



Lubricants based on Renewable Raw Materials

BIOREFINICA – Osnabrück – 27. 01.2009
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Lubricants – every days helper for ...

- ... friction reduction
- ... wear protection
- ... heating and cooling
- ... rust prevention
- ... power transmission
- ... noise reduction
- ... moving our world.

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2

Main drivers for the development of lubricants ...

- ... Cost/performance ratio
- ... Extended oil change intervals, smaller sump capacities
- ... Favourable influence on emissions: engine oils, metalworking
- ... Improved energy/fuel efficiency
- ... EU Chemical Policy: REACH
(Registration, Evaluation, Authorisation of Chemicals)

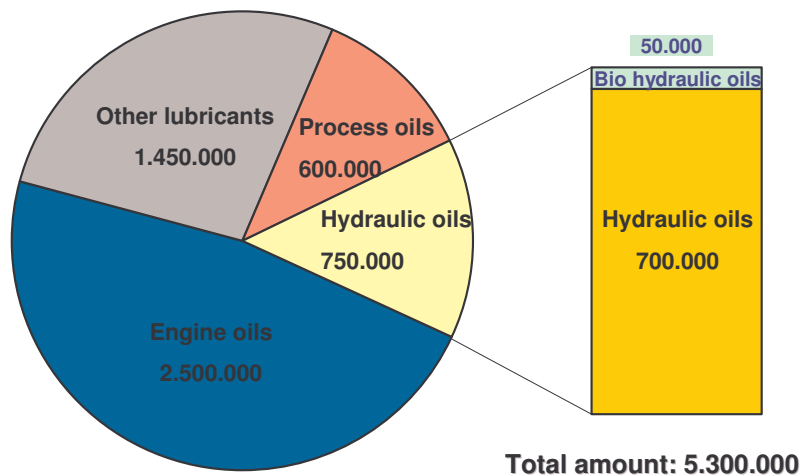
→ Target: **Lower overall impact to the environment.**

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3

EU Lubricant consumption 1999 (t/a)*



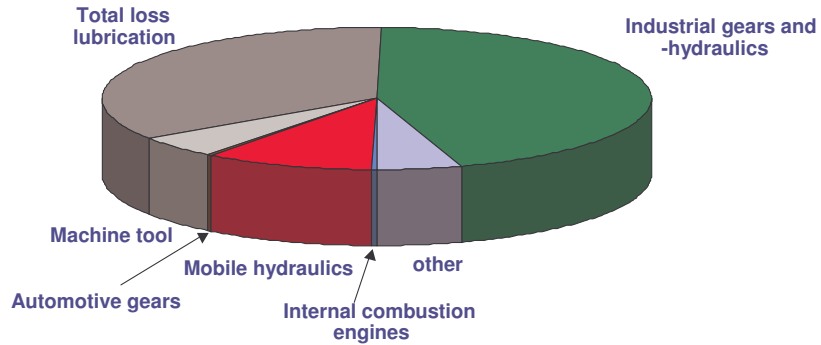
*Data source: 'Europalube' accord. "Background document" EEL, Amsterdam 2003

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4

Eco-Lubricants in Europe *



Market share of bio-lubricants: approx. 1-2% in Europe
approx. 4-5% in Germany.

* estimation based on own experience

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5

Environmentally Compatible Lubricants now available

**1.
TOTAL
LOSS
LUBRICANTS**

2-Stroke oils
Chain saw oils
Railway flange and switchgear lubes
Concrete mould oils
Greases
Chain lubricants
Corrosion preventives
Wire rope lubes.

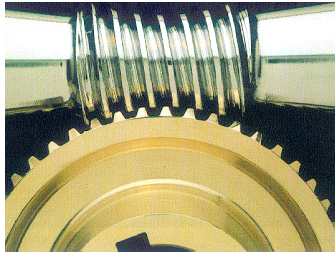
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6

Eco-Lubricants now Available

2. SEALED SYSTEM LUBES



Hydraulic Fluids
Compressor Lubricants
Tractor Transmission Oils
Gear Lubricants
4-Stroke Engine Oils
Metalworking Lubricants
Machine Tool Lubricants

⇒ From a technical point of view, >90% of all Lubricants could be "Eco-Lubricants" !

