메탈로센 촉매에 의한 폴리올레핀 제조 기술

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4. Summary
Polyolefin Biz

- World Polymer Demand = 169.6 Million Metric Ton (2006)
- Polyolefins Demand accounts for 66% (112 Mil MT) among polymers.

Comparison of Commodity PO Tolling

Polyolefin Market Trends

Polyolefin new capacity will increase with rate of 30% by 2010 focused in Middle East and Asia → Cannot survive with commodities
Polyolefin Market Trends

PE Market
- New Plant only in ME and Asia
- Specialty product based on metallocene

PP Market
- New Plant in Worldwide
- Product range expansion to the ENPLA

mPO Market
- mPE CAGR >20%
- Market leading by Dow and Exxon

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**Metalocene Catalyst**

- **Definition**
  Group IV transition metal (Ti, Zr, Hf) coordinating at least one bulky ligand + Activator (MAO or NACs)

- **Characteristics**
  - Highly active
  - Narrow molecular weight distribution of resulting polymer
  - Easy to control polymer property
  - Synthesis of new polyolefin (TPE, COC, PNB, PK etc)

![Metalocene Catalyst Diagram]

**Supported Catalysts: Components**

1. ZrCl₂
2. Si₃N₄Cl₆
3. ZrCl₂
4. ZrCl₂

Cocatalyst: Methylaluminoxane (MAO)

Silica Support
Supported Catalysts: Polymerization

<table>
<thead>
<tr>
<th>run no.</th>
<th>Catalyst type (mmol)</th>
<th>Activity (g-PE/g-Cat)</th>
<th>Mn</th>
<th>Mw</th>
<th>PDI</th>
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<td>1961</td>
<td>11388</td>
<td>101380</td>
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</table>

Supported Catalyst: Silica = Sylopol 948 (dehydrated at 200°C), MAO (5mmol)
Polymerization: ethylene pressure = 40 atm, temperature = 80°C, time = 1hr,
solvent = Hexane (1.2L), comonomer = 1-hexene(20mL)

Supported Catalysts: MWD Control

<table>
<thead>
<tr>
<th>run no.</th>
<th>Catalyst type (mmol)</th>
<th>Activity (g-PE/g-Cat)</th>
<th>Mn</th>
<th>Mw</th>
<th>PDI</th>
</tr>
</thead>
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<td>740590</td>
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<tr>
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<td>2+4 (0.5±0.5)</td>
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<td>27127</td>
<td>802290</td>
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<td>2266</td>
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<td>254600</td>
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</tbody>
</table>

Supported Catalyst: Silica = Sylopol 948 (dehydrated at 200°C), MAO (5mmol)
Polymerization: ethylene pressure = 40 atm, temperature = 80°C, time = 1hr,
solvent = Hexane (1.2L), comonomer = 1-hexene(20mL)

- Bimodal PE having broad PDI obtained at run 6 & 7.
- The combination of 2+4 and 2+4' was most effective to get broad MWD
→ MWD of PE in continuous single reactor can be controlled.
- Processability can be controlled by optimization of catalyst compositions
- Bimodal PE from hybrid catalyst is more effective than that from conventional cascade polymerization with Z/N catalyst

Recent Trend: Bimodal Polyethylene

Advanced Catalyst Engineering provides the capability to produce PE with bimodal molecular weight distribution and bimodal compositional distribution in a Single Reactor!
LG Metallocene PE History

1993 1st Metallocene research group in Korea
1995 Pilot plant start up
1997 mPE Rotomolding grade
1998 Commercial trial of mPE in hexane slurry process
1999 2nd generation catalyst development
2002 3rd generation catalyst development
       - New concept of supported metallocene tech
2005 Super strength PE in a slurry loop process
2007 4th generation catalyst development
       Commercial trial of Elastomer

LG Metallocene Catalysts

- 2nd Generation Metallocene (Commercial)
  - Narrow MWD / Narrow CD
  - MDPE, HDPE
  - (XL) Rotomolding, High-Speed Injection Applications

- 3rd Generation Metallocene (Commercial)
  - Broad or Bimodal MWD / Narrow CD (in a Single Reactor !)
  - LLDPE, MDPE, HDPE
  - Film (Easy Processing), Injection & Pipe (High ESCR) Applications

- 4th Generation Metallocene (Commercial)
  - Narrow or Broad MWD / Narrow CD
  - LLDPE, Plastomer/Elastomer
  - Film, Fiber, Wire&Cable, TPO Applications, etc
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LG PE-RT

LG PE-RT has outstanding Long-Term Hydrostatic Strength (LTHS) and mechanical properties in hot/cold water pipe system without cross-linking

- Excellent processability
- Easier installation (Flexibility)
- Cost effective

Non-Crosslinking!!!

PE-RT : Polyethylene of Raised Temperature Resistance
Applications

- Under-floor & Wall Heating
- Radiator connections
- Hot and Cold Drinking Water Pipe
- Snow Melt System
- Multilayer Aluminum Pipe

LG PE-RT SP980 Resin

- Metallocene Catalyst ensures excellent mechanical properties
  - high mechanical strength
  - good resistance against pressure
  - greatly enhanced ESCR
  - high clarity

- LG PERT SP980 resin allows for enhanced properties compared with other pipe resins.
  - high productivity ➔ cost benefit
  - the most flexible choice over PB, PVC, PEX

Superior Mechanical Strength
Higher Resistance to Slow Crack Growth (SCG)

Noble Polymer Architecture
ISO9080 for PE-RT pipes from SP980

The regression curves show no presence of a so-called "Knee (Brittle Fracture)" at any test temperature.

With respect to the valid ISO 9080 document, a ductile (LPL) long-term strength value of 9.2MPa at 50 years at 20℃.

POE (Polyolefin Elastomer)

Ethylene Elastomers are ethylene and α-olefin copolymers (0.860~0.910 g/cc) as a kind of thermoplastic elastomer like synthetic rubbers.
LG Polyolefin Elastomers are produced by optimum combination of our unique metallocene catalyst and solution process technologies.

- **Unique Metalloocene Structure for PO Elastomers**
  - high thermal stability
  - high activity
  - high molecular weight
  - excellent comonomer incorporation

- **Characteristics of LG PO Elastomers**
  - Solution process retrofitting
  - Wide density window (0.860 ~ 0.910 g/cc)
  - Uniform MW & comonomer distribution
  - Transparent & elastic

**Major POE Applications**

- **Hard & Soft TPO Compounds**
  - Excellent Physical Properties (Elasticity, Toughness)
  - Excellent Impact Resistance

- **Footwear & Foams**
  - More Flexible & Elastic, Lighter Weight

- **Molded Goods**
  - Improved Look & Feed
  - Tough yet Flexible

- **Auto Exterior**
- **Auto Exterior**
- **Mid Sole Foams**
- **Slipper Soles**
- **Soft Grips**
- **Multi-purpose Wheels**
Summary

LG Metallocene Technology

- LG Chem developed proprietary metallocene catalysts which cover full ranges of Polyethylene (PE) products.
- LG Chem carried out several commercial campaigns using own 2nd Generation in hexane slurry HDPE process.
- Especially, 3rd Generation is a new promising catalyst to produce broad or bimodal PE in a Single Reactor and commercialized in loop slurry process!
- LG Chem newly launched Polyethylene Elastomer.