Oil Seed Engineering For Chemicals and Fuels

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ABIC 2007

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Landscape

- Petroleum supply/cost/environment drivers
- There have been dramatic improvements in biotech methods, tools and cloning
- Patents allow control of novel materials
- Proprietary feed stocks will be developed
- Large scale production possible

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Challenges are many

- More that 100 years of cheap oil - tough habit to kick
- Petroleum/chemical/OEM's strong bias against plant derived oils – API etc.
- Public reaction to GMO's

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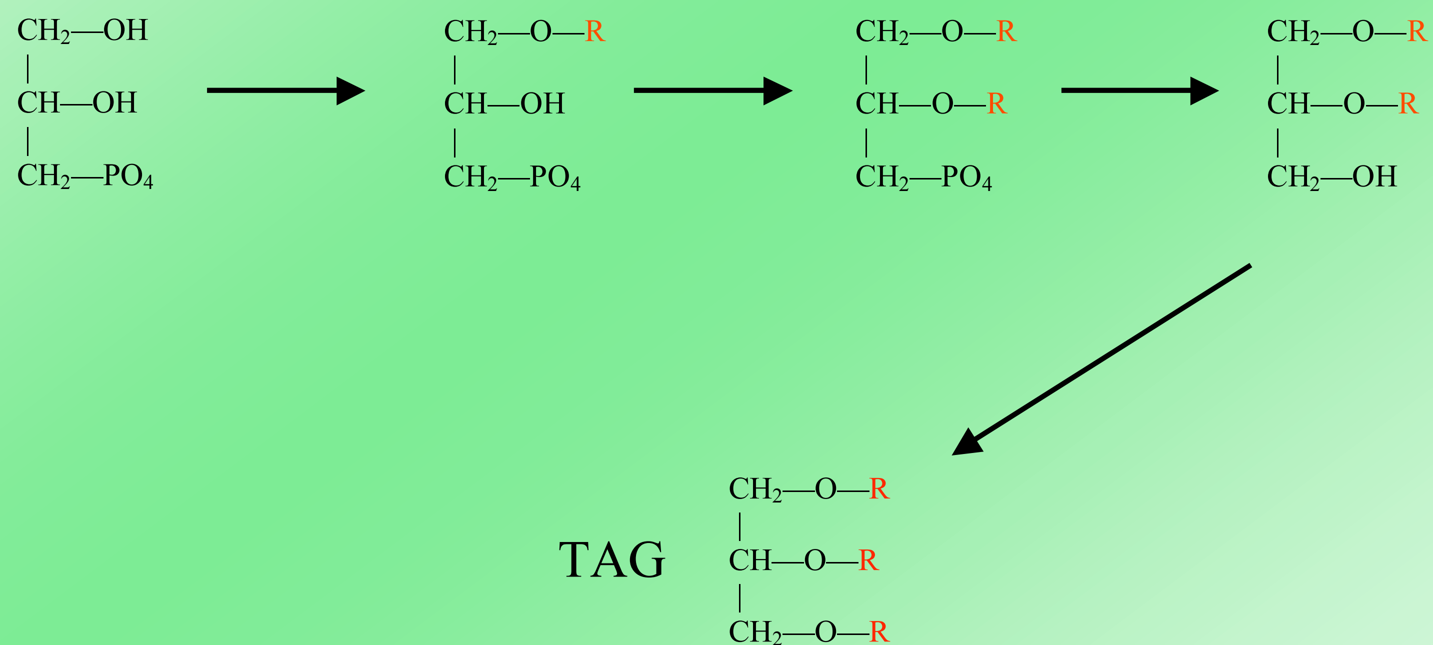
Plant Oils are Very similar to Petroleum

THIS IS WHERE CHEMISTRY WILL BE DONE IN THE FUTURE



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Interesting Genes have been Cloned

