PB-1 for compounding and Masterbatch

Basell Polyolefins India Pvt. Limited

SPE Technical Conference,
Mumbai, Hotel Leela
Content

- LyondellBasell At a Glance
- Masterbatch: Key requirements of the industry
- Polybutene -1 As dispersion modifier in masterbatch
- Polybutene -1: Target applications and case studies
- Catalloy resin for raffia as modifier for CaCO₃ masterbatch
- Conclusion
LyondellBasell At A Glance

- One of the world’s largest plastics, chemical and refining companies
- Annual revenues of $32.7 billion
- 13,000 employees worldwide

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales and other operating revenues</td>
<td>$44,062</td>
<td>$45,608</td>
<td>$32,735</td>
</tr>
<tr>
<td>Operating income</td>
<td>$5,102</td>
<td>$5,736</td>
<td>$6,122</td>
</tr>
<tr>
<td>Income from equity investments</td>
<td>$203</td>
<td>$257</td>
<td>$339</td>
</tr>
<tr>
<td>Income from continuing operations</td>
<td>$3,860</td>
<td>$4,172</td>
<td>$4,479</td>
</tr>
<tr>
<td>Diluted EPS from continuing operations</td>
<td>$6.76</td>
<td>$8.00</td>
<td>$9.60</td>
</tr>
<tr>
<td>Diluted weighted average share count (millions)</td>
<td>570</td>
<td>521</td>
<td>466</td>
</tr>
<tr>
<td>Cash flow from operations</td>
<td>$4,835</td>
<td>$6,048</td>
<td>$5,842</td>
</tr>
<tr>
<td>Capital expenditures</td>
<td>$1,561</td>
<td>$1,499</td>
<td>$1,440</td>
</tr>
<tr>
<td>EBITDA¹</td>
<td>$6,311</td>
<td>$7,050</td>
<td>$7,533</td>
</tr>
<tr>
<td>LCM adjustment¹</td>
<td>-</td>
<td>$760</td>
<td>$548</td>
</tr>
<tr>
<td>EBITDA excluding LCM¹</td>
<td>$6,311</td>
<td>$7,810</td>
<td>$8,081</td>
</tr>
<tr>
<td>Diluted EPS from continuing operations excluding LCM¹</td>
<td>$6.76</td>
<td>$8.92</td>
<td>$10.35</td>
</tr>
</tbody>
</table>

1. See reconciliations of non-GAAP measures to their nearest GAAP financial measures provided at the end of this presentation.
LyondellBasell’s global presence spans 18 countries and includes 57 manufacturing sites.
Global Capacity Positions

1st
- Polypropylene
- Polypropylene Compounds
- Polypropylene Technology Licensing
- Oxyfuels

2nd
- Propylene Oxide

5th
- Ethylene
- Propylene
- Styrene

6th
- Polyethylene

Refining Capacity - 268,000 barrels per day

Sources: IHS and LYB. All capacities as of December 31, 2015.
Note: Includes all wholly-owned capacity and our proportionate share of joint venture capacities. Propylene excludes refinery-grade propylene. Polypropylene includes Catalloy capacity.
We Make Products the World Counts On

**Olefins & Polyolefins**
- Ethylene
- Propylene
- Polyethylene
- Polypropylene
- Catalloy process resins
- PP Compounds
- Polybutene-1

**Intermediates & Derivatives**
- Propylene Oxide
- Styrene Monomer
- PG and PGE
- Acetyls
- Oxyfuels
- Ethylene Oxide
- EG and EOD
- BDO & Derivatives

**Refining**
- Gasoline
- Diesel
- Olefins Feed

**Technology**
- Process Licensing
- Catalyst Sales
- Technology Services

**End Uses**
- Food Packaging
- Textiles
- Automotive
- Appliances
- Films
- Flexible Piping

- Insulation
- Home Furnishings
- Adhesives
- Consumer Products
- Coatings

- Automotive Fuels
- Aviation Fuels
- Heating Oil
- Industrial Engine Lube Oils

- Polyolefins and Chemical Manufacturers
Masterbatch Compound Industry: Key Requirements in

Differentiation
- Unorganized and many supplier coupled with me-too products led to cut throat competition
- Need for continuous improvement in product & process for sustainable profit

Cost Reduction (Internal approach)
- Lower energy consumption.
- Lower cost by improving yield/coverage of masterbatch

Performance enhancement (external approach)
- Better dispersion and homogenization
- Higher loading without deteriorating key properties of end product
- Process friendliness - Higher screen life & lower fuming/degradation.

PB-1 enables product differentiation by contributing in both approaches
Polybutene -1 As dispersion modifier in masterbatch
What is PB-1?

