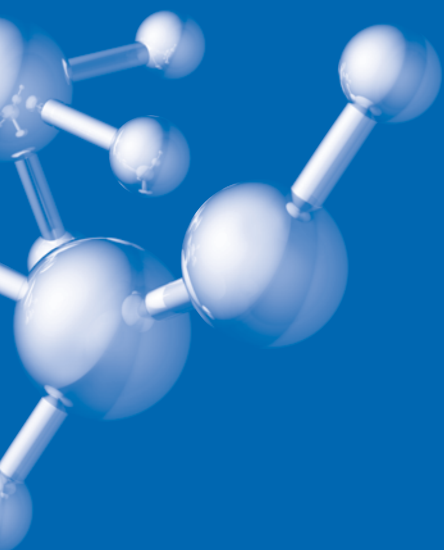
Lurgi



Fatty Alcohol Technology

Introduction

Fatty Alcohol for Detergent

In the past few years, fatty alcohol-based surfactants have gained growing significance in the detergent market due to their excellent washing properties and superior biodegradability compared to conventional detergents made from petrochemical feedstocks.
Nowadays, fatty alcohols derived from renewable resources are an important basestock for the production of cationic, anionic and nonionic surfactants such as fatty alcohol sulfates, ether sulfates, ethoxilates and alkyl polyglucosides.

Since the late 1950s, Lurgi has built a great variety of fatty alcohol plants operating on our proprietary Acid Route with capacities ranging from 3,000 to 30,000 tpa of fatty alcohols.

Drawing on the experience gained with the slurry process, in the early 1980s Lurgi tackled the development of a methyl ester-based process for the production of saturated and unsaturated fatty alcohols.

The first plant using this Methyl Ester Route went on stream in 1994 and can produce 30,000 tpa of unsaturated fatty alcohols or, alternatively, 60,000 tpa of saturated fatty alcohols.

The newly developed Wax Ester Route is now the third generation of Lurgi's fatty alcohol technology and combined the advantages of the two previous routes.

The background for a further Fatty Alcohol Route was the fact that the main chemical reaction of the Acid Route is the

