Animal Fat from Knackeries for Liquid Fuel and Chemicals Production

Bernd Weber

Ernst A. Stadlbauer, Sabrina Eichenauer,

Andreas Frank, Diedrich Steffens,

Elmar Schlich, Gerhard Schilling

THM TECHNISCHE HOCHSCHULE MITTELHESSEN

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Ideas for a sustainable world
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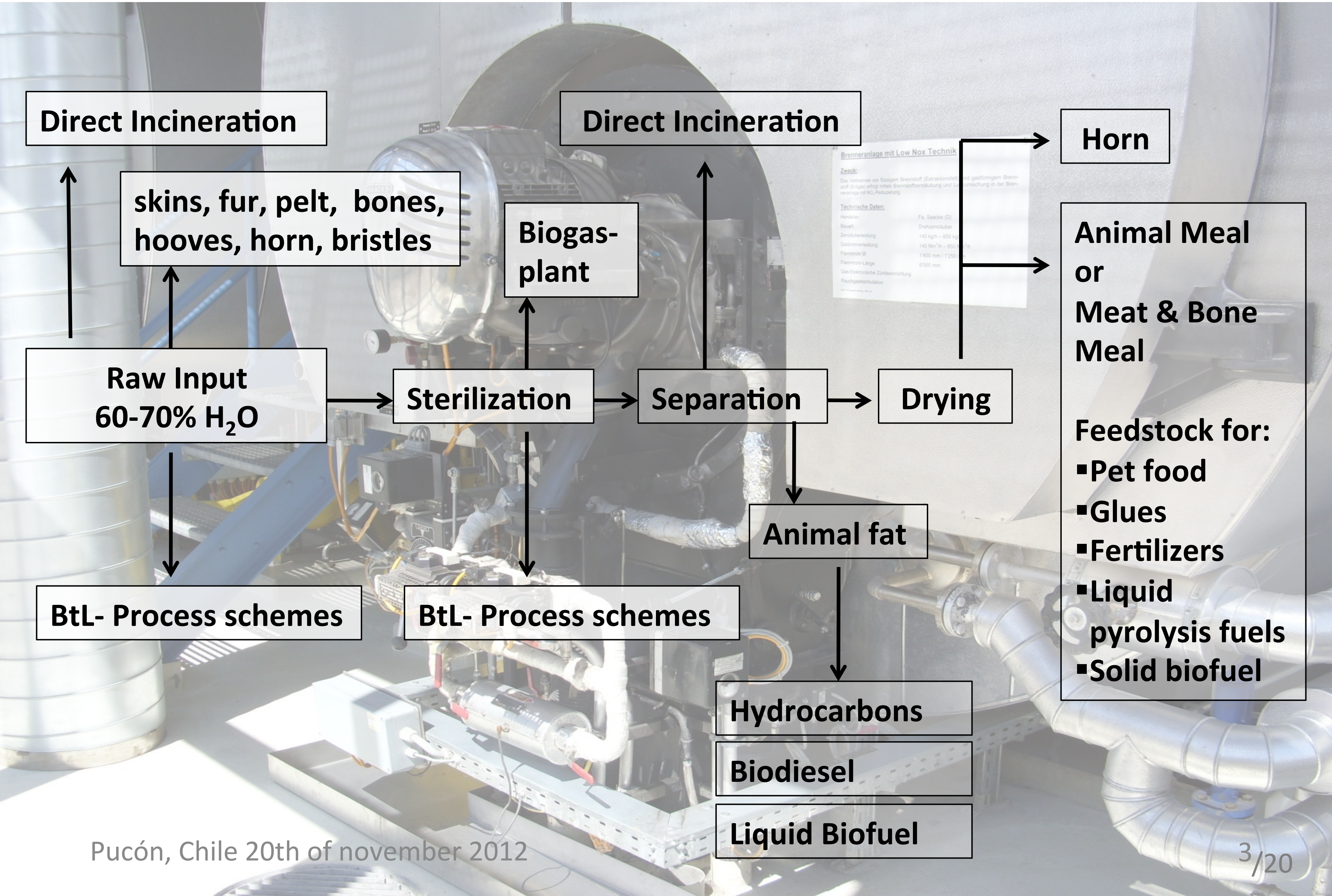
Added Value Products from Knackeries

			Food , Edibles
		3	Petfood, Materials
		3	Forage, Materials
	2	3	Fertilizers, Biofuels
	2	3	Biomass (Biogas/Electricity)
1	2	3	Substitution of primary fossil fuels
1	2	3	Incineration without energy utilization

1. **Animal remains, Animals suspected of TSEs, SRM**
2. **Products of metabolism, harmful animal remains**
3. **Slaughter cattle, suitable for use in food or inedible**
   → besides: blood, skins, fur, pelt, hooves, horn, bristles

Process Scheme of Modern Knackeries



Primary Objective

Feasibility study to explore production of hydrocarbons in view of biofuel and feedstock for chemical industry:

- **From Animal FAT**
- **From free fatty acids (FFA) removed from animal fat or vegetable oils**
- **From Meat & Bone Meal (MBM)**

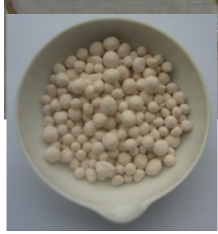
How give an Added Value to Animal Fat produced in Knackeries?

