



Introduction on Glycerol as co-product from biodiesel plants

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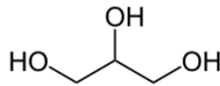
GENERAL OUTLINE OF THE PRESENTATION

1. GENERAL ASPECTS
 - Production, Market, Applications
2. GLYCEROL AS CO-PRODUCT OF BIODIESEL PROCESS
 - Current biodiesel market
 - Factors affecting crude glycerol composition
3. GLYCEROL REFINING
4. SECOND GENERATION BIODIESEL
 - New feedstocks/new technologies
 - How will it affect glycerol industry

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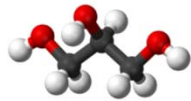


GLYCEROL : SOME CHARACTERISTICS



$\text{C}_3\text{H}_8\text{O}_3$ (92,09 g/mole)

Propane-1,2,3-triol
Glycerin, glycerine



Density : 1.261 kg/l

Colorless, odorless, hygroscopic
Viscous and non - liquid
Slight sweet taste

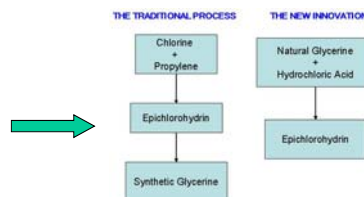
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Glycerol Production

SYNTHETIC ROUTE

- Produced from propylene
- Epichlorohydrin process;
- Not applied anymore (not economical)



NATURAL ROUTE

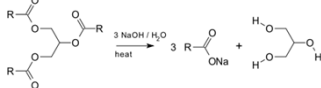
- Obtained as co-product from oils and fats processing;
- Traditionally obtained from Soap production and Fat Splitting
- Currently mostly obtained from biodiesel production;
- Varying quality and production volumes

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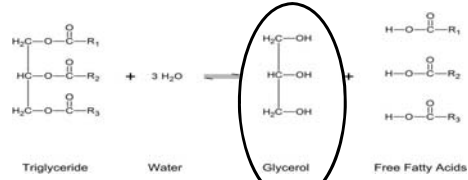


Glycerol as co-product from oils and fats processing

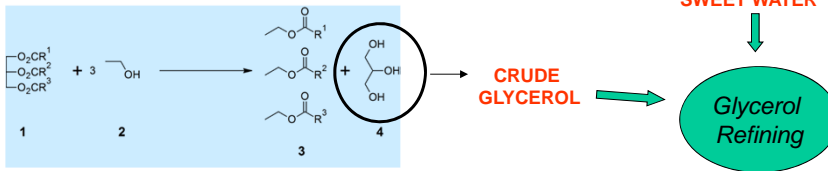
SOAP PRODUCTION



FAT SPLITTING



BIODIESEL PRODUCTION

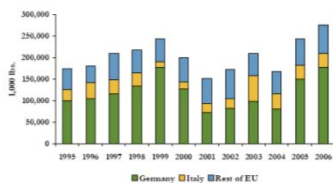


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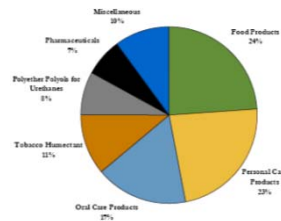
Earlier Glycerol industry (< 2004)

MARKET



- Stable market (production, price)
- 1 Mio ton/yr (mainly USA)
- Mostly from soap production/fat splitting
- Limited synthetic glycerol

APPLICATIONS



- Food products (humectant, ...)
- Personal care products
- Oral care products (tooth paste)
- Tobacco & pharmaceuticals

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Glycerol industry after biodiesel boom (> 2004)

- * **CRUDE GLYCEROL PRODUCTION MORE THAN DOUBLED**
 - More than 1 Mio ton extra crude glycerol from biodiesel industry;
- * **VERY VOLATILE MARKET**
 - Pricing strongly dependent on supply;
 - Growing supply due to growing biodiesel demand;
 - Global oversupply crisis;
- * **URGENT NEED TO FIND NEW APPLICATIONS**
 - Necessary expansion in glycerol refining capacity is delayed;
 - Especially need for new uses of 'crude, unrefined' glycerol