USDA Listed over 500 different FA's

Fatty acid type	**Species**	**Product**	
Hydroxy	*Ricinus communis* (Castor bean)	Ricinoleic acid	12-OH-18:1 $^{(\Delta 9\text{cis},\ \Delta 12\text{-OH})}$
	Lesquerella fendleri	Ricinoleic/Linoleic (Hydroxy fatty acid elongated to Lesquerolic acid)	Bifunctional enzyme 12-OH-18:1 $^{(\Delta 9 cis,\ \Delta 12\text{-OH})}$ and 18:2 $^{(\Delta 9 cis,\ \Delta 12 cis)}$
Acetylenic	*Crepis alpina*	Crepenynic acid	12-ynoic-18:1 $^{(\Delta 9 cis,\ \Delta 12\text{-ynoic})}$
Epoxy	*Crepis palaestina* *Vernonia galamensis*	Vernolic acid	12,13-epoxy-18:1 $^{(\Delta 9 cis,\ 12\text{-}13\text{-epoxy})}$
Conjugated	*Momordica charantia* *Impatients balsamina* *Aleurites fordii* (Tung)	α-eleostearic acid α-parinaric acid	18:3 $^{(\Delta 9 cis,\ \Delta 11 trans,\ \Delta 13 trans)}$ 18:4 $^{(\Delta 9\text{cis},\ \Delta 11 trans,\ \Delta 13 trans,\ \Delta 15 cis)}$
	Trichosanthes kirilowii *Punicia granatum* (Pomegranate)	Punicic acid	18:3 $^{(\Delta 9 cis,\ \Delta 11 trans,\ \Delta 13 cis)}$
	Calendula officinalis (Marigold)	Calendic acid	18:3 $^{(\Delta 8 trans,\ \Delta 10 trans,\ \Delta 12 cis)}$
	Dimorphotheca sinuata	Dimorphecolic	9-OH-18:2 $^{(\Delta 10 trans,\Delta 12 trans)}$

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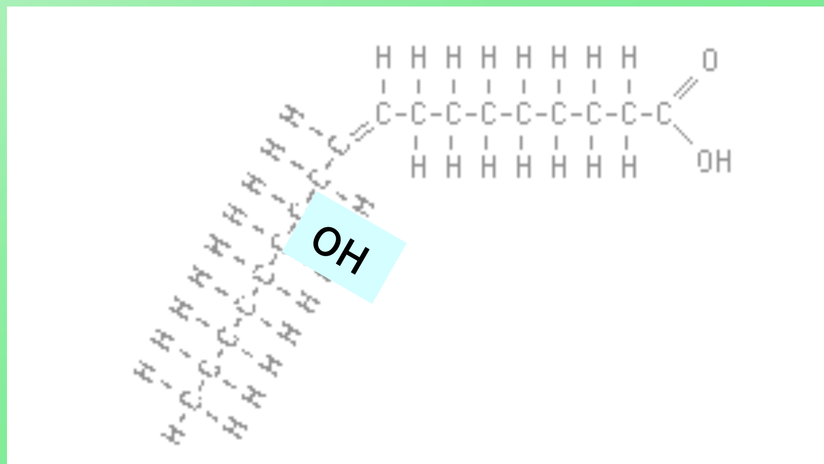
Ricinoleic Acid

Small change… big effect



Ricinoleic acid: a reactive fatty acid capable of numerous oleochemical conversions

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Problems with Castor

- Contains Ricin potent bio-terror weapon
- Main producers are India, China and Brazil
- India and others seek down stream capability
- Supply limited and variable
- Significant price fluctuations and fuel usage

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Hydroxy Fatty Acid (HFA) Technology

Hydroxylase Gene

Ricinus communis
(Castor)

Expression in Model

Arabidopsis thaliana

Expression in Conventional Oilseeds

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Comparison of Fatty Acid Prof les

The HFA clearly replaces oxidatively unstable polyunsaturates

Hyroxy Fatty Acid (HFA)	Fatty Acid Name	Linnaeus Oil*	Typical Oil Seed Profile	Castor Oil
		% Fatty Acid		
Hydroxy Fatty Acid	Ricinoleic & Others	15.6	0.0	89.2
C16:1	Palmitoleic		0.3	
C18:1	Oleic	59.1	60.9	3.5
C18:2	Linoleic	11.3	21.0	4.2
C18:3	Linolenic	3.4	8.8	
C20:1	Gadoleic		1.0	
C22:1	Erucic		0.7	
C12:0	Lauric		0.0	
C16:0	Palmitic	5.1	4.1	
C18:0	Stearic	1.7	1.0	1.8

*Expressed in *Brassica napus* (hydroxy fatty acids include ricinoleic and densipolic acid)

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Why Combine Conventional & Specialty Oils?

