Petrochemicals
Reliable, tailor-made solutions for high-quality products
Air Liquide Group

The world leader in gases, technologies and services for Industry and Health

Air Liquide is present in 80 countries with approximately 65,000 employees and serves more than 3 million customers and patients. Oxygen, nitrogen and hydrogen are essential small molecules for life, matter and energy. They embody Air Liquide’s scientific territory and have been at the core of the company’s activities since its creation in 1902.

Air Liquide’s ambition is to lead its industry, deliver long term performance and contribute to sustainability.

Air Liquide Engineering & Construction

A technology partner of choice

Air Liquide Engineering & Construction builds the Group’s production units (mainly air gas separation and hydrogen production units) and provides external customers with efficient, sustainable, customized technology and process solutions.

Our core expertise in industrial gas, energy conversion and gas purification, enables customers to optimize natural resources.

We cover the entire project life-cycle: license engineering services/proprietary equipment, high-end engineering & design capabilities, project management & execution services. In addition we also offer efficient customer services through our worldwide set-up.

As a technology partner, customers benefit from our research and development to achieve energy transition goals.

Our full suite of technologies

- Liquefied Natural Gas
- Cryogenics
- Hydrogen
- Syngas
- Petrochemicals
- Natural Gas Treatment
- Sulfur
- Standard Plants
- Oleochemicals

15 Engineering centers and front end offices
3 Manufacturing centers
60 Proprietary technologies
1,600 Patents
Producing premium petrochemicals

Air Liquide Engineering & Construction combines outstanding expertise with proven Lurgi technologies to produce high-grade petrochemicals.

Backed by a long tradition of excellence, we deliver plants that are safe, cost-effective and reliable. Moreover, we can tailor our tried-and-tested solutions to your requirements. As a result, you can enjoy maximum on-stream time, and rest assured that your final product will meet required quality specifications.

Air Liquide Engineering & Construction’s technology portfolio is focused on products in areas of growing demand. Our characteristic approach, which involves starting the processing route from either conventional feedstock from refineries or crackers, or from syngas, is a fundamental feature of our portfolio strategy. It is illustrated in the diagram below.
In addition to developing proprietary technologies and acquiring third-party technologies, we collaborate with partners when developing solutions. By combining strengths in this way, we can provide single-line responsibility, global support, and the ability to customize solutions. We draw on well-referenced, state of the art technologies, such as:

- Proprietary catalyst for Acrylic Acid (Nippon Kayaku)
- Acylates technologies (Synthomer)
- NMP technology for 1,3-Butadiene production (BASF)
- BTcB technology for on-purpose crude Butadiene (Mitsubishi Chemical Company)
- Melamine technology (Edgein)

**Technological highlights**

Our petrochemical technologies have a variety of key strengths, which help to address a range of economic, safety, and environmental challenges. Our solutions are tailor-made:

- We draw on our experience to address specific goals and needs.
- We emphasize excellence in concept development for feedstock and final products.
- We have particular strength in delivering top-of-the-line facilities, and offer licensing.
Acrylic Acid: combined Lurgi/Nippon Kayaku technology

Adding value to propylene by the production of ester-grade Acrylic Acid (EAA), via catalytic oxidation.

**Our strengths**

Two flagship projects in China and India, at up to 160,000 mtpa single train capacity (the highest in the industry)
- Combined competence in technology and catalysis.
- Freedom to take production decisions based on a non-restricted licence.

**Feedstock flexibility**
- Suitable for refinery grade propylene (> 80 wt-%) feedstock.

**Product quality**
- Premium final product.

**Cost effectiveness**
- Optimal equipment and space requirements.
- High-performance catalyst, long lifetime and highest Acrylic Acid yield.

**High efficiency and reliability**
- Proven technological features to ensure on-stream efficiency.

**Safe and clean**
- High safety standards, through rigorous design in accordance with safety regulations.
- Low environmental impact by minimizing waste generation and using non-toxic extraction solvent (other than benzene).