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7

Market demands for Bio-Lubricants

- Value for customers is based on price and performance
- "Bio or Eco" properties are so far not regarded as a value for most customers, it is only an add-on
- Customers are not interested in the source of chemistry
- Customers of Bio-Lubes pay for biodegradability, low toxicity and 'non water hazardous' characteristics (Germany)
- However, Bio-Lubes need technical advantages like
 - Higher oxidation stability
 - Longer life time
 - Longer oil change intervals
 - Superior wear properties
 - Superior lubricating properties

⇒ Today's Bio-Lubes need synthetic esters! Based on ???

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8

Lubricants & esters – two directions of view



- Blends with hydrocarbons due to technical requirements and properties: e.g. 4-stroke oils, metalworking (<30%)
- As dominant component for biodegradable lubricants: e.g. eco-labelled, not water hazardous products (> 50%).

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9

The European Eco-Label for Lubricants

Minimum amount of renewable resources according to Criterion 5:

Criterion 5	Hydraulic fluids	Greases	Chain saw oils, mould release agents and niche loss lubricants	Two-stroke oils
Carbon content from renewable raw materials % (w/w)	≥ 50%	≥ 45%	≥ 70%	≥ 50%.



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10

Criteria for the Base Fluids

1. Ecological characteristics:

- Rapidly biodegradable (OECD 301): >70% (Eco-Labels)
- Not water hazardous (only Germany)
- No R-phrases according to EU directive 99/45 (DPD)
- Not hazardous for aquatic organisms (Algae, Daphnia and Fish)
- **NEW - Growing interest in the source of base oils:**
High amount of renewable resources due to EU Eco-Label



2. Performance characteristics:

- Oxidation and hydrolysis stable
- Thermally stable
- Excellent low temperature properties
- Elastomer compatible.

Existing saturated biodegradable base fluids for Eco-Lubes, especially hydraulic applications

1. Petrochemical esters (e.g. Di-isotridecyl-adipate):

- Amount of RRM: 0%
- Water hazardous (German legislation)

ALCOHOL

ACID

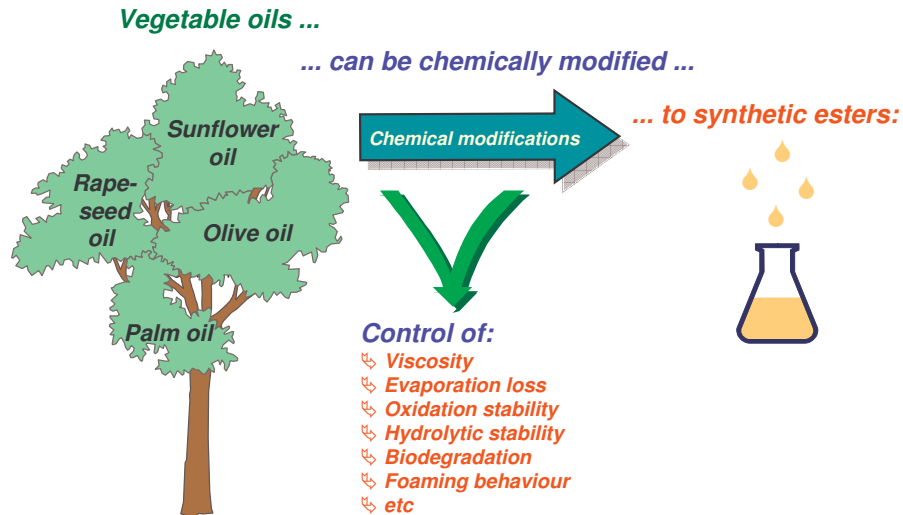
2. Esters from petrochemical alcohols and plant derived fatty acids (mainly Polyolesters):

- Amount of RRM: (mostly) > 50%
- but most saturated polyolesters of this type are 'Water Hazardous' (Germany) and not 'rapidly biodegradable' (OECD 301 with 10d-Window).

