

**Bioenergy - I:
From Concept to Commercial Processes
March 5-10, 2006
Tomar, Portugal**

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Archer Daniels Midland**

Oleochemical BIOFUEL



ADM in numbers

- 26,000 employees
- more than 700 processing plants, origination facilities and sales offices
- in 60 countries
- net sales 2004 of \$36.2 billion.

<http://www.admworld.com>

	Metric Tonnes	Bushels
Oilseed crushing plants	90,000	3.3 million
Corn milling plants	50,500	2.0 million
Wheat Flour mills	30,000	1.1 million



BIOFUELS 10

Renewable Energy Partners of New Mexico



„green fuel pump“

B 20, (20% Biodiesel)

E 85, (85% Ethanol)

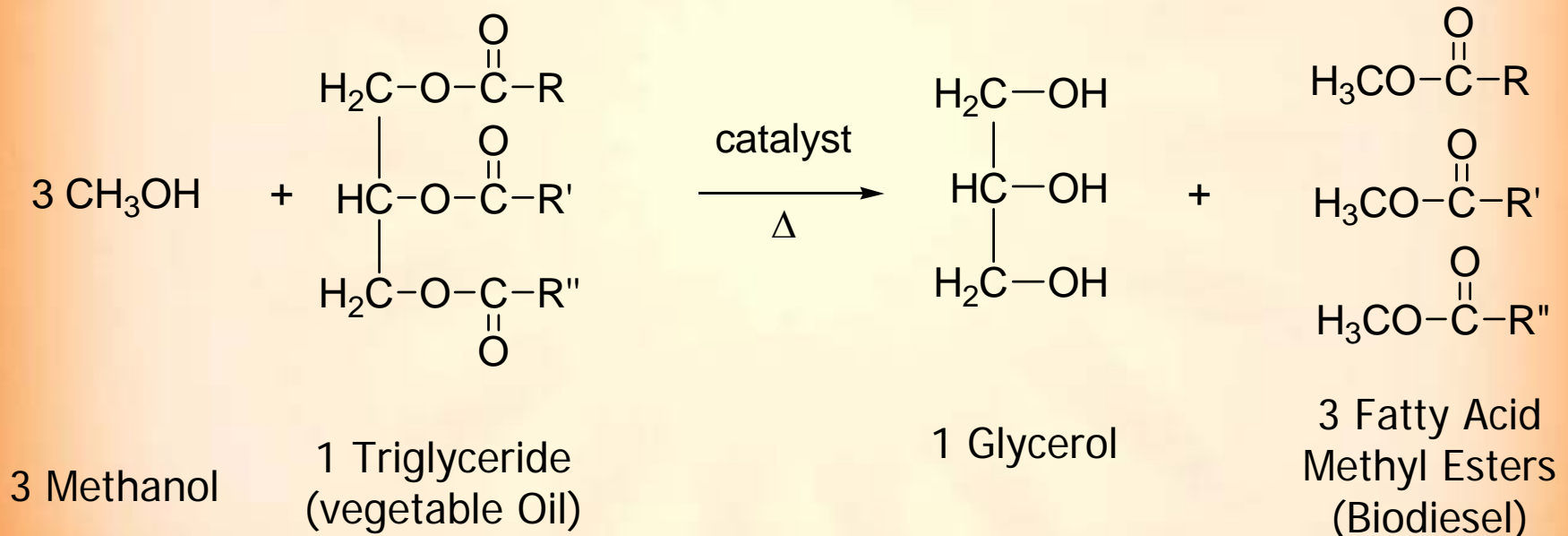
E 10, (10% Ethanol)

Oleochemical Biofuel

- Biodiesel in general
- Quality
- Capacities
- Production
- Glycerin

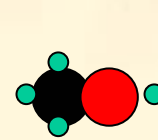
Biodiesel in general

Synthesis of Fatty Acid Methyl Esters (FAME)

