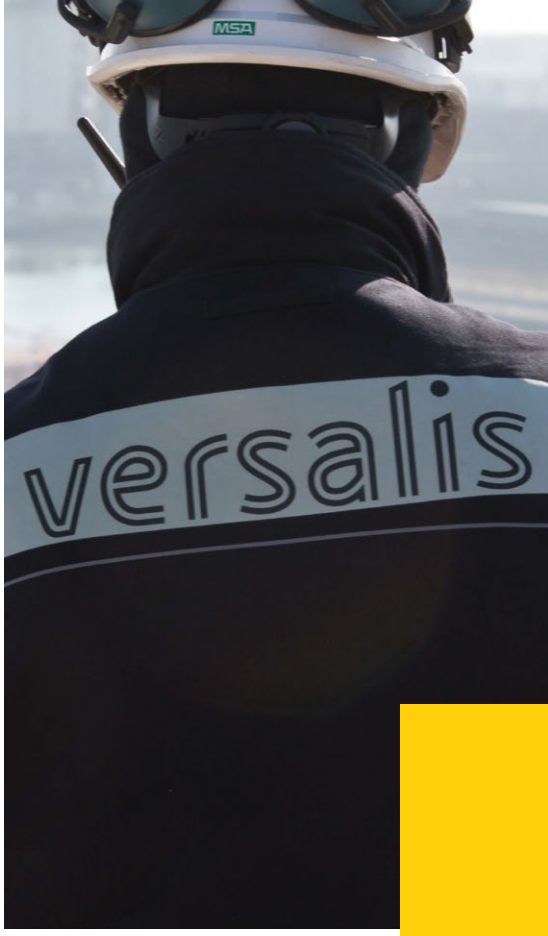
Proprietary catalyst

PBE-1

ZEOLITE BASED

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 PBE-1

General information

PBE-1 catalyst is a high-performance composite material specifically designed for industrial cumene and ethylbenzene synthesis in fixed bed reactors.
PBE-1 catalyst is the result of long-term research within Eni associated with direct Versalis experience in both cumene and ethylbenzene industrial production.

Applications

PBE-1 is the catalyst of choice in zeolite based Versalis Cumene and Ethylbenzene Technologies through benzene alkylation with respectively propylene and ethylene. Benzene is first alkylated with the olefin forming the monoalkylated product (cumene or ethylbenzene).
A small amount of dialkylated by-products are fully recovered in a separate transalkylation step with benzene forming addtional cumene.
PBE-1 catalyst is equally effective for alkylation and transalkylation reactions carried out in liquid phase as well as in mixed phase. It allows both recycle and once-through reactor mode operations.
PBE-1 catalyst can effectively replace other zeolite based catalysts in both cumene and ethylbenzene applications affording superior performances in terms of lower impurities formation and higher catalyst lifetime.

PBE-1 industrial catalyst can be fully regenerated by coke burning in proper conditions without any zeolite structural damage (as proved by XRD techniques).
Up to five reaction/regeneration cycles have been tested at pilot plant scale showing unchanged catalyst structure and performances as well as stable Al state into the zeolite (as proved by Al-MAS-NMR and FT-IR spectroscopy). Both in-situ or ex-situ industrial regeneration are possible for PBE-1 catalyst. Based on an economic stand-point and thanks to the extremely long lifetime of every reaction cycle, ex-situ regeneration, which inherently allows a better control of coke burning conditions, is preferred for PBE-1 catalyst. This in turn allows industrial reactors in carbon steel with a consistent investment saving.