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New potential uses of (crude) glycerol

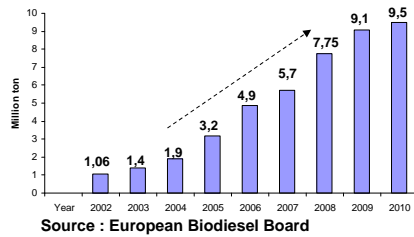
- * **ANIMAL FEED INGREDIENT**
 - Crude glycerol can be used in cattle and poultry feed;
 - Replacement of corn
 - Global oversupply crisis;
- * **POSSIBLE BUILDING BLOCK FOR MANY COMPOUNDS**
 - Epichlorohydrin production (Solvay)
 - 1,3 propanediol → Required glycerol quality ?
 - Hydrogen, methanol, GTBE,
- * **GLYCEROL AS ENERGY SOURCE**
 - Feedstock for biomethanisation plants;
 - Direct use as fuel (Calorific value : 19 – 25 MJ/kg, depending on purity)

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Biodiesel Production Process

Biodiesel production in Europe



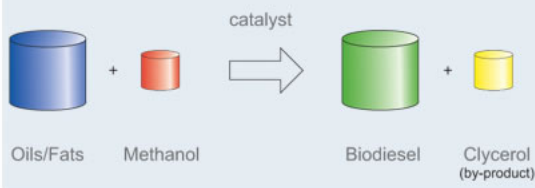
* **9.5 Mio tons** biodiesel produced in 2010 in EU-27



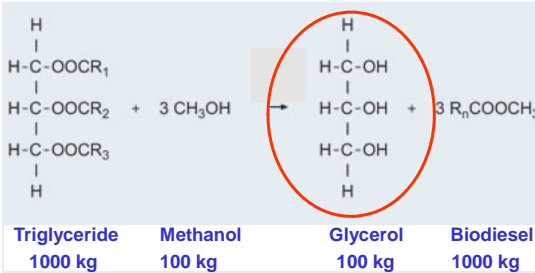
1.5 Mio ton crude glycerol

* World production : **Approx. 15 Mio tons**

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FIRST GENERATION BIODIESEL PROCESS



First Generation Biodiesel

* FEEDSTOCKS

- Triglyceride oils;
- Rapeseed, soybean, palm oil;

* PRODUCTION PROCESS

- Continuous process;
- 60°C/atm. pressure/2-3 hr;
- Catalyst

* CATALYST

- Mostly homogeneous catalysts (NaOH, KOH, NaOMe, KOMe)
- Heterogeneous catalysts (limited industrial application)