Possible Routs for Utilization and Upgrading of Animal Fat

- **Utilization as liquid fuel in steam boilers**
- **Feedstock for Biodiesel Production**
- **Co-Processing in Catalytic Cracking in Refineries**
- **NexBtL Schemes**
- **Catalytic single Cracking**
- **Decarboxylation in the Low Temperature Conversion Process (LTC) with Sodium Carbonate as Reaction Agent**

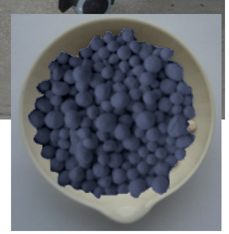
↘ ***These ways are in focus of subsequent discussion***

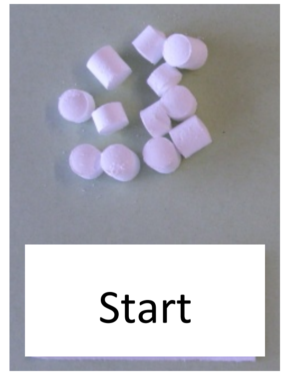
Laboratory Set Up for Thermal Conversion via Reaction with Zeolite or Vapor/Na_2CO_3



Carbon deposits

on Zeolite





Carbon deposits during reaction

on pellets of sodium carbonate

Basic reaction: Vapor/Na_2CO_3 Reaction

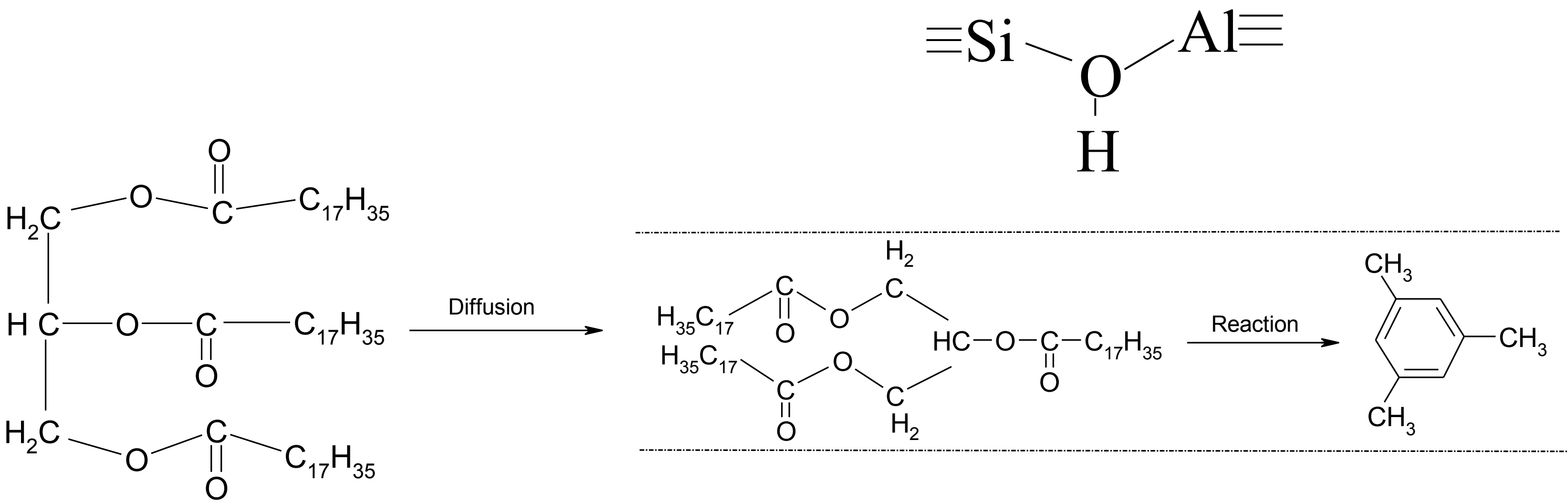
Hydrolysis of Animal Fat at high temperatures in contact with H_2O

$$Na_2CO_3 + H_2O \rightarrow NaOH + NaHCO_3$$

$$R\text{-}COOH + NaOH \rightarrow R\text{-}COONa + H\text{-}OH$$

$$R_1\text{-}COONa + NaOH \rightarrow R_1\text{-}H + Na_2CO_3$$

Model of Conversion of Lipids by Y-Zeolites: Thermal Fragmentation + Shape Selective Restructuring

