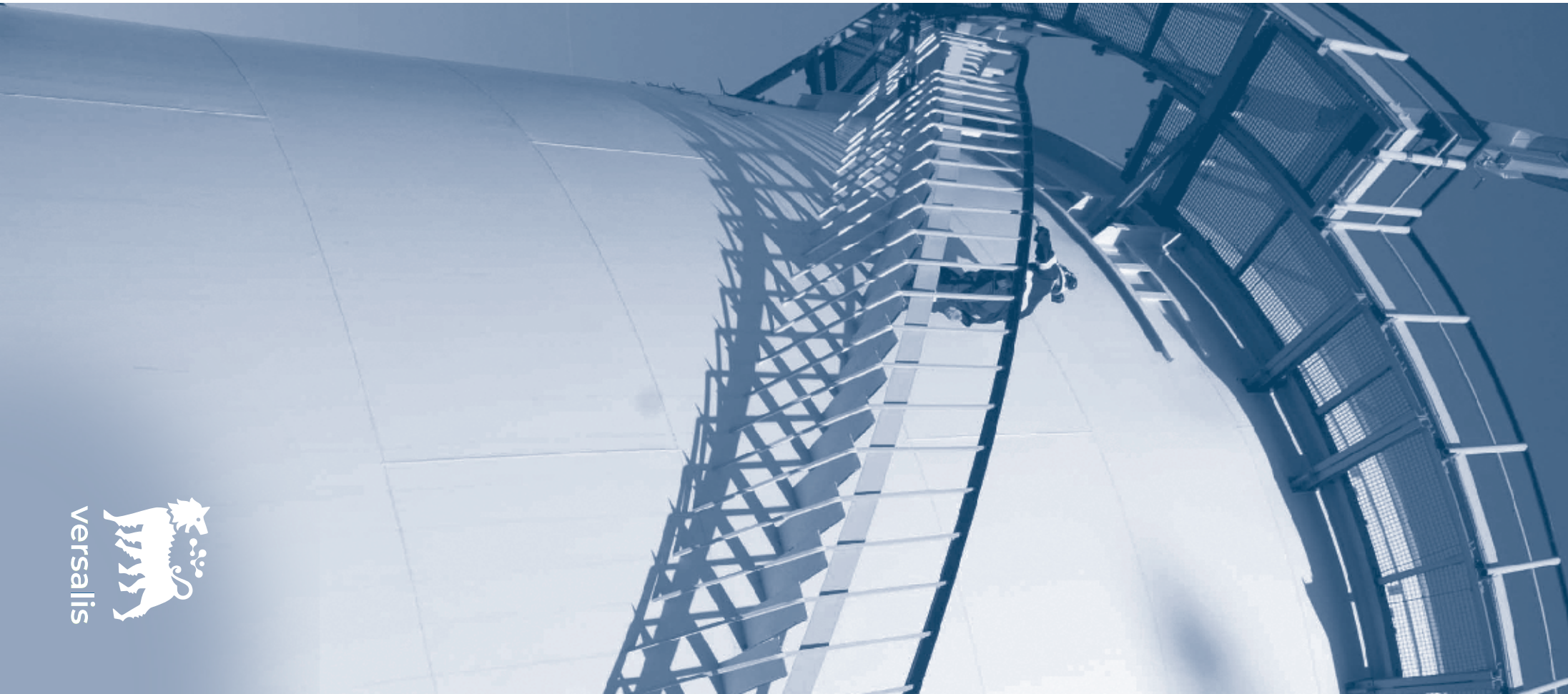
CUMENE

WITH PBE-1 ZEOLITE BASED PROPRIETARY CATALYST



versalis

Versalis proprietary process technologies available for licensing

Our company

Versalis - the petrochemical subsidiary of Eni - is a dynamic player in its industry sector facing the multifold market needs through different skills.

With a history as European manufacturer with more than 50 years of operating experience, Versalis stands as a complete, reliable and now global supplier in the basic chemicals, intermediates, plastics and elastomers market with a widespread sales network.

Relying on continuous development in its production plants as well as in its products, strengthening the management of the knowledge gained through its long industrial experience, Versalis has become a worldwide licensor of its proprietary technologies and proprietary catalysts. The strong integration between R&D, Technology and Engineering departments, as well as a deep market expertise, are the key strengths for finding answers to customers requirements.

Our commitment to excellence, in quality of our products and services, makes our company an active partner for the growth of customers involved in petrochemical business.

Through engineering services, technical assistance, marketing support and continuous innovation, our knowledge is the key strength to customize any new project throughout all phases.

Customers can rely on this strong service-oriented outlook and benefit from a product portfolio that strikes a perfect balance of processability and mechanical properties, performance and eco-friendliness.