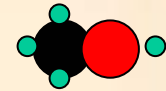


Chemistry – the Raw Materials

- Carbon
- Hydrogen
- Oxygen



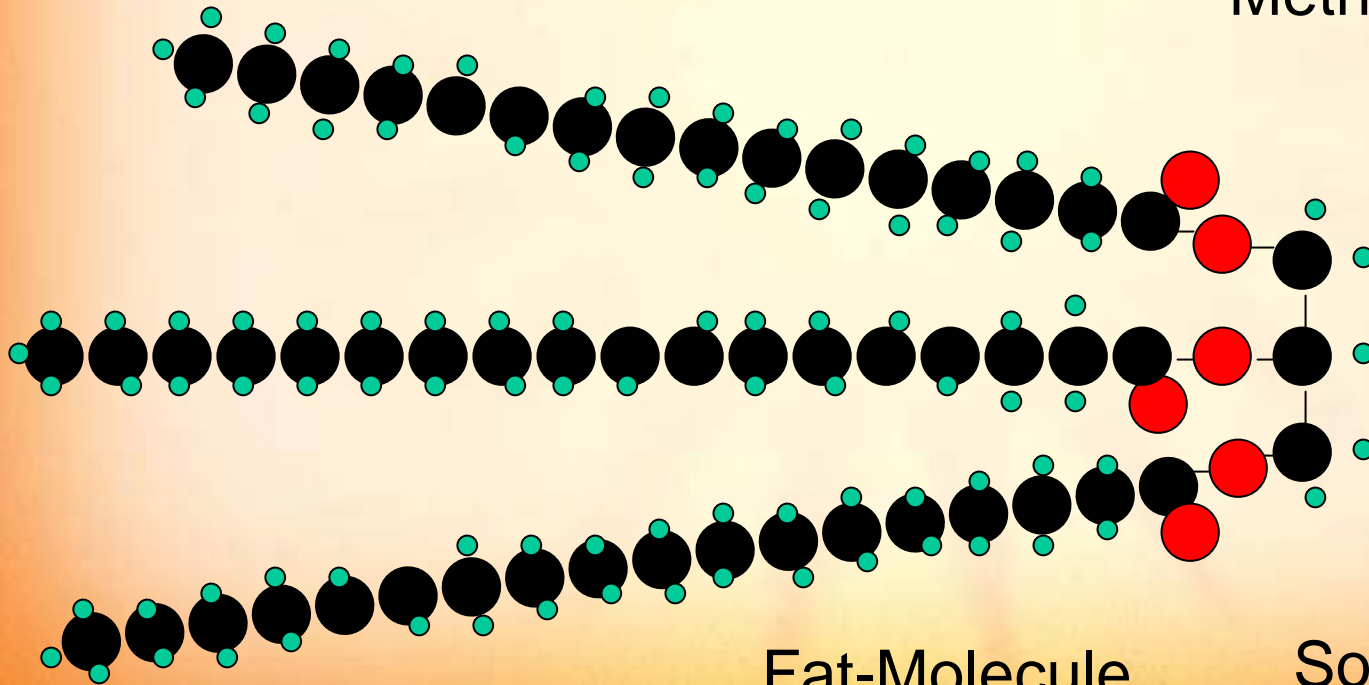
Methanol



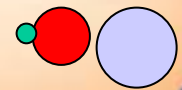
Methanol



Methanol



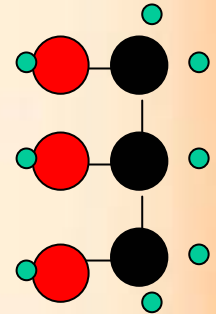
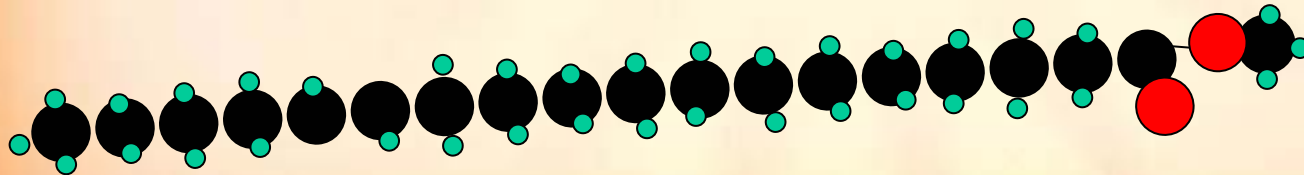
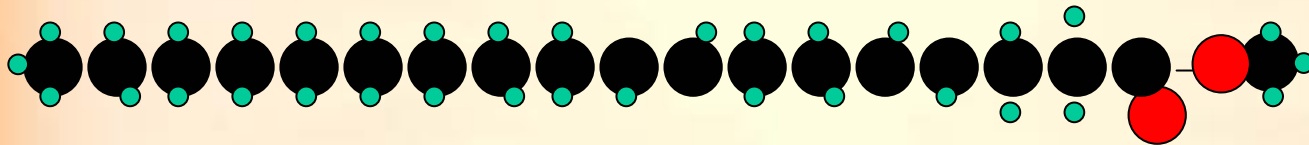
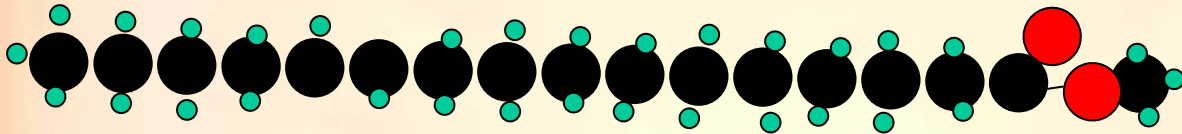
Fat-Molecule



Sodium hydroxide



Chemistry – the Products



Glycerine

Fatty acid methyl ester (Biodiesel)

Advantages

- lower emissions of HC, CO, PM
- sulphur free
- balanced CO₂-emissions
- non toxic, non water hazardous
- excellent lubricity
- high Cetane number

Critical aspects

- Solvent properties; limited resistance of certain materials (metals, plastics)
- Lower energy content, higher fuel consumption
- Hygroscopicity
- Increase of Nox-emissions
- Engine oil dilution
- Lower stability (thermal and storage)
- Higher viscosity at low temperatures

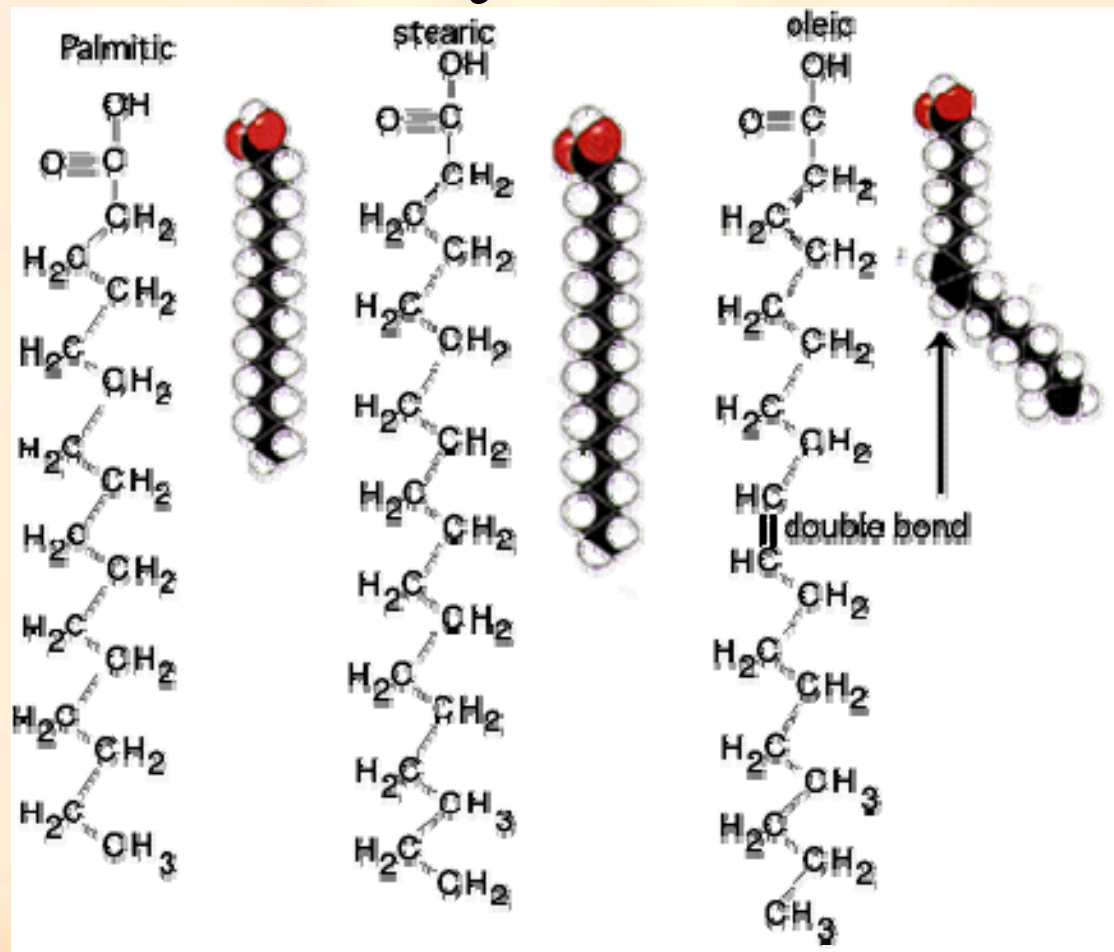
Unsuitable Materials

- +Nitrile Rubber, NBR
- +Hydrated Nitrile Rubber, HNBR
- +PVC
- +Copper
- +Brass
- +Lead
- +Zinc
- +Chromium / Chromated Surfaces

Suitable Materials

- +Flourinated Rubber, FPM
- +Polyamide
- +Polyoxymethylene
- +Aluminium
- +Stainless Steel
- +Tin