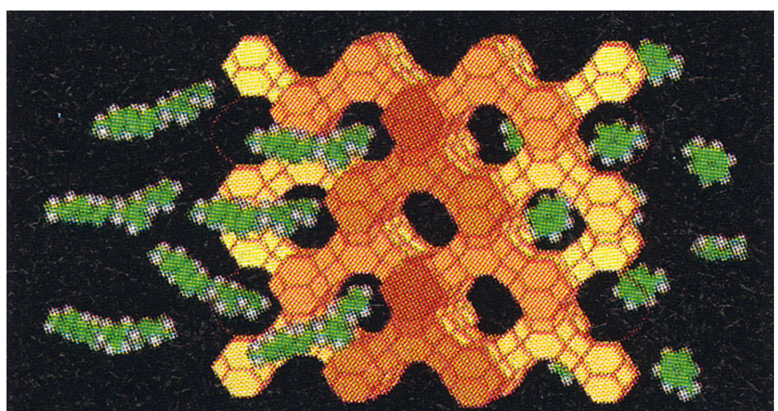


Animal fat

$C_{57}H_{110}O_6$

Zeolite

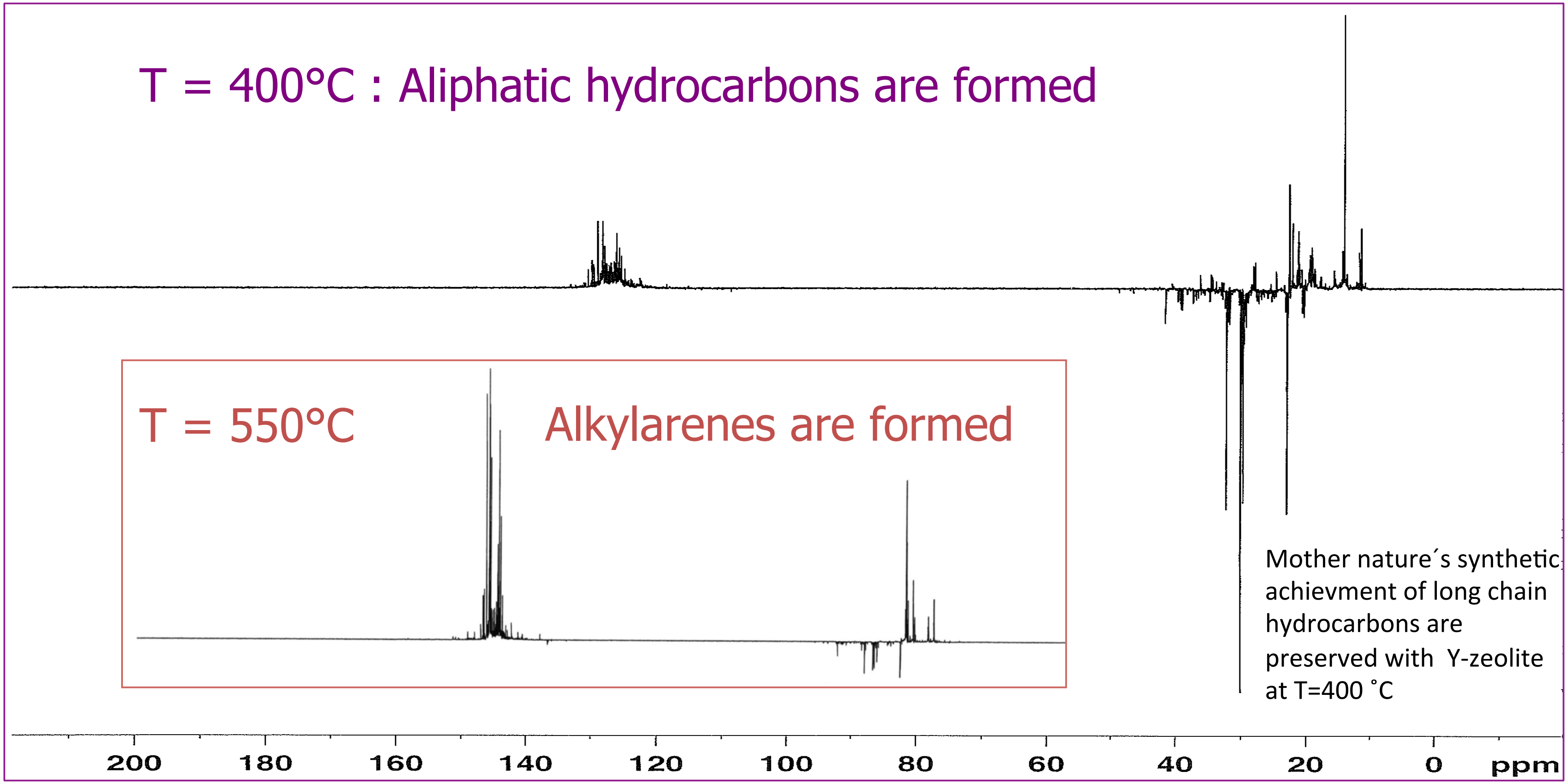
(T = 400 – 550°C)