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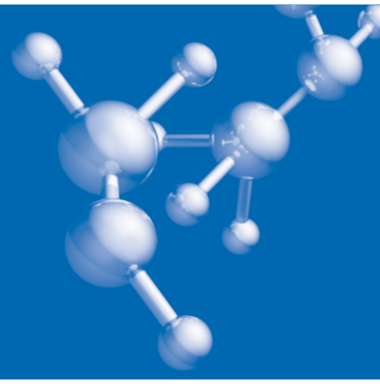
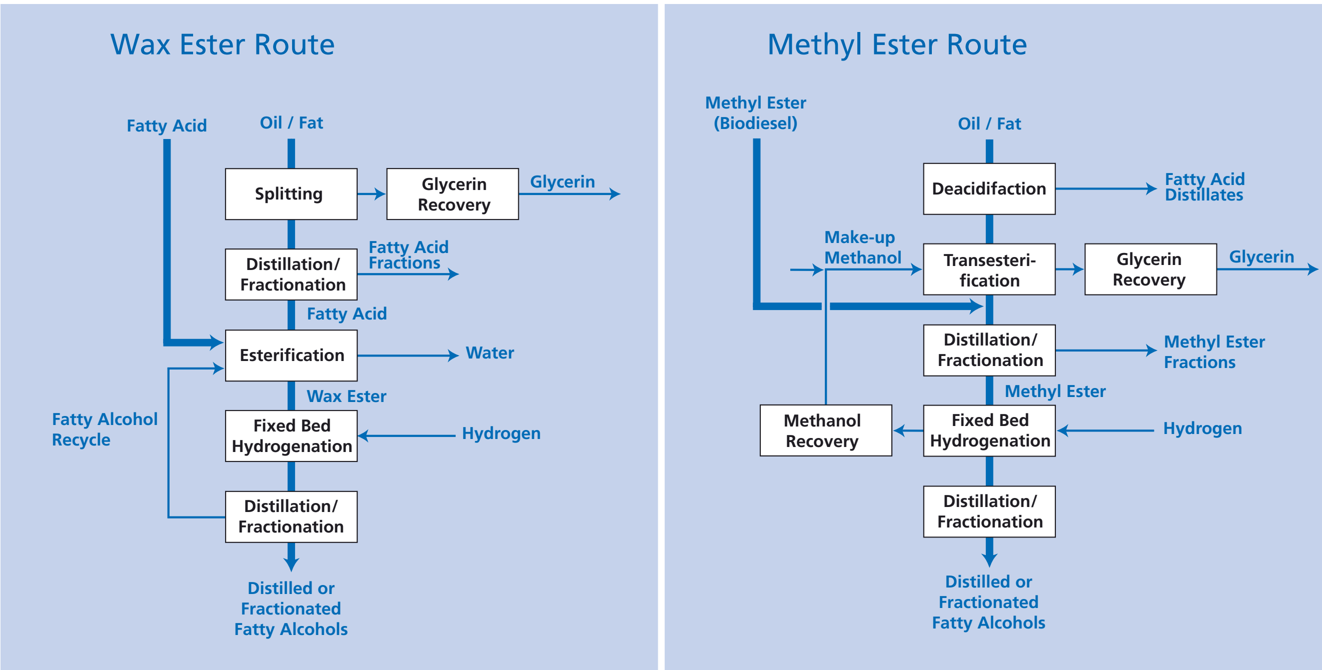
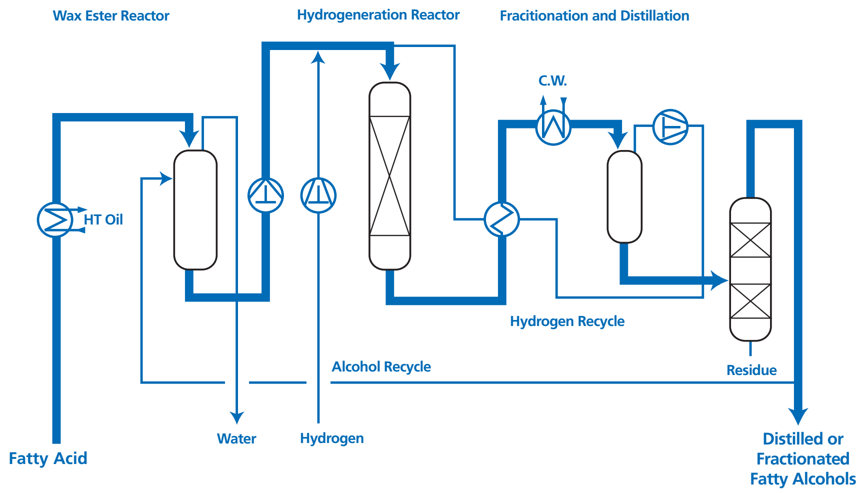


hydrogenation of the internally formed wax ester, and that excellent experience with hydrogenation in a fixed-bed reactor can be applied to this reaction. Because the Wax Ester Route is much more attractive with many advantages regarding investment cost and operating cost compared to the Acid Route, the latter will lose importance to give way to the Methyl Ester and the Wax Ester Route.

Common raw materials for the production of the fatty acid or methyl ester feedstocks are coconut, palm and palm kernel oils, tallow or lard. While fatty acid is produced through high pressure fat splitting, methyl ester for fatty alcohol applications is obtained by transesterification. For a detailed description of these processes, please read our brochure "Fatty Acid Technology".



Both Process Routes from Fatty Alcohol Production (Wax Ester Route and Methyl Ester Route).



Fatty Alcohol Production via Wax Ester

Production of Fatty Alcohol through Hydrogenation of Wax Ester

- No methanol used
- Low catalyst consumption
- Fixed bed reactor

General
The process consists in the preparation of wax ester from fatty acid and subsequent hydrogenation of the wax ester to form fatty alcohol using a fixed-bed reactor.

Feedstock
Distilled or fractionated fatty acid. For applications for detergents, preferred chain lengths are $C_{12/14}$.