Fatty acids



Fatty acids



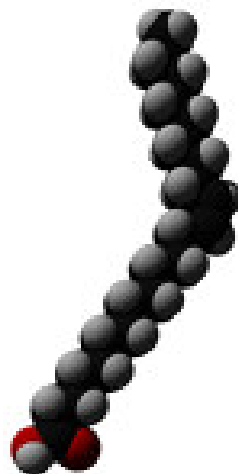
arachidic



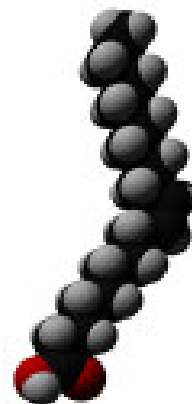
stearic



palmitic



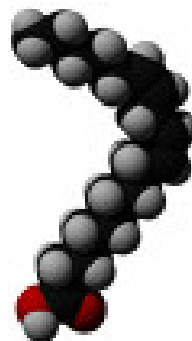
erucic



oleic



arachidonic



linoleic



linolenic

Crystallisation

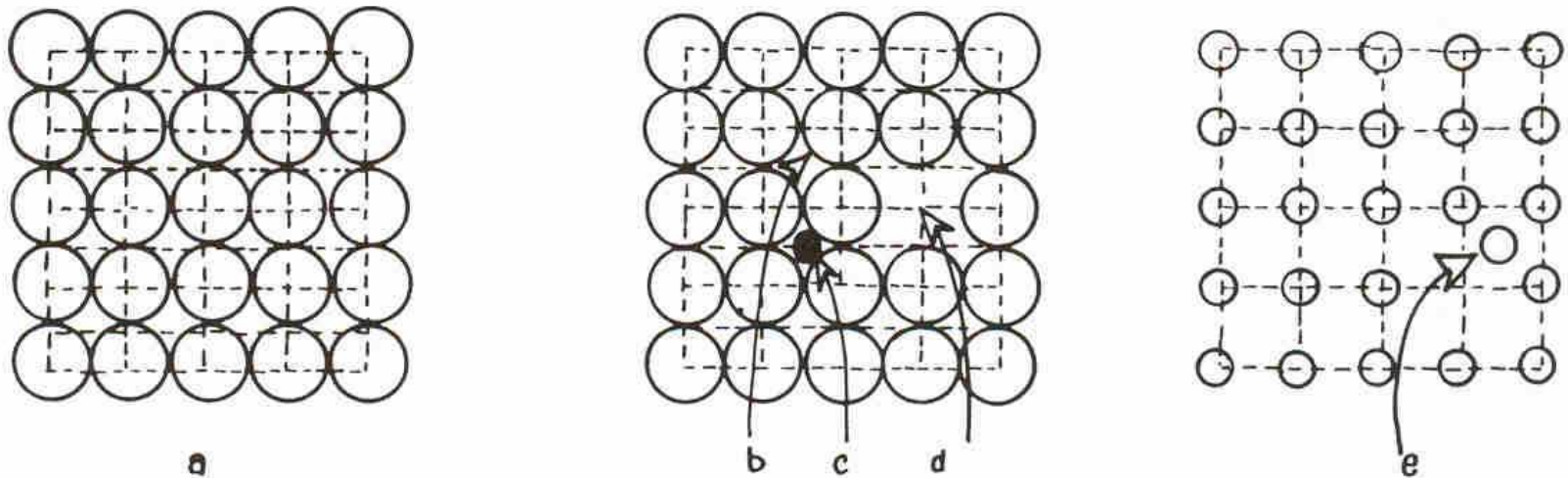
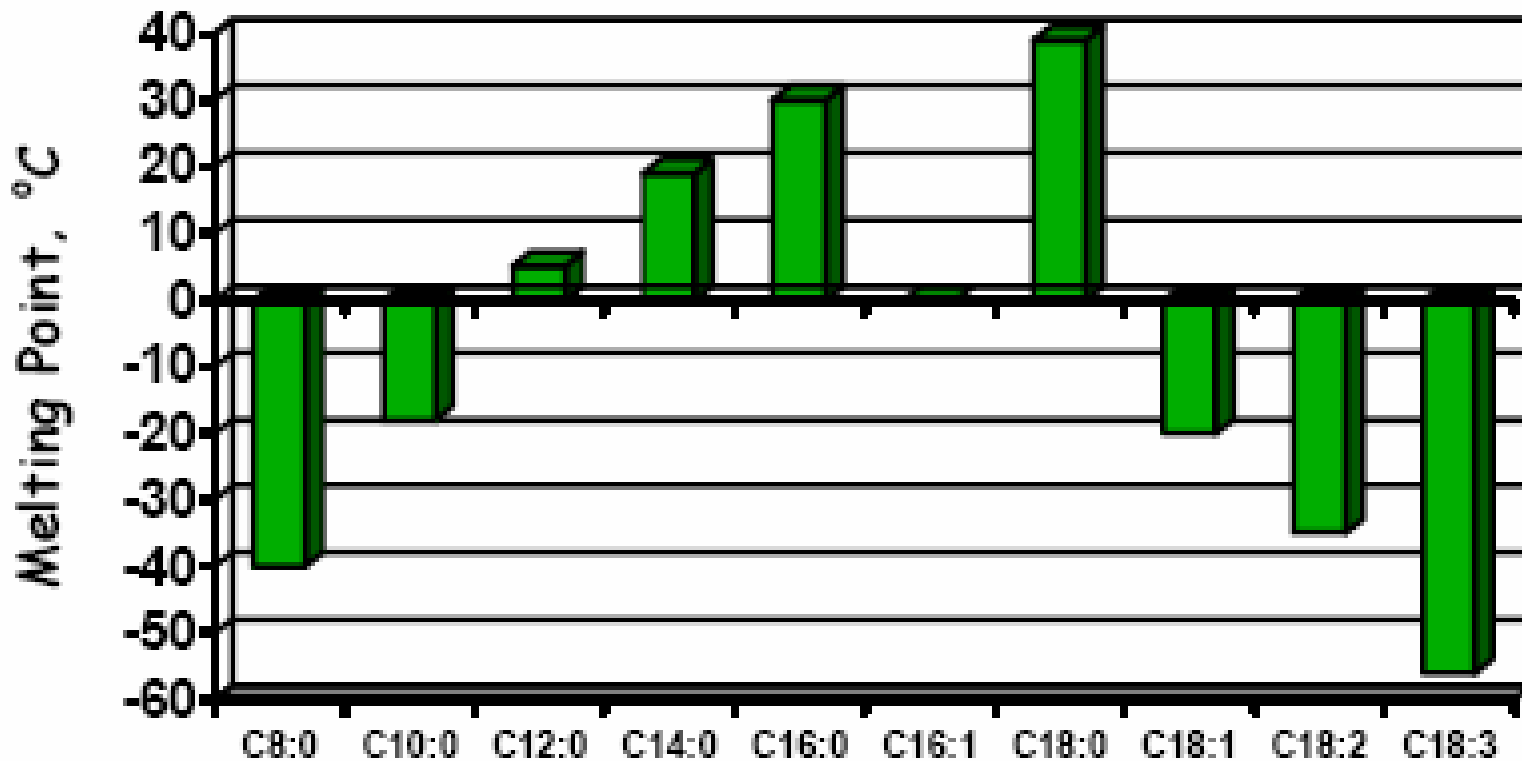


Figure 2.10 Imperfection in crystals: (a) perfect crystal; (b) substitutional impurity; (c) interstitial impurity; (d) Shottky defects; and (e) Frenkel defect. (From R.A. Laudise, *The Growth of Single Crystals*, © 1970, pp. 12–13. Reprinted by permission of Prentice-Hall, Englewood Cliffs, NJ.)



Types of Fatty acids methyl esters

Figure 4. Melting points of biodiesel components.