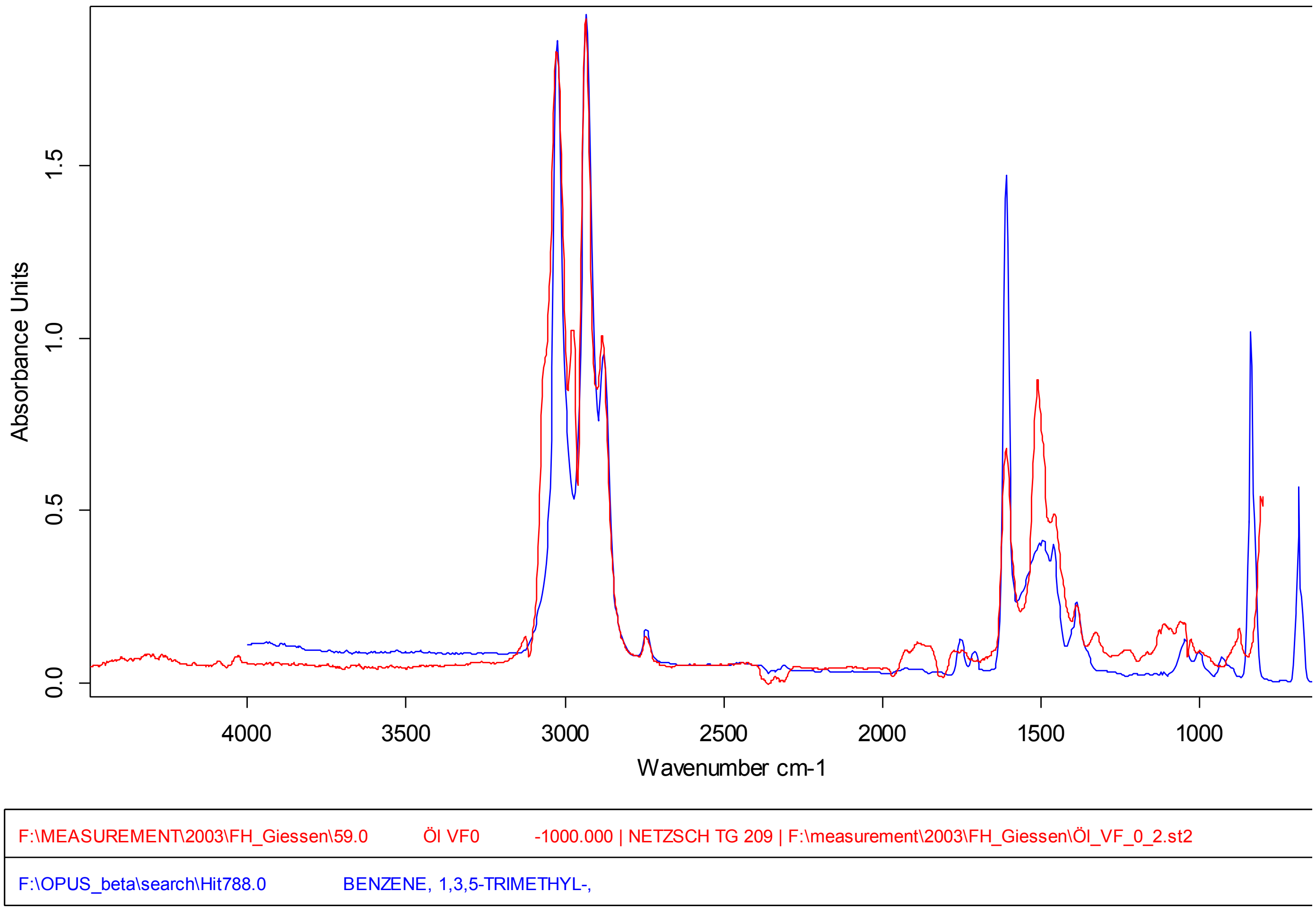
$CH_3\text{-}(CH_2)_n\text{-}CH_3$

$C_6H_3\text{-}(CH_3)_3$

Dept-135 ^{13}C-NMR of Hydrocarbons from Catalytic Decarboxylation of AF at T = 400°C and T = 550°C



Model of Conversion of Lipids by Y-Zeolites: Thermal Fragmentation + Shape Selective Restructuring



Comparison of the conversion of animal fat with Y-Zeolite or Vapor-Soda-Reaction

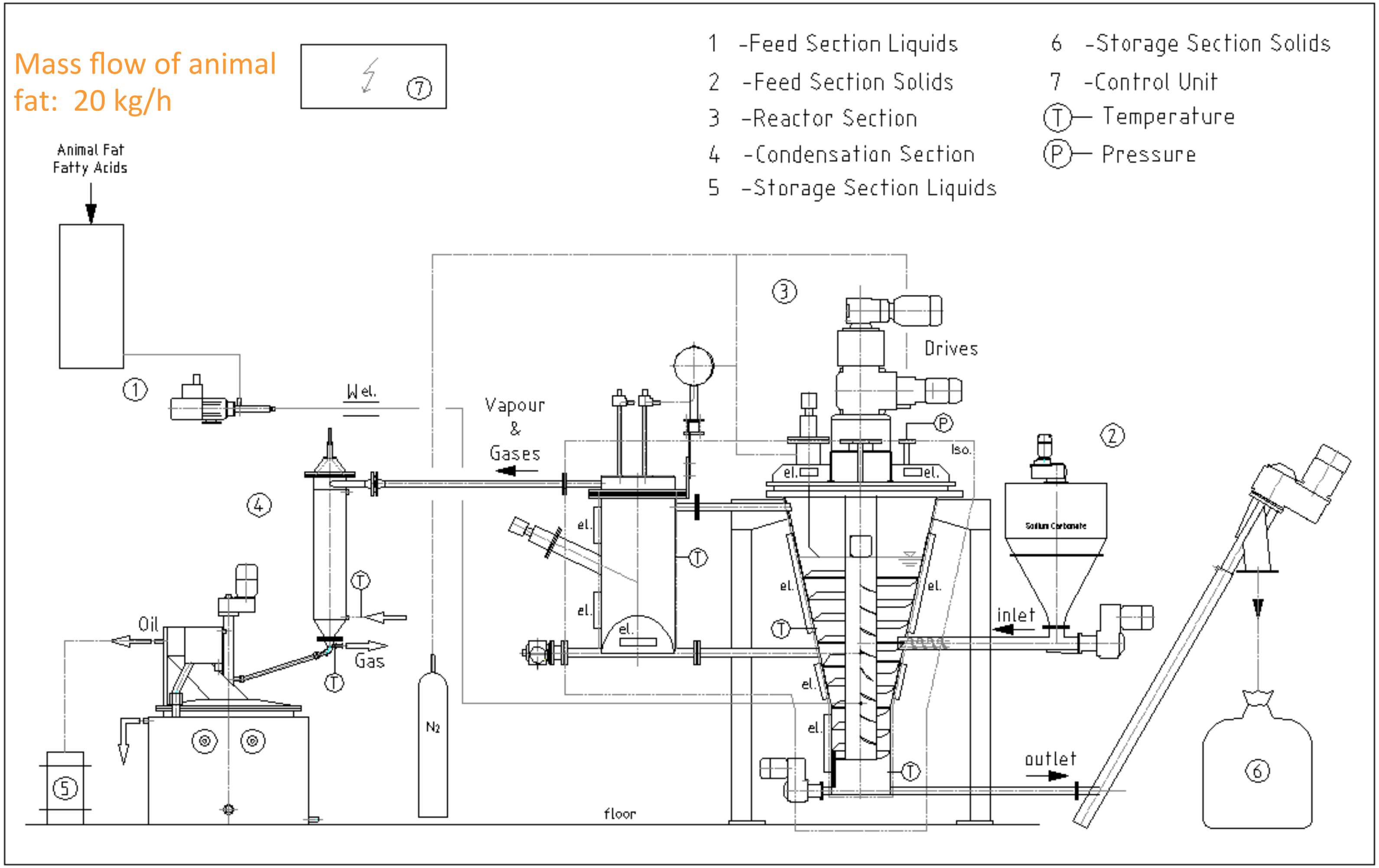
The production of alkylarens with Y-Zeolites could replace components for jet fuel ,but it has to be considered, that the yield of alkylarenes is low and the rate of catalyst deactivation due to carbon deposits is high.