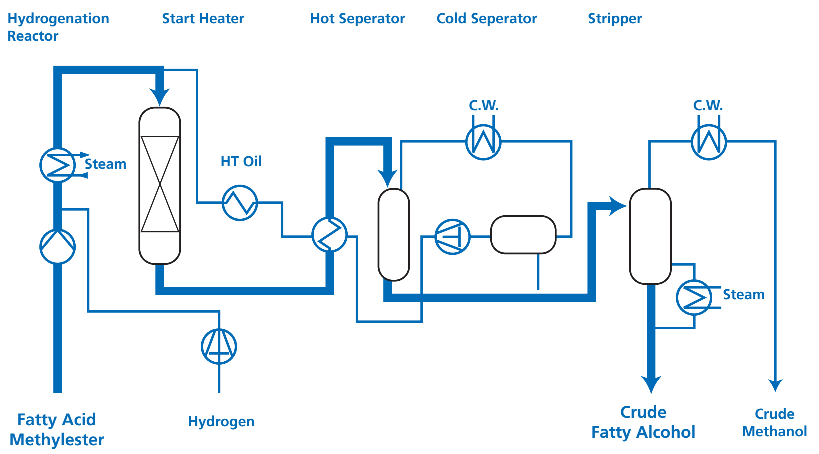
Product
Crude fatty alcohol with chain length according to the carbon number of the fatty acid feedstock.

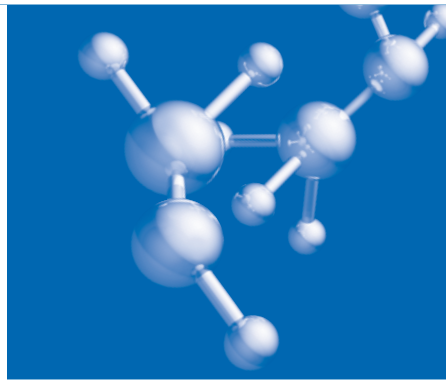
Process
Fatty acid feed is heated and, together with recycled fatty alcohol, enters a reaction system to form wax ester through esterification. Esterification takes place at atmospheric pressure without any use of catalyst. The reaction water leaves the plant. The wax ester is charged to the hydrogenation reactor, together with hydrogen. In the fixed-bed reactor, the liquid trickles down through the catalyst bed, forming fatty alcohols in the process. The reactor discharge product is cooled and separated into recycled hydrogen and liquid crude fatty alcohol. The latter is sent to distillation/ fractionation for further processing. From this, part of fatty alcohol is recycled to the wax ester preparation for further esterification.

Technical Data
Unit capacities: 50, 100, 150, 200, 300 tpd distilled fatty alcohols

Consumption Figures
The consumption figures vary with the feedstock. The figures given below provide a rough guideline and are based on the production of 1000 kg $C_{12/14}$ distilled fatty alcohol:

Fatty acid	1099 kg
Catalyst	< 1 kg
Hydrogen (Purity 99.9 vol. %)	230 m³ (STP)
Cooling water	55 m³
Steam (net consumpt.)	30 kg
Electric power	165 kWh
Nitrogen	10 m³ (STP)
Fuel	1500 MJ





Fatty Alcohol Production
via Methyl Ester

Production of Fatty Alcohols through Hydrogenation of Methyl Esters

- Low catalyst consumptionn
- Fixed bed reactor

General

The process uses a fixed bed reactor for the production of fatty alcohols through hydrogenation of methyl esters.

Feedstock

Distilled or fractionated methyl esters obtained from vegetable or animal feedstocks.

Products

Fatty alcohols with chain lengths according to the carbon number of the methyl ester feedstock. Methanol-water mixture is recovered for reuse in methyl ester production.

