HPPOa

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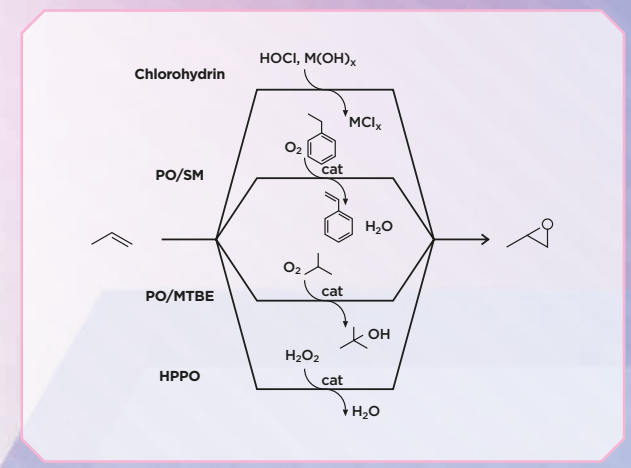
Preconditions of the creation of new technology

Propylene Oxide (C_3H_6O) is a colorless liquid with low boiling temperature and high chemical activity, which is currently one of the most important chemical intermediate products, especially in the field of polyurethane and solvents production. Its polarity and a strained three-membered epoxy ring makes it easier to open after the reaction with various substances.

Since the early 1950s the importance of propylene oxide for chemical industry has increased drastically. The major amount of propylene oxide is used for the production of polyurethane plastics and propylene glycol. Polyurethanes have a wide range of applications, including automotive components, construction and insulation materials, as well as materials for furniture cover, sports shoes and other products, moreover, the consumption of propylene oxide is highly growing.



There are several technologies of propylene epoxidation with hydrogen peroxide using methanol as a propylene solvent. **Techinservice** uses acetonitrile as a propylene solvent, which drastically reduces the amount of process byproducts.

Different ways of propylene oxide production are shown on the picture. The modern method of direct propylene epoxidation with hydrogen peroxide has no dangerous byproducts.

High propylene oxide demand has made **Techinservice** start the search and development of improved propylene oxide production technology.

The history of Propylene Oxide production technology

All currently active technologies of **Propylene Oxide** production are based on the use of TS-1 catalyst.

The TS-1 catalyst (Silicalite-1) – zeolite type TS-1 is used as a catalyst in the reactions of olefin epoxidation, hydroxylation of aromatic compounds, oximation of ketones and oxidation of alcohols.

The main method of TS-1 catalyst production is sol-gel synthesis. Tetraalkyl orthosilicates and titanates and tetraalkyl ammonia hydroxides are used as sources of silicon, titanium and template.

year 1983 — TS-1 catalyst was first synthesized by EniChem (Italy). The technology of direct propylene epoxidation with hydrogen peroxide (HPPO technology) was developed.

year 2008 — Evonik (formerly Degussa) and SKC have launched the first integrated plant for propylene oxide production based on HPPO technology with a capacity of 100,000 tons/year.

year 2009 — BASF and DOW Chemical have launched the propylene oxide production plant based on HPPO technology with a capacity of 300,000 tons/year.

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Development and implementation of Techinservice's own technology – HPPOa

Year 2017 — **Techinservice** has developed its own unique way of obtaining the TS-1 catalyst and was so named TIS-1 and is characterized by the use of solid pyrogenic silica (Aerosil) as a source of silicon ions.

Year 2017 — **Techinservice** has developed its own unique way to load the catalyst into chemical reactors, which makes the process flow smoother, and the heat formation during the reaction more evenly distributed throughout the chemical reactor.

Year 2017 — **Techinservice** has carried out the laboratory stage of the propylene oxide production process using its own TIS-1 catalyst.

Year 2018 — **Techinservice** has obtained a utility model patent (**No. 128666**) and a patent on invention (**No. 118740**) of TIS-1 catalyst production using solid pyrogenic silica as a source of silicon ions – «Method of TS-1 zeolite production».

Beginning of year 2019 — **Techinservice** has obtained a utility model patent (**No. 132506**) regarding the loading of catalyst into the chemical reactor – «A method of conducting catalyzed exothermic reactions».

Beginning of year 2019 — **Techinservice** has obtained a utility model patent (**No. u 2018 11110**) and a patent on invention (**No. a 2018 11109**) regarding propylene oxide production using its own catalyst and acetonitrile as a solvent (was so named HPPOa technology).

Year 2019 — **Techinservice** has begun industrial tests of its own method of propylene oxide production using HPPOa technology.

