

# A CATALYST FOR GROWTH

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discusses the growth of  
the global polyethylene  
industry.*

Fuelled by two rather conflicting market developments, the global polyethylene (PE) industry has experienced significant growth during the past decade. Faced with the need to capture more value in a predominantly commodity driven market, raw material producers offered standard grades based on the most cost effective manufacturing technologies. However, converters and end users required differentiated products with enhanced mechanical and processing properties compared to standard PE resins. To address these polarised market requirements, sophisticated PE process technologies have been developed that manufacture a wide range of products within a cost structure that considers the financial pressures and cyclical nature of a commodity market.

LyondellBasell Industries has been at the forefront of this pioneering effort. Utilising its innovative manufacturing processes, LyondellBasell produces a range of PE resins with the performance and economics necessary for today's dynamic market.



Figure 1. Crack resistant pipes made out of LyondellBasell's HDPE.

Industry consultants predicted several years ago that linear low density polyethylene (LLDPE) was poised to capture substantial market share from low density polyethylene (LDPE). As it turned out nothing could have been further from the truth. LDPE's growth skyrocketed, though this was no surprise to many industry producers, as it has been a well established polymer with a broad application range that has grown in line with the economy. Another growth contributor has been the rapid rise of per capita consumption in developing countries, especially during their transition phases. Product displacement has been another key growth factor, as PE properties have been extended for use in market segments traditionally the domain of glass, wood, paper and metal, for example.

However, arguably one of the most important contributors to LDPE resin growth has been the successful market penetration of LyondellBasell's *Lupotech T* PE process technology. With over 50 years of manufacturing experience, combined with state of the art capabilities such as process simulation, advanced control, polymer research and material and equipment optimisation, LyondellBasell has developed the *Lupotech T* process into the most popular tubular reactor technology for LDPE production.

*Lupotech T* offers unprecedented competitive operating costs in world scale sized plants, while the final product can be sold at a premium over standard PE resins. LyondellBasell has invested in the continuous improvement of the *Lupotech T* process, and capacities of up to 400 000 tpy per line are now possible. Products from the *Lupotech T* process cover the entire range of melt flow rates and densities, including vinylacetate copolymers (EVA).



Figure 2. LyondellBasell's LDPE unit in Carrington, UK, based on *Lupotech T* technology

Table 1. Significant market growth for high pressure tubular LDPE in newly installed PE plant capacities since year 2000

Reference capacities with start up after year 2000	
Total new PE global installed capacity	22.4 million t
Share of new LDPE licensed capacity	6.5 million t
LyondellBasell <i>Lupotech T</i> licensed capacity	4.7 million t
Source: Parpinelli Tecnon and LyondellBasell Industries	

Since 2000, more than 15 production lines have been licensed globally, with a total licensed capacity of more than 7 million tpy. Several world scale plants with capacities of up to 400 000 tpy have recently been built utilising the *Lupotech T* process. Several more are under construction, which will result in nearly 3 million t of new LDPE capacity in the next few years (Table 1).

## Breakthrough LDPE technology

LDPE was discovered in 1933 and attained commercial importance in electrical insulation due to its optical and mechanical properties. The first commercial plants became operational in the 1950s. In the 1970s, major discoveries in terms of process safety, plant reliability and operating windows were achieved that resulted in superior plant integrity and enabled higher operating pressures. These, in turn, facilitated the expansion of the LDPE product portfolio into higher density LDPE grades that produced improved film properties.

Higher conversion rates and more efficient process controls were realised as a result of the introduction of organic peroxides as radical initiators in the 1980s. In the 1990s, research and development refocused its energies on process scale-up, process simulation and modelling as well as advanced process control. The introduction of *Luposim T*, LyondellBasell's proprietary simulation program for high pressure tubular reactors, created a powerful tool for process and product improvements.

In terms of scale up, *Lupotech T* technology achieved a breakthrough in 2001 with the startup of the world's largest LDPE plant at Aubette, France, with a single line capacity of 320 000 tpy. The world's largest *Lupotech T* plant, a 400 000 tpy unit in Saudi Arabia, will come onstream at the end of this year, and will be operated by the company's joint venture Saudi Ethylene and Polyethylene Company (SEPC). Other key performance characteristics of *Lupotech T* technology include:

- Safety and loss prevention: polymerisation of ethylene under high pressure in a tubular reactor takes place in ethylene as a diluent. Therefore, no additional solvent is required. Worldwide, over 50 million t of PE have been produced to date using *Lupotech T* technology, without major incidents.
- Reduced resource intensity: in the *Lupotech T* process, unreacted monomers are constantly recovered and recycled. Since hydrocarbons are not needed, there are no major effluent streams.
- Process versatility: fast grade changes ensure the amount of offgrade material is kept very low, allowing a broad grade slate to run on one reactor.

