Advantaged Metalloocene PE Films from UNIPOL™ PE Technology

Indian Petrochem 2018

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mLLDPE Market Development & Catalyst Product Manager

Univation Technologies, LLC

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Metallocene Opportunities for Resin Differentiation

Plastic Flexible Packaging

mLLDPE Market Overview

XCAT™ Metallocene PE Resins for Resin Differentiation
Flexible Packaging Opportunities

**PRIMARY**
Package in contact with the product

**SECONDARY**
Packaging used to collate (bundle) primary packages into units for easier handling

**TERTIARY**
Packaging used to assemble unit loads and other stabilization used during transport
Brand Owners –
Driving Sophisticated Packaging Requirements

Container
- Ensure integrity of content
- Facilitate storage & transport

Protection
- Avoid physical damage to content
- Keep content for a longer shelf life

Identification / Promotion
- Identify content
- Brand recognition / consumer appeal
Packaging Requirements Drive Advanced Resin Design

From the list of requirements, we can segment the layers of functionality which a package needs.

**Stiffness**
- Optics
- Moisture BARRIER
- Breathability
- Heat Resistance
- Easy-opening
- hermeticity

**Grease Barrier**
- Shelf appeal
- Flex crack resistance

**Processability**
- Puncture resistance
- Elasticity

**UNIPOL™ PE Resin Performance Opportunities!**
- Sealant
- Abuse
- Processing
- Structural
- Barrier
- Tie (Adhesive)
- Bulk
- Print/Appeal
Advanced Resin Design – Balancing Performance and Cost

- Package designers must make choices and decisions that provide the best balance of attributes and cost

- Often the best material for one attribute sacrifices another

Multi-layer constructions can optimize attributes while reducing overall thickness and cost!
Globally ~4 million tonnes of new mLLDPE opportunity by 2025

Strong global growth; Very strong AP, China and India Growth
Mature & Developing Markets Value mLLDPE Resins

- **Mature Metallocene Markets (NA, WE, Japan)**
  - MCN capturing 22 - 40% of total LLDPE demand

- **Emerging Metallocene Markets**
  - Current LLDPE demand butene-1 comonomer grade focused (HAO limited)
  - <15% MCN market penetration \(\rightarrow\) significant MCN growth opportunities
  - High AAGR enables more than doubling market size by 2025

**HAO: Higher Alpha Olefins (C6, C8)**

Source: NexantThinking™ POPS GCA 2017
Univation Technologies – The Global Leader in Metallocene Technology

- **Univation XCAT™ Metallocene:**
  - >35% of world-wide production
  - > 20 yrs experience
  - > 18 million tonnes MCN resin produced since 1995
  - > 90% of global licensed MCN production

- **Broader coverage with XCAT™ MCN Resin portfolio**
  - Widest range of mLLDPE applications

- **Production in all large consumption regions**
  - >10 licensed plants producing with XCAT™ MCN Catalysts

Source: Townsend Solutions 2017 TPER & Univation view
XCAT™ mLLDPE Resins – Replace a Broad Range of Conventional LL & LD Films

**XCAT™ HPR**
Benchmark for highly engineered down-gauged films

**XCAT™ EZP**
Uniquely positioned for Low Density Polyethylene (LDPE) penetration

**XCAT™ VPR**
Opens new market opportunities with best balance of performance
XCAT™ HP mLLDPE Resins – Benchmark for Highly Engineered Down-Gauged Films

UNIPOL™ mLLDPE Commercial Applications include

- Heavy Duty Shipping Sack
- Medium Duty Shipping Sack
- Trash Bags
- High-Stiffness Cast Stretch

Bag in Box
- Blown Stretch Film
- Food Packaging
- Form Fill Seal
- Stand Up Pouches
- Heavy Duty Bags
- Ice Bags
- Premium Trash Bags

Easy-Processing Blown & Cast Films
- High-Performance Cast Stretch

Hexene comonomer
XCAT™ HP mLLDPE Resins – Advantaged Film Performance & Down-Gauging

XCAT™ HP Resin Advantages

- Differentiated performance over C4 & C6 (ZN) LLDPE structure
- Superior Impact & Toughness
- Improved Creep Performance
- Excellent sealing properties
- Adds value via down-gauging

Note: Graph values are in %
XCAT™ EZ mLLDPE Resins –
Replace a Broad Range of Conventional LL & LD Films

UNIPOL™ mLLDPE Commercial Applications include

- Shrink Film
- Food Packaging
- Multilayer Packaging Film

- Agricultural Film
- Food Packaging
- Heavy Duty Shipping Sack
- Multilayer Packaging Film
- Blown Film

- Stand Up Pouch; Food Packaging
- Stretch Film; Lamination Film
- Blown and Cast Film

Hexene comonomer
XCAT™ EZ mLLDPE Resins – Delivering Enhanced Film Properties with Excellent Processability

- Improved puncture resistance
- Improved clarity
- Improved TD shrink
- Down-gauged films
- Similar holding force