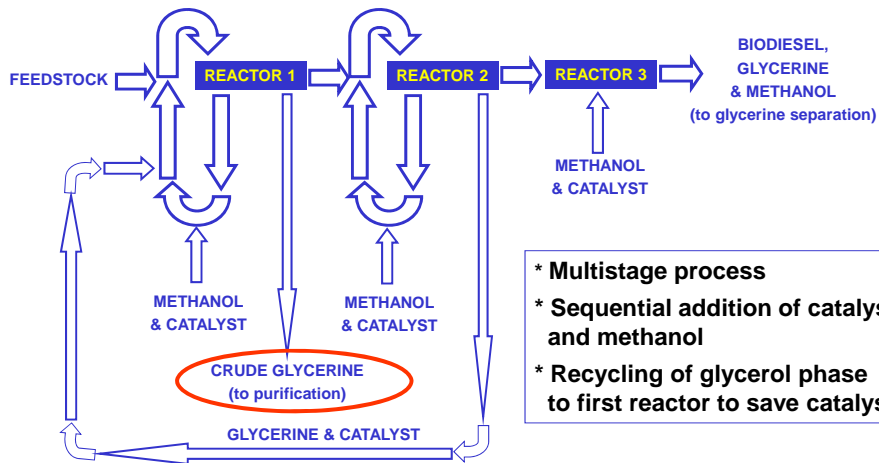
* BY-PRODUCT : GLYCEROL

- 10% of biodiesel production

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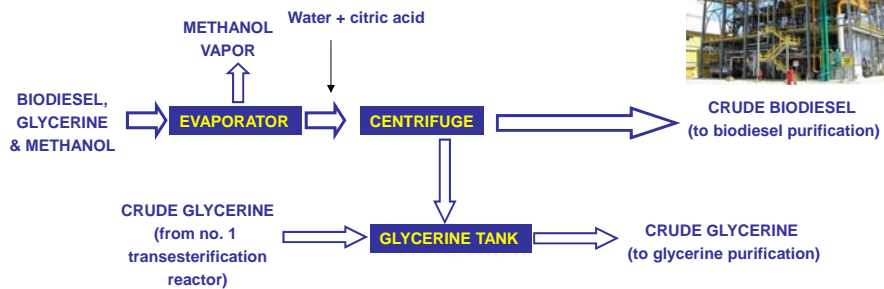
Biodiesel Production Process



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Glycerol purification

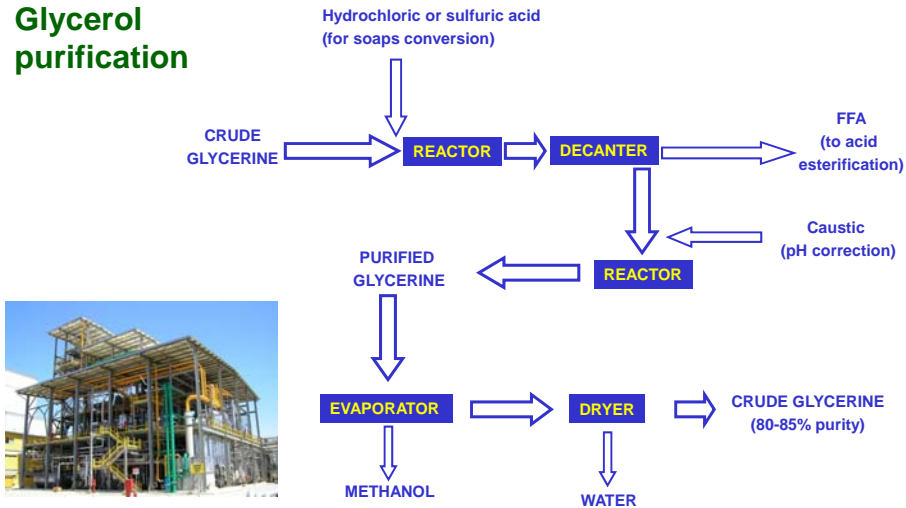


- * Crude biodiesel is first flashed (partial methanol removal) and then washed with citric acid (catalyst inactivation)
- * Heavy phase (water, methanol, glycerol, soaps, traces biodiesel,....) is blended in glycerine tank with crude glycerol from reactor 1

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Glycerol purification



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Crude Glycerol from biodiesel production

Property	Guarantee figures
Glycerine Content % by mass	80 – 85
Water % by mass	balance
Methanol % by mass	< 0.1
M.O.N.G. % by mass	< 2
Salt % by mass	< 7



