

First Generation Bio-Diesel and Bio-Jet Fuels Production

Michel Bloch



Agenda

- **Alternative Fuels in General**
- **Biodiesel (FAME)**
- **Renewable Diesel & Jet Fuels**
- **Lipid Feedstock Challenges**

What we do



Activities

Process Licensor

Catalysts & Adsorbents Manufacturer

Advanced Services Provider

Markets Served



Refining

Clean Fuels via

{ Hydrotreating
Reforming & Isomerization
Conversion

Petrochemicals /
Chemicals

Olefins purification
Aromatics production & purification
Chemicals purification

Gas Processing

Purification & drying
Liquefaction of natural gas

Alternative Fuels

Clean Fuels via

{ X to Liquid Technologies
Direct Coal Liquefaction
Vegetable oils to diesel & jet



Why Alternative Fuels ?

- **Reduce Pressure on Petroleum Resources**
 - Crude oil reserves are limited
 - Production plateau estimated to be about 95 Mbpd
- **Reduce Carbon Footprint of Transportation**
 - Use short cycle carbon sources (i.e. biomass)
 - Carbon free energy for transportation still to come
- **Reduce Risk on Energy Security of Supply**
 - Today, most major world economies are not self sufficient
 - Oil reserves are not evenly distributed



Well Known Challenges

- **Preferred Alternative Fuels for Transportation are Hydrocarbon Liquids (density of energy, compatibility with existing fleets)**
- **Large alternative carbon sources are gaseous or solid (natural gas, coal, ligno-cellulosic biomass, waste)**
- **They are often containing much more than Carbon and Hydrogen (oxygen, impurities)**



A Question of Chemistry not Generation

Three routes can be envisaged:

- **Convert/upgrade existing molecules**
- **Build the desired molecules from Syngas**
- **Force and/or control biological pathways**

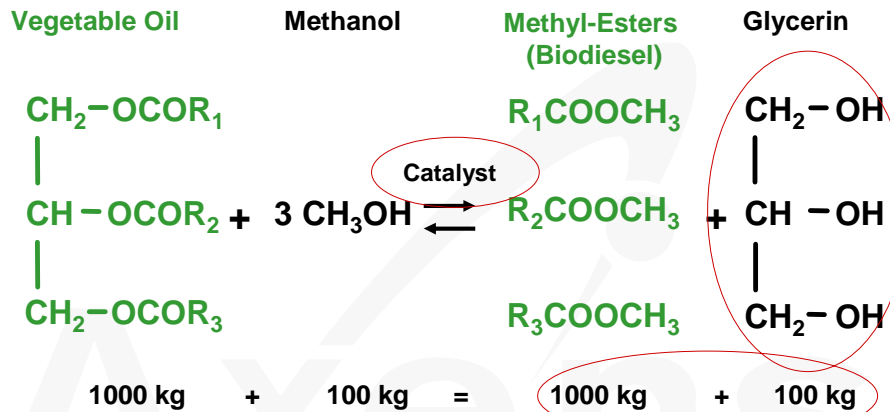


Convert / Upgrade Existing Molecules

- **Methyl esters (FAME) made from vegetable oils and animal fat**
- **Iso-Paraffins obtained by hydroprocessing of renewable oils and fats**
- **Petroleum like fuels by Direct Coal Liquefaction**
- **Refined Bio-Oils obtained from biomass Pyrolysis**

Trans-Esterification Reaction

A Three-Step, Catalytic, Reversible Reaction



IFP Sessions – Rueil Malmaison – December 9th, 2009

9

Axens A Pioneer in Biodiesel

1992 - first biodiesel plant start-up

2004 - commercialization of the world's first
solid catalyst based process for biodiesel: Esterfip-H

