



Fatty Acid Technology

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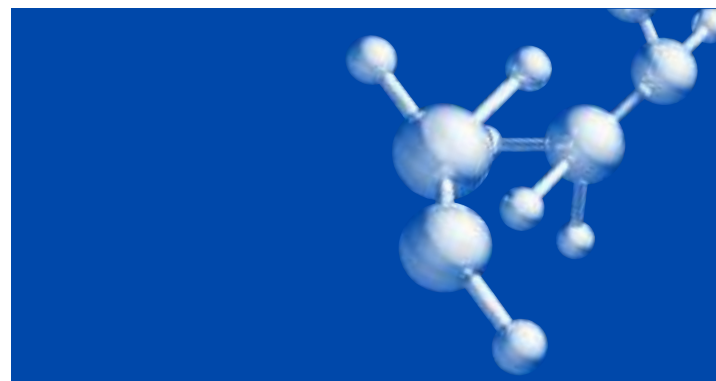
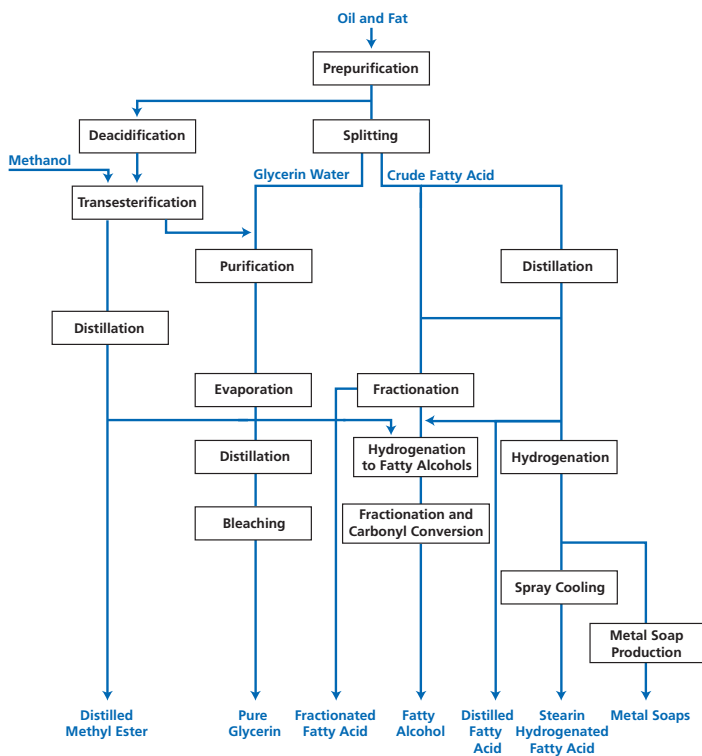
Introduction

Today, on account of their wide range of applications, fatty acids, glycerin, methyl ester and their derivatives have found their way into almost every branch of industry.

Although only approximately 15 % of the world production of oils and fats is used for making these products they are of major importance, particularly for the chemical industry.

This is relatively simple with regard to glycerin – glycerin is used for example for the production of anti-freezing compounds, softeners, solvents, lubricants, brake fluids, moistening agents, alkyd resins, emulsifying agents, nitro-glycerin.

It is advisable to provide a clear picture to subdivide the fatty acids and their derivatives into three groups according to their technical application as follows:



Processing Routes
Oil to Oleochemicals

Wax-like and oily compounds

This group comprises the fatty acids proper including iso-merized and dimerized fatty acids, fatty acid esters and, to a certain extent, also their amides, fatty alcohol and fatty alcohol esters. The properties "wax like" and "oily" indicate the possible applications of these compounds.

Surface-active compounds

These are mainly added to detergents and cleaners or serve as emulsifying agents such as soaps, fatty acid polyglycol esters, oxalkylized alkanolamides, fat amines, ester sulfonates and fatty alcohol derivatives such as sulfates, polyglycol esters and polyglycol ester sulfates.