ALCOHOL

ACID

Vegetable oils and their derivatives – as base oils

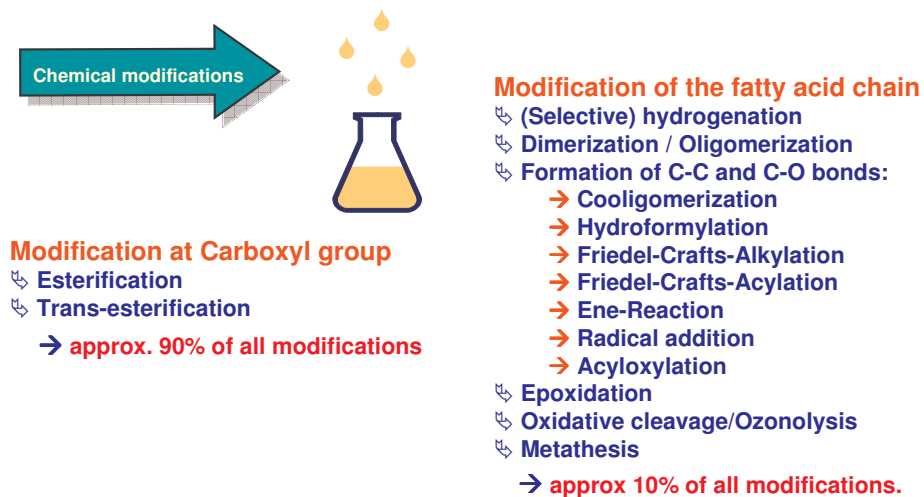


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13

Chemical modifications of vegetable oils



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14

Modification of the Carboxyl group - esterification



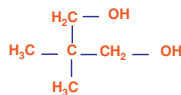
Alcohols:

- ↗ **linear alcohols** (2-EthylHexyl, IsoPropyl)
- ↗ **branched alcohols** (Guerbet)
- ↗ **diols** (NeoPentylGlycol)
- ↗ **polyols** (TriMethylolPropane, PentaErithritol)

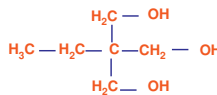
Acids:

- ↗ **mono-carboxylic acids**
- ↗ **di-carboxylic acids**
- ↗ **poly-carboxylic acids**
- ↗ **aliphatic carboxylic acids**
- ↗ **aromatic carboxylic acids.**

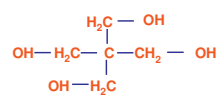
NPG



TMP



PE

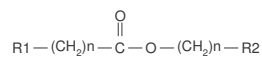


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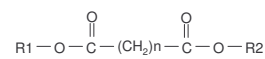
15

Modification of the Carboxyl group - esterification



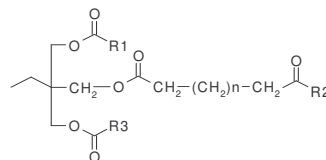
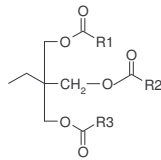
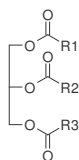
Monoester

→ 2-ethylhexyl, isopropyl, isotridecyl ester



Dicarboxylic acid ester

→ adipic, azelaic acid ester



Polyolester

Native oil **TMP ester**
 Rapeseed/Sunflower TMP-C8/C10, TMP-O.

Complex ester

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16

Modification of the fatty acid chain

Chemical structure of the ester influence the physical properties:

- High linearity → High viscosity index = good viscosity-temperature behaviour but relatively poor low-temperature characteristics
- High degree of branching → Good low-temperature characteristics & high hydrolytic stability but low viscosity index
- Low Saturation → Outstanding low-temperature characteristics but limited oxidation stability
- High saturation → Outstanding oxidation stability but poor low-temperature characteristics.