Oxidation stability

<u>Fatty Acid</u>	<u>Oxidation Rate</u>
Stearic Acid (C18:0)	1
Oleic Acid (C18:1)	10
Linoleic Acid (C18:2)	100
Linolenic Acid (C18:3)	150

Cold flow Feedstocks

ACID		Soy	Canola	Palm	Yellow grease	Tallow
Palmitic	C-16	10	4.5	45	25	24
Stearic	C-18	4	2	4	15	20
Oleic	C-18:1	22	60	40	45	45
Linoleic	C-18:2	54	20	10	10	4
Linolenic	C-18:3	8	9	0.2	0.5	0.5
IV		125	110	44	75	50
		140	115	58	80	60
Cetane		53	58	65	60	75
CFFP [°C]		-6	-14		5	10

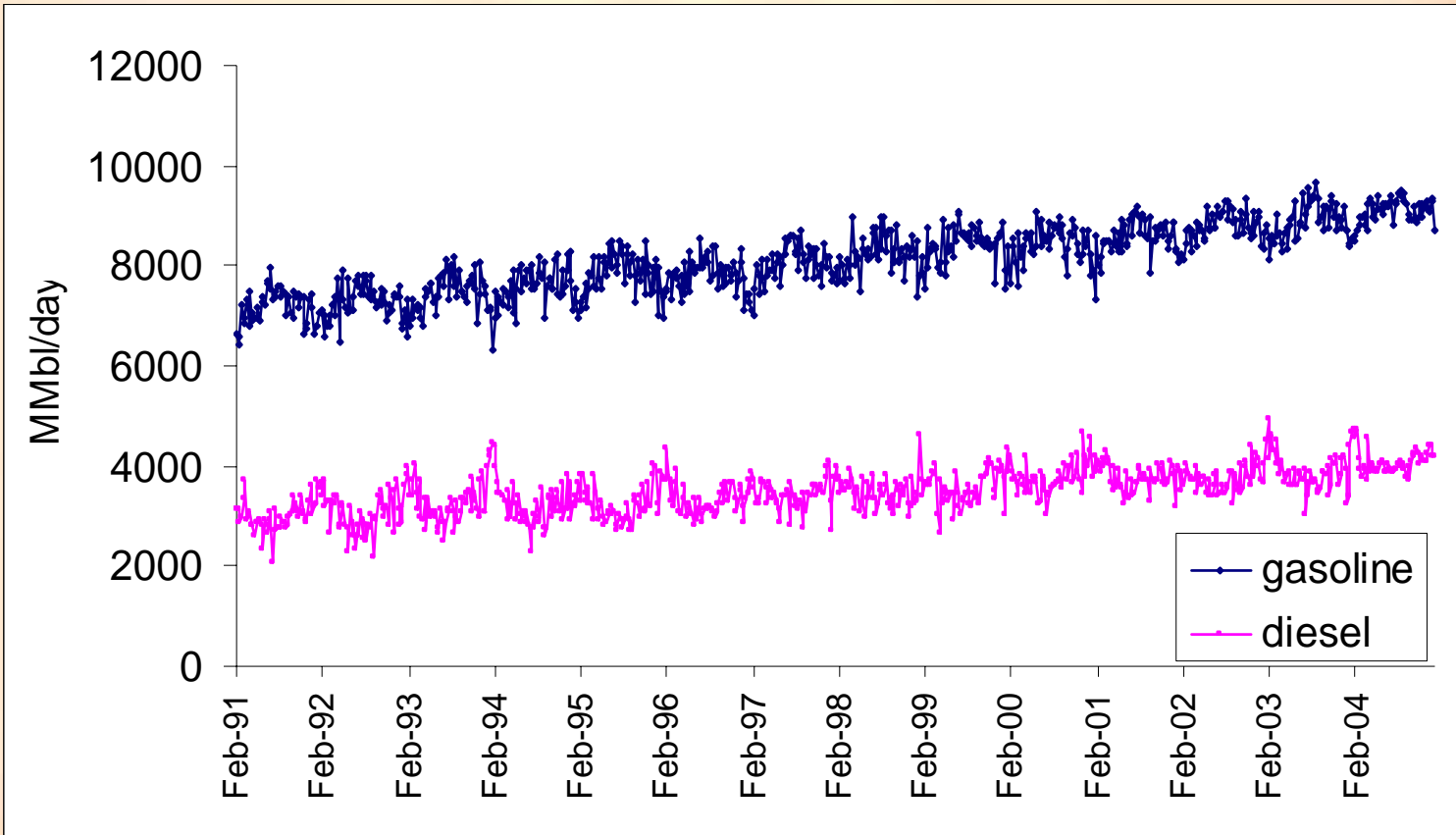
Polymerization

Energy content

<u>FUEL</u>	<u>Btu/gal (gross)</u>
Diesel Motor Fuel	140,000
Biodiesel (B100)	125,000

(source: Dep. of Energy)