Castor Oil*
•RBOT** Oxidation = 29 mins
•Pour Point ~ -33C
•Viscosity @ 40C = 255 cSt
•Timken OK Load = 30 kg
•4-Ball: Scar = 0.6, Coeff. Friction = 0.04
•High reactivity

High Oleic Canola Oil*
•RBOT Oxidation = 15 mins
•Pour Point ~ -15C
•Viscosity @ 40C ~ 37 cSt
•Timken OK Load = 20 kg
•4-Ball: Scar = 0.7, Coeff. Friction = 0.08
•Very low reactivity

Linnaeus Oil***
•RBOT Oxidation = 18-25 mins
•Pour Point ~ -15C to -21C
•Range of viscosities ~50-120 cSt
•Timken OK Load =20-30 kg
•4-Ball: Scar ~ 0.6, Coeff. Friction ~ 0.06
•Moderate reactivity

***RBOT = Rotary Bomb Oxidation Test (ASTM D2272)*
**** Based on blended oil data (10-60% HFA content)*

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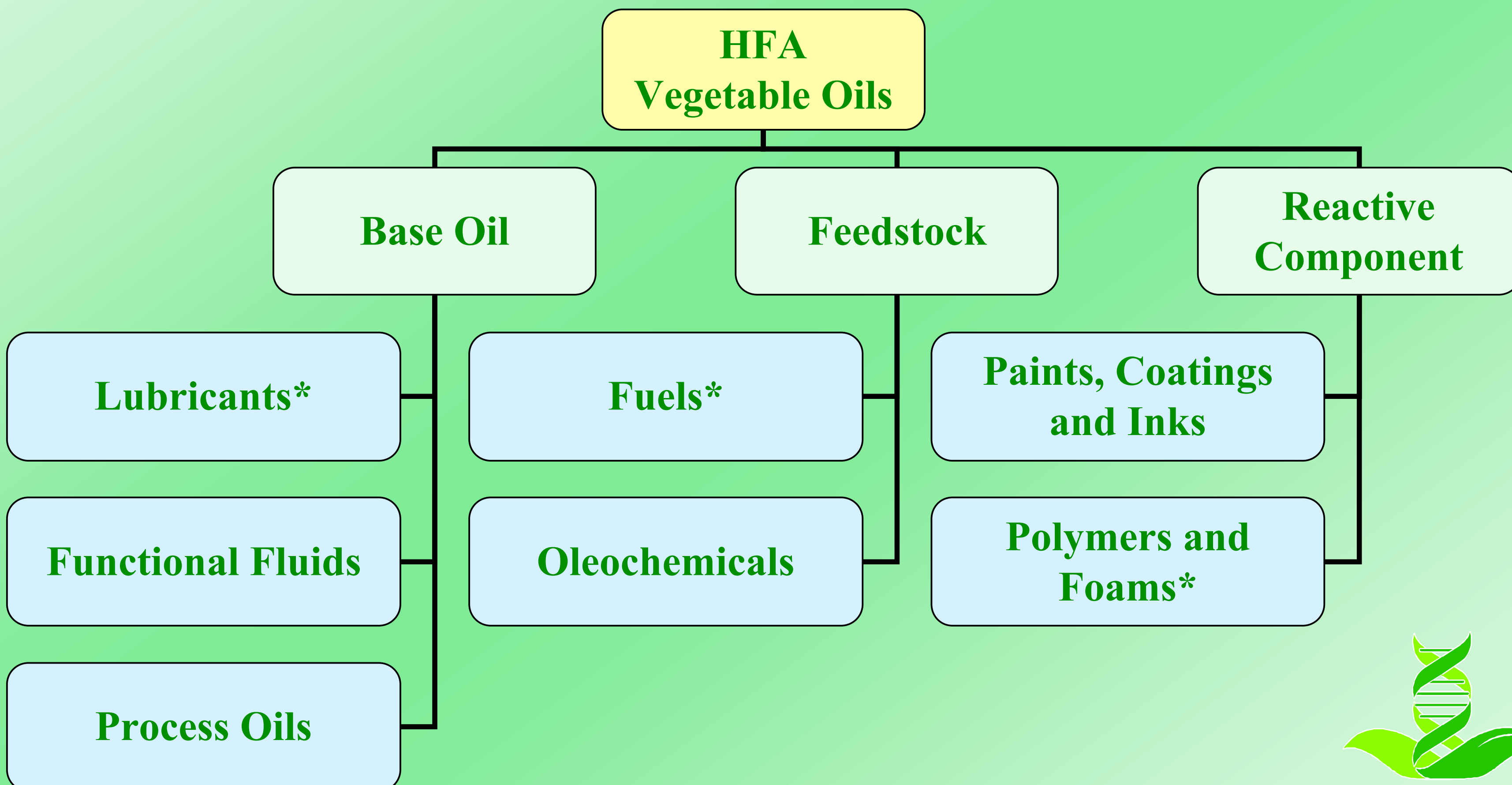
** Source: Vegetable Oils – Structure and Performance, S. Lawate, et al, 1997, Tribology Data Handbook, CRC Press, Ed. Rich Booser*