- PB-1 is polymerized from butene-1
- It is a semi-crystalline polymer \( \rightarrow \) partially crystalline & partially amorphous
- Available in granule form
Polybutene-1 industrial Plant in Moerdijk, NL

- Started-up in 2003 with an original capacity of 45KT after business takeover from Shell
- Capacity extension in 2008 to 67kTA
- Largest PB-1 plant in the world
- Product development is made at the Ferrara R&D center where LyondellBasell operates a PB-1 pilot plant

Source: LYB
Unique Properties of PB-1

Rheology: Shear Thinning

• Most shear sensitive member of Polyolefin

Lower melting point and Lower heat of fusion

• Enable to compound heat and shear sensitive additives

Compatibility with Polyolefin

• Highly miscible with PP
• Easily dispersible in PE

<table>
<thead>
<tr>
<th>Polymer</th>
<th>Melting point (°C)</th>
<th>Heat of fusion (J/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB-1</td>
<td>90 – 130</td>
<td>15 – 70</td>
</tr>
<tr>
<td>PP</td>
<td>140 – 165</td>
<td>40 -120</td>
</tr>
<tr>
<td>PE</td>
<td>110 – 135</td>
<td>120 - 200</td>
</tr>
</tbody>
</table>

Lower viscosity, and melting behavior of PB-1 provide plenty of time for homogenization
Benefits of PB-1 in Compounding and Masterbatch

- Easy to process and faster melting helps in lower motor load and longer time for better homogenization

- **Lower energy consumption** with PB-1

- When producing concentrates of pigments or fillers, PB-1 helps in wetting and avoid them to re-agglomerate

- Thermally stable like general polyolefin; does not exhibit characteristic issues shown by waxes - **exudation or interference with surface properties, degradation** (fuming or black particles)

- Reduce production downtime by improving screen life → **higher productivity**

- Ability to process thermo-sensitive additives, pigment, Flame retardants, peroxides etc.
# PB-1 grades & Target Application

<table>
<thead>
<tr>
<th>Grade Name</th>
<th>Melt Flow Rate (g/10min)</th>
<th>Density (g/cc)</th>
<th>Flexural Modulus (MPa)</th>
<th>Melting Point (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koattro PB 0801M</td>
<td>200</td>
<td>0.915</td>
<td>410</td>
<td>126</td>
</tr>
<tr>
<td>Koattro PB M1200M</td>
<td>1200</td>
<td>0.908</td>
<td>340</td>
<td>100</td>
</tr>
</tbody>
</table>

**Masterbatch**
- Organic or Inorganic Color Masterbatch
- White or Carbon Black Masterbatch
- CaCO₃ or Talc Filler MB for film application
Case study: PB-1 for Organic Color MB

Filter test as indirect measure of pigment dispersion

**Masterbatch composition:** 20% Red pigment, 80% PP HP + different dosage of PB-1

**Test Method:** Color MB + Poly passed through 20µ screen and increase in pressure recorded after passing 140gm of pigment through it.

Lower pressure drop for same amount of processing ➔ lesser pigment agglomeration as PB-1 dosage increases in the color MB
Case Study: PB-1 as Dispersion Modifier in Organic Pigment

Sample ID | Min Particle size | Max. Particle size |
---|---|---|
A: 29% Blue pigment + 10% PB M1200M +PP | 8.6µ | 42.7µ |
B: 17% Green Pigment + 10% PB M1200M + PP | 8µ | 49.1µ |
C: 29% Blue Pigment + PP | 9.6µ | 83.8µ |
D: 17% Green Pigment + PP | 8.9µ | 62.2µ |
Case study: PB-1 as Standalone carrier for Organic Color MB

- 26% organic red in:

- Transmitted light micrographs:
  - LDPE film (5% MB)
  - homo-PP injection moulded specimen (5% MB)

- Best pigment dispersion (of organic red) when a PB-1 coloured MB is used for both film as injection moulding applications

*Source: Cramez, M.C.; Oliveira, M.J.; Effect of the masterbatch carrier on the pigment dispersion and mechanical properties of colored polyolefins; Antec 2004 Chicago Conference Proceedings.*
Carbon-black Dispersion in PB-1 as Compared to PE

**Masterbatch composition:** 60% Carbon Black + different base resin

Dispersion measurement in Cast PP film measured by Polarized light Optical Microscopy (PLOM)

PB-1 based carbon black masterbatch gives more uniform dispersion
Case study: PB-1 in CaCO3 Masterbatch for HM Film