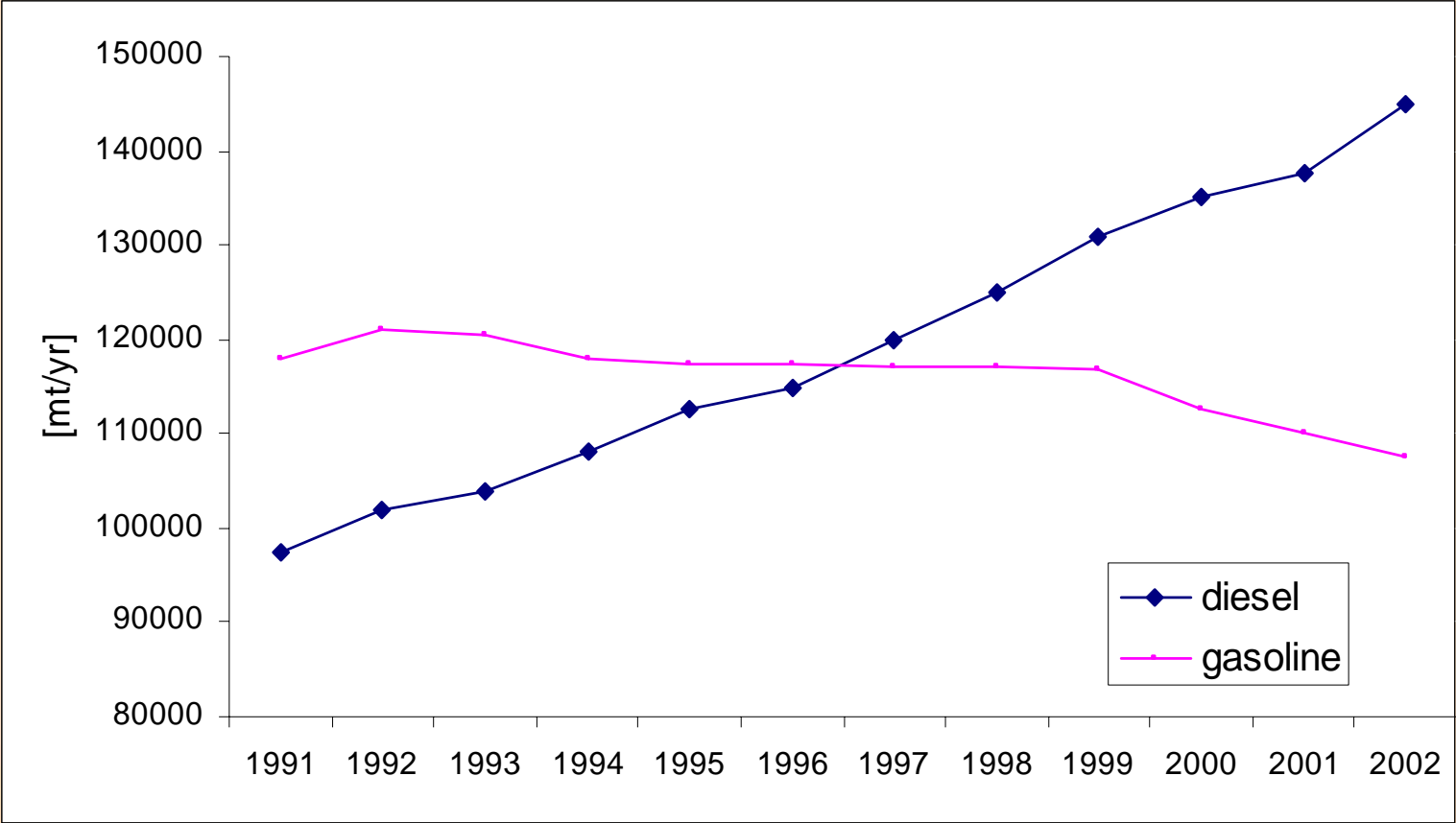
US Diesel and Gasoline consumption



Source: Dept. of Energy



EU Diesel and Gasoline consumption

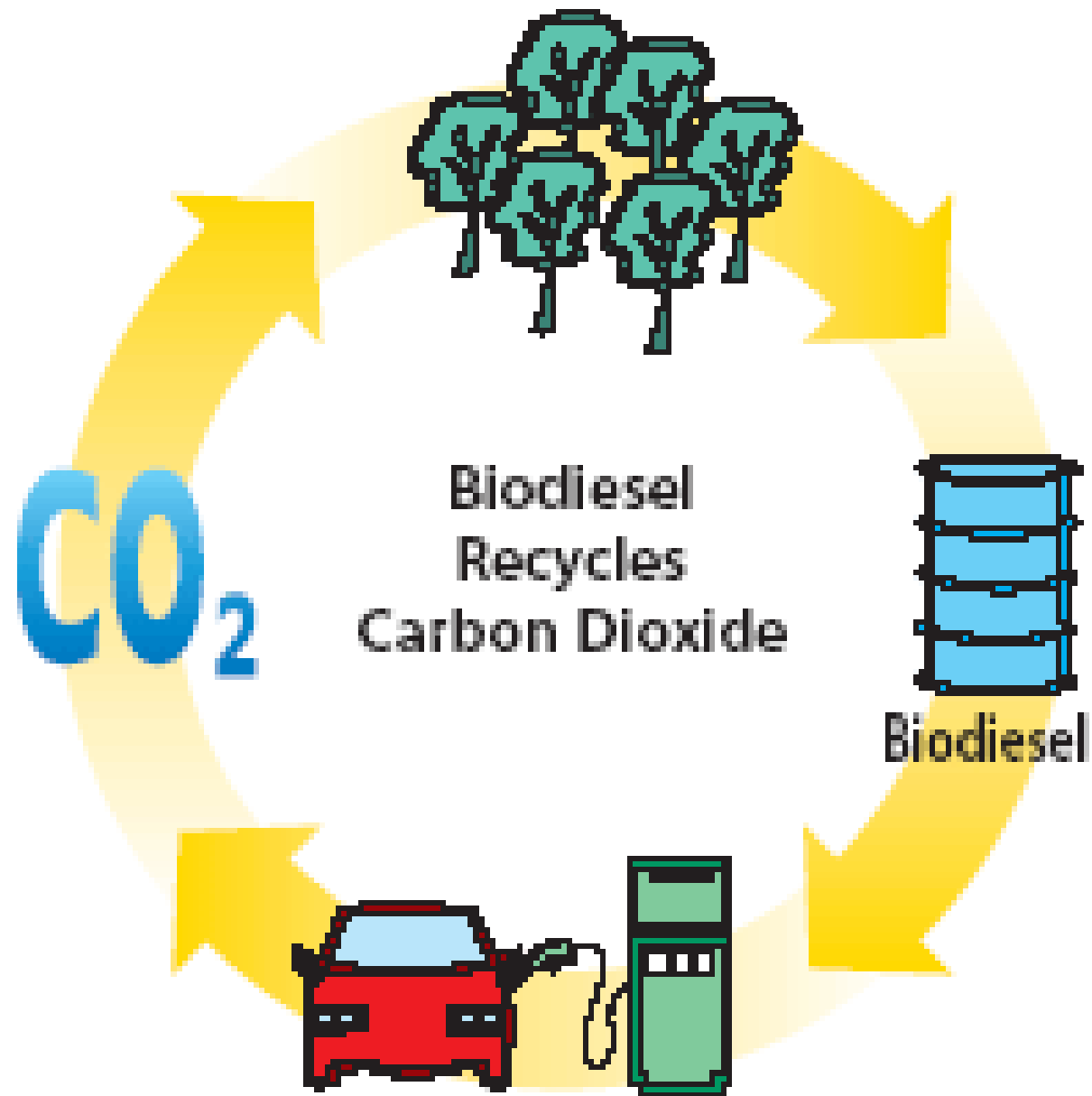


Source: Total



<http://www.bosch-presse.de>:

“..51.9 percent of newly registered passenger cars in Western Europe are diesel powered..”



Quality

- Cold Flow Properties
- Total contamination
- Oxidation Stability
- Free Glycerol
- Watercontent

Problems of a poor Quality

Feedstock related

Low Oxidation stability

- Formation of Deposits
- Corrosion due to aggressive oxidation products (e.g. Formic Acid)

High Iodine Number

- Nozzle Coking, Oil Sludge

Low Temperature Stability (CFPP)

- Filter Plugging

Problems of a poor Quality

Process related

High Glycerol-/Glyceride Content

- Filter Plugging, Corrosion of Nonferrous Metals (Cu, Zn)

High Metal Content (Na, K, Ca, Mg)

- Filter Plugging (Calcium Soaps)

