



MEASUREMENT INTELLIGENCE

Styrene monomers in high quality

Process analytics optimizes styrene monomer production

Global significance of styrene

Styrene is one of the most important monomers for the polymer industry. Today the total annual production of styrene is on high levels in the range of more than 30 million tons, so that the production of styrene is one of the most important industrial processes.

The colorless oily liquid is an aromatic olefin with the chemical formula $C_6H_5CH=CH_2$. It is easy to be polymerized due to the pres-

ence of a carbon double bond, and it is a main monomer block for the production of polystyrene and other polymer derivatives.

There are three types of processes generally used – suspension, solution and mass (bulk) polymerization.

[siemens.com/process-analytics](https://www.siemens.com/process-analytics)



Siemens PGC in a shelter.

SIEMENS

Process analytics contributes to plant efficiency

Styrene plants are equipped with comprehensive measuring and control instrumentation in order to comply with the requirements of quality and energy efficiency control. Field instrumentation

includes process analyzers and analyzer systems to monitor in detail the production steps by analyzing the process flow streams for their composition and communicate the measured data to the central control system.

The Siemens value add

Siemens offers proven-in-use analyzers and solutions together with a specific application expertise for aromatics plants such as for various EB-SM licenses.

The process gas chromatograph MAXUM Edition II for the multi-component analysis of aromatics as well as the continuous gas analyzer SIPROCESS GA700 series for the individual analysis of O₂ are offering convincing solutions for advanced process control (APC).

Let's have a deeper look into the process details

The most common technology for manufacturing styrene monomer is the dehydrogenation of ethylbenzene. Most of the world's actual styrene production is carried out using this technology. Licensors like McDermott/Lummus, TechnipEnergies/Badger or Versalis use alkylation of benzene with ethylene to produce ethylbenzene (EB) as intermediate. In a second step superheated steam is used to produce styrene monomer (SM) from ethylbenzene by dehydrogenation.

The ethylbenzene (EB) process as first production step uses a fixed-bed zeolite catalyst, which provides a run duration of several years. To get a mixture of alkylated benzenes and excess benzene the alkylation of benzene with ethylene is involved in the EB process. The mixture is then distilled to recover EB, and to recycle benzene and higher ethylated

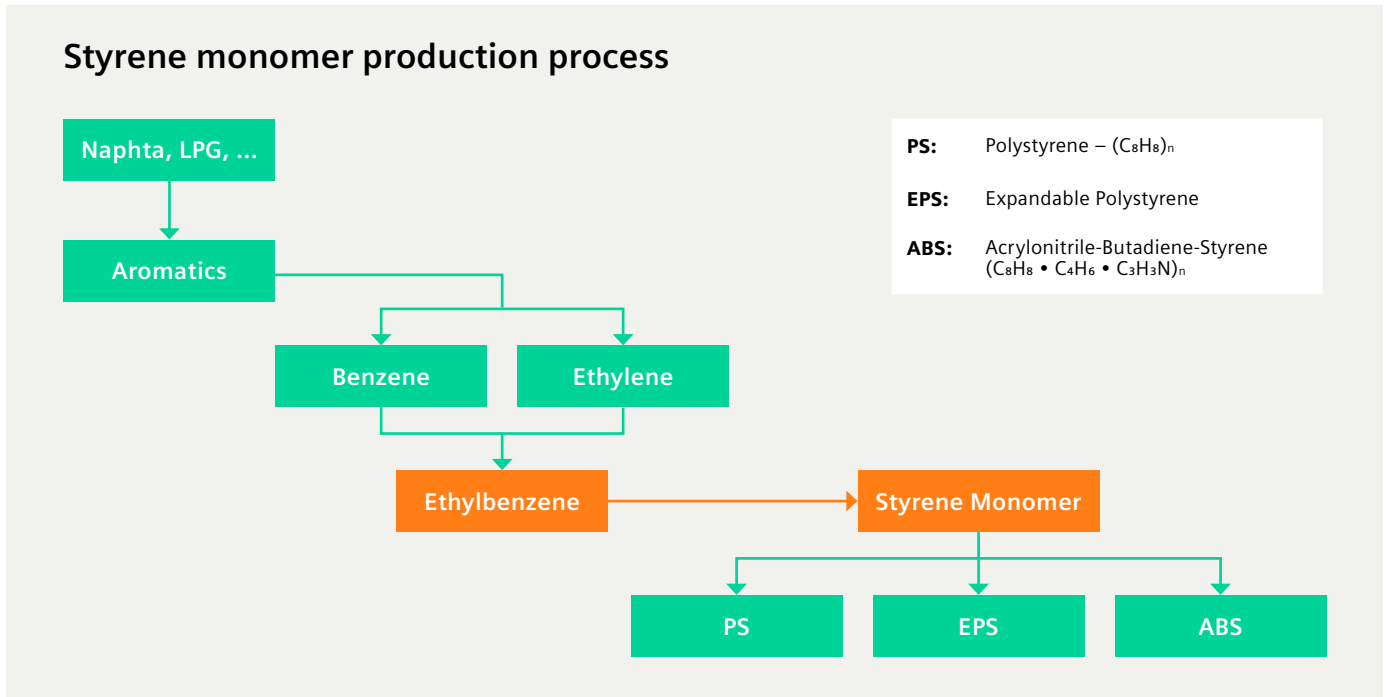
benzenes. The latter are trans-alkylated with benzene to form additional EB. The recycle benzene is sent back to the alkylator and transalkylation reactor vessels and the EB product to the dehydrogenation section of the styrene unit. Sampling points for measuring are the O₂ concentration at the outlet of the alkylation reactor and chemical byproducts at the ethylbenzene reactor.