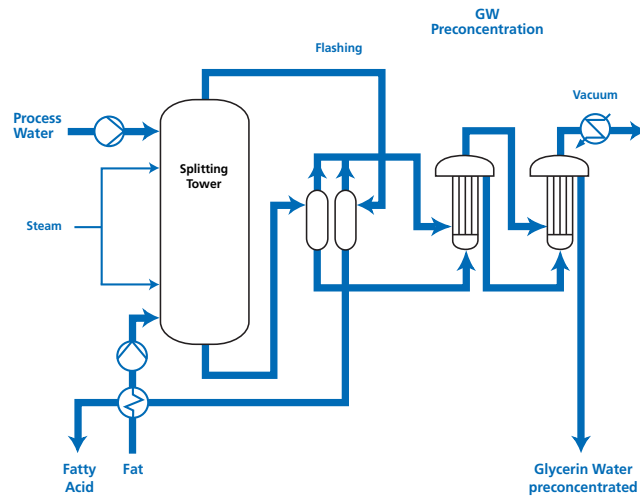
Fat-nitrogen compounds

This group comprises for example the fatty acid amides, fat amines and alkanol amides. These compounds are significant as anticorrosion agents for the production of textile additives and bitumen coatings and as anti-caking agents for dust-free fertilizers.

Lurgi incorporated this diversified field of fat chemistry into its activities many decades ago and developed its own processes which are applied in almost every country through-out the world.

Intensive research and extensive expertise from realized projects have placed Lurgi in an ideal position to offer complex or customized plants for the recovery of profitable, high-quality end products from the following processes:

- Pressure splitting of fats and oils
- Glycerin recovery
- Fatty acid distillation
- Thermal fatty acid fractionation (to high purity fractions)
- Catalytic hydrogenation of fatty acids
- Spray cooling of fatty acids
- Metal soap production
- Methyl ester/Biodiesel production
- Fatty alcohol production



Single-stage counter-current splitting with pre-concentration.

Pressure Splitting of Fats and Oils

Highlights

- High splitting degree of 99 % and above
- Built-in heat exchanger for thermal efficiency
- Low steam consumption by thermally integrated process flow

Since the late 1920s Lurgi has built numerous plants for the thermal pressure splitting of oils and fats with water into fatty acid and glycerin. The process is simple. Plant operation is economic without polluting of the environment. Lurgi today offers modern, continuous counter-current splitting towers (splitting temperature 260 °C, pressure 55 bar).

Feedstock

Crude fats and oils such as tallow, coconut oil, palm oil and palm kernel oil, fish oil, distillation and refining residues.

Products

Crude fatty acids and glycerin water.

Process Description

The single-stage counter-current splitting process in a tower is particularly suited for the handling of larger feed rates. It operates continuously, permitting maximum heat recovery. The splitting temperature of 245–255 °C ensures adequate dissolving of the aqueous phase in the fat so that physical agitation is not required. The crude fat passes through the tower from bottom to top as a coherent phase, while the heavy splitting water travels downwards as a dispersed phase through the mixture of fat and fatty acid. Splitting efficiencies of 99 % and above are reached consistently.

Technical Data

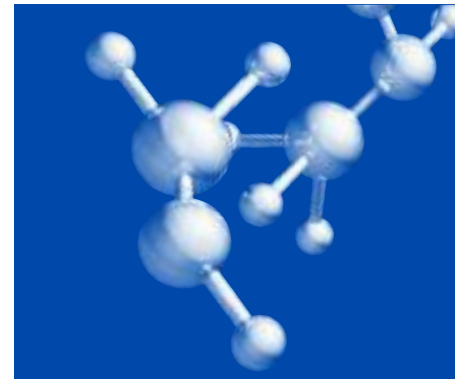
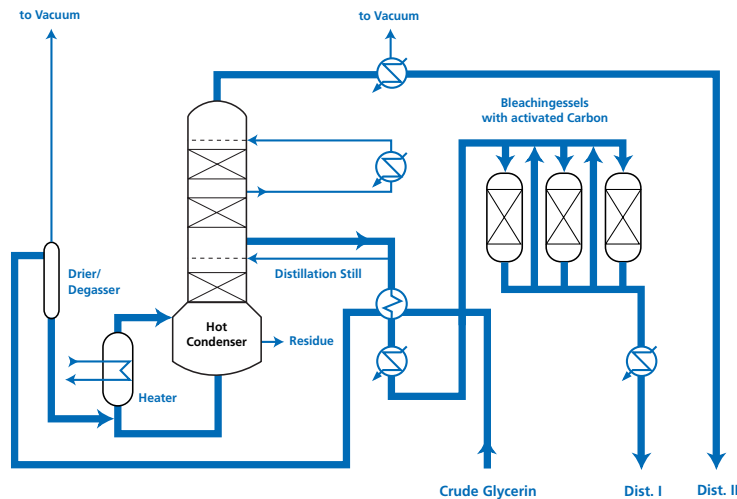
- Plant capacity 50–400 t/d