2006 - first Esterfip-H start-up

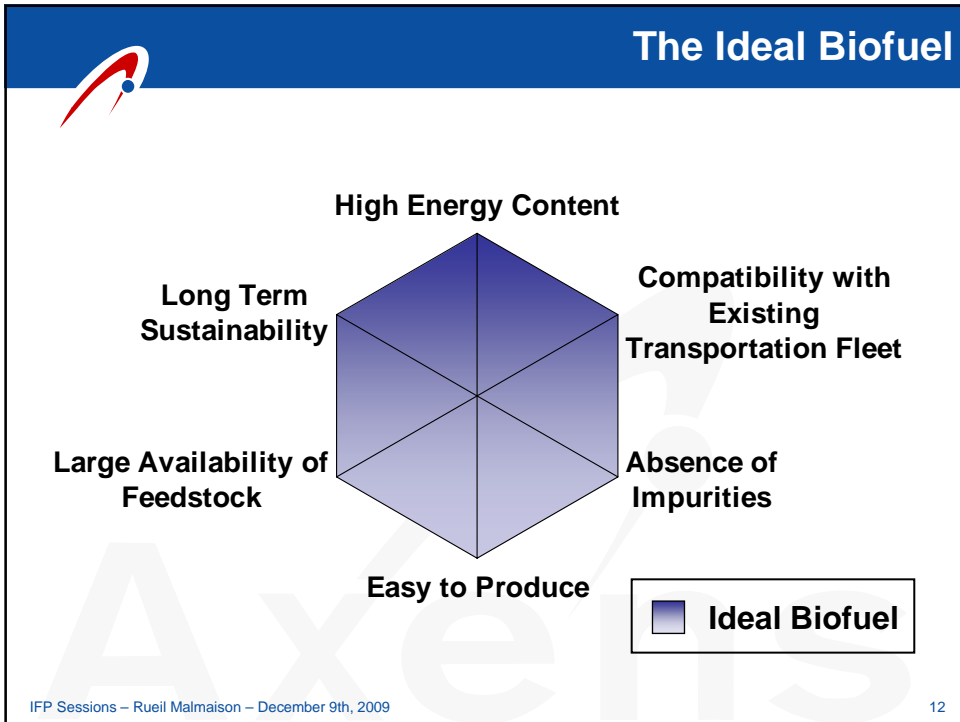
2007 - *Esterfip-H: winner of the
Kirkpatrick Chemical Engineering Achievement Award*

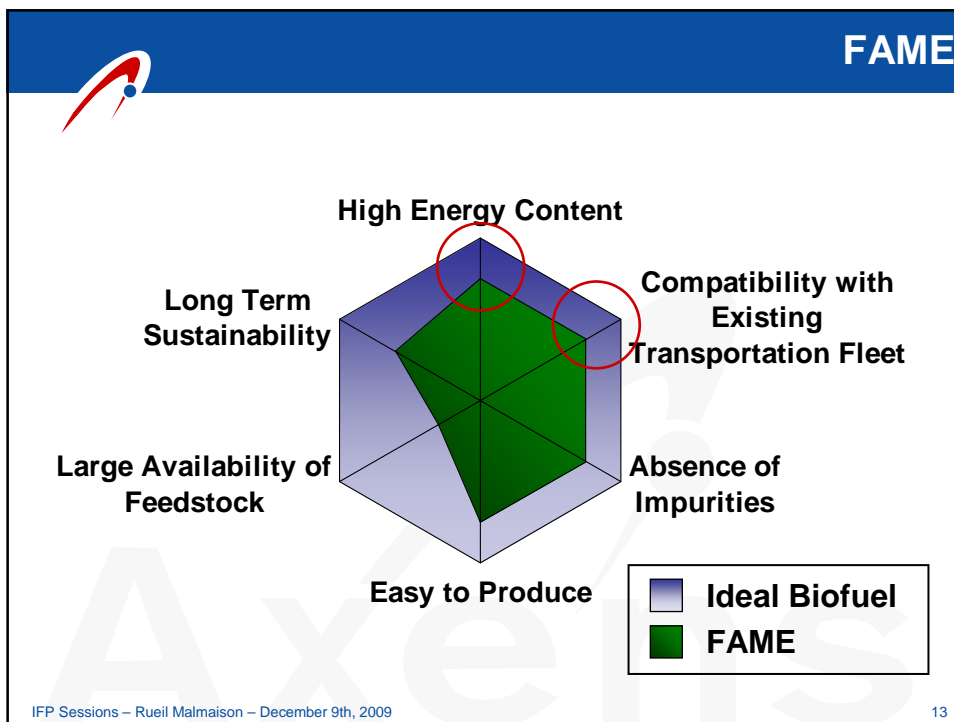


- 2.5 Mtpy cumulative capacity licensed since 1992
- Over 10% of 2008 world biodiesel production out of Axens licensed plants