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**Acrylic Esters**
- Water-based paints and coatings
- Adhesives
- Textile fibers, polymer resins and plastic additives

**Acrylic Acid**
- Ester-grade
- Polymer-grade (glacial)

**Polyacrylates**
- Super Absorbent Polymers (SAP) for diapers and sanitary products
- Thickeners, flocculants and dispersants
- Polyacrylates
Since 2002, Air Liquide has been the licensor and technology owner of the Lurgi/Nippon Kayaku Acrylic Acid process, which is a freely licensed/non-restricted technology on the market. This brings together the best of catalyst and technology worlds, in which Nippon Kayaku provides benchmark catalyst, with exceptional longevity.
The Acrylic Acid production process

Acrylic Acid is produced by the catalytic oxidation of propylene in a two-stage tubular fixed bed reactor system. The high-tech reactors are cooled by circulating molten heat transfer salt. The heat of reaction is recovered by the generation of steam.

Acrylic Acid is separated from the reactor product in a quench tower, and further routed to the extraction section. Uncondensed gases are sent to an absorber to recover remaining Acrylic Acid and to minimize product loss. The overhead gas is recycled to the reaction section and a side draw is sent for incineration.

A liquid extraction step is used to separate the Acrylic Acid from the water containing fraction. The solvent is recovered and recycled back to the process. In the raffinate stripping section, the solvent is separated from the wastewater. The next purification step – the crude Acrylic Acid recovery – removes traces of solvent and acetic acid. Finally, the desired ester-grade Acrylic Acid product is generated in the Acrylic Acid purification system.

Simplified flow scheme of Acrylic Acid process
Acrylates: Synthomer technologies

Esterification of Acrylic Acid to produce a range of light and heavy Acrylates.

Our strengths

- Single line responsibility from Propylene via Acrylic Acid to Acrylate product.
- Long standing history and competence in the operation of Acrylate plants by Synthomer.
- Use of environmentally friendly catalyst
- Capacities tailored to requirements, for butylacrylate design up to 160,000 mtpa available.

These technologies are used to produce Methylacrylate (MA), Ethylacrylate (EA), Butylacrylate (BA) and 2-Ethylhexylacrylate (2-EHA). The process varies depending on the desired product, but the starting point is always a reaction between the Acrylic Acid (AA) and an alcohol feedstock using an environmentally friendly sour catalyst (ion-exchange resin or p-Toluenesulfonic acid). The reactor effluent is purified in several process steps to recover and recycle unconverted Acrylic Acid and the respective alcohol as well as the catalyst in case of p-Toluenesulfonic acid. Finally, a highly purified Acrylate product is generated.
Simplified flow scheme of Butylacrylate process

- Butanol
- Water Removal Column
- Alcohol Recovery Column
- Waste Water
- Butylacrylate
- Light Ends Column
- Final Product Column
- Neutralisation Column
- Catalyst
- Esterification Reactors
- Decomposer
- Organic Waste
- Catalyst
- Catalyst
- Catalyst
- Catalyst
1,3-Butadiene: the BASF NMP process

Recovery of high purity 1,3-Butadiene from a crude C4 stream from olefins plants by extractive distillation with N-Methylpyrrolidone (NMP) as a selective solvent.

Butadiene is a key raw material for the manufacture of synthetic polymers such as Polybutadiene rubber, Styrene-Butadiene-rubber (SBR), latex compounds and Acrylonitrile-Butadiene-Styrene (ABS). These polymer products are mainly used for automotive parts, tires, cables and a wide range of other industrial applications. Petrochemical intermediates, like Adiponitrile are produced from Butadiene as well.

Our strengths

Our licensed Butadiene extraction technology is recognized worldwide as a benchmark for safety, efficiency, reliability and minimal environmental footprint.

Applications of the BASF NMP process
- Worldwide, more than 25 applications of the BASF NMP process, with capacities ranging from 50,000 to 250,000 mtpa, have been licensed by Air Liquide.

Feedstock flexibility
- Tailor made design for all industrial C4 mixes.

Customized Units
- Unique plant configurations; like upfront C3 separation and selective hydrogenation of Acetylenes.

Product quality
- Final product optimally suited for all polymerization processes (extraordinarily low in amines).

Cost effectiveness
- Comparably less equipment items and space requirement.

- Aqueous mixtures of NMP are non-corrosive, allowing for carbon steel construction.

Highly efficient and reliable
- Low specific energy consumption due to optimized heat integration.
- Ideal degassing conditions due to solvent properties resulting in very low content of unsaturated hydrocarbons in degassed solvent.
- Inherent plant design for prevention of polymerization.
- Minimal solvent losses.
- Plants can be operated for more than five years without a single shut down.