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17

Improved vegetable oils as base oils

"Natural chemistry"



Improved vegetable oils by breeding and genetic engineering, e.g. "high-oleic" sunflower oils

Physical-chemical data:

Viscosity @ 40°C: 40 - 46 mm²/s

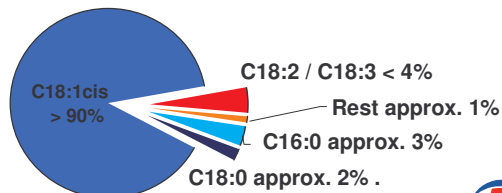
Viscosity @100°C: 8 - 10 mm²/s

Viscosity Index: 190 - 200

Pourpoint: HOSO -6 to -18°C

(TMP-O < -40°C)

Fatty acid distribution (e.g.):



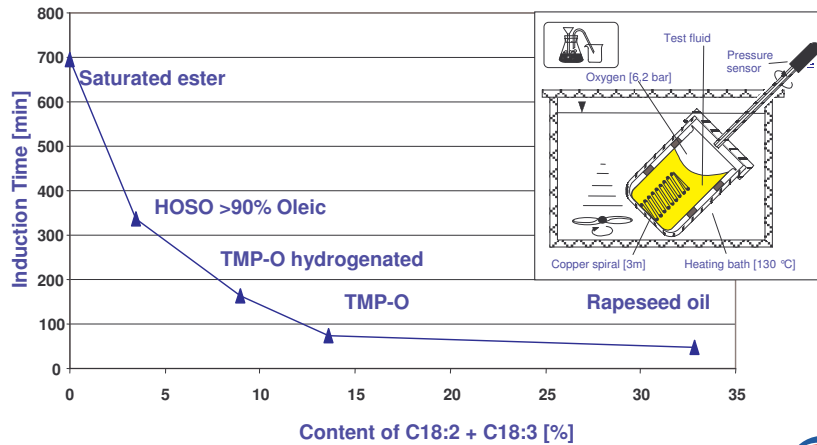
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18

Oxidation stability vs. Content of C18:2 + C18:3

Induction time in
Rotating Pressure Vessel Oxidation Test (ASTM D 2272-85 at 130°C)
depending on content of poly-unsaturated fatty acids



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19

New development: Base fluids from renewable Alcohols and Fatty Acids

Advantage of the new ester system:

- Very close to natural raw materials with very high biodegradability
- Not water hazardous (important in Germany)
- Toxicologically harmless
- Fulfilment of technical requirements for high performance applications (oxidation and thermal stable).

ALCOHOL | ACID

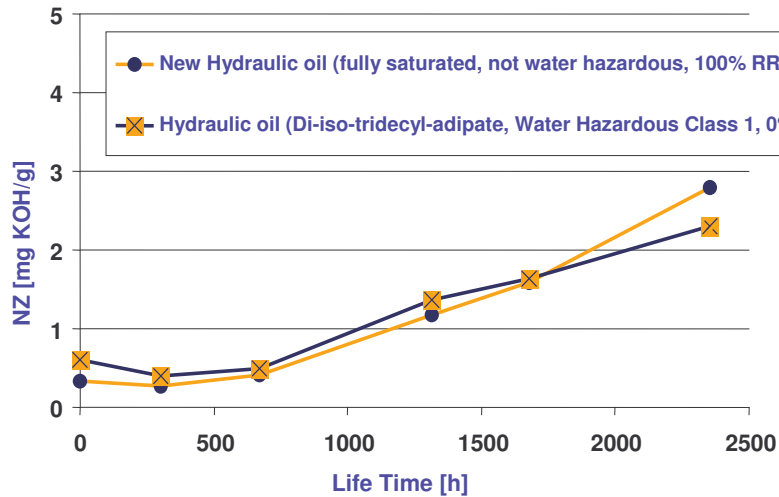
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20

Novel hydraulic fluid based on 100% RRM saturated ester

Oxidation stability TOST-Test* (ASTM D 943)