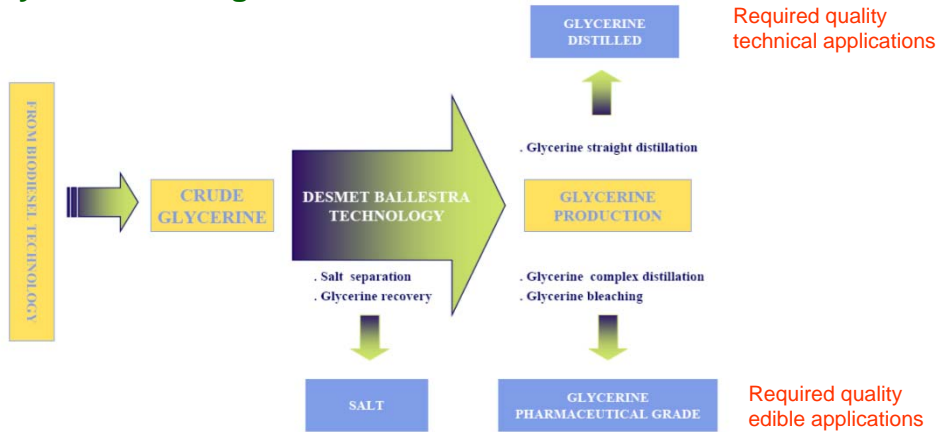
Crude Glycerol- color can vary depending on feedstock/process

- * **M.O.N.G. = Matter Organic Non Glycerine**
 - Biodiesel, Fatty Matter, FFA,....
 - Biodiesel production losses (has to be as low as possible)
- * **Salts content and type**
 - Depending on type and amount of catalyst (K- or Na-salts)
 - Depending on acid for catalyst inactivation (chlorides or sulphates)
 - No salts when a heterogeneous (solid) catalyst is used

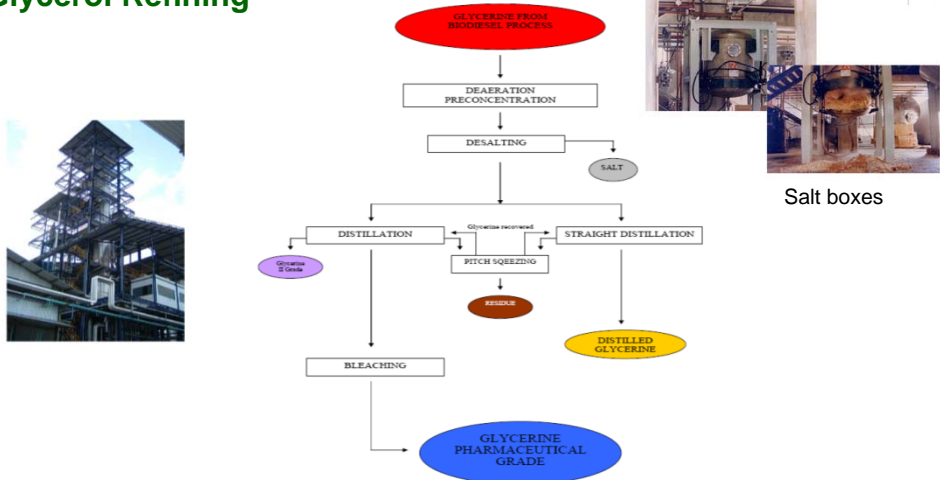
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Glycerol Refining

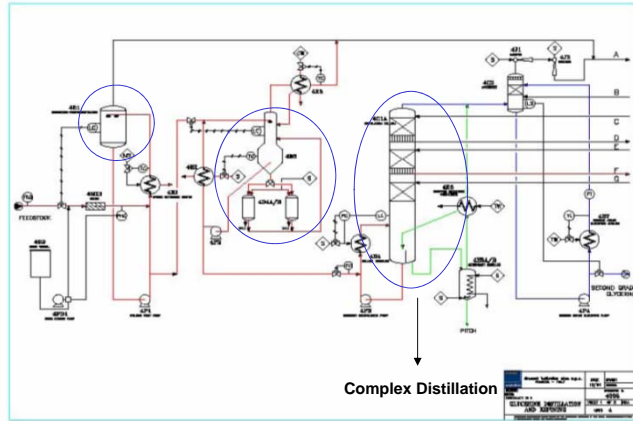


Glycerol Refining





Pharma-grade Glycerol Refining Process



→ To bleaching
(activated carbon)