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The general characteristics of HPPOa technology

The new technology of propylene oxide production using hydrogen peroxide (HPPOa) is the reaction of liquid phase epoxidation of propylene with hydrogen peroxide in an aqueous solution of acetonitrile on TIS-1 catalyst.

The raw material for propylene oxide production plant is a propylene and hydrogen peroxide. The byproduct of the reaction is water.

The reaction is characterized by mild flow conditions: pressure up to 30 bar, temperature up to 50°C. The heat of the exothermic reaction of propylene oxide epoxidation is being removed by the water, circulating in the cooling system of the reactor, maintaining isothermal conditions of the reaction.

This method allows maximum utilization of unreacted hydrogen peroxide and achievement of a total conversion ratio of hydrogen peroxide not less than 99.3% with selectivity based on propylene more than 95%. This reduces the decomposition of hydrogen peroxide with the formation of oxygen and improves the safety of the process because of additional degassing of the stream after the reactors.

The steps of Propylene Oxide production method:

- purification of propylene from impurities;
- absorption of propylene with acetonitrile solution;
- propylene epoxidation reactions;
- preliminary separation of the product mixture;
- purification of propylene oxide;
- regeneration of acetonitrile solution.

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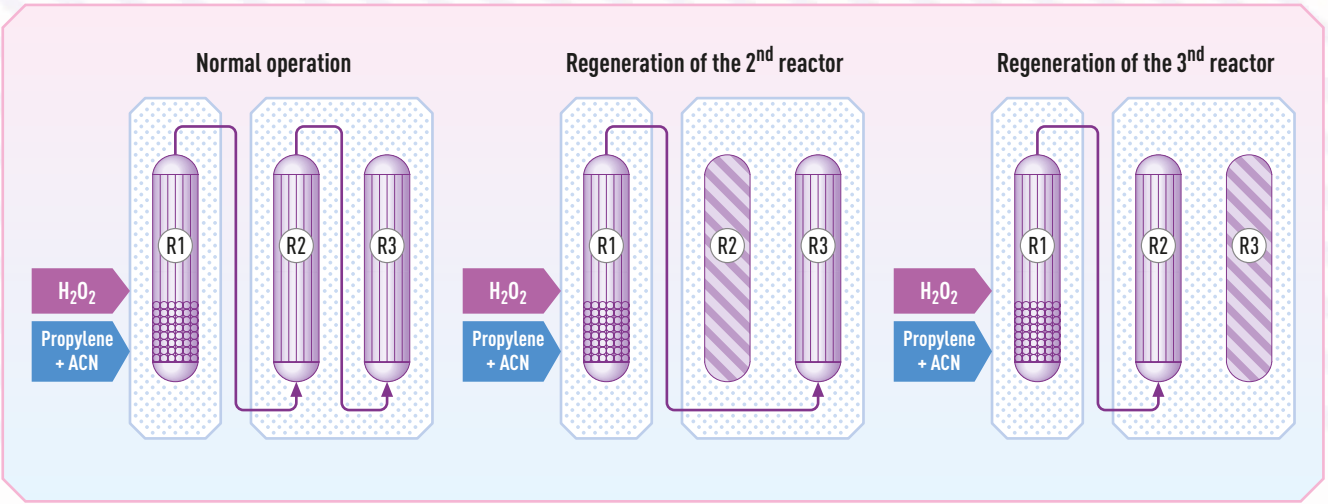
The technological benefits of HPPOa

- The process without the formation of byproducts due to the use of acetonitrile.
- Long-term use process catalyst obtained using our own highly efficient method. The developed method makes it possible to obtain a reaction mixture for the synthesis of zeolite in the form of a gel, the crystallization of which in zeolite occurs much faster and at lower temperatures than from liquid reaction solutions. The use of a gel with reduced water content allows to increase the concentration of silicate anions, which contributes to the faster formation of zeolite. This method makes it possible to simplify and reduce the cost of the process of synthesis by reducing the amount of the template and conducting the crystallization of zeolite at a lower temperature, which allows to increase the productivity of the process and reduce the cost of the product – TIS-1 zeolite, without compromising its quality.
- The smoothness of the reaction and a more even heat distribution throughout the reactor height due to the patented technology of catalyst loading into the chemical reactor.
- Specific feature of the 3-stage reaction allows to reduce unit capacity and conduct catalyst regeneration deactivating reactors one at a time. At the same time, the mobility and flexibility of the whole unit is achieved.



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Ecologically safe production using HPPOa technology

- Acetonitrile, which is used as a solvent, is twice less hazardous to human life and safety (based on MPC) compared to methanol, which is used in other technologies.
- Completely closed solvent and raw material cycles.