## A history of firsts in HDPE processes

In the high density polyethylene (HDPE) market, downgauged products that exhibit expanded mechanical properties with faster processing capabilities continue to be in high demand. To address this unique combination of requirements, LyondellBasell developed the bimodal product concept, licensed under the trade name *Hostalen*. This leading slurry cascade technology delivers products

with outstanding HDPE bimodal molecular weight distribution. With total worldwide installed capacity of over 6 million tpy, the process has emerged as the number one bimodal slurry technology.

The *Hostalen* process has been scaled up continuously from the original 16 m<sup>3</sup> reactors to a current reactor design volume of approximately 200 m<sup>3</sup>, facilitating production capacity of up to 400 000 tpy. The extrusion technology has also developed accordingly, optimising homogenisation performance for bimodal product requirements.

In 1953, LyondellBasell predecessor company scientist Professor Karl Ziegler discovered the first linear polyethylene chain in a low temperature, low pressure process by using a transition metal catalyst in conjunction with an organo aluminium as co-catalyst. Subsequently, the first discontinuous production plant was constructed in 1955 using BC catalyst, the first Ziegler catalyst developed for industrial PE production. Startup of the first *Hostalen* process plant using hexane as diluent in large reactor volumes took place in 1975. Today, over 30 million t have been produced worldwide without incident. The maximum capacity of a 400 000 tpy single line is restricted by the extrusion section.

In 1995, LyondellBasell's intensive research programme resulted in the development of a third generation catalyst, and the PE 100 class of resins for use in pipe applications was born. Today's new generation catalysts have further enhanced the capabilities of the *Hostalen* process, and ongoing developments are expected to deliver a single catalyst/co-catalyst system that can continuously enhance the range of HDPE applications.

*Hostalen* processes can produce HDPE resins with an excellent combination of processability and performance. Depending upon product requirements, the *Hostalen* process can accommodate different configurations of reactors. For unimodal HDPE the reactors are operated in parallel and for bimodal HDPE they are operated in series (cascade). Both modes can achieve the same capacity and can be switched in short transition times. *Hostalen* process technology also provides favourable production costs, due to a high conversion rate of up to 99.5% for ethylene, as well as butene recovery and hexane recycling, loss of co-monomer and diluent can be significantly reduced.

LyondellBasell's development of the new slurry *Hostalen* advanced cascade process (ACP) multimodal HDPE process provides a new dimension in product performance for HDPE. The technology has increased market growth of HDPE by offering high performance, tailored products for a wide range of demanding applications.

Multimodal resins produced using the *Hostalen* ACP process offer a combination of mechanical product properties and processing behaviour not achievable with conventional HDPE. The technology enables producers to address market requirements ranging from thin wall packaging to needs for higher crack resistance in pipe applications. In 2004, the first world scale *Hostalen* ACP plant became operational in Germany; another followed in 2005 in Poland. At the end of this year, the world's largest *Hostalen* ACP plant, a 400 000 tpy unit in Saudi Arabia, will come onstream and will be operated by the company's joint venture SEPC.

Figure 3. Medical uses of LDPE



### Spherilene PE technology

Especially in dynamic markets, producers with a smaller PE asset base require a high degree of flexibility. LyondellBasell's *Spherilene* technology can address this need, due to its innovative gas phase reactor concept, which is available in single and cascade configurations.

The *Spherilene* technology is a modular gas phase process designed to produce the entire range of linear polyethylene products, including high density polyethylene (HDPE), bimodal high density polyethylene (HDPE), medium density polyethylene (MDPE) and linear low density polyethylene (LLDPE). It uses a single Ziegler catalyst family for the complete product range, allowing easy and fast grade changes, including 'extreme' swings from low density LLDPE grades (0.915 g/cm<sup>3</sup>) to high density HDPE grades (0.962 g/cm<sup>3</sup>). The *Spherilene* process is a true swing technology, which does not require shutdown and cleaning in order to transition between product families.

In the single phase reactor version, *Spherilene* S, benchmark LLDPE grades and HDPE grades with narrow molecular weight distribution can be manufactured. This configuration can also utilise LyondellBasell's Avant C chromium catalysts to produce HDPE and MDPE grades with a broader molecular weight distribution.

Configured with two gas phase reactors in series, the *Spherilene* C process enables, in addition to the portfolio of the single reactor configuration, the production of premium grades with bimodal molecular weight distribution for sophisticated applications such as high strength film and certified pressure pipes. The flexibility of the *Spherilene* process facilitates fast response times to address changing market conditions and needs.

Today, the design capacity of *Spherilene* process plants ranges from 100 000 tpy to more than 500 000 tpy. The actual size and configuration of an individual *Spherilene* process plant is based upon market requirements and the targeted product slate. In addition to LyondellBasell's own *Spherilene* process assets in Europe, the process technology is in operation in all major regions of the world, including China, the Middle East and the USA, with five new lines under construction or in startup at present. 