IFP Sessions – Rueil Malmaison – December 9th, 2009

10





Influence of Feedstock on Biodiesel Properties

Fatty acids	Palm	Soybean	Rape	Jatropha	Methyl Ester Melting point (°C)	Cetane number
C 16:0	44	10	5	15	+ 30	74.3
C18:0	6	4	2	6	+ 39	75.7
C18:1	38	23	59	42	- 20	55
C18:2	10	53	21	35	- 35	42.2
C18:3	0	8	9	0	- 46	22.7
Others	2	2	4	2	-	-
CFPP	+ 10	- 4	- 12	-2		
Cetane	62	46	52	56		

IFP Sessions – Rueil Malmaison – December 9th, 2009 14

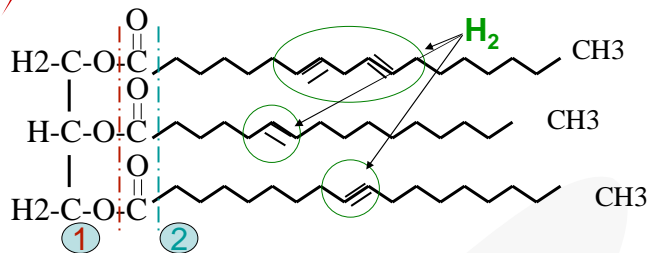
Possible Feedstock Strategies for FAME production

- Country specific requirements
- Feed or product blending
- Product fractionation