*Oxygen 3 l per hour, steel and copper contact, 95 °C

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21

The bio-lubricant case within the EU Lead Market Initiative

The production & use of bio-lubricants (based on $\geq 50\%$ RRM's) can contribute to save fossil resources & reduce Green House Gas emissions, both in production & applications. This product group will form an innovative area for agriculture & industry and at the same time forms a concrete example for a positive economic & environmental impact in the areas soil & water because of their biodegradability. From a technical point of view modern bio-lubricants can reach the high performance levels needed in ambitious applications. (EU DG Enterprise)

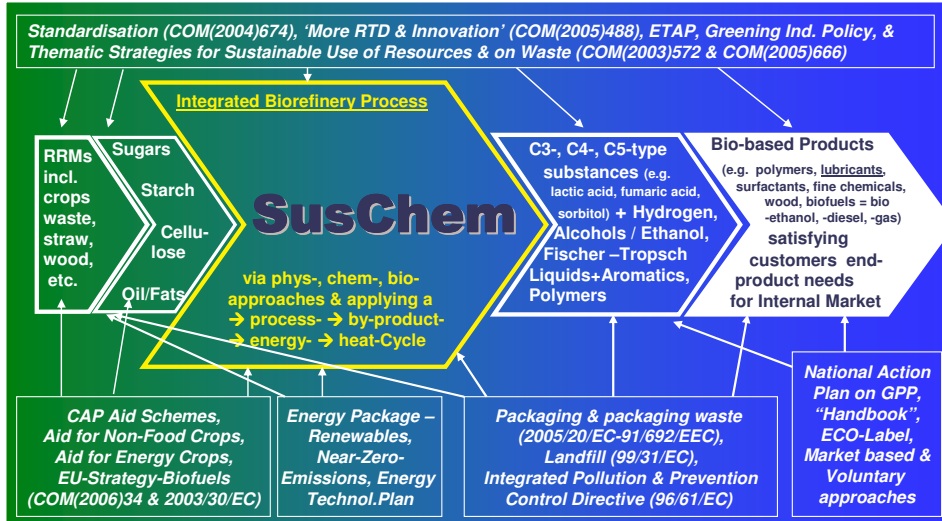
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22

Bio-refinery within existing European legislation:

Overall, comprehensive & strategic actions along the product chain for an internal bio-based product lead market



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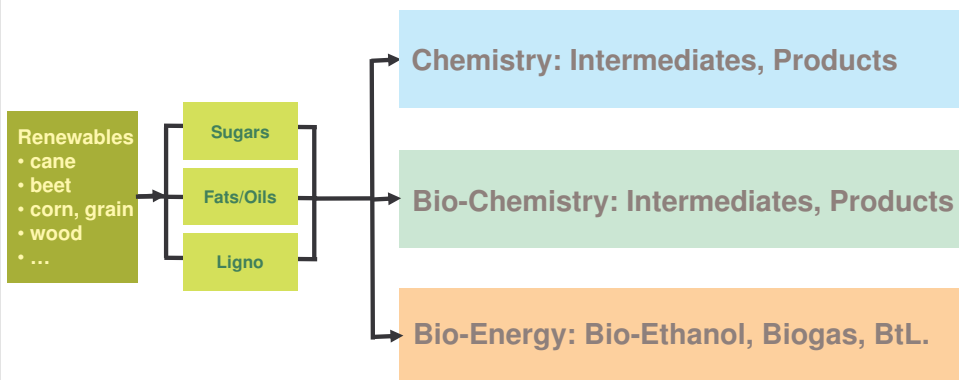
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23

The use of Renewable Raw Materials:

Bio-based chemicals & bio-energy have the same raw material base
⇒ the competition of applications has to be balanced!



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24

Summary

- Due to EU policy RRM-based lubricants will have good chances in the EU lubricants market
- Fully saturated ester oils can combine technical performance and low environmental impact
- From a technical point of view more than 90% of all lubricants could be based on RRM.

Thank you for your attention



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25