Industrial Applications For Linnaeus HFA Technology



** Initial focus areas*

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Rilsan®

Over 40,000 tonnes/year polymer

- Automotive
- Aerospace
- Cable Industry
- Oil and Gas
- Medical
- Food Packaging
- Sports

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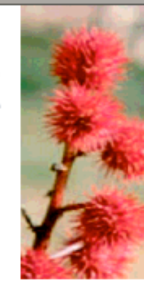
2006 Bioplastics Awards Winner

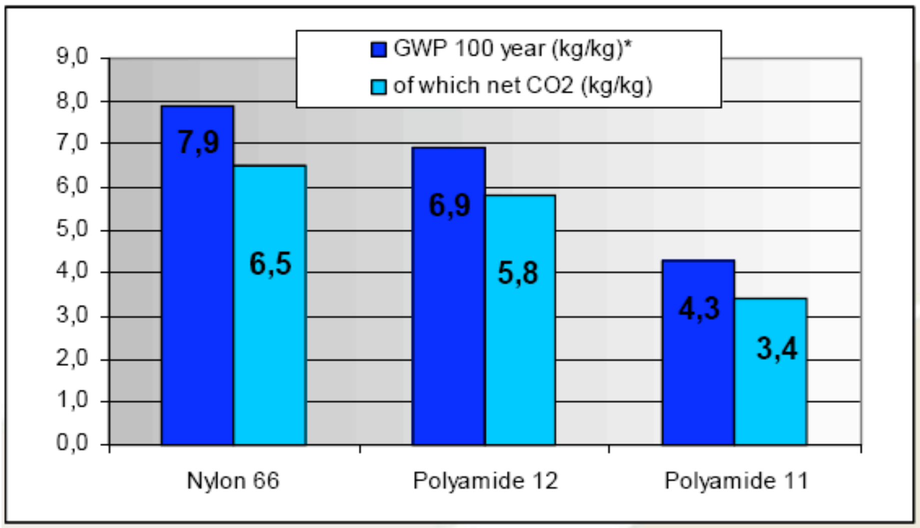
Rilsan® Polyamide 11 for Biodiesel Wins "Best Application, Non-Packaging" category for its application "Rilsan® Bioplastic for Biodiesel Fuel Lines". Bioplastics conference in Frankfurt

