

# Licensed Polyolefin Technologies and Services

## *Spherizone*

Latest-generation polypropylene process technology based on a multi-zone reactor that produces high-performance polypropylene and novel polyolefins.

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*Spherizone* plant – SamsungTotal, Daesan, South Korea

LyondellBasell's breakthrough *Spherizone* multi-zone circulating reactor process provides an economical and efficient method of manufacturing a wide range of high-quality polypropylene and novel, propylene-based polyolefinic resins. Since the launch of the *Spherizone* process in 2004, more than three million tonnes of capacity have been licensed.

### A new chapter in polypropylene technology

For many years, polypropylene process development has focused on bimodal technology and increasing operating temperatures to improve product properties. Bimodality has been achieved by operating two reactors in series at different operating conditions, resulting in a polymer with two performance characteristics combined on an "intraparticle" level. In the *Spherizone* process, bimodality involves one single reactor operating different conditions within each zone, resulting in the blending of multiple properties on a macromolecular level.

With the ability of the *Spherizone* process to drive products to new property and performance extremes, the technology continues to emerge as the new benchmark for polypropylene production. *Spherizone* process resins have the potential to expand polypropylene's use into entirely new applications and markets.

### Key characteristics of *Spherizone* process technology

#### Safety and environment

- LyondellBasell's process technologies have a safety record among the best in the industry
- Reduction of both resource consumption and emissions and low energy consumption
- Recovery and recycling of non-reacted monomers
- No undesired by-products from the reaction

#### Product capability and versatility

- Wide range of high-quality PP products possible
- Novel resins with expanded properties and performance
- High product quality, allowing bimodality in MFR and composition
- Minimum property variation due to process stability and LyondellBasell's *Avant* catalyst performance

#### Reliability

- Structurally identical to the *Spheripol* process, *Spherizone* has demonstrated high reliability

#### Design flexibility

- Single-line capacities of up to 500 kt/a can be provided
- Homopolymer, random copolymer or heterophasic impact copolymer production designs
- Polymer grade propylene or chemical grade propylene feedstock

#### Modular flexibility

- A modular design enabling the low-cost addition of a fluidized bed gas-phase reactor for heterophasic impact copolymers

#### Economics

- Capital costs are competitive with any PP technology currently available
- Best in class operating costs

## Spherizone process description

In combination with LyondellBasell's *Avant* catalysts, the *Spherizone* process produces spherical polymer particles directly in the reactor. The specially designed loop reactor consists of two reaction zones, and the growing polymer granules are circulated between the two different zones of the multi-zone circulating reactor (MZCR). In the riser zone, the polymer particles are entrained upward through a fast fluidization regime in the monomer gas flow. At the top of the reactor, the polymer particles then enter the downer zone, where a downward, dense phase plug flow pattern occurs under gravity. At the bottom of the reactor, the polymer particles are again fed to the "riser" section, and the reaction cycle is repeated.

In order to create reaction conditions in the downer, which are different from the conditions in the riser, a barrier stream is injected in a stripping zone below the level of the polymer bed at the very top part of the downer.

With this type of system, a "One-Reactor Cascade" has been created. The stripping zone is the core of the MZCR, as it gives the unique feature of two fully controlled but separate polymerization conditions in just one single reactor.

The optional gas-phase copolymerization reactor and finishing section consist of highly efficient process steps utilizing the well-proven design of the *Spheripol* process technology.

## Spherizone process – Product properties and performance

The versatility of the *Spherizone* process is demonstrated by the high-quality product range it produces, which includes all standard polypropylene grades as well as unique polyolefin products. The capabilities of the *Spherizone* process to deliver new performance potential across the entire product portfolio is illustrated by the extended product property graphic in figure 2.

As a result of the "One-Reactor Cascade" reactor, the operating window of the technology is drastically expanded and the product quality is greatly enhanced, resulting in the production of polypropylene resins that can outperform standard polypropylene grades.

