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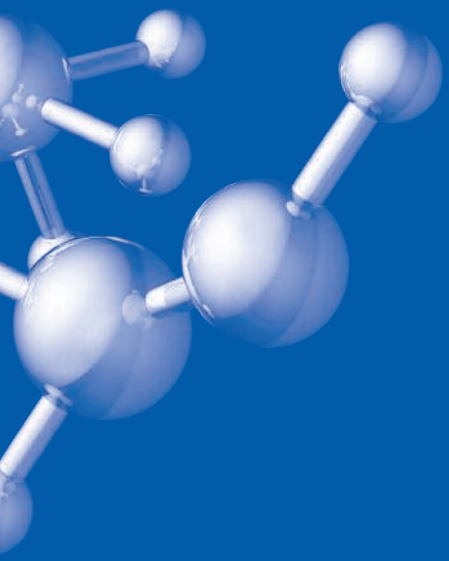


Butadiene Extraction

BASF NMP Process

Introduction

The BASF NMP process is a worldwide recognized, efficient and reliable technology for the production of high purity 1,3-Butadiene. From the early days to the most recent project, the process has undergone continuous improvements to satisfy the ever increasing demand for product purity, on-stream time, efficiency and environmental protection. Today, more than 32 Butadiene Extraction Plants are using the BASF process. In order to cope with the steadily increasing demand for butadiene, further units are currently under design. The feedstock for butadiene extraction is usually a C_4 cut which is obtained as a by-product from naphtha-based steam cracking in ethylene plants.

Uses/Applications

Butadiene is a key raw material for the manufacture of synthetic elastomers such as polybutadiene rubber and styrene butadiene rubber, latex compounds, thermoplastics such as ABS or intermediates like adiponitrile. These products are successfully commercialized and used mainly for automotive parts, tires, cables and a wide range of other industrial applications.

Lurgi's Expertise

Lurgi can look back on almost 50 years of engineering, erection and commissioning of Butadiene Extraction Units using several technologies. The first Butadiene Unit based on the BASF technology was built by Lurgi in 1968. Since 1990, Lurgi is in a position to offer both license and basic engineering for the BASF NMP process. For this technology, Lurgi's portfolio comprises a wide range of services ranging from studies (e.g. for expansion), basic and detail engineering through to turn-key projects.

Besides standard process concepts Lurgi also offers tailor-made solutions to meet the specific requirements of its clients. In this regard, we would like to highlight the first Butadiene Unit based on the BASF NMP process, which has been designed to process selectively hydrogenated C_4 feedstock and comprises a single extraction stage only.

Moreover, Lurgi is also active in expanding and revamping existing Butadiene Extraction Units by applying individual solutions. For existing Butadiene Extraction Units using different technologies, Lurgi is offering conversion to the BASF NMP technology.

Process Overview

1,3-Butadiene is recovered from a C_4 cut by extractive distillation using aqueous N-Methylpyrrolidone (NMP) as selective solvent. NMP substantially improves the relative volatilities of the components and prevents the formation of azeotropes. While the bulk of accompanying C_4 hydrocarbons are separated from 1,3-butadiene by extractive distillation certain light and heavy components are separated by conventional distillation. Different process configurations are available so that the process can be designed to suit the specific requirements of the project.

The Butadiene Extraction Unit typically comprises the following sections:

- Propyne Separation (Front or Tail End)
- Extractive Distillation (2 stages)
- Degassing
- Butadiene Distillation
- Solvent Regeneration