Products obtained passing catalyst pellets	Y-Zeolite		Na_2CO_3 / H_2O
	550 °C	400 °C	400 °C
Carbon on Catalyst	20 - 23%	9 - 19%	5%
Condensates	26 - 29%	39 - 61%	46%
Non Condensable Gas	49 - 51%	29 - 38%	50%

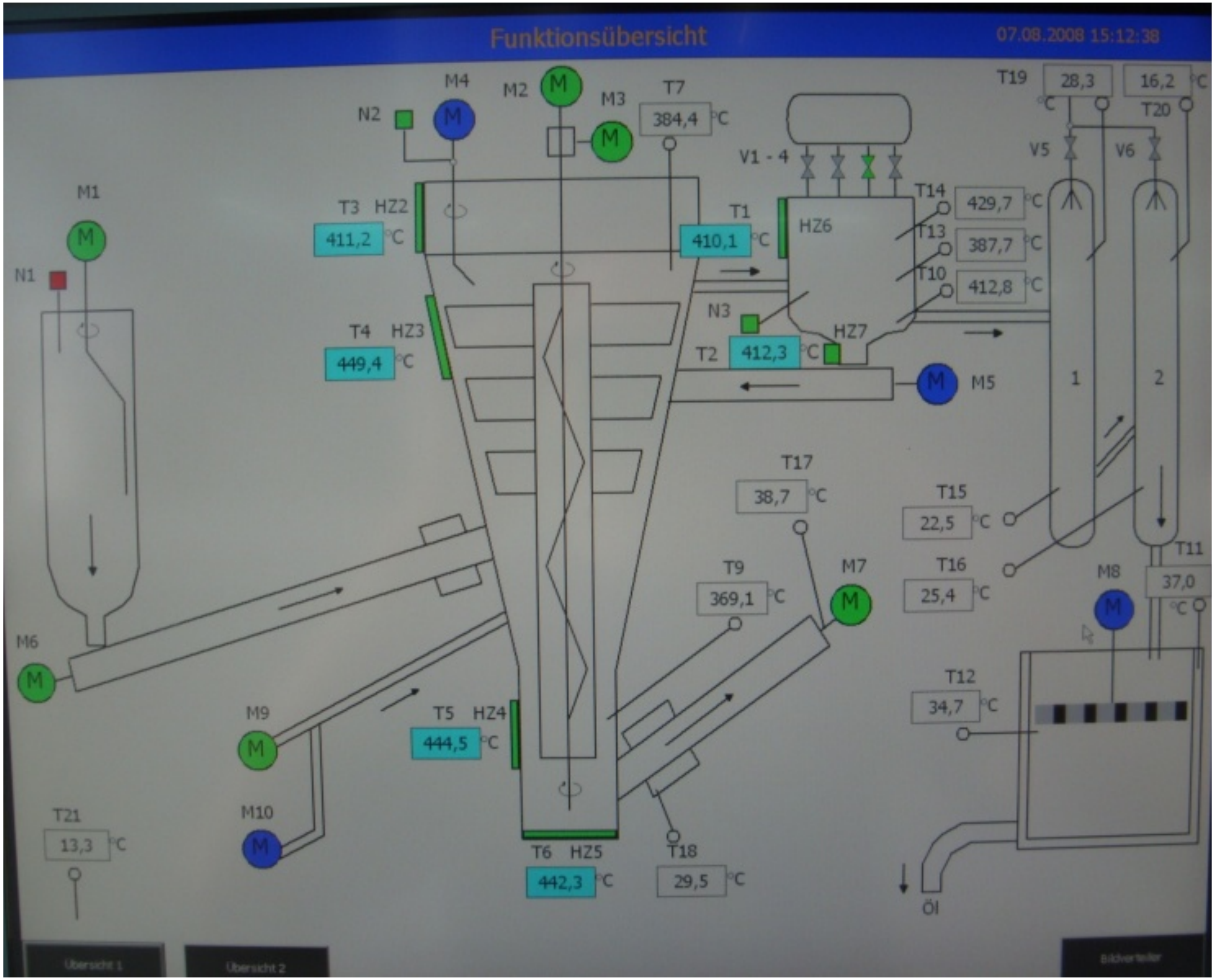
↘ ***The Vapor-Soda-Reaction may be the best option to produce hydrocarbons from animal fat***

