LyondellBasell Leading Polypropylene Technologies

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Agenda

- Introduction to LyondellBasell
- LyondellBasell Polyolefin Technologies Portfolio
  - *Spheripol*: the benchmark PP technology
  - *Spherizone*: a PP technology with unique product capabilities
- Conclusions
LyondellBasell is a strong, global company delivering outstanding performance

**LEADING**
World’s largest licensor of polyolefin technologies.

#1
Producer of polypropylene compounds globally
Producer of oxyfuels in North America and Europe
Producer of polypropylene in North America and Europe
Producer of polyethylene in Europe

**GLOBAL**
Every day, our employees work around the clock to safely advance solutions to our world’s biggest challenges.

**DIVERSE**
Many of our materials go into products that people use every day, such as food packaging, electronics, children’s toys and fuels.

**GROWING**
Increased U.S. ethylene capacity by 21% since 2012
Expanded polypropylene compounds capacity in China, India and Europe
Building the first world-scale Hyperzone HDPE plant and world’s largest PO/TBA plant
Acquired A. Schulman, expanding our position in the advanced polymers markets

One of the world’s largest plastics, chemical and refining companies producing products and materials key to advancing solutions to modern challenges

(1) 2017 data as of December 31, 2017
LyondellBasell has the scope and scale to serve global markets

We manufacture and have joint ventures in 24 countries
Our products are sold in more than 100 countries

Note: Map is as of August 2018.
LyondellBasell capacity positions – 2017

1st
- Polypropylene Compounds (Global)
- Polyolefin Technology Licensing (Global)
- Polypropylene (North America, Europe)
- Polyethylene (Europe)

2nd
- Oxyfuels (Global)
- Propylene Oxide (Global)
- Ethylene (North America)
- Propylene (North America)

3rd
- Polyethylene and Polypropylene (Global)

Sources: IHS and LYB. All capacities as of December 31, 2017.
Note: Includes all wholly-owned capacity and our proportionate share of joint venture capacities. Propylene excludes refinery-grade propylene. Polypropylene includes Catalloy capacity.
LyondellBasell licensing offering

Polyolefins Technologies

- **Spheripol**
  Benchmark PP process

- **Spherizone**
  Differentiated PP process

- **Lupotech**
  LDPE/EVA processes

- **Spherilene**
  LL/HDPE process

- **Hostalen**
  Multimodal HDPE process

Chemicals Technologies

- **Olefins Recovery and Conversion**
  Trans4m for Butadiene, Butenes, Isoprene, DCPD

- **Aromatics Extraction**
  From Coke Oven / Pygas
  Benzene, Toluene, Xylenes

- **Acetyls**
  *Glacido* acetic acid process,
  *Vacido* vinyl acetate monomer (VAM) process

- **Oxiranes & Derivatives**
  Propylene oxide, Styrene, Butenes
  MTBE/ETBE, Butanediol

A comprehensive portfolio of technologies for license
Optimization Embedded in Technology Offering

Benchmarking and Continuous Improvement

Manufacturing → R&D → Licensee → Manufacturing

Creating value for customers through innovation
World Installed PP Capacity by Technology

Leading Position of LyondellBasell’s Spheripol and Spherizone PP Technologies
Spheripol
115 lines licensed with a total capacity over 25 MM t/a

Recent licenses include: Qingdao Jinneng, PT Chandra Asri, SK Advanced
Hyosung Vietnam, Shandong Dongming, Liaoning Bora, Wanhua Chemical, Fujian Zhongjing

North America 13 lines
South America 8 lines
Europe & CIS 30 lines
AFME 6 lines
Asia Pacific & India 58 lines

Incl. LYB captive
**Spheripol - Process Set-Up with Heterophasic Copolymer**

- Homo
- Random
- Terpolymers
- Butene Random
- Heco
- Softer Heco/TPO

Diagram:
- Propylene + Hydrogen
- Catalyst
- Ethylene and/or 1-Butene
- Gas Phase Reactor
- Steam
- Nitrogen
- To polymer handling and extrusion
- Propylene + Hydrogen
- Ethylene
Spheripol - Product capabilities

- Benchmark products covering full range of PP applications
  - Products present in all global markets, recognized and valued worldwide
  - Wider range of products from single catalyst system
  - Broader portfolio of peroxide free products

- Excellent Quality and Consistency
  - Quick and efficient product transitioning with maximum prime production
  - Production grade flexibility with no impact on manufacturing efficiency
  - Quick and efficient product transitioning with maximum prime production

Benchmark products meeting customer needs
Spheripol technology evolution

Maintaining leadership through continuous improvement
Why *Spheripol*?