High Water Content

- Corrosion, Filter Plugging, Microbiological growth

Problems of a poor Quality

Process related

High Acid Number

➤ Corrosion

High Phosphorus Content

➤ Catalyst Ageing

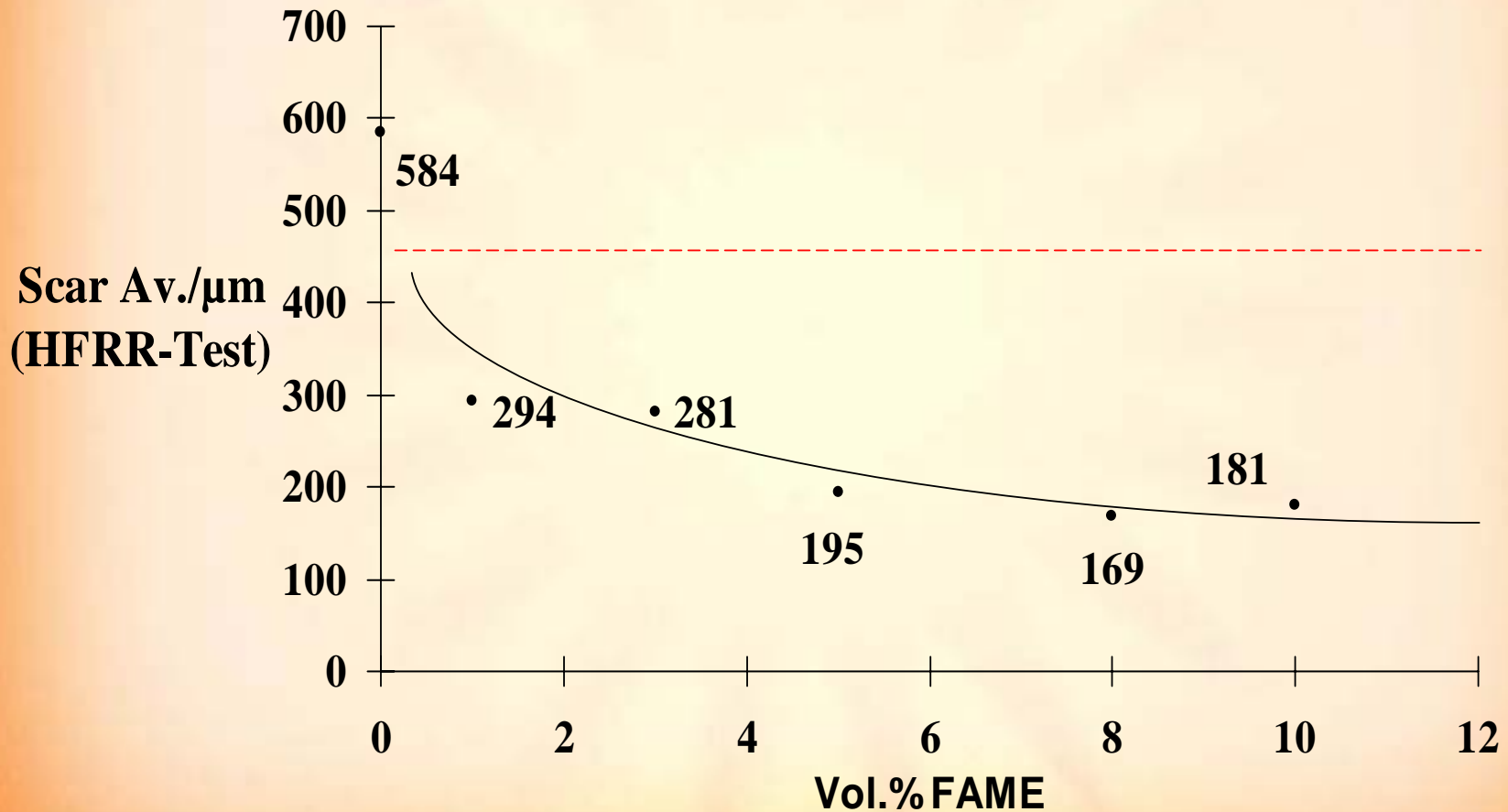
Which blend makes sense?

B 100: biodegradability

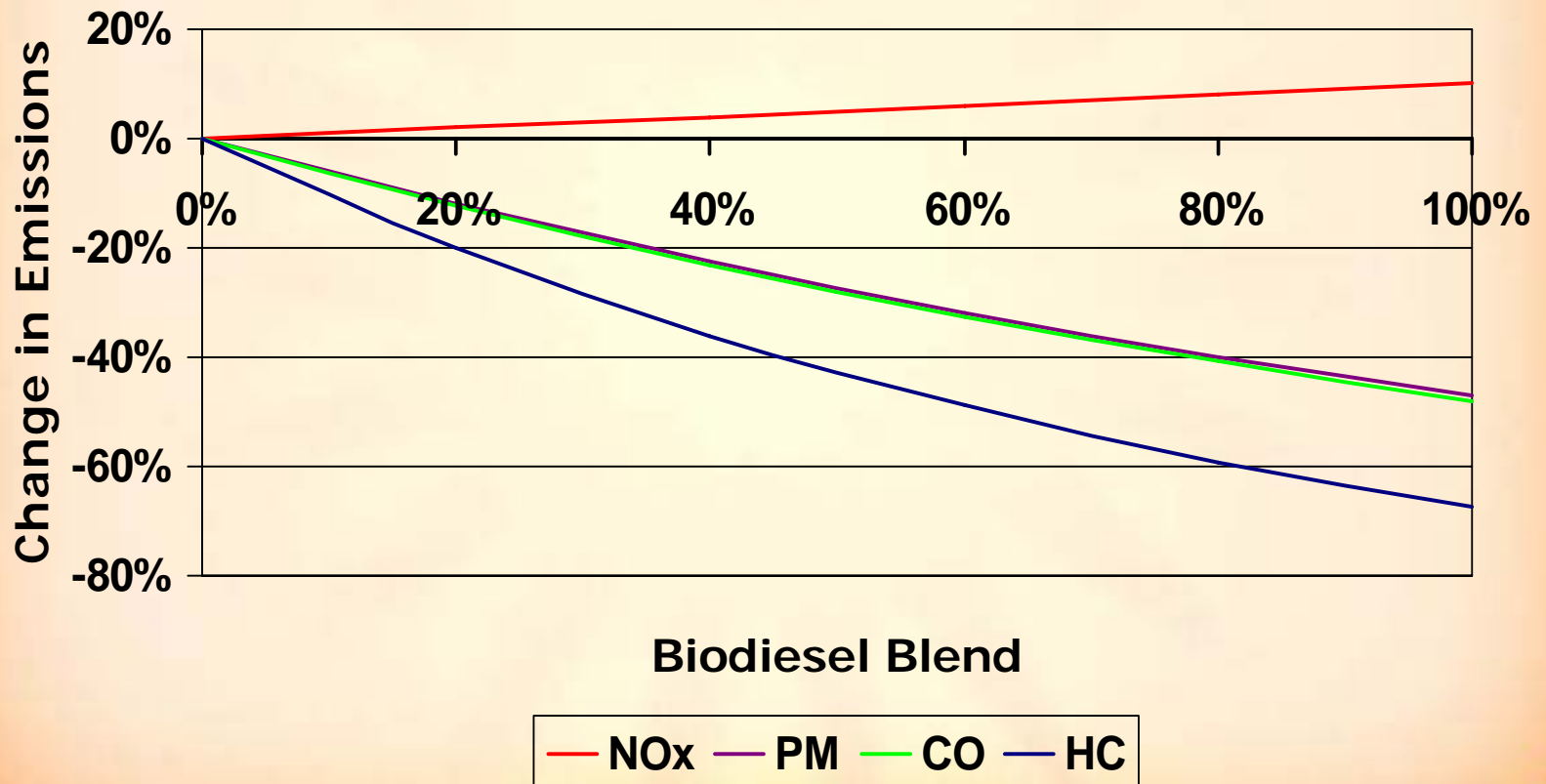
B 20: emission reduction

B 2: lubricity

..significant lubricity enhancement at 2%...



..significant emission reduction at 20%...