Product and utility consumption for tallow processing products

- Degree of splitting glycerin water ≥ 99 %
- Concentration, with pre-concentration 12–16 %
- By flashing vapours 20–35 %

Approx. utility consumption per ton of crude fat

- Heating steam, 60 bar 160 kg
- Cooling water, 20 °C 12 m³
- Electrical energy 10 kWh
- Process water 0.6 m³



Glycerin Distillation and Bleaching

Glycerin Recovery

Highlights

- Continuous operation
- Optimized chemical dosing
- Low glycerin losses
- High yield
- Best color APHA <5
- Low ester value <0.3

Feedstock

Glycerin water from the splitting of fats and oils containing 12 to 25 % glycerin ("saponification glycerin").

Products

Glycerin with 99.8 % purity and pharmaceutical quality.

Process

- Impurities – dissolved fatty material and proteins – are separated from the crude sweet water by the addition of mineral acids in a purification step; subsequently, the crude glycerin is treated with acid and neutralized.
- In a continuous, multi-stage evaporation unit the glycerin water is concentrated by water evaporation to crude glycerin of approx. 88 %.
- In a still, the glycerin is then distilled off the crude glycerin in a vacuum of approx. 15 mbar and at a temperature of approx. 160°C.

Undistilled residue is drained from time to time from the bottom of the still and processed further either in post distillation stills or wiped film evaporators. The major part of the glycerin vapor (approx. 92–95 % distillate I) is condensed in the "hot condenser". In the downstream "cold condenser", low-volatile components and the residual glycerin vapor are separately condensed together with the low-volatile com-

ponents (approx. 5–8 % distillate II) in order to secure odor and color-free quality of the distillate I.

- For the production of pharmaceutical glycerin, traces of color and odors are removed by adsorption on activated carbon in a fixed bed bleaching unit to meet high quality requirements.

Technical Data

Plant capacities

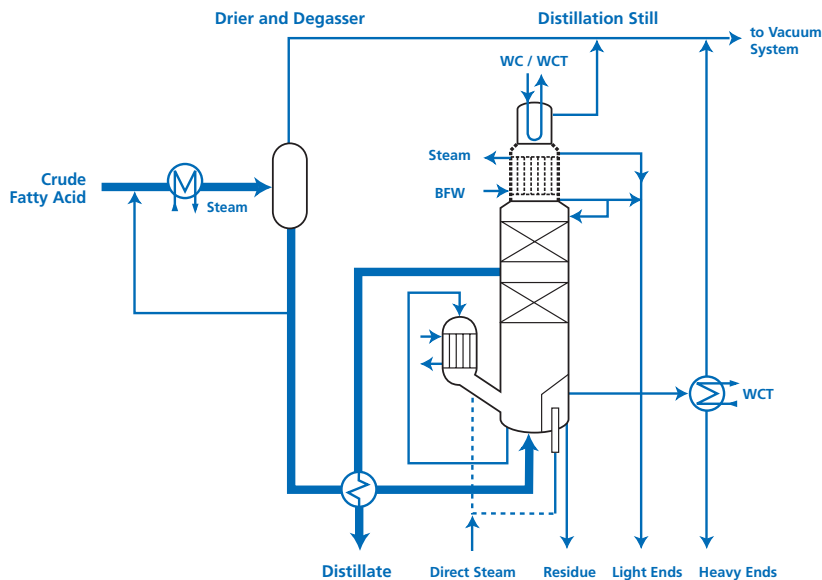
(1) Glycerin water pre-purification	from 50 t/d or more
(2) Glycerin water evaporation	from 50 t/d or more
(3) Glycerin distillation*	from 5 t/d or more
(4) Glycerin bleaching*	from 5 t/d or more

*Referred to glycerin distillate I

Approximate utility consumption per ton of distillate I

	(1)	(2)	(3)	(4)
Saturated steam 4 – 13 bar kg	600	800	2100	
Cooling water 20 °C, dt 6 °C m ³	–	90	130	5
Electrical energy kWh	15	12	30	8
Hydrochloric acid 35 % kg	3–4			
Sodium hydroxide kg	3–4		2–3	
Activated carbon kg				1–3

- (1) Pre-purification plant, 70 t/d with glycerin water feed concentration = 36 %
- (2) Evaporation plant, 1,750 kg/h water evaporation
- (3) Glycerin distillation plant, 24 t/d, distillate I
- (4) Glycerin bleaching plant, 24 t/d



Fatty Acid Distillation with falling film evaporator heavy/light ends separation and steam generator.