Process Scheme of Pilot Plant for the Vapor/ Soda reaction

Mass flow of animal fat: 20 kg/h

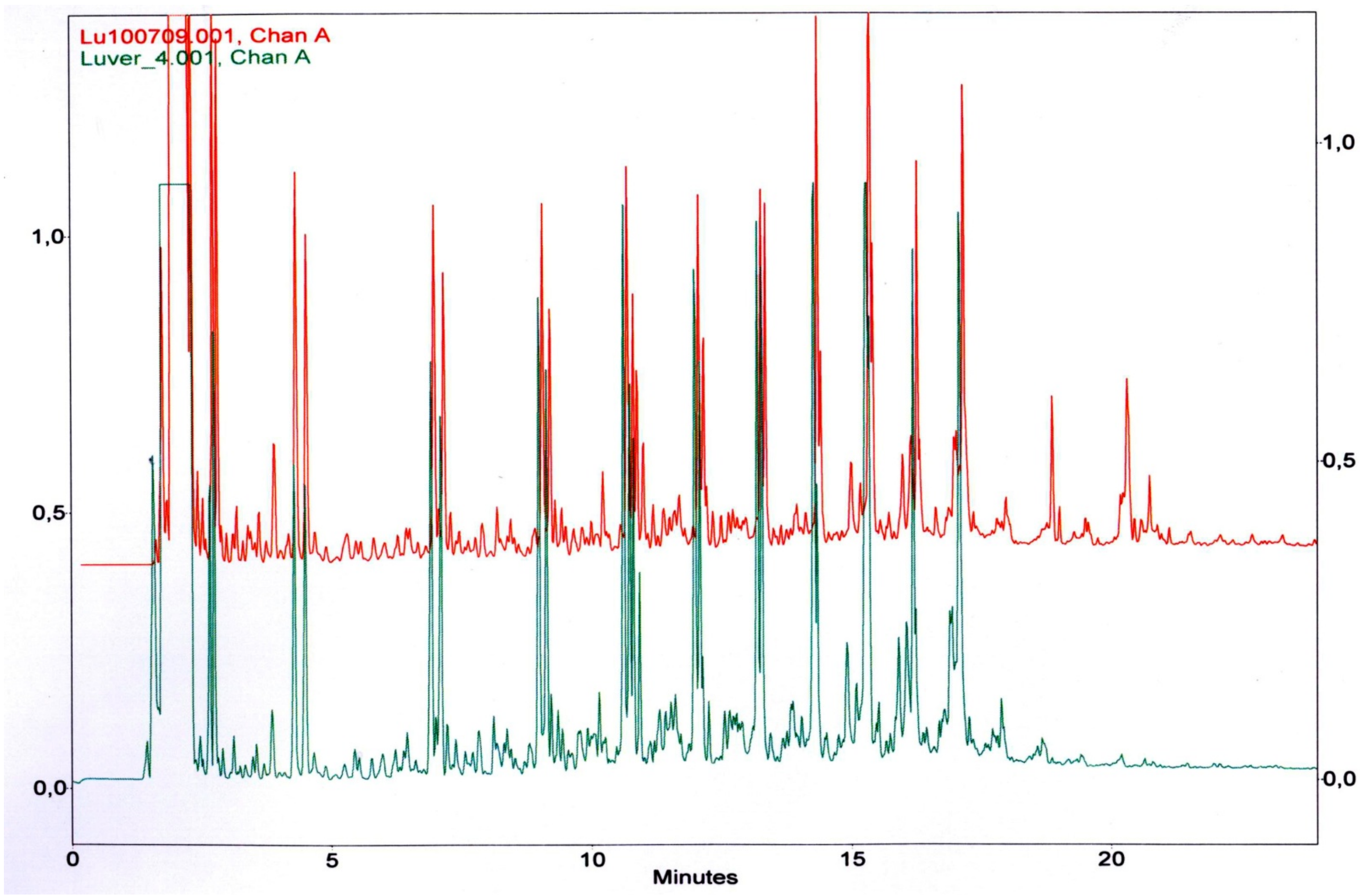


Pilot Plant in Operation in Knackery in Germany



GC of Crude Oil from Animal Fat

(Pilot plant; T = 400°C ±20 °C /Na_2CO_3)