During the styrene monomer process as the second production step the dehydrogenation of EB to SM and byproducts is the major reaction. This catalytic reaction is endothermic. The reaction heat will be supplied by steam from a super heater. The steam is the source of heat and it removes coke that tends to form on the iron oxide catalyst. On the other hand the reactor effluent is cooled by generating steam.

The dehydrogenated mixture is distilled to recover SM product, recycle EB, as well as benzene and toluene by-products. Inhibitors are added to prevent styrene polymerization. The measuring task in this production step are: O₂, N₂, CO and CO₂ concentrations in fuel gas to compressor, various by-products

during distillation and fractionation processes.

For the third production step to polymerize styrene to polystyrene there are three types of processes generally used – suspension, solution and mass (bulk) polymerization.



Use case: Process analyzer set-up for EB-SM route

In order to comply with the requirements of quality, safety and energy efficiency control styrene plants are equipped with comprehensive measuring and control instrumentation.

Field instrumentation includes process analyzer solutions to monitor in detail the production steps by analyzing the process flow streams for their composition and communicate the measured data to the central control system.

Siemens process analytics supports with its high performance PGC MAXUM Edition II, the Continuous Gas Analyzers SIPROCESS GA700 and the in situ gas analyzers SITRANS SL and LDS 6 together with specific application knowledge.

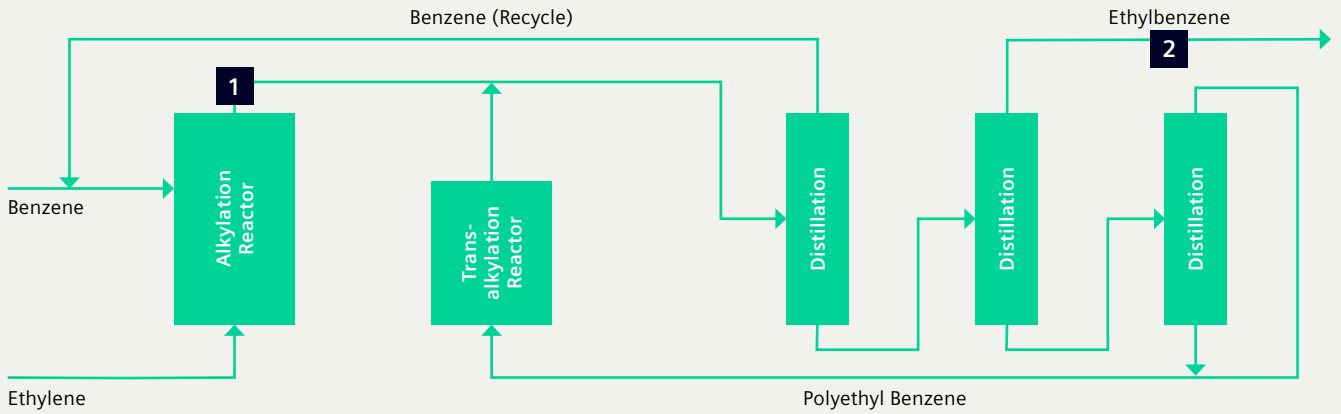
MAXUM Edition II represents the top technology in process gas chromatography for analyzing liquids and vapor process samples with significant benefit for the user:

- Liquid injection modules optimize the vaporization of liquid samples and guarantee a representative and sample analysis
- A broad range of column types and columns switching technologies secure an interference free and accurate determination of measured components
- Sensitive detectors enable also the determination of critical trace components to meet product specifications
- Airless ovens minimize utility costs

Siemens process analytics offers a comprehensive portfolio of continuous extractive and in situ measuring gas analyzers. The analyzers such as the SIPROCESS GA700