Fatty Acid Distillation

Due to their thermolability, fatty acids have to be distilled at low temperatures and in high vacuum. In conventional vacuum distillation, however, the hydrostatic pressure of the liquid above the heating surfaces partly destroys the effect of the vacuum. In the system developed by Lurgi, evaporation therefore does not take place on the heating surface, but only in the vapor space; this way, the vacuum becomes fully effective. This method is generally suitable for all distillation materials that are susceptible to heat, such as fatty alcohols, caprolactam, etc.

Feedstock

Crude fatty acids from splitting oils and fats.

Products

Distilled fatty acids, free of light and heavy boiling components.

Process Principle

The fatty acid is evaporated under vacuum (occasionally with the addition of live steam for fatty acid circulation and partial pressure reduction).

Process

The crude fatty acid is pre-processed in the drier and degasser under vacuum to prevent oxidative reactions in the subsequent operation. It is then pumped into the distillation still, which is equipped with two segments of structured packing and, optionally, with a heavy ends separation

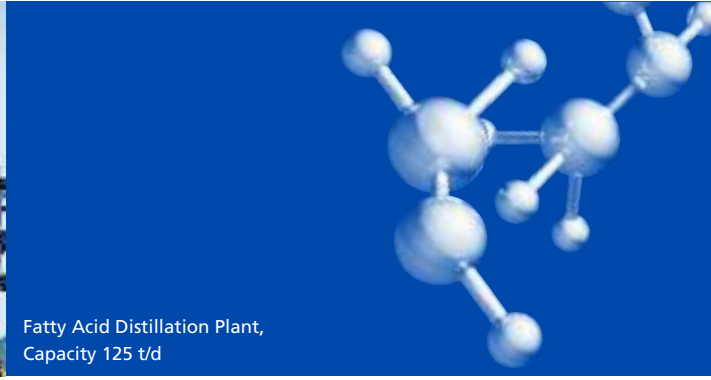
chamber at the bottom. Modern falling film evaporation systems ensure a gentle thermal evaporation of the fatty acids without adverse effects on the product quality. The fatty acid vapors are condensed in surface condensers. To remove low-volatile light end components causing odor and color, the main distillate is taken out as a middle fraction and the light ends as the top fraction. Heavy ends, primarily color carriers, can either be withdrawn separately or recycled directly for complete or partial redistillation.

Highlights

- Reduced thermal stress by use of falling film evaporators
- Best product color by use of internal heavy ends sections
- Heat recovery by steam generation and efficient use of heat exchangers

Technical Data

Plant sizes	50–200 t/d
Approx. utility consumption per ton of crude fatty acid	
Heating steam 50 bar	370 kg
Steam 3–10 bar	150 kg
Cooling water 20°C	15 m ³
Electrical energy	5 kWh
Export steam 3 bar	120 kg



Fatty Acid Distillation Plant,
Capacity 125 t/d

Fatty Acid Fractionation

Highlights

- Tailor-made design for highest product quality
- Low thermal effect on product material
- Optimized heat recovery

Fractionation facilitates the separation of fatty acid mixtures into composite cuts or even into individual components. The process developed by Lurgi is also suited for the fractionation of methyl esters of fatty acids, fatty alcohol and other organic substances of high molecular weight and distinct boiling patterns of the individual carbon chain components. Due to the fact that fatty acids are susceptible to excessive heat exposure, distillation is performed at the lowest possible temperatures and under high vacuum.

Feedstock

Distilled and undistilled fatty acids (splitting efficiency not less than 96 %).

Products

Fatty acid fractions of purities up to 99.5 %.

Process

The fatty acids are fractionated in vacuum columns equipped with structured packing which allow high separation efficiency and low pressure drop. Falling film evaporators are provided to gently evaporate the liquid phase. The vapors are condensed in surface condensers.