Main physical properties

Physical form	Extrudate
Nominal diameter	2.1 mm
ABD	500 kg/m^3

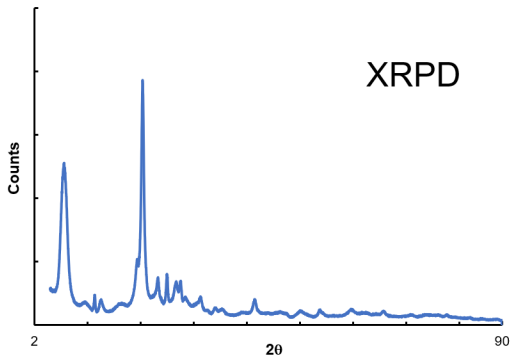
Packaging

Packed in 200 liters steel drums with internal polyethylene liner.

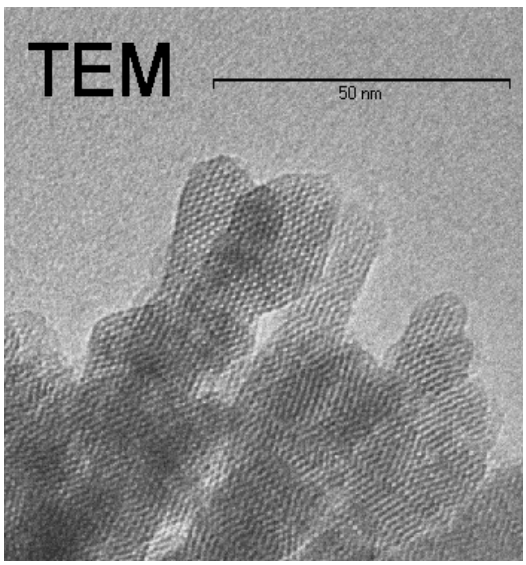
Extrazeolite and Zeolite properties

PBE-1 is a beta zeolite based catalyst displaying unusual and unrivalled performances in industrial cumene and ethylbenzene synthesis thanks to its unique combination of extrazeolite properties (given by binder selection and forming procedure) and zeolite properties (given by the specific features of the zeolite contained into the catalyst).