Propyne Separation

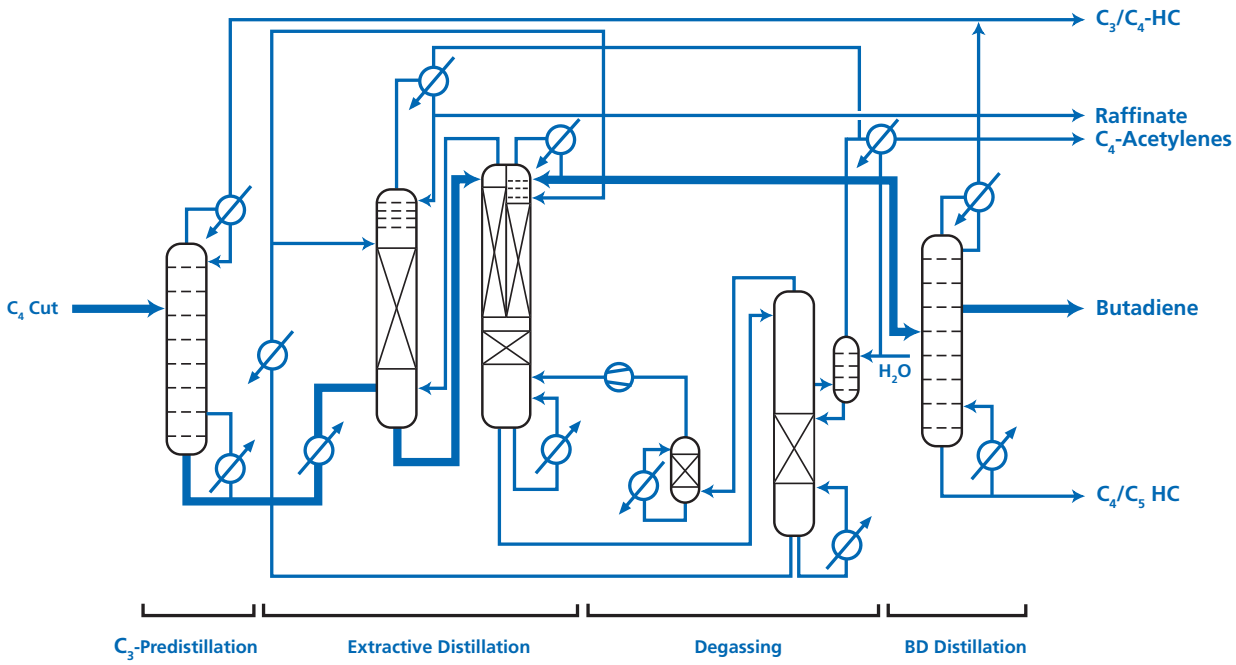
The C_4 cut from Battery Limits enters the Pre-Distillation Tower, in which Propyne, Propadiene and other light components are separated as gaseous overhead product.

Extractive Distillation

Its bottom product will be evaporated and fed into the bottom section of the Main Washer. The solvent (NMP containing approx. 8 % by weight of water) enters the column a few trays below the top, absorbing butadiene and part of the butenes in counter-current flow. At the top of the column, the raffinate consisting of butanes and butenes is drawn off. Traces of solvent in the raffinate vapors are washed out by reflux.

The solvent loaded with butadiene and some butenes is drawn off at the bottom of the Main Washer and passed onto the top of the Rectifier. A vertical plate, which is installed in the upper section of the Rectifier separates the first extraction stage (first compartment) from the second extraction stage (second compartment). In the first compartment the less soluble, i.e. more volatile butenes are stripped from the solvent. The gaseous mixture of butadiene and butenes withdrawn from the top is recycled to the bottom of the Main Washer.

The butadiene vapors rising from the Rectifier lower section enter the second compartment and are routed in counter-current to fresh solvent. The C_4 acetylenes are separated from the 1,3-Butadiene due to their lower vapor pressure in NMP. Crude 1,3-Butadiene is drawn off as overhead product. Traces of solvent are separated by reflux.



BASF NMP Process - Overview

Degassing

The solvent collected in the Rectifier bottom is heated up and flashed into a separate bottom compartment before it is sent to the Degassing Tower. Here, the solvent is completely stripped from hydrocarbons using solvent and water-containing vapor generated by a steam-heated reboiler. The C_4 acetylenes diluted with water vapor and 1,3-Butadiene are drawn off as a side stream of the Degassing Tower and enter the Acetylene Washer where remaining NMP is separated by condensate reflux.

The energy of the hot stripped solvent drawn off from the bottom of the Degassing Tower is recovered by heat integration. The solvent is cooled and recycled to the extractive distillation section.

The overhead vapors of the Degassing Tower enter the recycle gas compressor and are sent to the bottom section of the Rectifier.

Distillation

The crude butadiene from the top of the Rectifier's second compartment is fed into the Butadiene Distillation Column. In its top section, water and a bleed stream comprising remaining light components are separated from butadiene product. A small stream containing heavy ends is drawn off as bottom product.
The butadiene product is withdrawn as liquid side product.

Solvent Regeneration

For regeneration of the solvent, a small bleed of stripped solvent is continuously drawn off, distilled in a stirred vessel under vacuum and recycled to the process. When the residue in the stirred vessel rises to such extent that the heat transfer decreases, the solvent supply is stopped and the residue is discharged as waste.