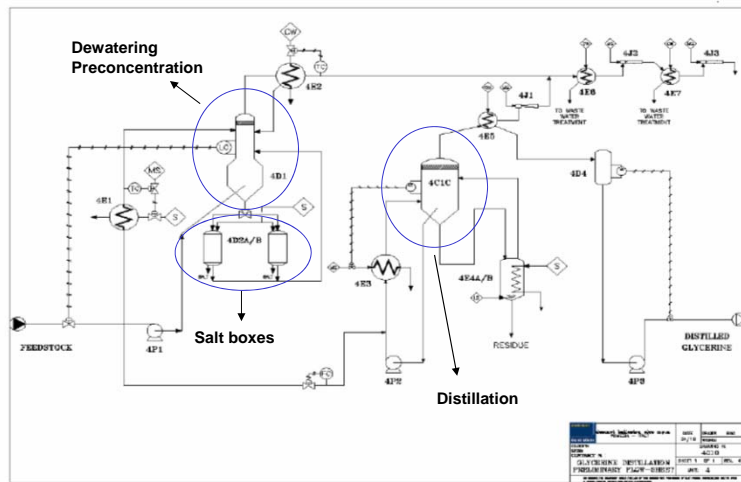
Pharma grade glycerol
Quality specs

Purity : min. 99.7%
Color : max. 5 APHA
Ash : max. 0.01%
Water : max. 0.2 %

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Distilled Glycerol Refining Process



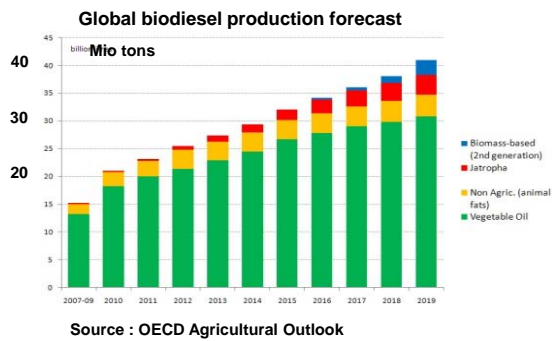
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Biodiesel Industry in 2020

Biodiesel production will increase, but to which volume ?

OECD forecast : 40 Mio tons in 2020



MAIN ISSUES/UNCERTANTIES

- Policy measures supporting biofuels
- Availability of new feedstocks
- Sustainability criteria
- Development of second generation (lignocellulosic) biofuels
- Evolution of diesel fleet

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Second generation biodiesel

= Biodiesel (FAME) produced from more 'sustainable' feedstocks by a more 'sustainable' technology

Second Generation Feedstocks

- * High FFA feedstocks (like Palm FAD,...)
- * Technical (non-edible) oils (e.g. Jatropha)
- * Waste oils (e.g. Cat. 1 tallow)



Less 'useful' glycerol per ton biofuel

Second Generation Technology

- * Advanced acid esterification processes
- * Solid catalysts (chemical/enzymes)



More 'pure' glycerol

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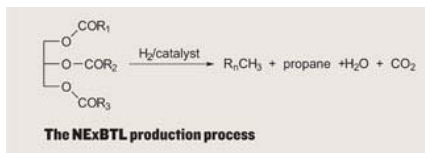


Second generation biofuel

= Biofuel (non-FAME) produced from 'sustainable' feedstocks (oils/fats or lignocellulosic biomass)

Biofuels from Ligno-cellulosic biomass not expected next decade

Second generation biofuel from oils and fats (hydrotreating process)



- Branched alkanes (no FAME)
- No glycerol as co-product
- High cetane number
- Low cloud point

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CONCLUSIONS

- First generation biodiesel boom created a 'glycerol' problem
- Glycerol is an interesting building block for mainly different applications. Current oversupply can be an opportunity
- Glycerine production will always be largely dependent on the biodiesel industry.
- Growth of biodiesel industry is highly uncertain and dependent on a number of unpredictable external factors
- Glycerine market will remain volatile on short-mid term

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oils & fats

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THANK
YOU
FOR
YOUR
ATTENTION
!!!

Science behind technology !

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