowering in Dec-Feb
- Harvesting in Feb-Mar
- Major Crop in India
- Oil Content: 30-40%
- Rich in Oleic, Linoleic and Erucic Fatty Esters
- High Erucic Fat (30-40%) is characteristic feature of Indian Mustard

# BIODIESEL SYNTHESIS

## TRANS-ESTERIFICATION OF

- JATROPHA / MUSTARD / PALM / PONGAMIA OILS



## ESTERIFICATION OF

- ERUCIC ACID FREE MUSTARD FATTY ACIDS
- PALM FATTY ACIDS



# Biodiesel Production

- Feedstock Quality
  - Gums / Phospholipids
  - Free Fatty Acids
  - Saturated Fats
- Catalyst
  - Alkali Metal Hydroxides
  - Metal Alkoxides
  - Acidic Catalysts
  - Heterogeneous Catalysts
- Process
  - Batch
  - Semi Continuous
  - Continuous

# Biodiesel Production

- Plant Capacity
  - matching feedstock availability
- Plant Location
  - near feedstock or market
- Integration
  - backward / forward
- Quality Control Lab.

# BIODIESEL TECHNOLOGY PROVIDERS



- ENERGEA, Austria
- LURGI, Germany
- ADM, Germany
- IFP / AXENS, France- Heterogeneous catalyst
- Desmet Bellestra
- Biodiesel International, Austria
- BBD & BioForce Biodiesel, USA etc.

# PLANT CAPACITY / LOCATION

## Advantages of small and distributed plants

- Lower capital investments
- Less control sophistication
- Lower transportation and distribution costs
- Capacity buildup relatively easy
- Easy availability of plant equipment

## Advantages of large and centralized plants

- Better and consistent quality
- Relatively lower number of quality checks
- Minor advantage in processing costs

# Trans-Esterification Innovations

- Homogeneous Alkali / Acidic Catalysts
- Lipase catalyst
- Heterogeneous catalysts/Continuous processes
- Super Critical Synthesis

# Technology Issues

- Quality of Biodiesel is of prime concern
- To meet ASTM / EN / BIS Specifications
- Biodiesel to be free from Catalyst, Moisture, unreacted glycerides & by-product glycerol
- Methanol needs to be recycled after drying
- Glycerol requires purification to fetch some value