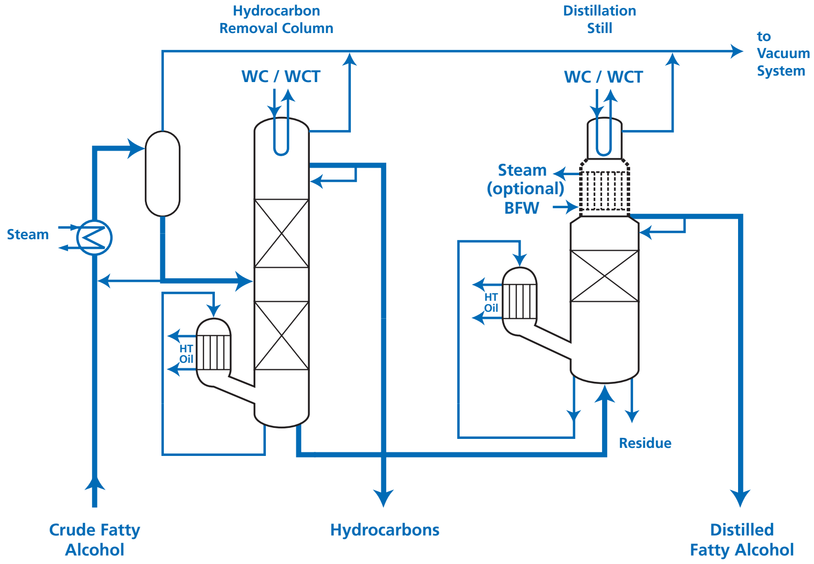
Process

Fatty acid methyl esters and hydrogen are compressed to 250– 300 bar and heated to 210°C. The individual streams are fed to the reactor where the methyl esters are converted to fatty alcohols and methanol. The reactor is packed with copper chromite catalyst in a fixed-bed arrangement. The feed stream trickles through the catalyst bed from top to bottom, from where it discharges into a heat exchanger where its thermal content is used to preheat the circulating hydrogen.

The gaseous phase obtained in the downstream hot separator consists mainly of hydrogen and methanol vapors. This mixture is further cooled to condense the methanol vapors which are then separated from the hydrogen in the cold separator.

The resultant gaseous phase contains the hydrogen which is recycled to the process via the recycle compressor, the heat exchanger and the start heater which controls the reaction temperature.

The liquid phase discharged from the hot separator contains the fatty alcohol product. It is further cooled down, expanded to atmospheric pressure and routed to the stripper together with the liquid phase leaving at the bottom of the cold separator.



Distillation of Fatty Alcohols

Distillation and Fractionation of Crude Fatty Alcohols

General

The distillation process is designed for the removal of side products contained in the crude fatty alcohol feed. If fractionation of the fatty alcohols to defined cuts, e.g. $C_{6\text{-}10}$, $C_{12/14}$, $C_{16/18}$ or $C_{12/18}$ or to pure individual cuts like C_{12}, C_{14}, C_{16}, C_{18} is required, fractionation columns in a suitable number are incorporated into the process chain. Depending on the specific customer requirements, these columns can be designed either for the production of specific cuts or as multi-purpose columns allowing for the production of other composites.

Feedstock

Crude fatty alcohols as obtained from a fatty alcohol production unit.

Products

Distilled fatty alcohols or fatty alcohol fractions with chain lengths according to the carbon number of the fatty alcohol feedstock. In addition, the process generates a residue consisting mainly of unconverted esters. The amount of residue obtained depends on the saponification value of the crude fatty alcohol feedstock.
Fractionation of the fatty alcohols yields the desired pure cuts at purities of up to 99.5% each. Fractionation likewise generates a residue stream in a quantity depending on the saponification value of the crude fatty alcohol feedstock.

Methanol removal from the fatty alcohols is accomplished by direct steam stripping. The crude methanol/water mixture obtained from vapor condensation at the stripper top is routed to intermediate storage before being reprocessed in a methanol recovery unit to recover pure methanol as feedstock for the transesterification process.

The crude fatty alcohols discharged from the stripper bottom are routed to the tank farm. From there, they are sent to a distillation or fractionation unit for further processing into single cuts or composites. Alternatively, they can be directly converted to alpha-olefins.

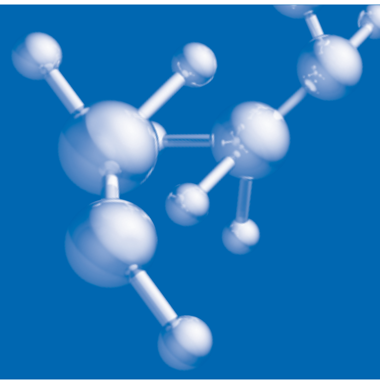
Technical Data

Unit capacities: 50, 100, 150, 200, 300 tpd distilled fatty alcohols

Consumption Figures

Methyl ester	1099 kg
Catalyst	< 1 kg
Hydrogen (Purity 99.9 vol. %)	230 m³ (STP)
Cooling water	85 m³
Steam (net consumpt.)	30 kg
Electric power	165 kWh
Nitrogen	–
Fuel	1000 MJ

Aribhawana Plant



- tailor-made design for highest product quality
- low thermal affection of product material
- optimized heat recovery

Process

The crude fatty alcohol feedstock is preheated by means of the hot distillate from the distillation still and routed to a drier and degasser where it is freed from moisture and gas under vacuum conditions.