- Cost ~ $8.00/lb
- 100% bio-based technical polymer
- Reduced CO_2 emissions

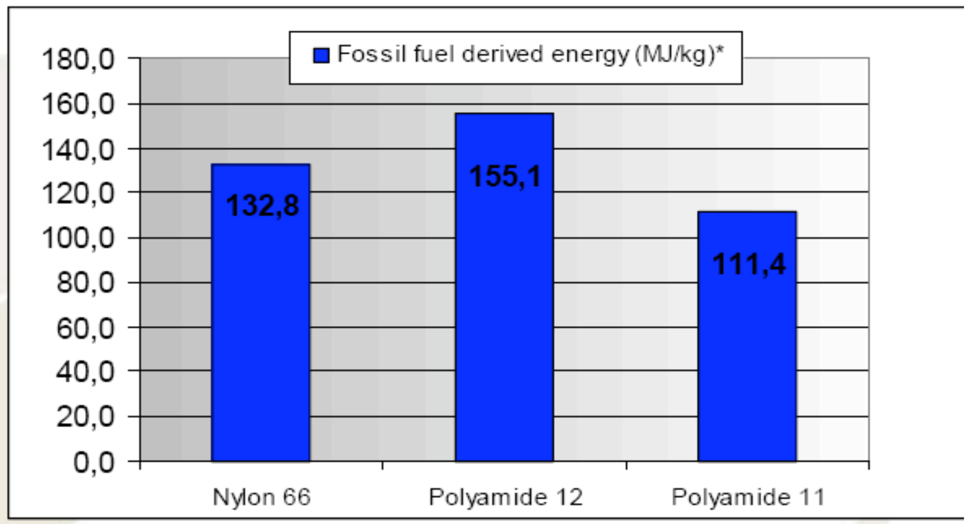
Rilsan® PA11 : EcoProfile and Environmental Impact



Global Warming Potential Net CO_2 Emissions**



Fossil Fuel Use Measured in Energy**



*Report By Third Party according to ISO 14040 to 14043 – Subject to later adjustments
**From Cradle to Pellets

Rilsan®

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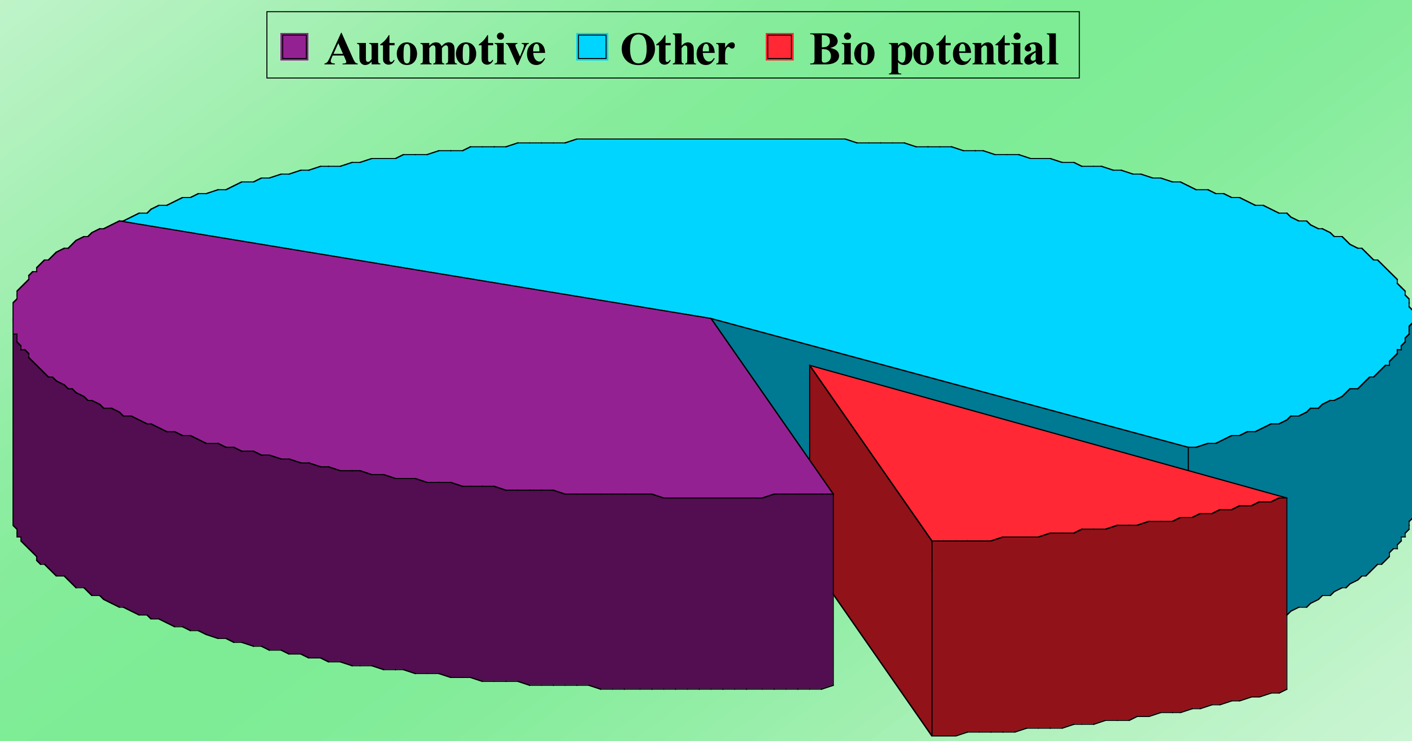
What is the potential U.S. motor oil market?