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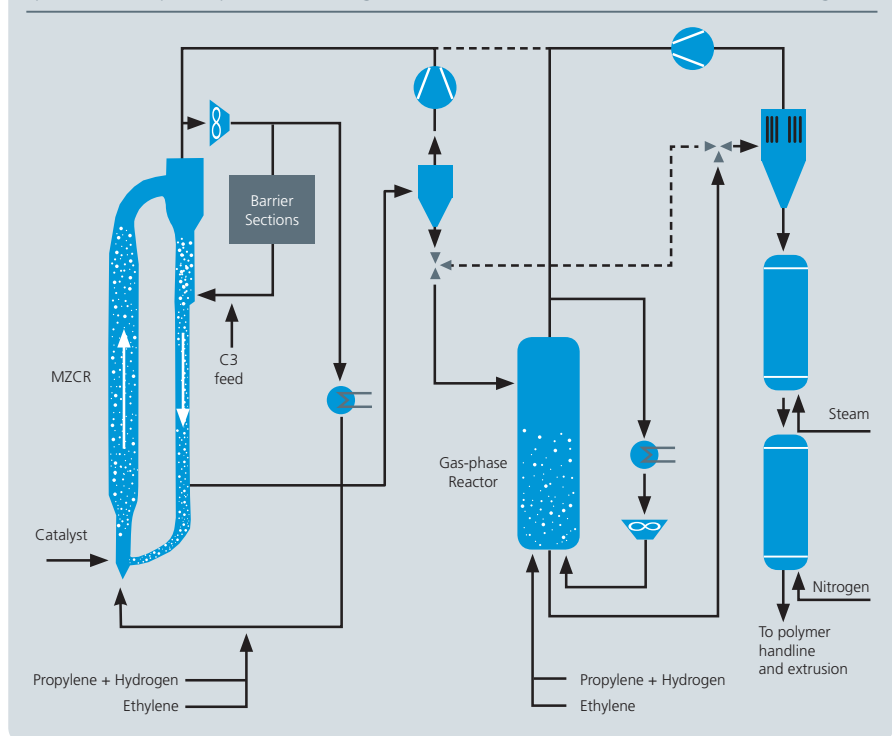
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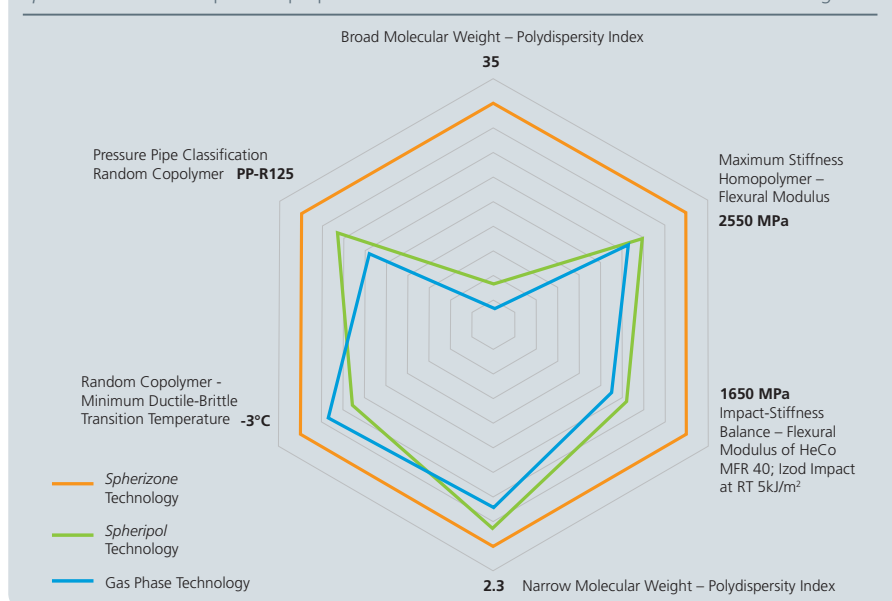
Spherizone simplified process flow diagram

Figure 1



Spherizone extended product properties

Figure 2



Products from the *Spherizone* process, for example, have surpassed the performance of conventional polypropylene used in pipe applications, including novel random copolymers with PP-R 125 classification

and new high-modulus heterophasic copolymers used in sewage and drainage pipe applications.

*Spherizone* process technology also enables the production of novel polyolefins, which are being used in entirely new applications previously the domain of traditional materials and competitive plastics. By extending the boundaries of polypropylene performance, the *Spherizone* process manufactures products with a very broad molecular weight distribution. These *Spherizone* process polyolefins replace conventional materials used in rigid packaging and other applications where extremely high melt strength is essential.