A continuous stream is withdrawn from the drier recycle and fed into the hydrocarbon removal column which contains structured packings. Evaporation of the bottom product is accomplished in a falling film evaporator. The hydrocarbons contained in the feedstock are separated under vacuum conditions and discharged as column overhead product.

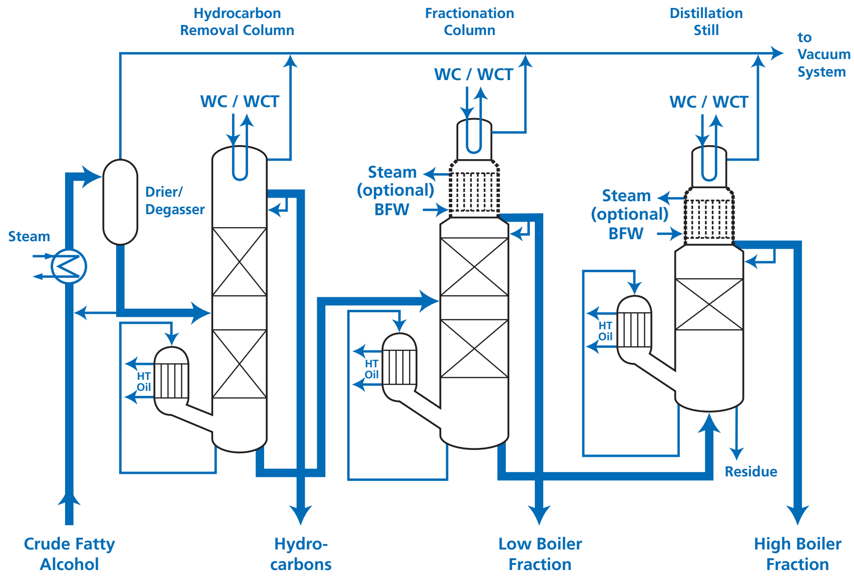
The bottom product is routed to the distillation still. Here, the fatty alcohols are separated from the high boilers. The greater part of the latter accounts for unconverted esters from the fatty alcohol section.

Evaporation of the fatty alcohols is achieved in a thermal-oil heated falling film evaporator. The distilled fatty alcohol product is condensed, subjected to final cooling and routed to the tank farm. The condensation heat can be put to effective use for producing low pressure steam.
For the fractionation of fatty alcohols, the requisite number of fractionation columns is arranged between the hydrocarbon removal column and the distillation still.

The separation of the individual cuts is performed under vacuum conditions in columns containing structured packings. The desired pure cut(s) is/are obtained as overhead product of the individual fractionation column(s). Evaporation is accomplished in a thermal-oil heated falling film evaporator.

A defined branch stream is continuously drawn from the recycle of each column and fed to the next fractionation column or the distillation still.

Depending on the specific customer requirements, a heat recovery system can be provided for each column. This allows the generation of low pressure steam (typically 4 bar) by condensing the product vapors at the column top. Otherwise, the top vapors are condensed by means of cooling water or tempered cooling water.



Fractionation of Fatty Alcohols

Reduction of the Carbonyl Value in Distilled Fatty Alcohols

General

In order to meet the market's strict requirements for superior-grade fatty alcohol distillates or fractions, the carbonyl content of distilled fatty alcohols is restricted to an upper limit of a few ppm only. Carbonyls are inevitably formed during the processing and/or storage of the fatty alcohols. The process presented here ensures reliable carbonyl reduction to meet the stringent criteria for superior-grade fatty alcohols.

Feedstock

Distilled or fractionated fatty alcohols with CO-contents up to 1500 ppm.

Product

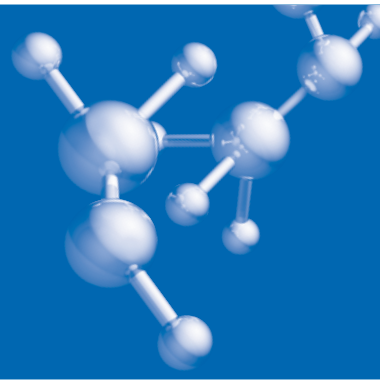
Fatty alcohols with reduced carbonyl values (<50 ppm) and chain lengths according to the carbon number of the feedstock.

