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Polystyrene

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Report Abstract
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Nexant

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INTRODUCTION

Polystyrene is a commodity polymer with a broad range of end-uses. It is a high molecular weight linear thermoplastic resin widely used in a variety of applications across the world.

There are two main types of polystyrene: general purpose polystyrene (GPPS), and high impact polystyrene (HIPS). HIPS contains a small proportion of butadiene rubber, giving it higher strength and better impact resistance. GPPS is normally used in the transparent or "glassy" form, or foamed. GPPS accounts for slightly more than half of the market, and is mainly used in disposable packaging, transparent containers and foamed applications, while HIPS is used for housings of electrical appliances and for refrigerator internal panels.

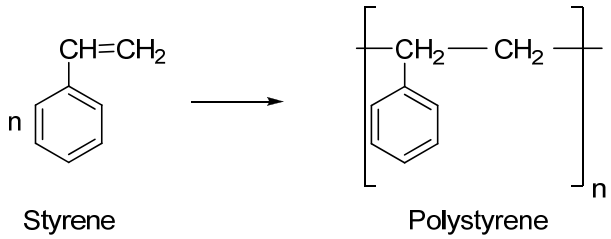
Another important type of polystyrene is expandable polystyrene (EPS). EPS is a form of polystyrene with a propellant such as pentane dissolved in it. On heating, the EPS granules expand rapidly into a foam structure, and EPS is therefore useful in applications requiring a rigid, light and insulating material.

The outline of this report is as follows.

- An overview of the licensing technology status is given
- Current production technology including an overview of polymerization mechanisms and chemistry is discussed
- Specific licensor processes are also described in detail (INEOS, Polysty and Versalis)
- A patent review has been carried out and developing technologies and improvements are discussed
- Generic cost of production economics for GPPS, HIPS and EPS (via suspension and continuous polymerization) are provided
- Commercial end-use applications, global and regional market overview analysis is given

COMMERCIAL TECHNOLOGY

All polystyrene is prepared by polymerizing styrene in an exothermic reaction:



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Styrene can be polymerized by all four of the discrete polymerization mechanisms: anionic, cationic, free-radical and Ziegler Natta. Of the four mechanisms, free-radical mechanism is the one most commercially prevalent and forms atactic (amorphous) polystyrene, which is the type most widely used in packaging and durable goods. Free–radical polymerization is used industrially in two different processes: continuous (mass or bulk) polymerization and suspension polymerization.

Although General Purpose Polystyrene (GPPS) is the main commercial form, there are three other types of polystyrene: High Impact Polystyrene (HIPS), Expandable Polystyrene (EPS) and Syndiotactic Polystyrene (SPS). These are created through slightly different polymerization procedures.

General purpose polystyrene (GPPS) and high impact polystyrene (HIPS) are made using continuous mass polymerization (i.e., most polystyrene is manufactured using continuous bulk polymerization plants).

Expanded polystyrene is traditionally produced using the suspension process and consists of a high molecular weight crystal grade polystyrene with five to eight percent composed of low-boiling-point aliphatic hydrocarbon blowing agent that is dissolved within the polymer. The blowing agent is typically pentane. This process can be adapted in two ways: either the blowing agent is added to the reactor after polymerization or the agent is added to the monomer before polymerization. The former method is more common in industry. Recent developments using the continuous process have surfaced in industry.

The report covers in-depth descriptions of the technology and chemistry behind continuous mass polymerization for GPPS and HIPS; and suspension and continuous mass polymerization for EPS. Reactor types and various equipment configurations are discussed. A separate section provides a generic description of syndiotactic polystyrene production via Ziegler Natta systems.

Processes offered by various licensors are also discussed including:

- INEOS GPPS, HIPS and EPS technologies
- PolySty GPPS, HIPS and EPS technologies
- VERSALIS GPPS, HIPS and EPS technologies

PATENT REVIEW

Nexant has performed a thorough search of the patent applications filed in the last six years (i.e., since the last Polystyrene PERP report was published) and highlights some of the most interesting developments. (Where pertinent, many of the lessons learned from the review are already incorporated in the discussion of the commercial technologies.)

Polystyrene production is a relatively mature field, and, as a result, most developments are in the field of additives that increase or alter the properties of the final product.

PROCESS ECONOMICS

Nexant has evaluated costs of production estimates for the production of polystyrene via the following commercial processes:

- Continuous (mass) polymerization to form GPPS
- Continuous (mass) polymerization to form HIPS
- Continuous (mass) polymerization to form EPS
- Suspension polymerization to form EPS

The above cost estimates highlight the different process economics for various products as they are all on a same capacity and USGC location basis, having the same raw materials, utility and labor costs basis. However, the USGC location is not reflective of the developing industry as no new project is planned to be built in this region. Therefore, Nexant has also developed and compared the process economics for production of polystyrene in locations where major global capacity additions are planned in the next five years, namely:

- North-East Asia (China)
- South-East Asia (Singapore)
- North West Europe

Between 2004 and 2009, the price of polybutadiene rubber in the U.S. Gulf Coast fluctuated over a very wide range and therefore Nexant included a sensitivity analysis on the cost of production of HIPS using historical polybutadiene rubber (PBR) prices.

All cost tables given in this report include a breakdown of the cost of production in terms of raw materials, utilities, and direct and allocated fixed costs. These categories are presented annually by unit consumption and per metric ton. The contribution of depreciation is also included to arrive at a cost estimate.

COMMERCIAL MARKET REVIEW

The most common commercial form of polystyrene is a clear, colorless, hard, odorless, tasteless material that exhibits exceptional optical, thermal and electrical properties; and it has excellent mechanical strength. Due to these properties as well as the ease of heat fabrication, thermal stability, relatively low density and low production costs, polystyrene is utilized over a variety of end uses.

Most forms of polystyrene have good UV stability and resistance to gamma radiation which means that they are used frequently in products that require sterilization.

GPPS and HIPS

Global polystyrene consumption rebounded in 2010 after two years of decline that was partly due to the economic crisis and partly due to industry rationalization and feedstock costs. Polystyrene is widely used in the packaging sector in such products as disposable cutlery, vending cups, egg and meat trays, salad boxes, soup bowls, and hamburger clam shells.

Moreover, it is used in the electronic and electrical sector for applications such as media closures. Despite a small base, polystyrene also finds use in the construction sector for drainage boards, displays, prefabricated walls, decorative gables and facades.

- Global supply, demand, and trade data are given and discussed.
- Discrete regional supply, demand and trade data are also given and discussed for North American, Western Europe and Asia Pacific
- A listing of plant capacities in each of the regions listed above is given, denoting owning company, plant location, and annual tonnage produced.

EPS

The largest use of EPS is in the production of foam boards for buildings insulation, and it is widely used to create moulded shapes for packaging fragile goods, such as TV sets, and in foam cups for hot drinks. GPPS can also be blown into foam with the use of a propellant, while EPS is distinguished by having a hydrocarbon propellant dissolved in the granules themselves.

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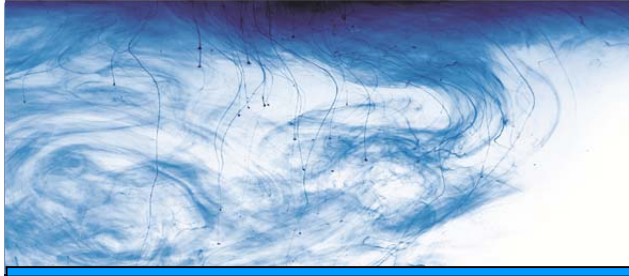

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