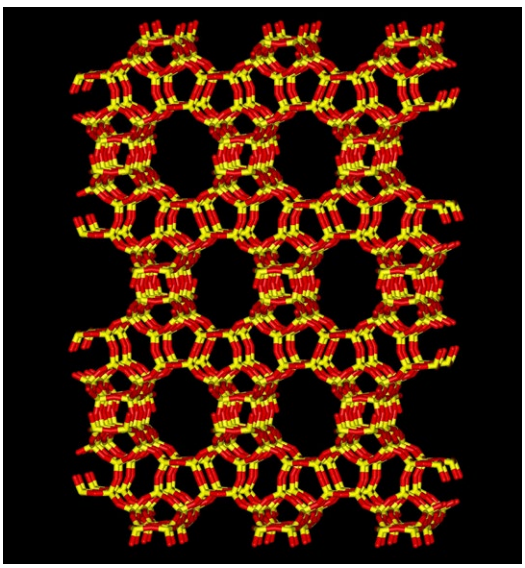
Catalyst pellet



Beta X-Ray Diffraction

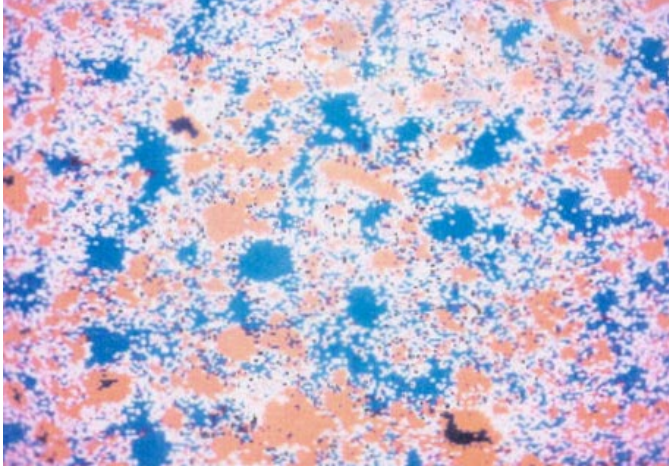


Beta Zeolite crystals



Model Beta Zeolite structure

Extrazeolite properties



● Zeolite and ● binder dispersion in catalyst particle

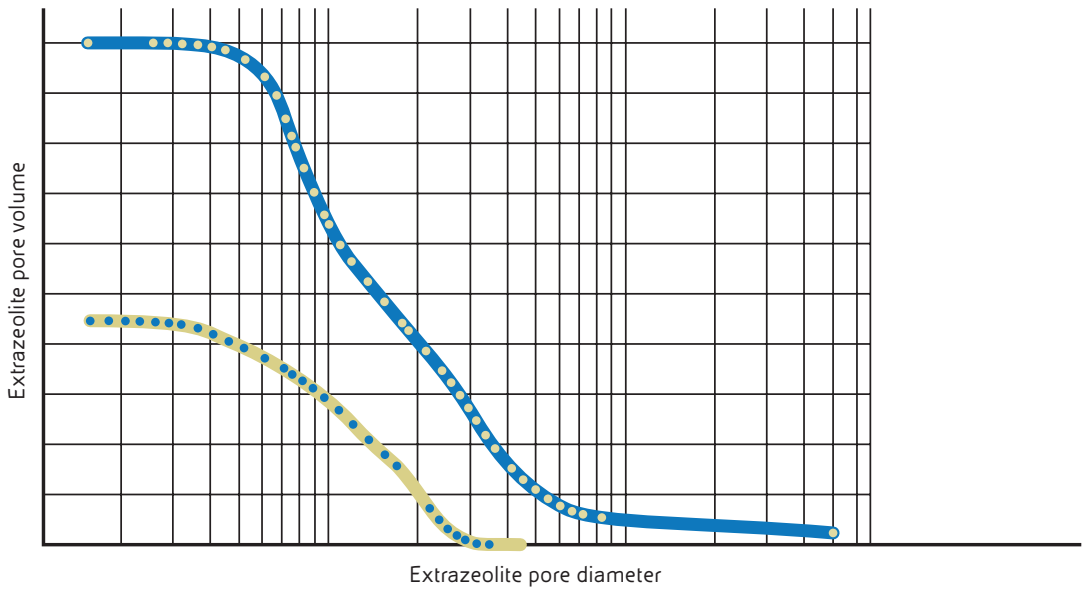
Extrazeolite porosity

PBE-1 catalyst deactivation rate is the lowest one ever seen in a zeolite based catalyst for cumene and ethylbenzene synthesis. This is due, beside to the specific features of the beta zeolite, to the extrazeolite porosity provided by the proprietary forming procedure. The resulting unusually high and well distributed extrazeolite porosity allows optimal diffusion of reactants and products through the catalyst particle, avoiding consecutive reactions responsible for coke precursors formation.

Catalyst Forming procedure

Thanks to the proprietary forming procedure beta zeolite is highly dispersed into the PBE-1 catalyst matrix giving incomparable high strength and negligible loss on attrition to the catalyst particle. Mechanical properties of the catalyst ensure very low and constant pressure drop as well as a negligible fine production during loading and unloading operations for several reaction/regeneration cycles in industrial cumene and ethylbenzene synthesis.