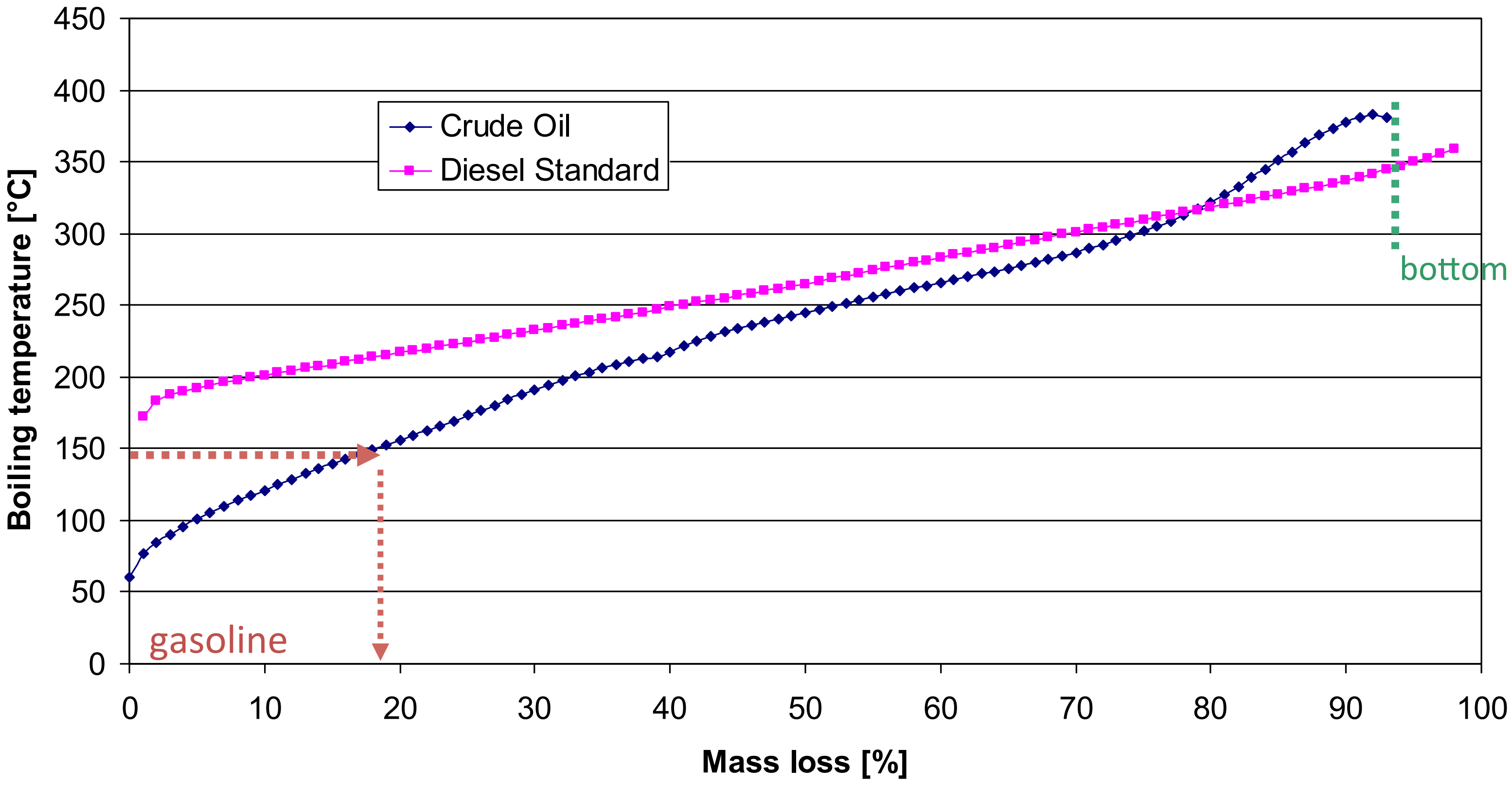


Upper red GC pattern: Original oil

Lower green GC pattern:

Oil after SPE: Removal of polar compounds

True boiling point curve of Crude Oil obtained from Animal Fat at Atmospheric Pressure (EN 3405): 18% gasoline, 72% diesel, 10% bp>360°C



Characteristics of Bio Crude obtained from Conversion of Animal Fats

Parameter	Unit	DIN EN 590	Pilot Plant
Density at 15°C	kg/m³	820-845	815
Viscosity 40°C	mm²/s	2,0 - 4,5	1,78
Flash Point	°C	max. 55	< 30
NCV	MJ/kg	≈42	41,6
Water Content	mg/kg	max. 200	400
Total Sulphur	mg/kg	max. 50	50
Na and K	mg/kg	max. 5	0,1
Ca and Mg	mg/kg	max. 5	0,5
Phosphorus	mg/kg	max. 10	0,5

Upgrading of Bio Crude

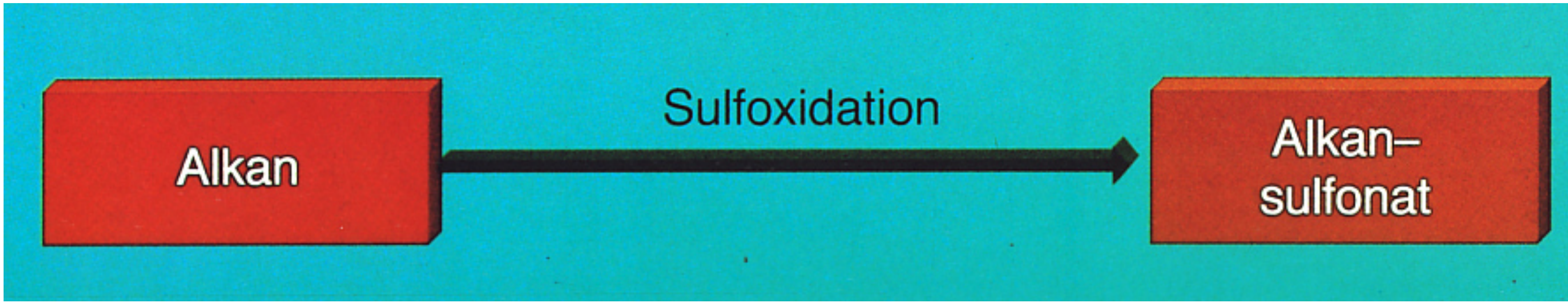
Distillation yields of Bio Crude

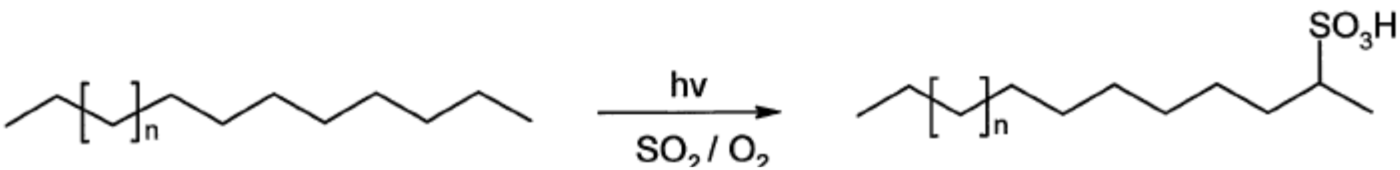
	Yield	
	ref. Animal Fat	ref. Bio Crude
Heavy Oil	9%	13%
Bio Diesel	43%	66%
Bio Gasoline	14%	21%