# Biodiesel Specifications

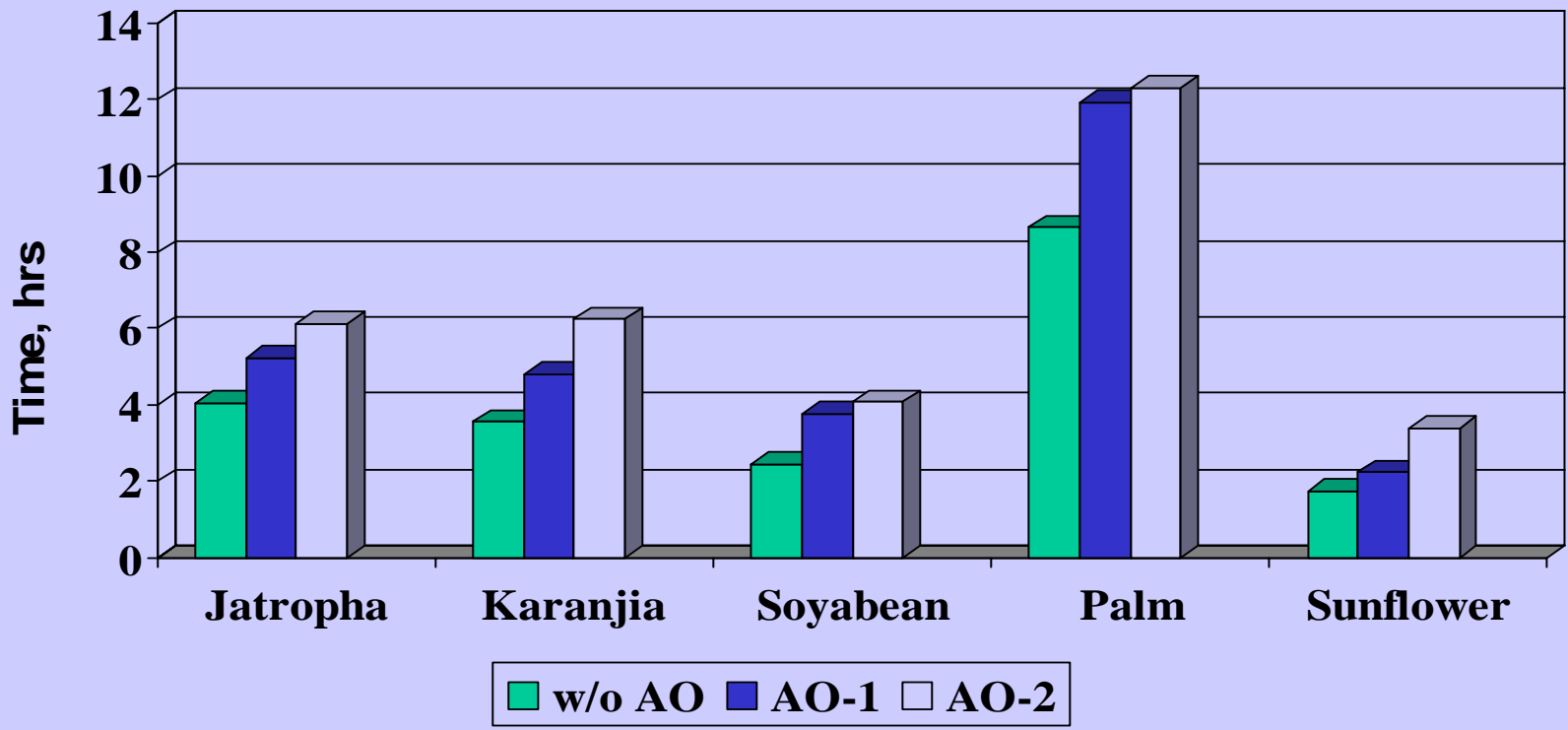
- ASTM D-6751
- EN 14214
- IS 15607: 2005



# Biodiesel / Diesel Specification Issues

- Distillation Range
  - Indian Mustard Biodiesel has high boiling range
- Cloud, Pour & CFPP
  - Palm Oil
- Oxidation Stability
  - All Biodiesel except Palm
- Specifications of B10 & B20