Technical Data

Unit capacities: 50, 100, 150, 200, 300 tpd distilled fatty alcohols

Consumption figures per ton of crude fatty alcohols: The performance data vary with the separation duty defined by the customer. Exact figures are determined in each individual case. For reference, performance data for two typical applications based on a capacity of 100 tpd are given below. The purity of the fractionated cuts is assumed to be 99.5% each.

	Distillation	Fractionation to $C_{12/14}$ and $C_{16/18}$ cut
HT Oil	240 kWh	240 kWh
Cooling water (dT = 10 °C)	9 m³	10 m³
Tempered cooling water (dT = 10 °C)	10 m³	14 m³
Boiler feed water	160 kg	180 kg
Propelling steam (4 bar)	50 kg	60 kg
Instrument air	10 m³ (STP)	12 m³ (STP)
Electric power	10 kWh	10 kWh
Export of 4 bar steam	160 kg	180 kg



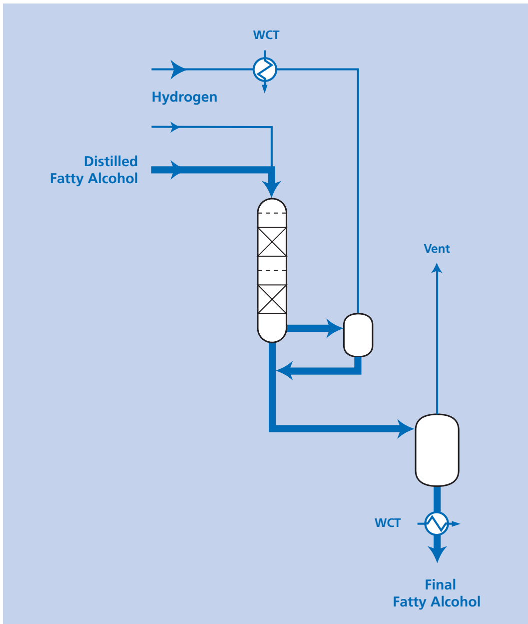
Fatty Alcohol
Fractionation Unit

Process

After distillation or fractionation, the fatty alcohols are processed through a reactor packed with a Ni-based catalyst at a hydrogen pressure of approx. 26 bar and a temperature of approx. 130 °C.
If defined fractions of a fractionated feedstock are to be processed simultaneously, each fraction requires a separate reactor. As the fatty alcohol feed trickles down the catalyst bed, the carbonyl groups are reconverted in the presence of a surplus of hydrogen.

The reaction mixture discharging from the reactor bottom goes to the gas/liquid separator where the surplus hydrogen is separated from the fatty alcohols. The hydrogen can be routed back to the suction side of the hydrogen compressor.

The fatty alcohol product is expanded and liberated from dissolved hydrogen in a degasser, cooled down and finally routed to the tank farm.



Carbonyl Conversion

Technical Data

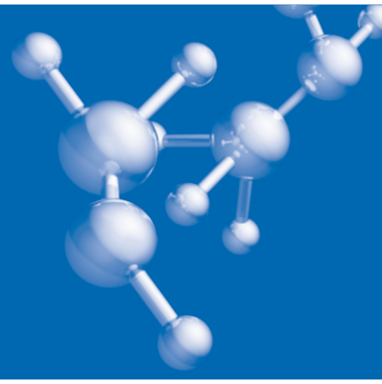
Unit capacities: according to the composites or fractions produced in the upstream distillation or fractionation unit.

Consumption figures per ton of fatty alcohol: as the consumption figures vary with the feedstock to be processed, the figures given below only provide a rough guideline. Exact figures will have to be determined on a case-to-case basis.