IFP Sessions – Rueil Malmaison – December 9th, 2009

15

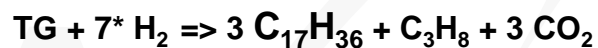
Alternative: Hydroprocess Lipids



① Hydrogenolysis/Hydrogenation



② Decarboxylation



③ Shift + Methanation reactions

CO & CH₄ by-products

* Assuming 4 double bonds saturation per TG

IFP Sessions – Rueil Malmaison – December 9th, 2009

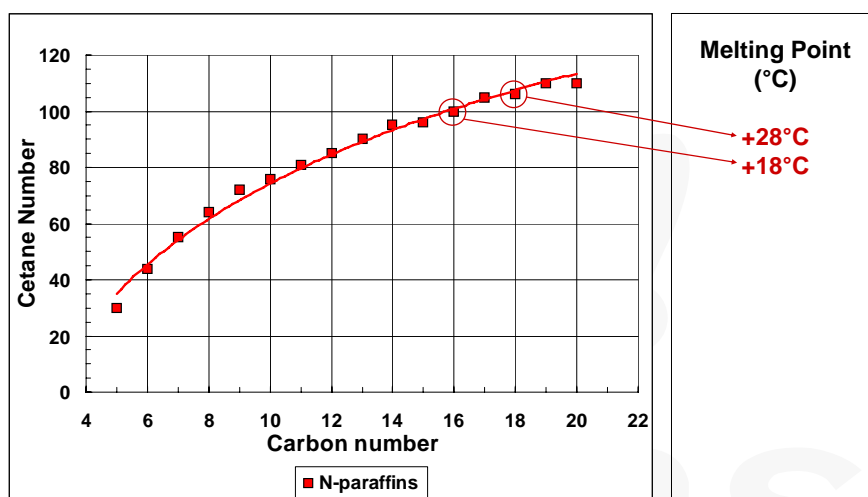
16

Yields

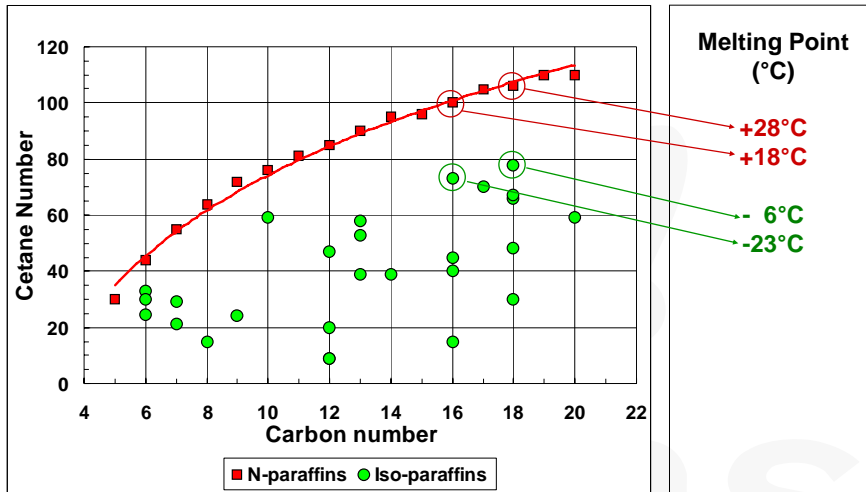
Theoretical Yields on Rapeseed Oil in wt% (in vol. %)

	Transesterification	Hydrogenolysis Hydrogenation	Decarboxylation
In			
Methanol /Hydrogen	10.9	3.6	1.6
Out			
FAME / Paraffins	100.5(105.1)	86.4(101.9)	81.6 (96.3)
Glycerol/Propane	10.4	5.0	5.0
Water/CO2	0.0	12.3	15.0

Paraffins Properties



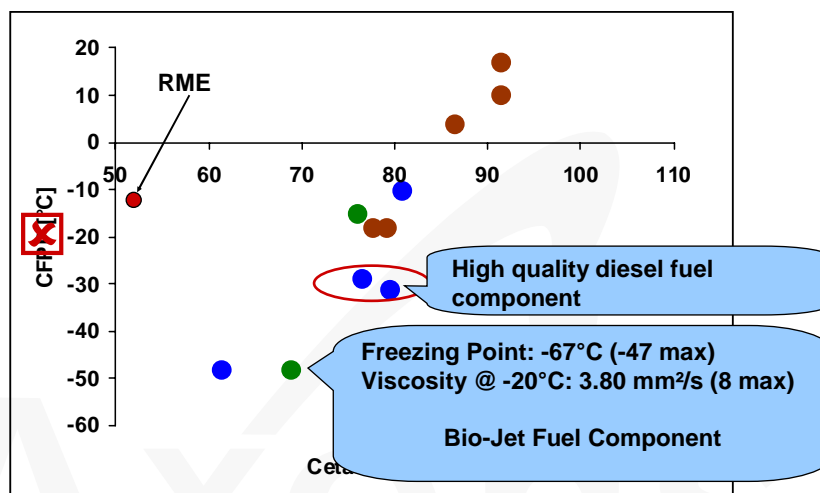
Paraffins Properties



IFP Sessions – Rueil Malmaison – December 9th, 2009

19

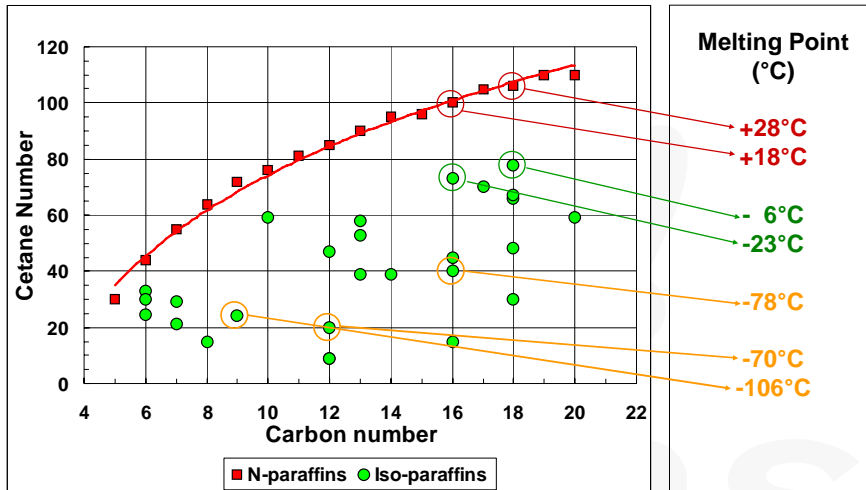
Much More than High Quality Diesel



IFP Sessions – Rueil Malmaison – December 9th, 2009

20

Paraffins Properties



IFP Sessions – Rueil Malmaison – December 9th, 2009

21

Benefits of Renewable IsoParaffins

- **Petroleum like molecules**
 - Energy content
 - True drop-in fuels for Diesel and Jet-Fuel
- **Tunable fuel properties**
 - Compensate for feed composition
 - Price premium as blending component
- **No aromatics**
 - Cleaner combustion
- **No sulphur, no Nitrogen**
 - "dirtier feeds" accepted