Introduction to Versalis Cumene technology

The Versalis cumene process, based on a PBE type zeolite based proprietary catalysts, has been industrially applied since mid 1990s. PBE-1 is a proprietary zeolite based catalyst showing higher selectivity to cumene than other common zeolite catalysts and is equally effective for alkylation of benzene and transalkylation of polyisopropyl benzenes to cumene. The mechanical resistance of the catalyst is at the highest level for a zeolite based catalyst. Since 2007 Versalis and Lummus Technology, offer the Versalis / Lummus technology for the production of cumene. This technology incorporates many decades of operating and design experience by Versalis and Lummus' design expertise, as well as proven and superior technology features. Main features of Versalis / Lummus cumene technology are:

- proprietary, non-corrosive and extremely tolerant to poison PBE-1 zeolite based catalyst;
- proven catalyst run-length of up to 8 years;
- catalyst fully regenerable with an easy ex-situ regeneration procedure allowing several reaction cycles;
- product yield of 99.7wt% or higher;
- high catalyst activity and selectivity with minimal formation of by-product impurity; typical cumene purity is 99.95% or higher;
- low pressure and low temperature operation;
- it can be designed to process chemical and refinery grade propylene feedstock in addition to polymer grade propylene;
- all carbon steel construction and no critical proprietary equipment that have to be supplied by the licensor;
- low investment and plant maintenance costs;
- low environmental impact;
- simple and safe operations;
- no acid waste stream and minimal fugitive emission.

In addition the revamping of existing units still based on traditional SKPA technology can achieve an extra-capacity up to 80% in the same reaction section.

Versalis can always provide appropriate solutions to different client's needs thanks to its capabilities and experience in the following fields:

Research and operation

Versalis background and expertise in cumene production technology comes from manufacturing experience and constant lab & pilot plant testing. Since the early stages of development, our Versalis cumene proprietary process technology has gained benefit from a deep cooperation between leading scientists in the zeolite field within eni and technicians involved in industrial cumene production at Versalis (former EniChem). A complete kinetic model for alkylation and transalkylation reactors loaded with proprietary catalyst PBE-1 is available.

Process design

Process design is flexible and able to face different conditions and constraints. Any project is individually evaluated to offer the best solution, tailored to specific customers needs. Thermal and fluodynamic analysis (CFD) are extensively applied to the design of key equipment such as reactors, their internals and main heat exchangers.

Mechanical design

Versalis Engineering Dept. has been working in close coordination with the Process Dept. since a long time. This fact has allowed to develop unique and well sound engineering solutions for critical equipment, that guarantee the best results in terms of mechanical reliability and process performances.

PBE type catalysts

PBE type catalysts show very high selectivity for alkylation and transalkylation and, above all, a very high stability, at the highest level among common zeolite based catalysts. More particularly, the preparation procedures allow optimal values for extrazeolite porosity and degree of interconnectivity, which results in very high catalyst stability, with very low deactivation due to coke deposition. Versalis has also developed and experienced, for its PBE catalysts, industrial scale production and regeneration.

Up to now, hundreds of tons of PBE catalyst have been produced and loaded in industrial reactors since 1996. In addition, the proprietary catalyst regeneration procedure, which is able to prevent any catalyst modifications (such as zeolite dealumination and/or catalyst sintering) has been proven in industrial scale.

Wastes and emissions

The process produces no liquid or vapour emissions with the exception of oily water and vacuum pumps vents. Spent catalyst can be regenerated several times and, at the end of its lifetime, can be disposed in a normal landfill.

Industrial applications

First PBE zeolite catalyzed industrial application dates back to March 1996 when, at Porto Torres site (Sardinia, Italy), a first industrial test-run based on an initial cumene capacity of 70 kt/y was done.
In 1997 the new zeolite based technology was extended to 130 kt/y cumene capacity. In 2000, following four years of continuous trouble-free test-run operation, the fully proven technology was applied to the revamp of the existing cumene plant for a total of 400 kt/y cumene capacity at Versalis Porto Torres site. In 2015 a further 450 kt/y cumene capacity plant has come on stream in China, currently under revamping to 600 kt/y.

Product quality

Cumene	99.95 % wt typical
Bromine index	1 typical

Main process parameters

Material Balance	**MT per MT Cumene**
Benzene	0.651
Propylene	0.352

Utilities Consumption	**per MT Cumene**
Net Steam Consumption [1]	0.2 MT

[1] As a Balance between HP Steam Import and LP Steam Export.
All exported Steam can be consumed in the Downstream Phenol Plant.

Process description

Cumene is made by the alkylation of benzene with propylene, which yields a mixture of alkylated and polyalkylated benzenes. Excess benzene is used so propylene reacts completely. Propylene is injected before each catalyst bed to improve catalyst selectivity and enhance its activity and stability.