**Advantaged Economics**
- Maximized feedstock yields
- Leading operating costs
- 5th Generation: Simple optimised design
- Simple & robust equipment

**Benchmark Products**
- Globally recognized benchmark PP grades
- Broadest range of products with one catalyst
- Broadest range of products without peroxides
- More than 25 million tons of licensed capacity

**World Scale & Versatile**
- Worlds Largest Single line capacity (600kta)
- Optionality, flexibility: Single loop plus addition of gas phase for Hecos
- Advantaged product transitioning

**Operational Excellence**
- Unrivalled industry experience
- Outstanding reliability achievable with on-stream factor of 99%
- More than 100 production lines in operation
- Low environmental impact
Spherizone – Licensing
18 lines licensed with a total capacity of 6 MM t/a

Recent licenses include: Zhejiang Petroleum (ZPCC), Liaoning Bora

North America
1 line

Europe & CIS
1 line

AFME
2 lines

Asia Pacific & India
14 lines

Incl. LYB captive
Spherizone – Process Set-Up

Unique platform to produce novel PP grades

Product Families

- Homo
- Adstif Homo
- Random
- Terpolymers
- Homo-Random
- Dual Random
- Butene Random
- Random Heco
- Heco
- Adstif Heco
- Softer Heco
The Multi Zone Circulating Reactor:

■ One polymerization reactor with two separate reaction zones

■ By variation of operating conditions the MZCR can produce:
  ▪ Standard monomodal homopolymers and random copolymers
  ▪ New PP architectures:
    Homopolymers, random copolymers and combinations thereof with monomodal and bimodal molecular weight distribution
The Heart of *Spherizone* Technology: The Multi Zone Circulating Reactor

**high H₂ concentration and / or high C₂ concentration**

**low H₂ concentration and / or low C₂ concentration**

**barrier fluid**
Spherizone - Polymerization Principle

Classical cascade

Feed A  

Feed B

Residence time and phase distribution in bimodal operation

Spherizone process

Product homogeneity is independent from particles residence time

Feed A

Feed B

τ₁

τ₂

τ₁

τ₂

τ_{p1}

τ_{p2}
Spherizone – Product Capabilities

■ Full range of existing Spheripol grades as well as those of any other existing PP-technology

■ Grades with improved properties compared to current Spheripol grades
  ▪ Homopolymers and heterophasic copolymers with higher stiffness
  ▪ Random copolymers with higher co-monomer content

■ New product families
  ▪ Very broad MWD grades (with additional distillation)
  ▪ Homo/random and dual random structures
  ▪ Random heterophasic copolymers

■ Copolymers of 1-butene or higher α-olefins, as demonstrated on pilot-level, broadening further the Spherizone product slate
  ▪ Very broad MWD grades (with additional distillation)
  ▪ Homo/random and dual random structures
  ▪ Random heterophasic copolymers
Spherizone Technology Product Mapping

Diagram showing various properties such as Stiffness, Flex. Mod., Shore D, Thermal Resistance, Melt Strength, Sealing Initiation Temperature, Mw/Mn, Narrow MWD, and Broad MWD.

- MZCR + GPR
- PP commercial
Spherizone Product Capabilities
Expansion of the HeCo Product Portfolio

Spheripol technology
Heterophaseic Copolymers

Spherizone technology allows to expand the HeCo product portfolio in all directions.
Why *Spherizone*?

**Unique Platform**
- Revolutionary Multi-zone circulating reactor
- One unique reactor for bimodal grades
- Potential to expand use into entirely new applications and markets

**Added Value Portfolio**
- Novel PP grades suitable for inter-material replacement of PVC, ABS, PS, etc
- Unique product families such as Homo-RaCo, dual-Raco, Soft HeCo

**Performance Products**
- High product quality, allowing bimodality in one reactor
- Superior product homogeneity
- Extends the product envelope of PP

**Operational Excellence**
- Unrivalled industry experience
- Outstanding reliability achievable with on-stream factor of 99%
- PP expertise built on >100 licensed Spheripol lines and largest PP catalyst manufacturer
Achieving Differential Performance
Drivers of success

LyondellBasell’s PP Technology Portfolio

Economy & Efficiency
- Maximising feedstock yields
- Low operating costs
- World scale plants, low capital costs
- Versatility: adaptation to fast-changing market requirements

Value-added Products
- Unique product families
- Novel grades suitable for inter-material replacement
- Differentiation of quality and mix

Operational Excellence

Unique technology offering matching customer needs
Conclusions

- LyondellBasell offers an industry leading polypropylene technology portfolio, supported by its expertise and strong focus on innovation

- *Spheripol* is the benchmark polypropylene technology

- *Spherizone* enables licensees to develop innovative and added value polypropylene solutions
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