The mode of operation depends on the particular fractionation task, for example:

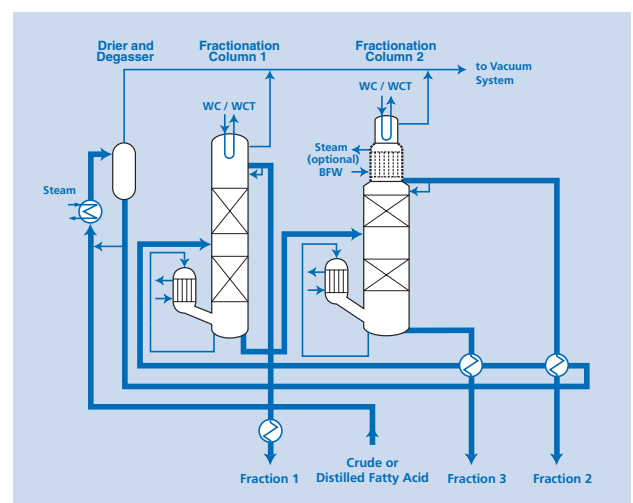
Crude fatty acid is dried, degassed and then evaporated in fractionation column 1 under a residual vacuum.

Fraction 1 is withdrawn from the column top. The bottom product from column 1 is transferred to the feedpoint of column 2 and evaporated under a vacuum. The condenser for column 2 is designed for heat recovery by steam generation followed by a final condenser.

Achievable purities are approx. 99.5 % for a C₁₂ fraction from palm kernel or coconut fatty acid and approx. 95 % for a C₂₂ fraction from rapeseed oil fatty acid, respectively.

Plant Size

350 tpd fatty acids or higher. Utility consumption depending on fractionation task. Multi-column plant concept possible to meet specific separation objectives.



Fractionation column with falling film evaporator and steam generator

Hydrogenation of Fatty Acid

Highlights

- Continuous operation
- Low iodine value
- Low catalyst consumption
- Low hydrogen consumption

Continuous hydrogenation of fatty acids can be done either in a classic Slurry Batch Process or, alternatively, in continuous mode.

Both systems can also be used for processing neutral oils.

Feedstock

Unsaturated crude and distilled fatty acids. Hydrogen with a purity of more than 99.5 %. Ni catalyst for Slurry Reactor. Pd catalyst for Fixed Bed Reactor.

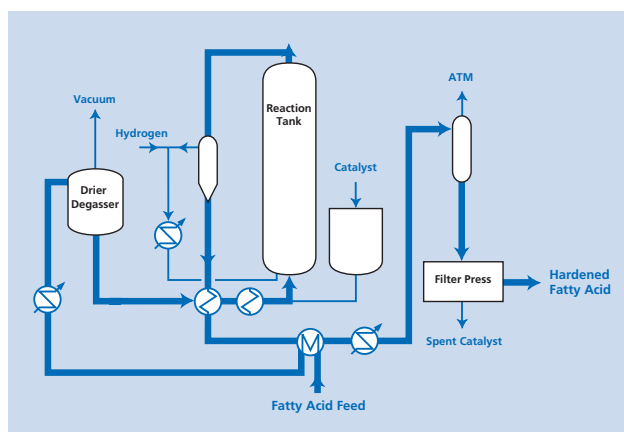
Products

Completely hydrogenated fatty acids for a great variety of applications.

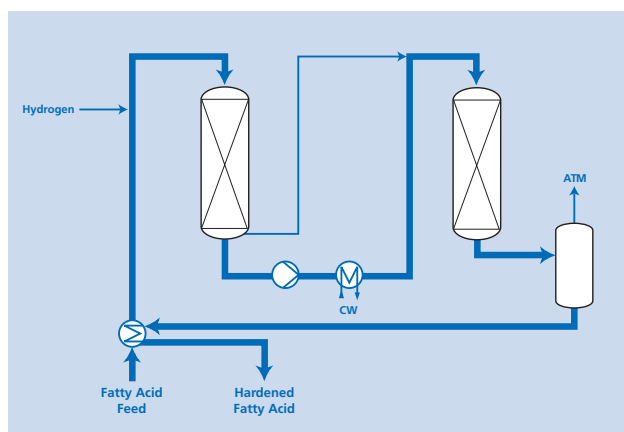
Process

Unsaturated fatty acids are continuously hydrogenated in the liquid phase of a Slurry Reactor in the presence of nickel powder catalyst or, alternatively, in the trickle phase of a Fixed Bed Reactor in the presence of palladium pellet catalyst.