Hydrogen (Supply pressure: 27 bar, purity: 99.9%)	5 m^3 (STP)
Tempered cooling water (dT = 10 °C)	4 m^3
Instrument air	5 m^3 (STP)
Electric power	2 kWh

Dehydration of Fatty Alcohol to Alpha-Olefin

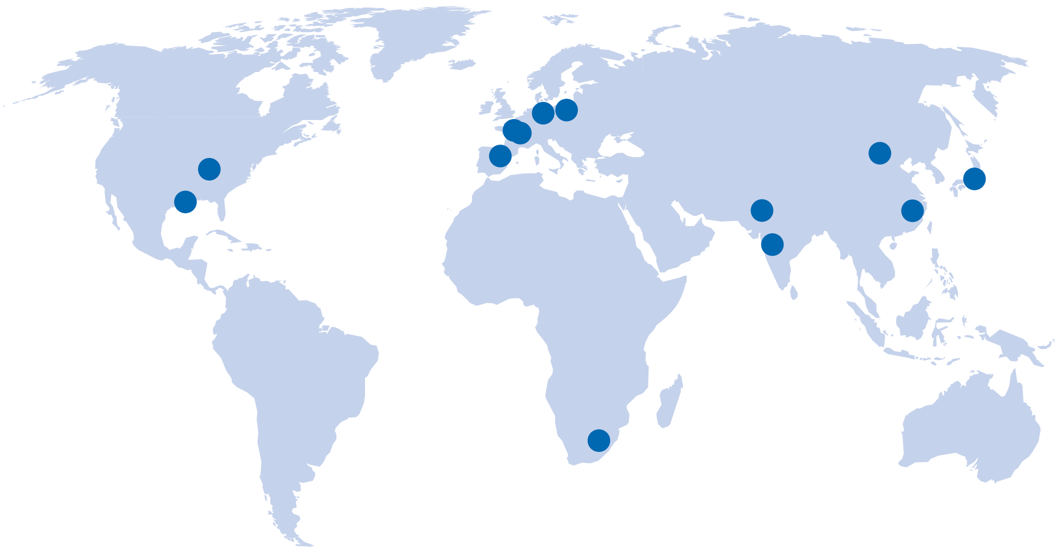
The alpha-olefin is produced from crude fatty alcohol by an endothermic dehydration reaction using a proprietary catalyst. The reaction takes place under vacuum in a tubular reactor. The finished product contains distilled alpha-olefin with the carbon number according to the chain length distribution of the fatty alcohol.



Reactor and Catalyst Building

Worldwide Engineering

Thanks to the close cooperation with all group engineering centers, Lurgi is able to provide faster and more efficient project execution services for its customers. This represents a significant cornerstone of our sustainable success.



Engineering Center of Air Liquide and Lurgi

Lurgi is a leading technology company operating worldwide in the fields of process engineering and plant contracting. The strength of Lurgi lies in innovative technologies of the future focusing on customized solutions for growth markets. The technological leadership is based on proprietary technologies and exclusively licensed technologies in the areas gas-to-chemical products via synthetic gas or methanol and synthetic fuels, petrochemicals, refinery technology and polymer industry as well as renewable resources/food.

Lurgi is a member of the Air Liquide Group. AIR LIQUIDE

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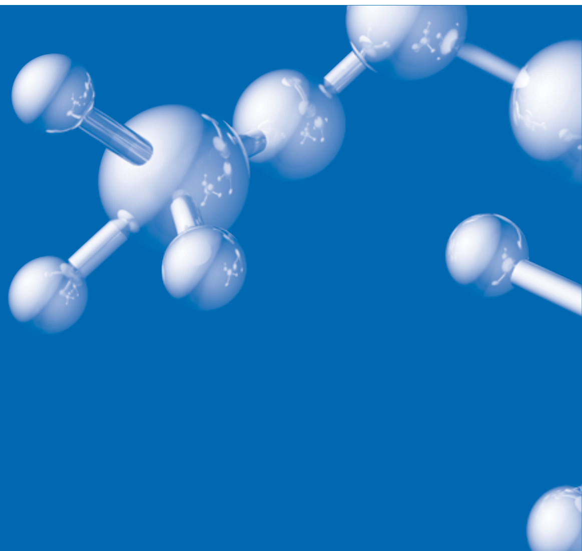

Lurgi GmbH
Lurgiallee 5 · D-60295 Frankfurt am Main
Phone: +49 (0) 69 5808-0 · Fax: +49 (0) 69 5808-3888
E-Mail: communication@lurgi.com · Internet: www.lurgi.com