Source: National Biodiesel Board



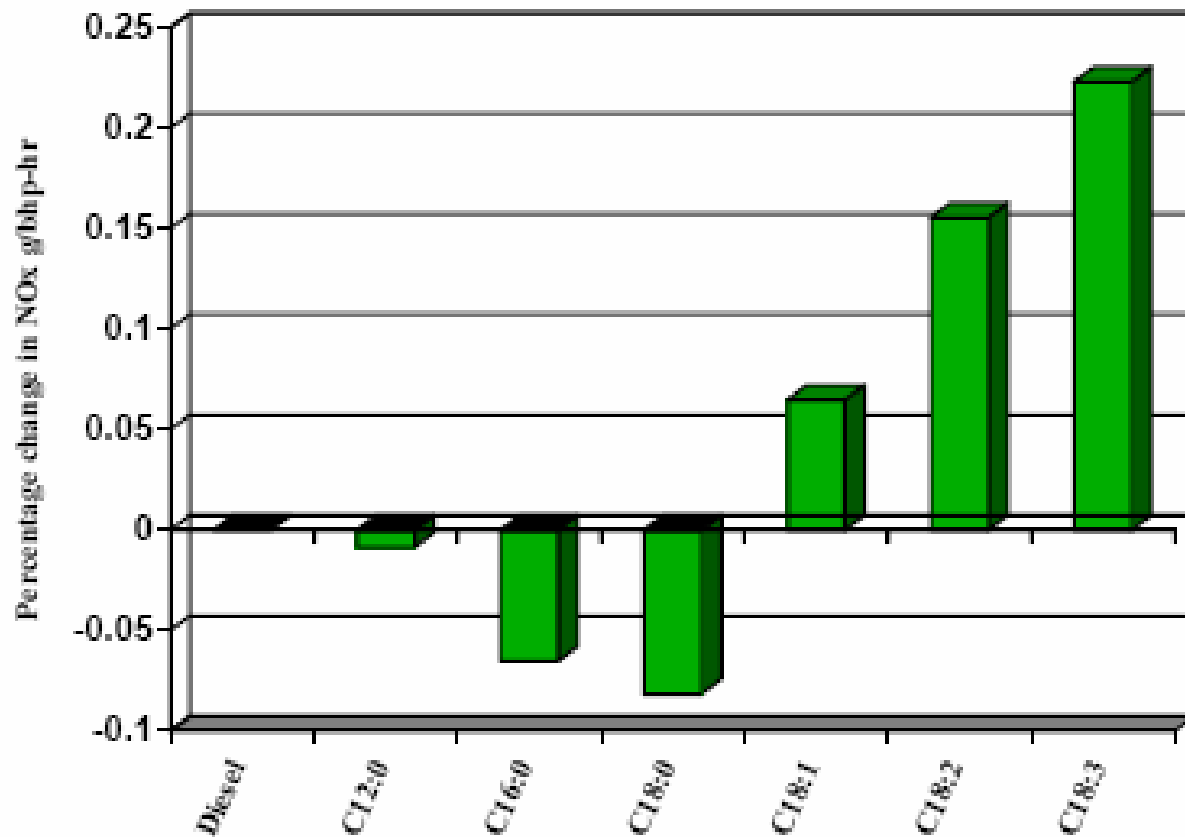


Figure 8. NOx emissions of B100 made from single types of fatty acids¹⁰

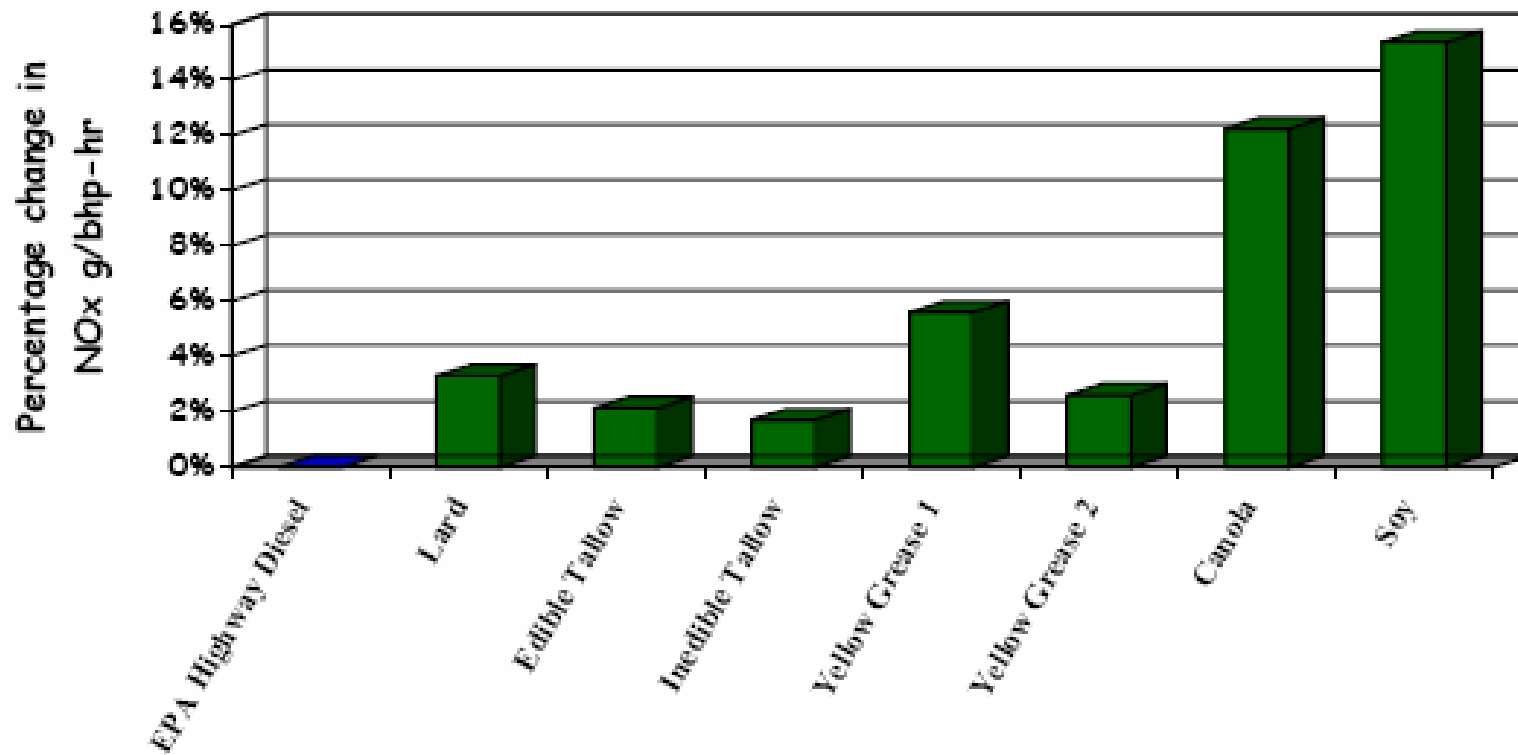
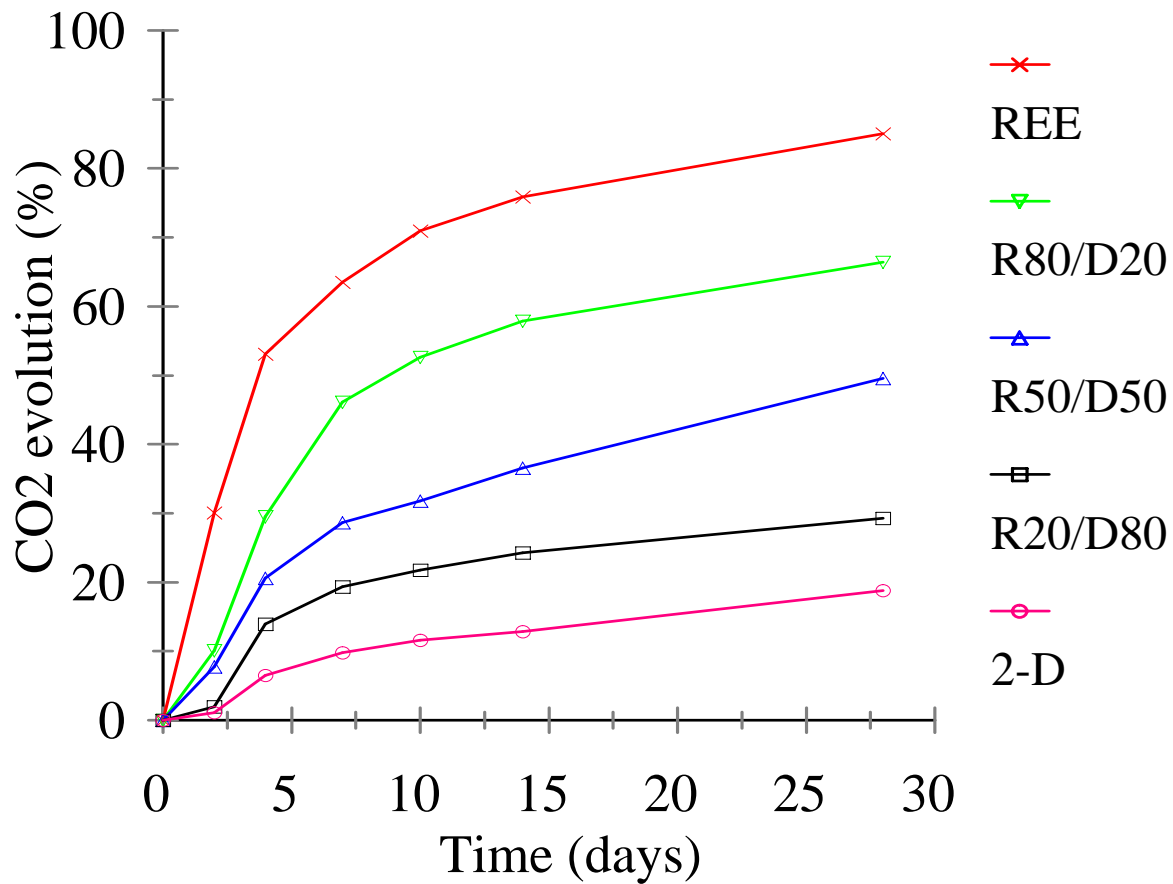
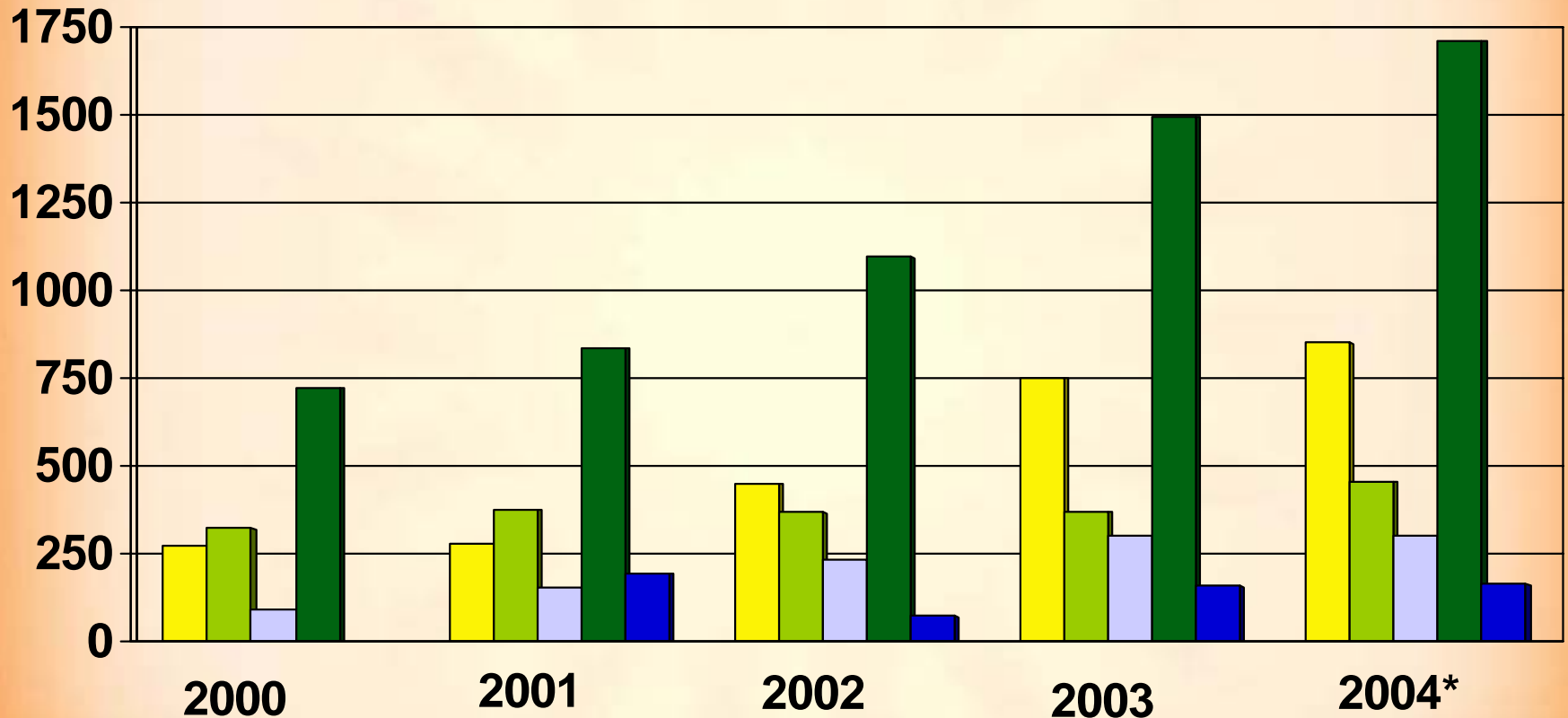


Figure 9. Increase in NOx emissions from CI engines using various B100 fuels

..significant biodegradability at 100%...



EU and New Member States in mio. Mt/year



- Germany
- France
- Italy
- EU
- New member states (Czech Republic/Slovakia/Poland)

What's different in the US?

US Production

[MM gal/a]

[1000 mt/a]

2000	2	6.2
2001	6.5	21.3
2002	8.8	30
2003	18.5	60
2004	70	62
2005 ¹	180 ¹	600
2006 ¹	360 ¹	1200

1) estimates

Source: USDA 2004, CCC Data,



Interesting new projects

India: Jatropha

Brazil: Castorseed

Thank you!

Any questions?