The melting point of the feedstock will be increased and the iodine number reduced. While in the Slurry Process the feedstock, hydrogen and catalyst are mixed prior to entering the reactor from the bottom, the Fixed Bed Process does not involve any slurry handling and the feedstock directly enters the Fixed Bed Reactor at the top as a trickle phase.



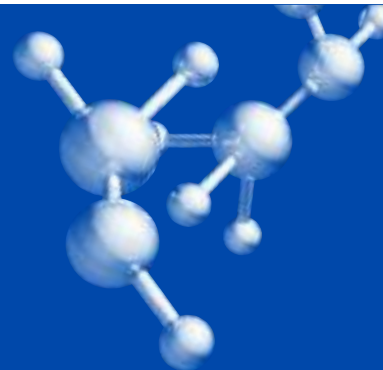
Continuous Hydrogenation with Slurry Reactor



Continuous Hydrogenation with Fixed Bed Reactor



Continuous Hydrogenation Plant



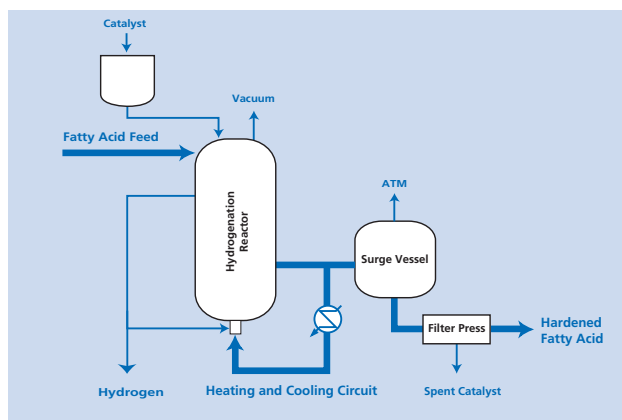
Batch Operation

Highlights

- High product flexibility by batch operation
- Complete or partial hydrogenation
- Discontinuous hydrogenation of fatty acids (jet reactor system)

Feedstock is pumped into the hydrogenation autoclave and heated with steam (approx. 10 bar) in an external heater/cooler. At the same time, the residual moisture is evaporated under vacuum (40–55 mbar). When the feedstock is dry, the vacuum is shut down and the connections are closed. Catalyst is added and hydrogen admitted.

As the circulating fatty acid passes the ejector in the reactor bottom, it draws the hydrogen. This provides for an intimate mixture of the components and facilitates an efficient adsorption of hydrogen by the fatty acid as it rises in the inner tube of the autoclave.

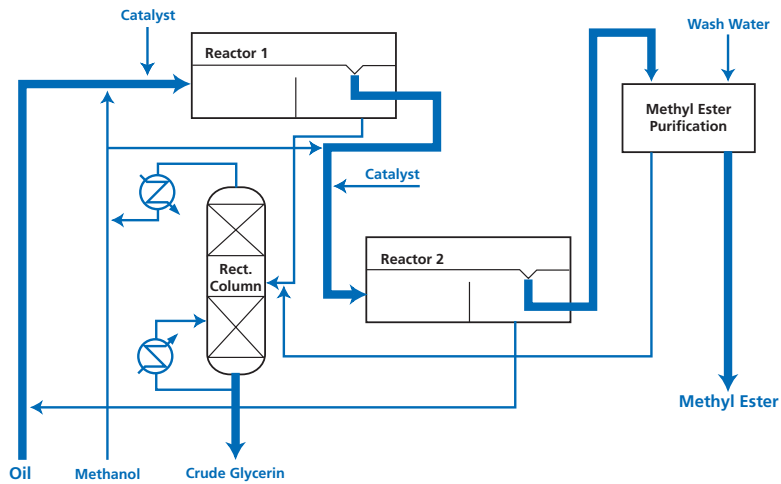


Batch Hydrogenation

When the desired melting point and/or iodine number has been reached, the hydrogen supply is interrupted. The product is cooled down in the external heat exchanger and flashed into the surge vessel. The catalyst is removed in a filter press.