# OXIDATIVE STABILITY STUDIES



Oxidative Stability correlated to unsaturation and fatty chain length

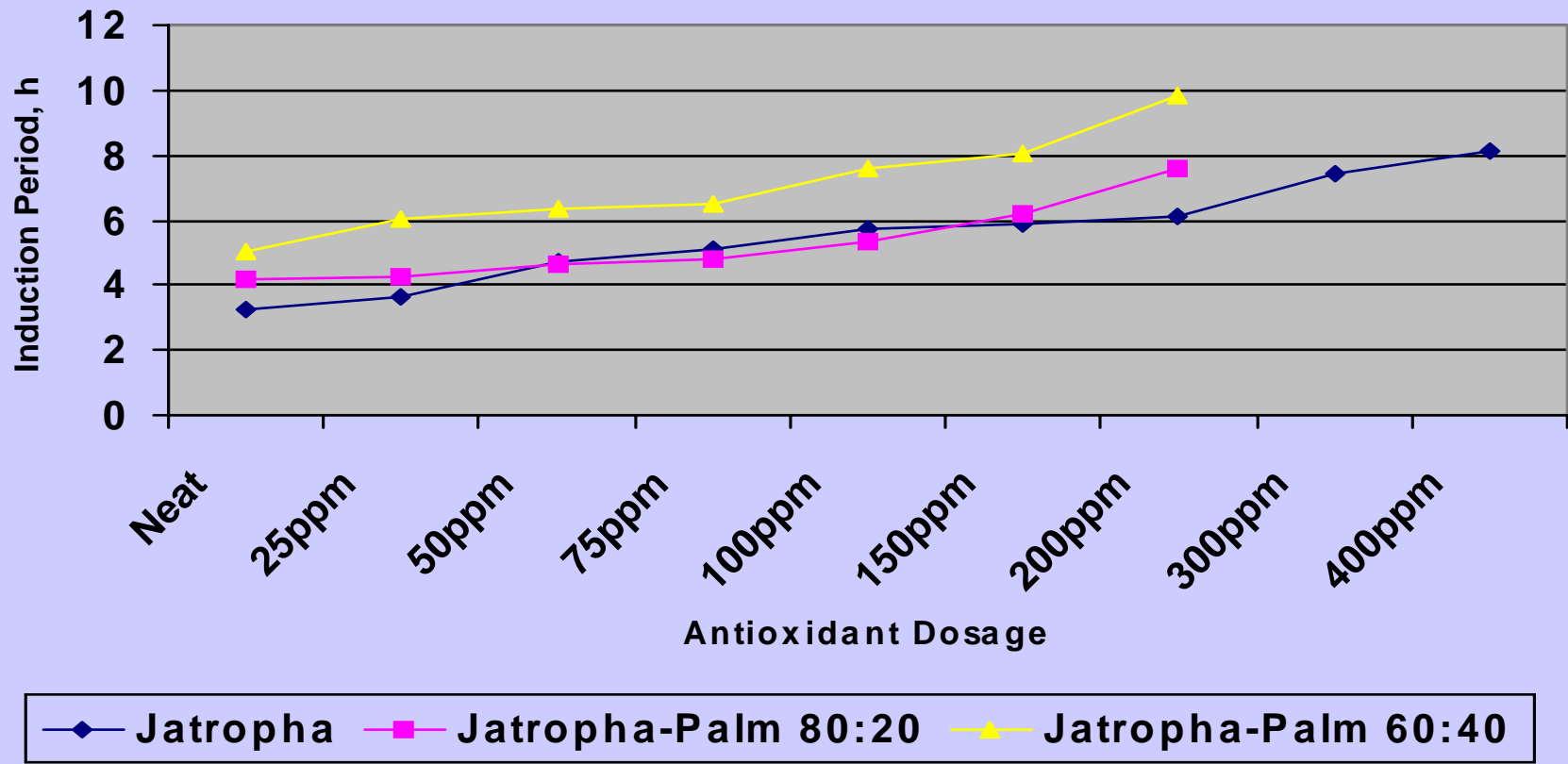
As per EN-14112



# JATROPHA – PALM BIODIESEL BLENDS

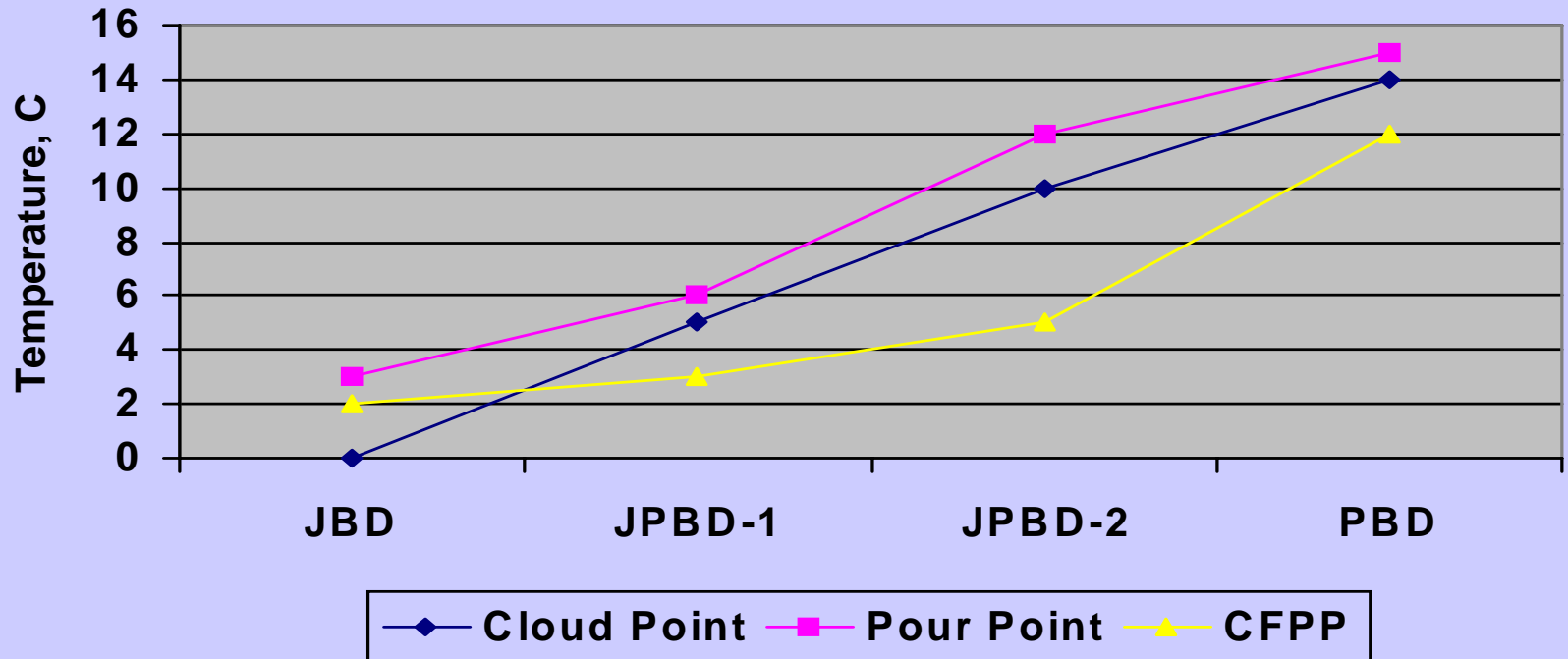
- Jatropha Biodiesel, like Rapeseed / Soybean has poor storage stability and good low temperature properties
- Palm Biodiesel has good storage stability and poor low temperature properties
- Blends of Jatropha – Palm (80:20 & 60:40) were found to be optimum combination
- Palm Biodiesel blending can cut antioxidant requirement by 80%

# ANTIOXIDANT STUDIES ON JATROPHA-PALM BIODIESEL BLENDS



Antioxidant Dose cut from 200 ppm to 25 ppm, to meet 6 hr Pass Limit

# LOW TEMPERATURE STUDIES ON JATROPHA-PALM BIODIESEL BLENDS



JPBD-1 (80:20) ; JPBD-2 (60:40)

# BIODIESEL PURCHASE POLICY



- MoPN&G declared Biodiesel Purchase Policy on 9<sup>th</sup> Oct. 2005
- Effective from 1.1.2006
- Emphasis on
  - Standard Quality (as per BIS Spec)
  - Uniform Price (Rs. 26.5 / Litre)
  - Setting up of 20 Purchase Centres by Oil PSUs
  - Assured Market to Farmers & Entrepreneurs

*However, no supplier has offered Biodiesel at above price.*

# IOC - HARYANA ROADWAYS TRIALS



- 20 Buses being run from April 2004 on 5% Biodiesel – Diesel Blends, another 20 Buses being run on petrodiesel as reference.
- No significant difference in fuel consumption observed on buses with or without biodiesel.
- 10-15% Reduction in Smoke