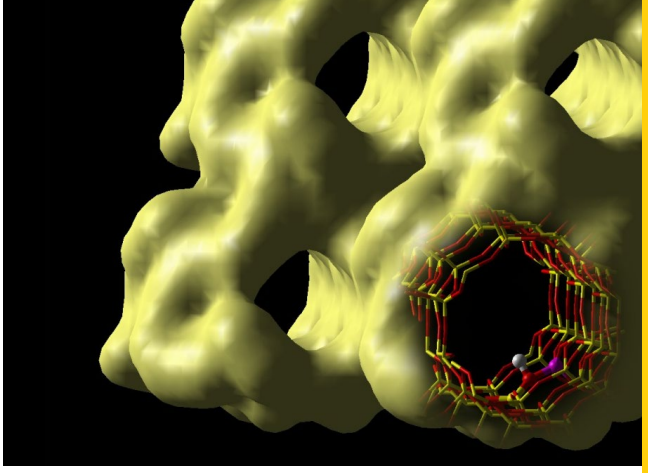
Extrazeolite pore size distribution



Proprietary zeolite based catalyst forming procedure

Conventional zeolite based catalyst forming procedure

Zeolite properties



Zeolite surface and Acid Site in BEA structure

Zeolite morphology

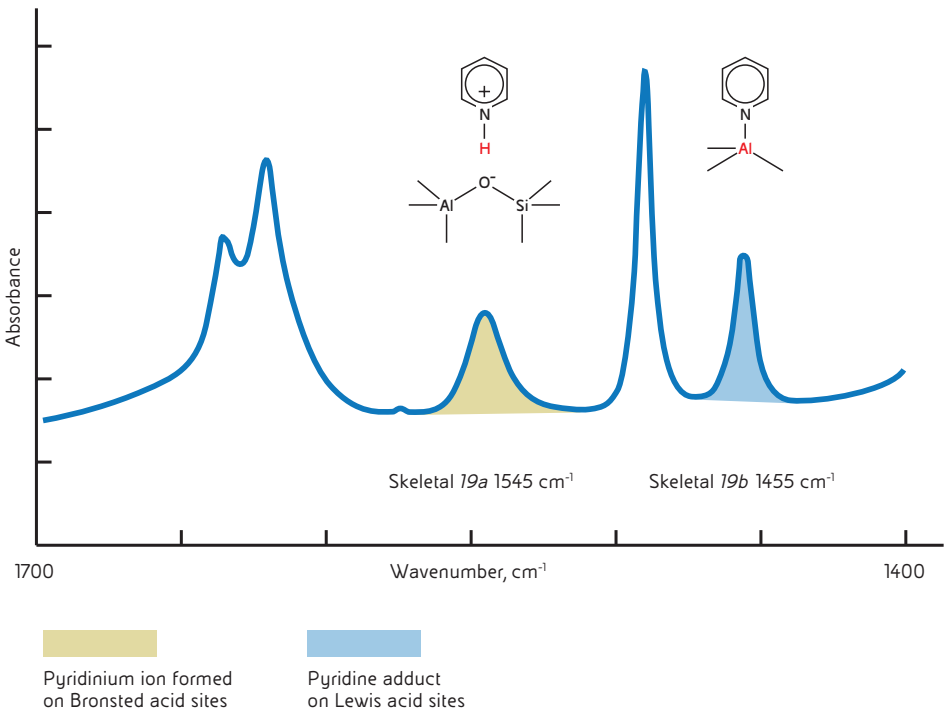
Zeolite morphology is also a peculiarity of PBE-1 catalyst. The small dimension of zeolite crystals together with their uniform distribution allow faster diffusion of reactants and products into and out of the zeolite crystals leading to better performances in terms of monoalkylation selectivity as well as negligible formation of recognized coke precursors.

Zeolite Acidity

The overall amount of acid sites as well as their distribution between Bronsted and Lewis types into the beta zeolite (BEA) structure are peculiar in PBE-1 catalyst.

The combined effects of acid sites amount and distribution leads to an unusually high activity and selectivity to cumene and ethylbenzene in both alkylation and transalkylation reactions. These unique acid properties give to PBE-1 catalyst an incomparable tolerance to all poisons normally present in benzene and propylene feedstocks as directly proven through pilot plant experiments with doped feedstocks. Both acid sites amount and distribution in the zeolite are strictly regulated by specifications in PBE-1 catalyst production and carefully controlled by FTIR spectroscopic titration titration after adsorption/ desorption of pyridine probe molecule.

Acid sites titration by FTIR-spectroscopy of adsorbed Pyridine



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