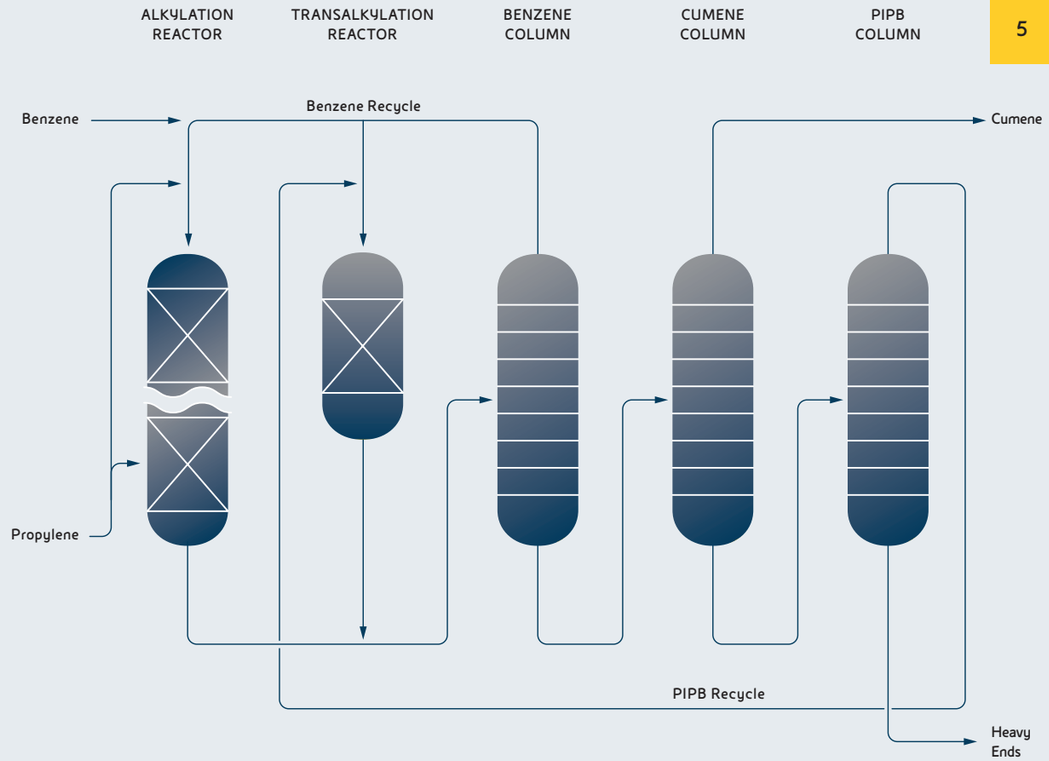
The mixture of alkylated and polyalkylated benzenes is sent to a distillation train that consists of a benzene column, cumene column and poly-isopropylbenzene (PIPB) column. The polyalkylated benzenes recovered in the PIPB column are transalkylated with benzene to produce additional cumene for cumene yield maximization. The alkylation and transalkylation effluents are fed to the benzene column, where the excess benzene is taken as the overhead product for recycle to the reactors.

The benzene column bottoms goes to the cumene column, where product cumene (isopropylbenzene) is taken as the overhead product. The cumene column bottoms is sent to the PIPB column, where overhead PIPB is recycled back to the transalkylation reactor.

The bottom of the PIPB column is composed of a small amount of high boilers that can be used as fuel. Propane and other non-condensables contained in the propylene feed pass through the process unreacted and are recovered as propane product or as fuel. The cumene unit has considerable flexibility to meet a variety of local site conditions (i.e., utilities) in an efficient manner.

fig. 1

Cumene • process scheme



Proprietary process technologies portfolio

Biotech

PROESA® 2G Ethanol and Cellulosic Sugars

Phenol and derivatives

Cumene (with PBE-1 zeolite based proprietary catalyst)*
Phenol, Acetone, Alphamethylstyrene*
High selectivity Cyclohexanone
Acetone hydrogenation to Isopropyl Alcohol*
Isopropyl Alcohol to Cumene**
Ammoximation (with Titanium silicalite based proprietary catalyst TS-1)

DMC and derivatives

Dimethylcarbonate (via Carbon Monoxide and Methanol)*
Diphenylcarbonate*

Proprietary catalysts

Titanium silicalite
PBE-1 Zeolite
PBE-2 Zeolite

Styrenics

Ethylbenzene (with PBE-1 and PBE-2 zeolite based proprietary catalyst)
Styrene
GPPS
HIPS
EPS suspension polymerization
ABS continuous mass polymerization
SAN

Polyethylene

LDPE
EVA

Elastomers

Emulsion-SBR
HSL Latices
Solution-SBR
TPR
LCBR
HCBR
NBR
Carboxylated latices
EP(D)M

* Co-licensing in cooperation with Lummus Technology (a McDermott International Company).
** Close to commercialization.

versalis

Versalis spa
Piazza Boldrini, 1
20097 San Donato Milanese (MI) - Italy
Ph. 0039 02 520.1

info@versalis.eni.com
versalis.eni.com

Responsible Care

SINCERT

Licensing:
Piazza Boldrini, 1
20097 San Donato Milanese (MI) - Italy
Ph. 0039 02 520.42931 - fax 0039 02 520.42286

info.licensing@versalis.eni.com

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