# IOC - TATA MOTORS TRIALS



*Launching of 43 Employee Buses at Pune on B10*

# BIODIESEL TRIALS WITH INDIAN RAILWAYS



**SHATABDI / JAN SHATABDI  
TRIAL RUNS ON 5-10%  
BIODIESEL CONDUCTED**

## LOCO ENGINE TESTS / TRIALS

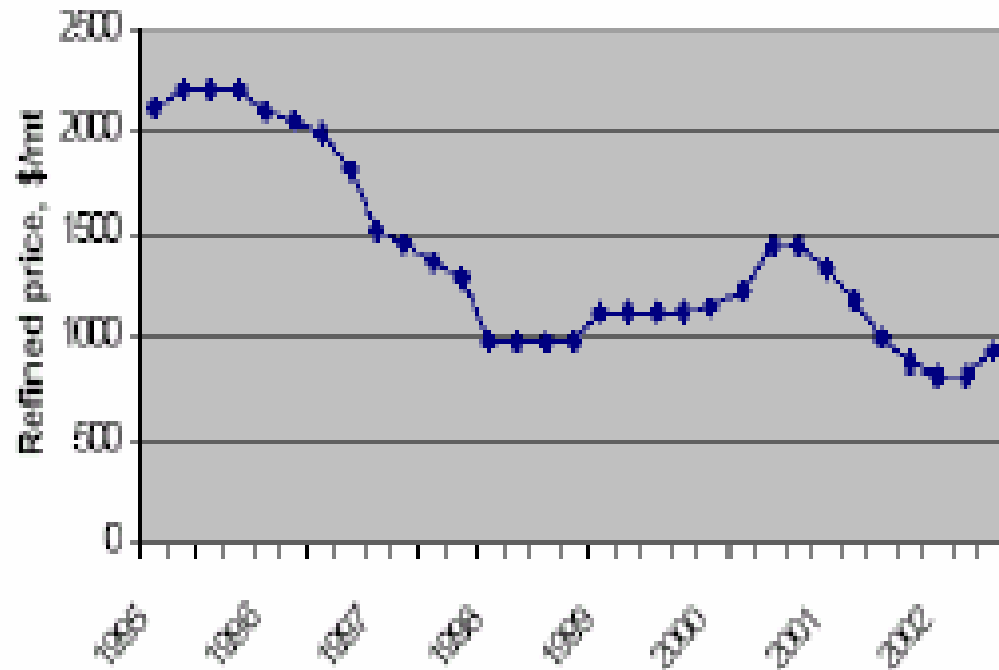
- Testing on 5%, 10% and 20% Biodiesel blends on 16 Cylinder Alco Engine (3100 HP) at RDSO, Lucknow
- Horse Power, Firing pressures and Exhaust Gas temperature found OK

# Improving Profitability

- Alternate uses of Jatropha Biomass
- Higher Jatropha Productivity
- Value added Chemicals from Glycerol
- CDM Benefits
- Tax Concessions / Subsidies



# Impact of World Biodiesel Production on Glycerol Markets



\$1000 per ton =  
\$0.50/lb

By 2010, glycerol price could be as low as \$0.35/lb if world wide biodiesel production continues to grow.

USP 97% + glycerol, Source: Proctor & Gamble, 2009

At prices approaching \$0.35/lb or less by 2010, glycerol can become a significant platform chemical.



# Exploitation of Glycerol

- 1,3-Propanediol
- 1,2-Propanediol
- Dihydroxyacetones
- Polyglycerols
- Succinic acid
- Polyglycerols & Polyesters
- Hydrogen

# Hydrogen from Glycerol

- Hydrogen is the cleanest & next generation renewable fuel
- One mole of glycerol can produce seven molecules of hydrogen through Microbial fermentation or reforming processes



# THREATS TO BIODIESEL INDUSTRY

- Uptake of Jatropha oil / biomass by Power Plants
- Generation of Second Generation Biofuels by Cracking / Hydrogenation in Petroleum Refineries

# Conclusions

- Biodiesel manufacturing is a technology intensive industry
  - The specification for automotive applications fairly stringent
- Need for cultivation of high yielding Jatropha genotypes
  - Low yield reported in certain varieties of Jatropha
- Need for setting up of Biodiesel production plants
  - Capacity building in line with raw material availability
- Explore new uses of byproducts, like Glycerol and Jatropha Biomass
- Explore use of Multi feedstocks – Palm & Jatropha etc.



*Thank You*