Butadiene Plant,
Germany

Advantages of the BASF Process

- All industrial C_4 hydrocarbon mixtures can be processed regardless of the Butadiene content.
- Hydrogenation, carbonyl washes or any other pre-treatment of the C_4 feedstock is not required.
- The 1,3-Butadiene produced is optimally suited for all polymerization processes. The amine content which often is a poison to the catalyst of polymerization processes is extraordinarily low.
- Low specific energy consumption due to efficient heat integration.
- The BASF process requires a comparably low number of equipment items resulting in low investment costs, reduced space requirements and decreased maintenance costs.
- N-Methylpyrrolidone (NMP) and its mixtures with water are not corrosive, even in long-term operation. Carbon steel is used exclusively, resulting in low investment costs. Any moisture content in the feedstock does not have a negative effect.
- Out of the main solvents used in butadiene extraction NMP offers the best properties in economic and ecological terms. NMP has a very low vapor pressure and can be degraded easily in a biological treatment plant.
- The water content in the solvent results in optimized degassing conditions and improved stripping properties. The concentration of high-boiling and unsaturated hydrocarbons in degassed solvent is extremely low.
- Solvent losses can be kept very low due to its good stability to hydrolysis and thermal decomposition and its high boiling point.
- A hazardous accumulation of C_4 acetylenes cannot occur. The plant is safe even in case of operational malfunctions.
- Plant operation times of more than 5 years can be achieved without shut down.

Technical Data

Feedstock

Typical C_4 feedstock (naphtha cracker).

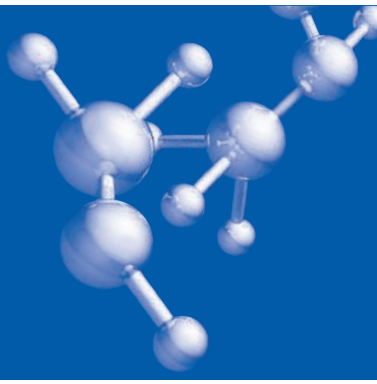
C_4 Feedstock		
Propane	wt. %	0.03
Propene	wt. %	0.1
Propadiene	wt. %	0.02
Propyne (Methylacetylene)	wt. %	0.15
n-Butane	wt. %	3.0
i-Butane	wt. %	1.0
n-Butene	wt. %	14.0
i-Butene	wt. %	26.0
trans-2-Butene	wt. %	5.1
cis-2-Butene	wt. %	4.3
1,3-Butadiene	wt. %	45.0
1,2-Butadiene	wt. %	0.15
1-Butyne (Ethylacetylene)	wt. %	0.15
Butenyne (Vinylacetylene)	wt. %	0.7
C_5+-Hydrocarbons	wt. %	0.1

Product Specifications

Typical Butadiene and Raffinate specifications are indicated below (can be adapted to individual requirements).

1,3-Butadiene Product		
1,3-Butadiene	wt. %	> 99.7
Propyne	wt. ppm	< 5
Propadiene	wt. ppm	< 5
1,2-Butadiene	wt. ppm	< 20
Total acetylenes	wt. ppm	< 20
C_5 Hydrocarbons	wt. ppm	< 10
Butadiene dimer	wt. ppm	< 50
NMP	wt. ppm	< 3

Raffinate		
1,3-Butadiene	wt. ppm	< 2000
NMP	wt. ppm	< 10



Effluents

By-Products

The by-products below are usually recycled to the cracker.

- C_4 acetylene stream
- C_3/C_4 hydrocarbons
- C_4/C_5+ hydrocarbons

Regeneration Residue

The viscous residue discharged discontinuously from the solvent regeneration is usually incinerated. Approximately 6 batches/year of 1–2 tons for a 100 kta Butadiene Unit

Process Waste Water

The process waste water is usually treated in the waste water facilities of the petrochemical complex. Approximate flow is 0.5 m^3/hr for a 100 kta Butadiene Unit.

Utility Consumption

Typical utility consumption per ton of Butadiene product:

■ electrical power	150	kWh/t
■ steam (10 bar g)	1.7	t/t
■ cooling water $\Delta t = 7$ °C	150	m^3/t
■ NMP make up	0.20	kg/t

Required Plant Area

The required area for a 100 kta unit is approx. 35 x 74 m (will be adapted to actual requirements).

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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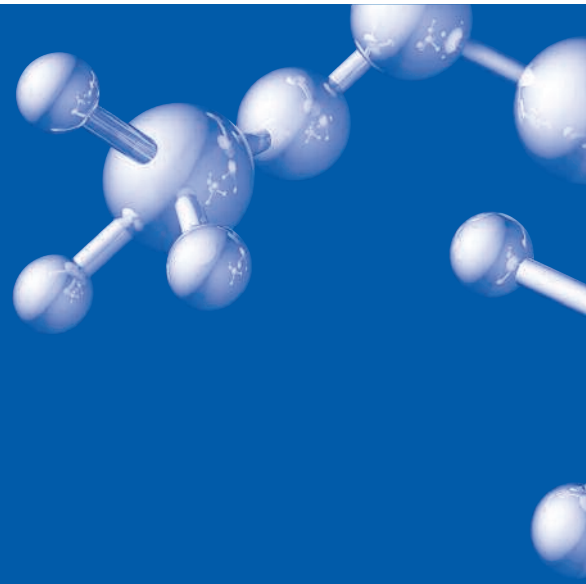

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