Technical Data

Plant sizes – continuous	80 t/d or more		
– discontinuous	from 5 t/batch; 8 batches/d		
		(1)	(2)
Pressure	bar	approx. 25	approx. 25
Hydrogenation temperature	°C	up to 220	up to 220
Approximate utility consumption per ton of distilled dry fatty acid			
Steam approx. 3–10 bar	kg	25	40
Cooling water, 20 °C	m ³	4	12
Electrical energy	kWh	13	16
Catalyst consumption (pure nickel)	kg	0.1–0.3	0.3
Hydrogen consumption (0 °C, 1.013 bar)	m ³	60	66
(1) For a continuous plant: Average iodine number reduction of 60 capacity > 100 t/d			
(2) For a discontinuous plant: Average iodine number reduction of 60 capacity 50 t/d < 100 t/d			



Transesterification of Oil to Methyl Ester

Methyl Ester Production

Fatty acid methyl ester (FAME) is the starting material for the production of fatty alcohol and is processed to an active substance in sulfation/sulfonation plants. Moreover, FAME is increasingly used as environmentally-friendly biodiesel fuel.

Feedstock

Degummed and deacidified vegetable oil.

Product

Fatty acid methyl ester, glycerin.

Process

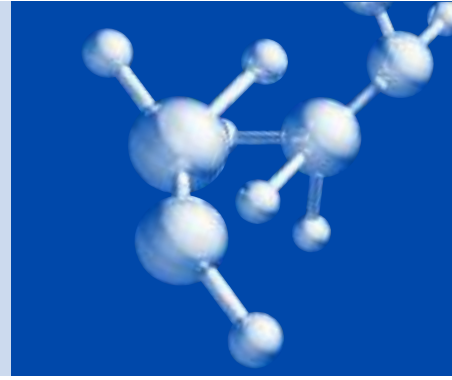
Degummed and neutralized vegetable oil and methanol are reacted in a two-stage mixer/settler arrangement in the presence of a catalyst. The glycerin produced in the reaction is dissolved in the excess methanol and can be recovered in a rectification column. The methyl ester is purified in a counter-current washing column where residual glycerin and methanol are removed. If required, the methyl ester

may be distilled in addition. Degummed and deacidified neutral oil is mixed with the heavy phase from reactor 2, essentially consisting of catalyst-laden methanol and some glycerin, and then fed to reactor 1. The oil is reacted with the methanol in the mixing chamber and the mixture is then separated into a heavier and a lighter phase in the downstream separation chamber.

The glycerin, which contains all the catalyst along with the impurities introduced with the oil, can be upgraded to premium grade pharmaceutical glycerin in a downstream purification stage.

Highlights

- High plant availability
- Ease of operation
- Premium quality biodiesel and glycerin product
- Shortest implementation time due to standardized design and project execution.



Technical Data (per mt of feed)

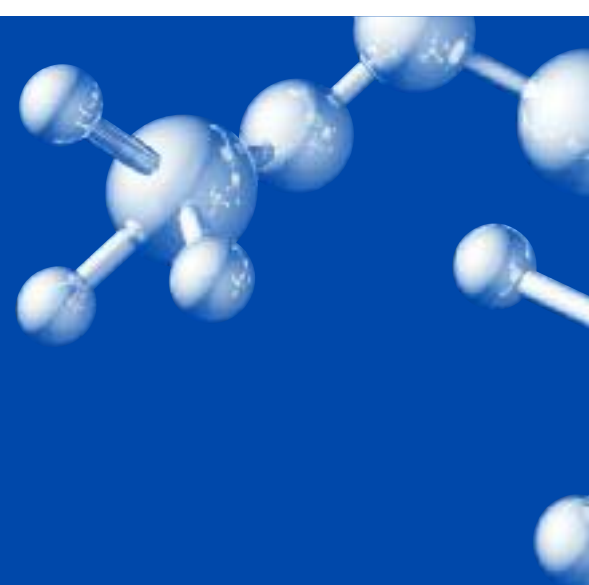
Plant sizes	120 – 750 tpd
Feedstock and utility consumption per ton of ester:	
Methanol depending on feed composition	100 – 140 kg
Oil (PKO)	995 kg
Steam, 4 bar	290 kg
Cooling water; 29 °C	25 m ³
Electrical energy	10 kWh



Lurgi is a leading technology company operating worldwide in the fields of process engineering and plant contracting. Based on syngas, hydrogen production and clean conversion technologies for fuels or chemicals Lurgi offers innovative solutions that allow the operation of environmentally compatible plants with clean and energy-efficient production processes.

Its technological leadership is based on proprietary and exclusively licensed technologies which aim to convert all carbon energy resources (oil, coal, natural gas, biomass, etc.) in clean products.

Lurgi is a member of the Air Liquide Group.



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