Safe and clean
- NMP can be treated by conventional biological wastewater treatment.
- A hazardous accumulation of C4 Acetylenes is strictly avoided. The plant is safe even in case of operational malfunctions.
With a track record of more than 50 years, Air Liquide has offered licensing and engineering services for 1,3-Butadiene extraction employing a variety of technologies. The first Butadiene units based on the BASF process were built by Air Liquide in 1968. Since 1990, Air Liquide has offered both licensing and engineering services – from studies to turnkey projects – for the BASF NMP Process.
The extraction process

In the pre-distillation tower Methylacetylene, Propadiene and other light components are separated from the C4 cut feedstock which then enters the bottom section of the main washer column while NMP solvent enters at the top. C4 raffinate consisting of Butanes and Butenes is drawn off as overhead product.

The loaded solvent is sent to the rectifier. In the first compartment of the divided wall column, the less soluble Butenes are separated and recycled to the main washer while C4 Acetylenes are separated from crude Butadiene in the second compartment.

The solvent from the rectifier is sent to the degassing tower where hydrocarbons are stripped from the solvent and recycled to the rectifier by a compressor. The side stream of the degassing tower containing diluted C4 Acetylenes is fed into a scrubber to recover NMP solvent. After further dilution with raffinate or other suitable materials, the C4 Acetylene stream is discharged to battery limits for further processing.

The crude Butadiene withdrawn as overhead product from the second compartment of the rectifier is sent to the Butadiene column for final purification.

Simplified flow scheme of 1,3-Butadiene extraction process

We offer tailor-made plants designed on individual C4-cut specifications as well as solutions for expansions and revamps based on specific project requirements.
On-purpose crude Butadiene: the Mitsubishi Chemical Company (MCC) BTcB process*

Air Liquide offers MCC’s Butene dehydrogenation technology for on-purpose 1,3-Butadiene production.

This technology enables maximum Butadiene output from crackers and/or FCC units. The BTcB process converts Butenes to crude Butadiene by oxidative dehydrogenation. Other Butene sources, such as Methanol to Propylene (MTP)/Methanol to olefins (MTO) units or other petrochemical facilities can be considered as well. In both cases, the Butadiene product from the BTcB process will require downstream purification by means of extractive distillation.

*Butene to crude Butadiene Process

Enlarged Sources for 1,3-Butadiene Production

Maximizing Butadiene output from crackers and/or FCC units by converting Butenes into crude Butadiene using MCC’s BTcB technology.

SOURCES:
- C4 from cracker (Raffinate)
- C4 from FCC
- C4 from MTP/MTO
- C4 by dimerization of Ethylene (from Ethane cracking)

Oxidative dehydrogenation (BTcB) → Butadiene Extraction (NMP) → 1,3-Butadiene
**Benzene: Lurgi Distapex™ process**

Recovery of aromatics from a heart-cut feedstock by extractive distillation.

Benzene is a petrochemical building block for the production of major downstream products such as Ethylbenzene and Cumene, as well as Styrene and Phenol/Acetone for the production of a wide range of plastics, fibers, resins and films.

Other important intermediates, such as Cyclohexane and Nitrobenzene, are produced from Benzene.

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**Our strengths**

Proprietary Lurgi Distapex™ technology was developed in the 1960s & continuously developed, and installed more than 25 times – with individual capacities ranging from 20,000 to 280,000 mtpa.

**Feedstock flexibility**
- Tailored design according to C6 feedstock requirements.

**Product quality**
- High purity of the recovered aromatics.
- Adaptation of purity and yield by design aimed at the pertinent requirements.

**Cost effectiveness**
- No corrosion issues.
- No pipe tracing for the solvent due to the low solidification point.

**Highly efficient and reliable**
- Economic recovery of the aromatics by simplicity of the process and low utilities consumption.
- Low solvent consumption.

**Additional Synergies**
- Use of same solvent as in Butadiene extraction process; synergies for olefin plant operators.

**Safe and clean**
- High thermal stability of the solvent.
- No environmental problems as closed circulation system applied.