Note: Graph values are in %

XCAT™ EZP mLLDPE 1.0 Ml; 0.920d 50 µm monolayer

LDPE Reference 1.9 Ml; 0.920d 50 µm monolayer
UNIPOL™ mPE Commercial Applications include

- Heavy Duty Shipping Sack
- Food Packaging
- FFS Packaging
- Stand Up Pouches
- Heavy Duty Bags
- Ice Bags
- Premium Trash Bags
- Blown Stretch Wrap

Hexene comonomer
XCAT™ VP mLLDPE Resins – Processability and Performance

XCAT™ VP Resin Advantages

- Processability & throughput...
- with bubble stability
- Excellent property retention in LD blends

- Superior stiffness & toughness balance – ideal for heavy duty applications
- Excellent optical properties

Extrusion Processability

<table>
<thead>
<tr>
<th>Processability &amp; Performance</th>
<th>Specific Output</th>
<th>Motor Load</th>
<th>Head Pressure</th>
<th>Melt Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>20% LDPE blend</td>
<td>106%</td>
<td>104%</td>
<td>102%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Toughness Retention in LD Blends

<table>
<thead>
<tr>
<th>Dart Impact Strength (g)</th>
<th>No LDPE</th>
<th>5% LDPE</th>
<th>30% LDPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>1200</td>
<td>1000</td>
<td>400</td>
</tr>
</tbody>
</table>

C6 mLLDPE
1.0 MI; 0.918 d
50 µm monolayer

XCAT™ VP mLLDPE
1.0 MI; 0.918 d
50 µm monolayer
XCAT™ VP mLLDPE Resins –
Down-Gauge, Toughness & Speed for Film Conversion

XCAT™ VP Resin Advantages

- Puncture, Impact, Tear (MD & TD)
- Clarity
- High performance sealing & hot-tack (with retained Heat Seal)

C6 (ZN) LLDPE
1 MI; 0.918d + LDPE
65 µm thickness

XCAT™ VP mLLDPE
1 MI; 0.918d + LDPE
55 µm thickness

XCAT™ mLLDPE Resin provides performance with 15% downgauge!
100% XCAT™ mLLDPE for 100% Recyclability in Multi-Layer Construction

**XCAT™ HPR Skin Layers**
- Outstanding mechanical toughness
- Optical clarity
- Seal through contaminants

**XCAT™ EZP Core Layer**
- Easy processing
- Excellent bubble stability
- High rates with HAO-type toughness

**XCAT™ Metalloocene Resin** well-suited for sophisticated packaging solutions preferred by evolving demands of the Indian consumer

- **Highly-engineered food packaging**
  - Excellent package integrity
  - Superior aesthetic appeal
  - Food spoilage protection
Outstanding Opportunities for Resin Differentiation

<table>
<thead>
<tr>
<th>HDPE</th>
<th>LLDPE</th>
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<tbody>
<tr>
<td>Pipe</td>
<td>Metalloocene Film</td>
</tr>
<tr>
<td>PE80/PE100</td>
<td></td>
</tr>
<tr>
<td>Unimodal</td>
<td></td>
</tr>
<tr>
<td>Bimodal</td>
<td></td>
</tr>
<tr>
<td>Large Part</td>
<td>Rotomolding</td>
</tr>
<tr>
<td>Blow Molding</td>
<td></td>
</tr>
<tr>
<td>HIC Blow</td>
<td>Hexene Film</td>
</tr>
<tr>
<td>Molding</td>
<td></td>
</tr>
<tr>
<td>HD Film/</td>
<td>Injection Molding</td>
</tr>
<tr>
<td>Extrusion</td>
<td></td>
</tr>
<tr>
<td>Unimodal</td>
<td></td>
</tr>
<tr>
<td>Bimodal (Film)</td>
<td></td>
</tr>
<tr>
<td>Injection</td>
<td>Butene Film</td>
</tr>
<tr>
<td>Molding</td>
<td></td>
</tr>
<tr>
<td>(Conventional &amp; Metalloocene)</td>
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XCAT™ Metalloocene LLDPE

‘Make in India’ facilitates investment, fosters innovation, enhances skill development, protects intellectual property & builds best-in-class manufacturing infrastructure.

Source: PMINDIA.gov.in
Univation Technologies –
XCAT™ Metalloocene PE

Proven Global Leadership in Metalloocene Polyethylene Technology
✓ Streamlined, single-reactor design enabling reliable mLLDPE resin supply
✓ World class aim-grade and on-stream time
✓ World-class XCAT™ Metalloocene Catalyst implementation support

Providing Broad Product Capability
✓ Global leader in metalloocene polyethylene technology
✓ Global market acceptance of UNIPOL™ PE Metalloocene Resin grades

Leading Innovation
✓ Continued commitment to new technology development & implementation
✓ Driving Metalloocene Technology innovation with broadest MCN offering in the market
✓ Commercial Innovation – XCAT™ Metalloocene Catalysts for Market-Leading
MCN resin performance

Univation & UNIPOL™ PE Process
Delivering Performance Across the Entire PE Value Chain
Proven Designs. Limitless Possibilities.
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