Replacing 10% of 1.1 billion gallons



110 million gallons @ 50 gallons/acre would require 2.2 million acres!

Value Proposition

- Canola oil $.25 CDN per pound
- Motor oil $1.25 USD per pound based on $2.50 quart
- Add pour point and anti-oxidant package
- What about emission credits and lifecycle?

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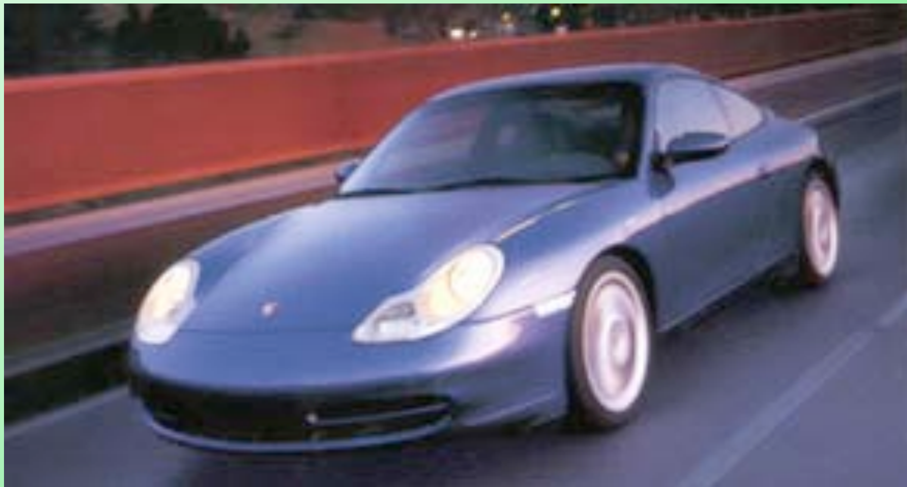
Fuel consumption with Titan GT 1 acc. to EG3 Test
VEG. LUBES REDUCE EMISSIONS

Data provided by G. Fingg FUCHS Lubircants Co. Ltd.

Presented at Bio-logical futures conference



	PORSCHE	MERCEDES-BENZ
Model	**911 Carrera Coupé**	**E 220 CDI**
Speed	280 km/h	198 km/h
Fuel	Gasoline	Diesel
Cubic capacity	3,387 Liter	2,151 Liter
Power	221 kW (300 PS)	92 kW (125 PS)
Max. revs	6800 1/min	4200 1/min
In comparison with SAE 15W-40:		
Fuel/Diesel-Consumption	-6,4 %	-3,2 %
Emissions NO_x	-24 %	-16 %.

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Where Oil Seeds are Grown
LARGE ACREAGE!

Feasibility of Production

- Canada produces 10 Million acres of Oil seeds
- Oil yield typically 50 gallons per acre
- If half acreage is planted yield 250MM Gallons
- Increase price over .25 per pound X large acreage
- USA and Australia produce large acreages

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Conclusions

- Oil seeds are future factories
- Marketing and regulatory strategies needed
- Plants allow costs to be managed and scaled
- Use 3rd world bio-diversity with 1st world agronomics

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- Ongoing support for development of Hydroxy's in crop plants

- Researching New Applications of HFA

- ARKEMA leading in developing plants as suppliers of new industrial chemistry

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Thank you for your support…

Saskatchewan Canola Development Commission

Saskatchewan Agriculture and Food

ACS
AGRICULTURE COUNCIL OF SASKATCHEWAN INC.
(FORMERLY SCCD)

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