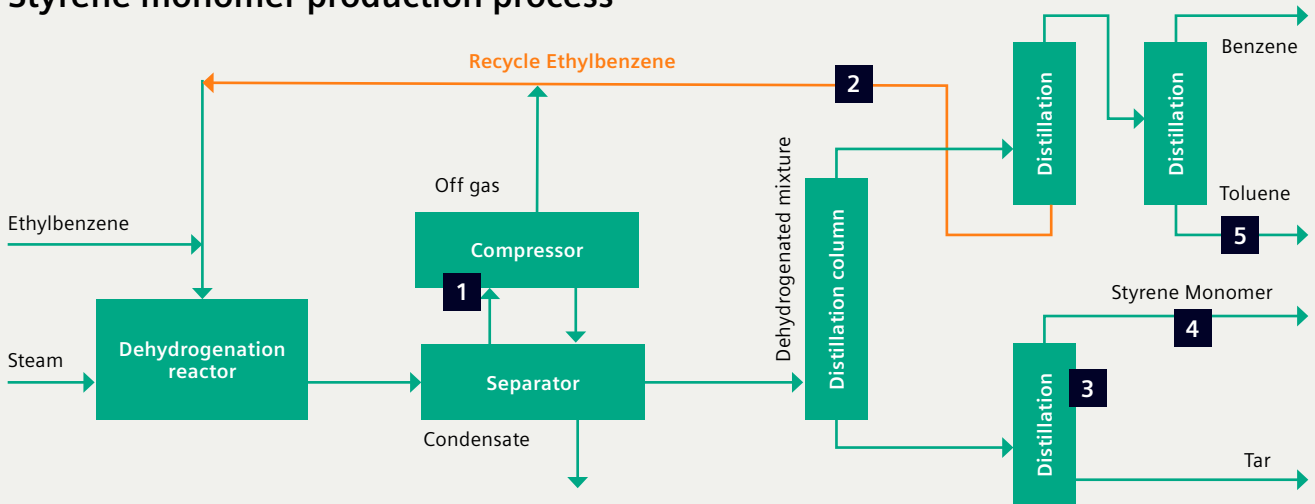
OXYMAT 7 can be easily integrated into the Totally Integrated Automation (TIA) concept and are programmed using SIMATIC PDM software and PROFIBUS DP/PA interfaces.

Ethylbenzene production process



Sampling point	Location and application	Measuring component	Measuring range	Siemens analyzer
1	Alkylation reactor outlet	O ₂	0 – 5%	OXYMAT 7 or SITRANS SL
2	Ethylbenzene purity	o-Xylene, m-Xylene, p-Xylene, Benzene, Toluene, Cumene, Styrene	High ppm to low % level	Maxum Edition II

Styrene monomer production process



Sampling point	Location and application	Measuring component	Measuring range	Siemens analyzer
1	Fuel gas to compressor	O ₂	0 – 2%	OXYMAT 7, SITRANS SL
		N ₂ , O ₂ , CO, CO ₂	Low to medium % level	Maxum Edition II
2	Recycle ethylbenzene	Nonaromatics, Benzene, Toluene, Styrene	Low to medium % level	Maxum Edition II
3	Styrene distillation – plateau	Styrene, Nonaromatics, Ethylbenzene, m-/p-Xylene	Medium to high % level	Maxum Edition II
4	Fractionation overhead – SM purity	Ethylbenzene, m-Xylene, p-Xylene, Phenylacetylene, Alpha-Methylstyrene, Cumene	Medium to low ppm level	Maxum Edition II
5	Toluene fractionation bottom	Benzene	0 – 2%	Maxum Edition II

Process Gas Chromatograph MAXUM Edition II



MAXUM Edition II represents the top technology in process gas chromatography for analyzing liquids and vapor process samples. The multiple analytical tools such as injectors, ovens, sensitive detectors or columns adapt the hardware perfectly to the analytical needs. The airless oven reduces utility costs as well as the use of corrosion-resistant materials when required for the application.

When the chromatographs are installed on an Ethernet network, the “Gas Chromatograph Portal” software provides real-time analysis and maintenance information for reliable monitoring and control.

SITRANS SL



The measuring principle of the diode laser gas analyzer SITRANS SL is based on the specific light absorption of different gas components. SITRANS SL with its extremely rugged design and minimum maintenance requirements is suitable for fast and non-contact measurement of gas concentrations in process or flue gases. The sensors (transmitter and receiver) are meant to be mounted directly on the process with no need of sampling systems. The hardware for processing the measurement signal into a concentration value as well as monitoring, control and serving of the communication means are also integrated into two main modules.

Continuous Gas Analyzer SIPROCESS GA700



With its long service life, the SIPROCESS GA700 OXYMAT 7 is an exceptionally reliable measuring device and can even handle small measuring ranges (0 to 0.5% O₂). With its vibration compensation and physically suppressed zero point (99.5 to 100% O₂) it delivers highly precise measurements. The module can be operated in either a rack or wall-mounted housing. Furthermore, the operating concept is based on a clearly laid-out menu structure. The advantages offered by the OXYMAT 7 make it indispensable for many applications in incineration plants, in environmental protection, or in quality assurance monitoring purity, and many more areas.

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