Parameters of Bio Diesel in comparison to DIN EN 590

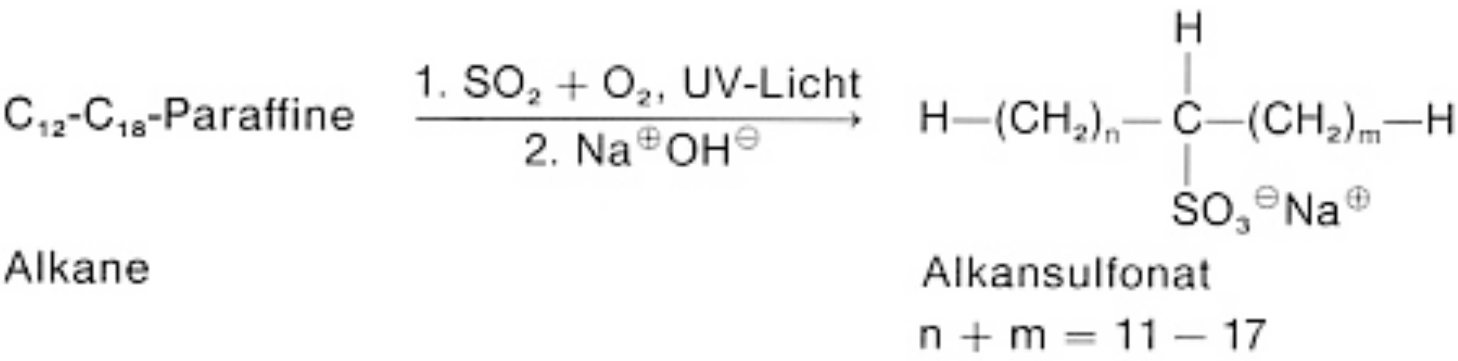
Parameter	Unit	DIN EN 590	Pilot Plant 1
Density at 15°C	kg/m³	820 - 845	818
Viscosity 40°C	mm²/s	2,0 - 4,5	2,0
Flash Point	°C	min. 55	>71
Cetane number	-	min. 51	57
NCV	MJ/kg	≈42	42
Water Content	mg/kg	max. 200	<200
Total Sulphur	mg/kg	50	67
CFPP	mg/kg	03.01 – 11.15	-18
Acid Index	mg/kg	-	1.05
Water Content	mg/kg	max. 200	0.5
Oxidation Stability	g/m3	max. 25	42

Synthesis of Anionic Surfactants





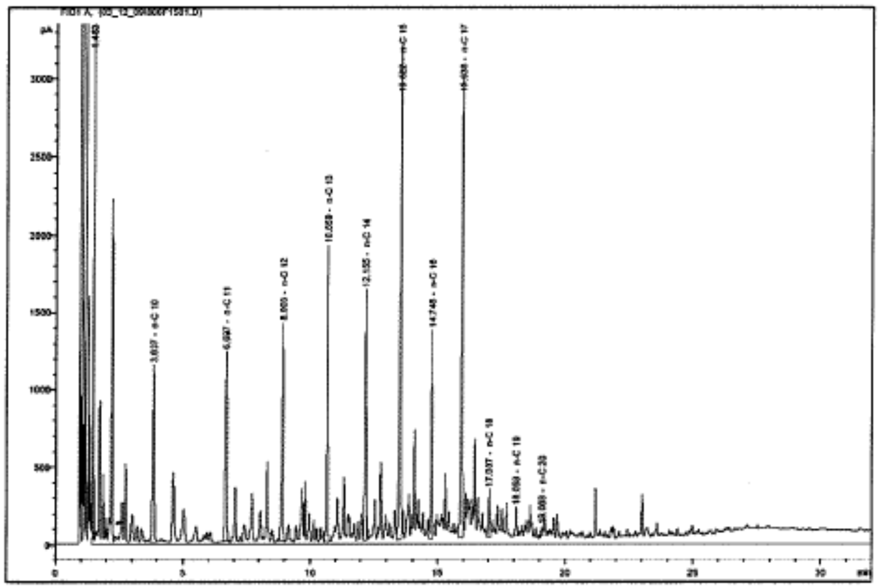
Alkansulfonat-Herstellung:



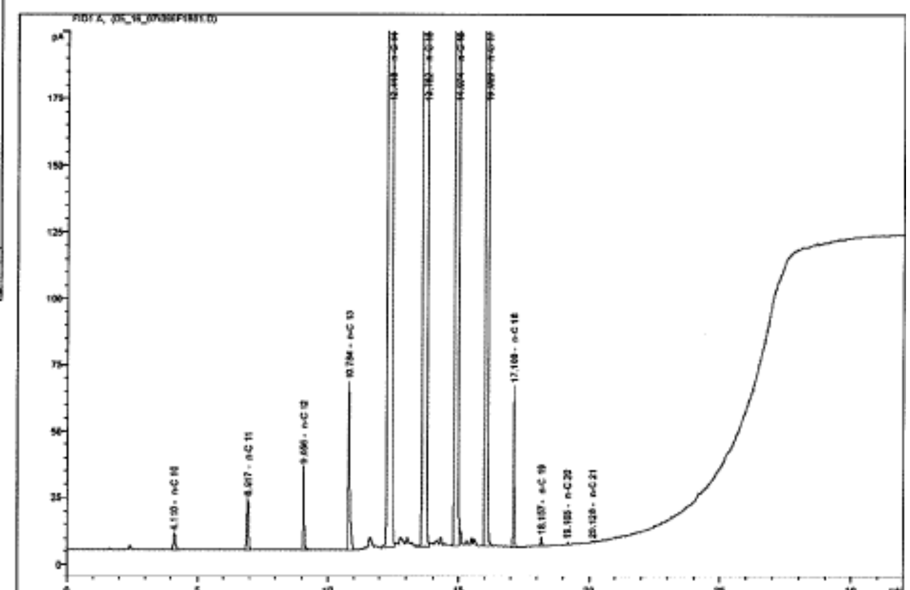
Synthesis of Anionic Surfactants

n-paraffin from NTK Crude Oil: Purity 41.4 % (n-paraffin content) with paraffins from C8 to C18

Cost of industrial n-paraffin	1 €/kg
Cost Fossil Diesel Fuel	1.2 €/kg



n-paraffin from refinery:
Purity 99.7 % mainly contains C15; C16; C17 and C18



Results from Experiments:
Presence of alkenes and greenish color of Bio Diesel does not permit the photo-oxidation of alkanes into sulfoalkanes.

Conclusions

- **The Decarboxylation of Lipids in the Vapor/Soda Reaction is more effective than common catalytic cracking processes in refineries due to lower carbonization rate.**
- **Main disadvantage is the production of various fractions.**
- **Quality of Biodiesel obtained by Distillation is better than Biodiesel via trans-esterification.**
- **Bio Crude can be Feedstock for Alkansulfonates but in addition to Distillation the Hydrotreating of Alkenes is required.**

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bweber@uaemex.mx