Economic benefits of HPPOa technology

- Low cost of TIS-1 catalyst production without the loss of quality compared to other production methods
- High process selectivity based on propylene oxide and as a result complete absence of byproducts in production
- Possibility of the use of polymeric and chemical grade propylene.

Estimated cost

Propylene (as per 100%)	**0.73 kg/kg Propylene Oxide**
Hydrogen peroxide (as per 100%)	**0.65 kg/kg Propylene Oxide**
Steam	**3.0 kg/kg Propylene oxide**
Electricity	**230 kW•h**

Propylene oxide specification

Purity of propylene oxide	**is not less than 99.97 % wt**
Mass fraction of water	**is not more than 100 ppm**
Mass fraction of aldehydes	**is not more than 50 ppm**
Color, Pt-Co (APHA color)	**is not more than 10**

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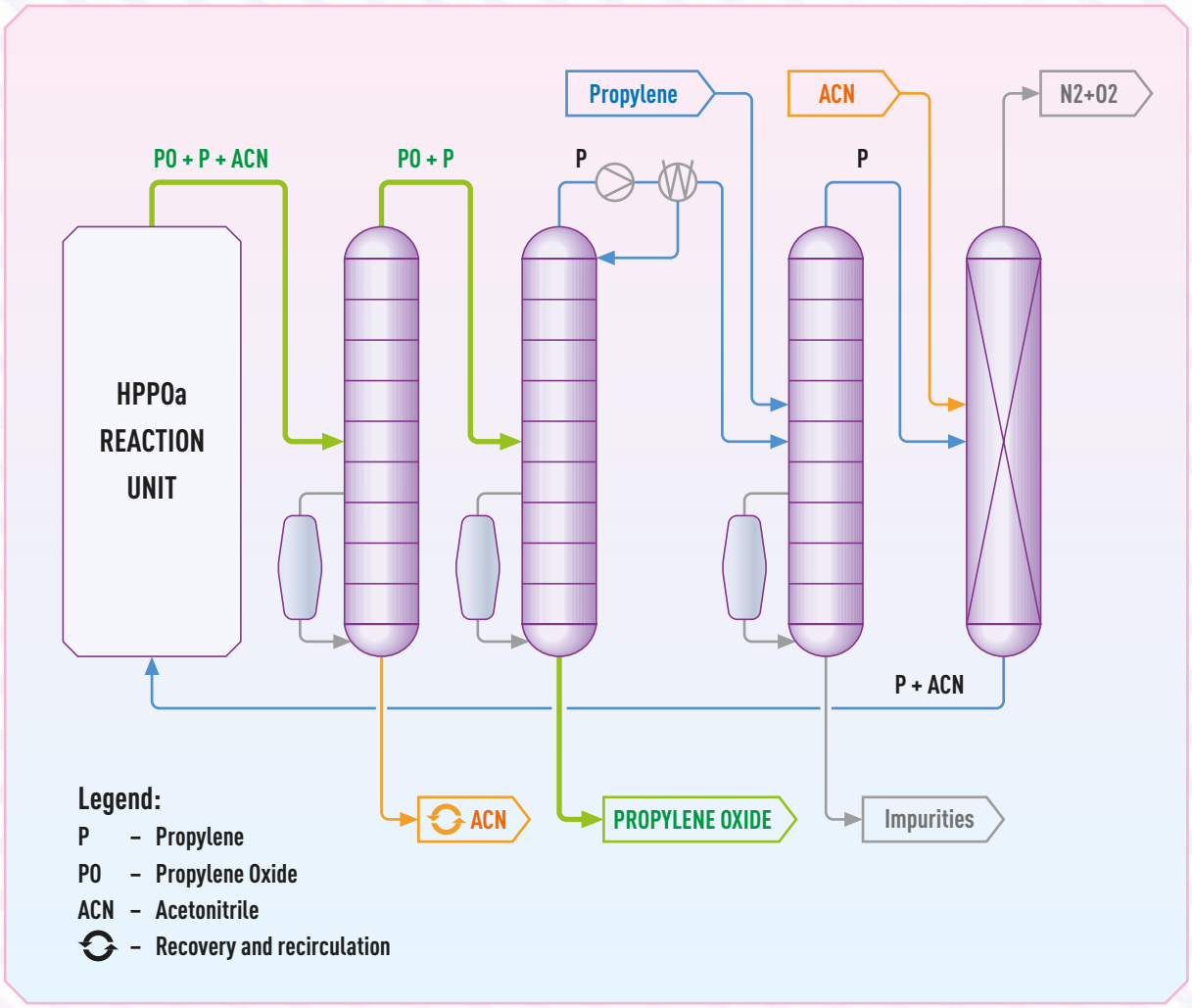
Process flow chart



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