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**The Distapex™ process**

The Distapex™ process requires a minimum number of equipment items and is renowned for its high reliability and availability as well as for its low operating cost. Due to the unique properties of NMP, the process has an excellent ecological footprint and requires medium pressure steam only.
Pyrolysis gasoline (pygas), a product of olefin production by steam cracking of naphtha or gas oil feedstocks, contains a high proportion of aromatics, especially Benzene. The Benzene is separated by extractive distillation using N-Methylpyrrolidone (NMP) as selective solvent. The raffinate containing the non-aromatics leaves the extractive distillation column via the top. The loaded solvent is routed to a stripper column where the final product is recovered as the overhead product while the lean solvent is recycled to the extractive distillation column.

**Simplified flow scheme of DISTAPEX™ benzene extraction process**
The Melamine produced with the Lurgi/Edgein technology is characterized by an excellent quality, small particle sizes and a uniform particle size distribution exceeding the standard requirements for the downstream applications.

Molten Urea is fed to a fluidized bed reactor using a silica/aluminum-oxide catalyst. In contact with catalyst, Urea reacts to Melamine and process gas. Process gas, an Ammonia and CO₂ mixture, is used for catalyst-bed fluidizing. Required reaction heat is supplied via heated molten salt circulated through internal coils. Process gas, leaving the reactor together with gaseous Melamine is cooled down to an intermediate temperature in order to desublimate the by-product, which can be removed together with catalyst fines in a gas-filter. In the crystallizer the filtered process-gas is quenched with cool process gas coming from the Urea-scrubber to desublimate Melamine.

Fine Melamine crystals are recovered from the process gas in the product cyclone and are leaving the product cyclone as final product to storage without further treatment. Process gas is recycled to the Urea-washing-tower. In the Urea-washing-tower process gas is scrubbed by means of molten Urea before being partially recycled as fluidizing gas to the reactor and as quench gas to the crystallizer. Surplus on process-gas can be recycled to the upstream Urea plant or to a separate process gas treatment unit.

Melamine produced from Urea via low pressure vapor-phase catalytic process.

Our strengths

Edgein has licensed 13 plants with a total capacity of 470,000 mtpa since 2011. Air Liquide Engineering & Construction has licensed and delivered a world-scale plant of 50,000 mtpa in Stavropol, Russia which has been in operation since 2012.

Perfect product for all downstream applications, including laminates, adhesives, paints and coatings.

Feedstock flexibility
- Low raw material consumption.

Product quality
- High-end product quality.
- Low water content.
- Small particle size with uniform particle size distribution.
- Excellent color properties.

Cost effectiveness
- No high pressure steam.
- No complicated rotating equipment.
- No drying unit.

Highly efficient and reliable
- High on-stream time.

Safe and clean
- No water quench.
- No corrosion.
Gas Scrubbing Reaction and Filtration Crystallization and Separation

Urea

Scrubber

Urea

Melt

Ammonia

Reactor

Molten
Salt

Catalyst

Fines

Filter

Off-Gas
to Treatment

Crystallizer

Melamine

Product

Product

Cyclone

Simplified flow scheme of Melamine process
Customer commitment

Evolving with you

Continually stepping up our game

Air Liquide Engineering & Construction provides you with a range of plant options designed to maximize efficiency, improve the quality of your product and help to minimize your operating costs.

All of the components of our plants are manufactured to the highest standards and are backed by the reliability of a company with over a century of experience.

You help make us smarter

Since acquiring Lurgi technologies in 2007, Air Liquide Engineering & Construction continues to build on the knowledge we gain from our customers.

We rely on the operational experience of our customers to guide us in our innovation. They help us find solutions through the research and development that we and the entire Air Liquide Group undertake.

The great strides we made in our petrochemical offering arose from a need for greater energy efficiency. Our expertise in design and engineering ensure that our offering meets or exceeds the most stringent safety and environmental standards.
Vitry Champigny
Frankfurt
Krakow
Kiev
Moscow

Singapore
Kuala Lumpur

Ras Al Khaimah
Abu Dhabi
Dubai

Calgary
Montreal
Houston

New Delhi

Beijing
Hangzhou
Shanghai
Kobe
Seoul

Johannesburg

Engineering centers and front-end offices
Manufacturing centers

Contact us
petrochemicals@airliquide.com
www.engineering-airliquide.com