IFP Sessions – Rueil Malmaison – December 9th, 2009

22

Mastering the Challenges of Renewable Iso-Paraffins Production

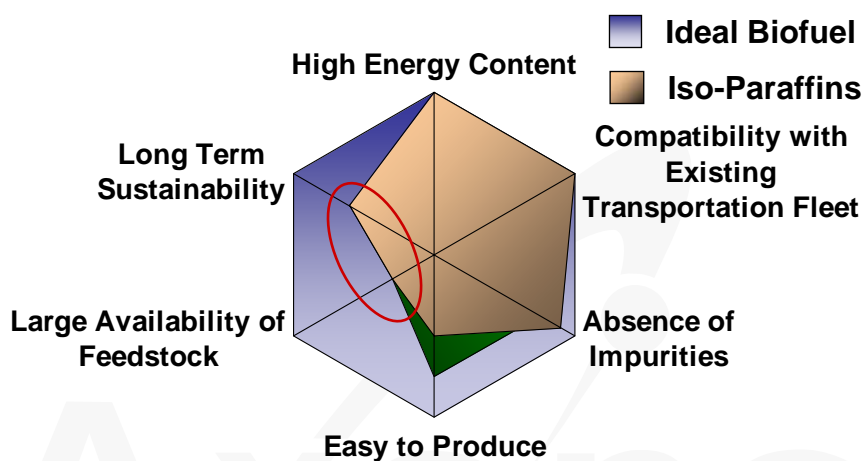


- Feeds impurities
- Highly exothermic reactions
- Corrosive reaction effluents
- Light ends production

- Optimal catalyst selection
- Optimized process design

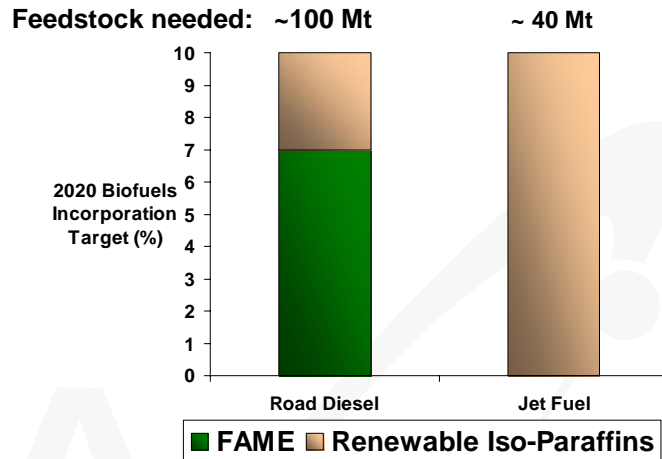
Vegan™
Renewable Iso-Paraffins
production by Axens

FAME vs Renewable Iso-Paraffins





Sharing the Market









IFP Sessions – Rueil Malmaison – December 9th, 2009

25



Increasing Oil Yields and Production

Palm	Soybean	Rapeseed	Sunflower	Jatropha	Algae
					
Annual Crop Yield (t/ha)					
25	3	3.5	2.5	3.75	60-240
Oil Content %					
20	20	42	43	40	50
Annual Oil Yield (t/ha)					
5	0.4	1.5	1.1	1.5	30-120
2007 Estimated World's Production (Mt)					
39	37.5	18.9	10.7	<1	0

IFP Sessions – Rueil Malmaison – December 9th, 2009

26

- Two renewable oils and fats upgrading routes now available from Axens:

ESTERFIP-H™ & VEGAN™

- Renewable Iso-Paraffins production is feed flexible
- High quality road and air drop-in fuels produced ready for high blending rates
- Availability of abundant & sustainable feedstock remains today's challenge

First Generation Bio-Diesel and Bio-Jet Fuels Production

For more information, please visit our website

www.axens.net