Objective: Increase filler loading in 20µ printable HM film

Critical Properties: Strength, Elongation, Gloss & Surface finish

Upper limit of CaCO₃ (CC MB) in 20µ HM film

<table>
<thead>
<tr>
<th></th>
<th>HM HDPE</th>
<th>CC MB</th>
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</thead>
<tbody>
<tr>
<td>10%</td>
<td>90%</td>
<td>10%</td>
</tr>
<tr>
<td>20%</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>30%</td>
<td>70%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Generic CC MB | Specialty CC MB | PB-1 based CC MB

Tensile properties of HM film with filler masterbatch

Sample A: 20% Specialty MB, Sample B: 20% PB-1 based CC MB, Sample C: 25% PB-1 based CC MB, Sample D: 30% PB-1 based CC MB

No deterioration in tensile & optical of HM film after increasing PB-1 modified filler masterbatch dosage by 10%
Catalloy Resin for Raffia as Modifier for CaCO₃ Masterbatch
### Adflex as Modifier to optimize performance-cost balance in Raffia

**Stretching**

<table>
<thead>
<tr>
<th>What contributes</th>
<th>What are limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance – PP Homo</strong></td>
<td>Tenacity ↑ Stiffness ↑</td>
</tr>
<tr>
<td><strong>Cost – Filler MB</strong></td>
<td>Cost ↓</td>
</tr>
</tbody>
</table>

**Wish** – Achieving strength with high stretching and load high filler to reduce cost

**Challenge** – High tape breakage, minimum elongation retention reqd. for weaving
Use of Modifier for Filler MB: Why to use Adflex Z 101H

Performance Improvement in Filler Masterbatch:

- Compatible with PP or PE – *Adflex* Z 101H can be added with both LLD or PP based master-batches
- Improved dispersion of fillers – Improved Tape stretchability, superior Film surface / Mechanicals
- Lower dust generation – Improvement in process condition
- Possibility of reduction in additives such as lubricants – Low die deposition
- Increased production efficiency through lower processing temperature

Advantages* for Filler master-batch Compounders – Higher Profitability

- Product Differentiation - Superior performance of the filler master batch in Raffia / film
- Ability to earn premium for the specialty masterbatch – Higher profitability
## Adflex Z 101H – A Reactor Made Elastomer

### Highlights

*Catalloy* platform, Propylene Ethylene elastomer,

High MFI was considered to be an advantage

High Ethylene modified rubber; compatible with PP or PE

- MFI: 27 g/10min @ 230 Deg C
- Flexural Modulus ~ 76 MPa
- Notched Izod impact strength @ -20 C ~ No break (Indicator of high amorphous phase)

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Adflex Z101H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>[g/cm²]</td>
<td>0.88</td>
</tr>
<tr>
<td>MFI @ 230°C/2.16kg</td>
<td>[g/10min]</td>
<td>27</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>[Mpa]</td>
<td>76</td>
</tr>
<tr>
<td>Notched Izod impact</td>
<td>[KJ/m²]</td>
<td>No break</td>
</tr>
<tr>
<td>strength @ -20°C</td>
<td></td>
<td>&gt;40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
# Adflex Modified Filler MB to Enhance the Performance: Case Studies

<table>
<thead>
<tr>
<th>Composition</th>
<th>Unit</th>
<th>Competitor Modifier</th>
<th>Adflex Z 101H</th>
</tr>
</thead>
</table>
| • Modified AF MB: 30 %; PP homo (Reliance): 70%  
• Modifier (Adflex and competition) added at same level in AF MB  
• Tape strength requirement: 4.5 gpd and elongation 19 % | Denier | 791 | 822D; 791D |
| Denier | Stretch ratio | 6.93 | 6.85 |
| - | Screw | 44 | 44 |
| Melt Pump Pressure | Melt Pump Pressure | 117 | 117 |
| Motor Load | Motor Load | 146.6 | 146 |
| Processability / Tape Breakage Frequency | Processability / Tape Breakage Frequency | Frequent tape breakage observed + | Smooth / Occasional tape breakage +++ |
| Tape Strength, | Tape Strength, | 4.9 | 4.9 |
| Elongation | Elongation | 22 | 22.5 |

**Direct benefit for raffia mfrs: Improved Performance**

*Based on customer feedback*
**Adflex as Modifier to optimize performance-cost balance in Raffia**

<table>
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<td>Tenacity ↑, Stiffness ↑</td>
</tr>
<tr>
<td><strong>Cost – Filler MB</strong></td>
<td>Cost ↓</td>
</tr>
<tr>
<td><strong>Balance – Adflex Z 101H</strong></td>
<td>Stretching ↑, Tenacity ↑, Breaking ↓, Filler ↑</td>
</tr>
</tbody>
</table>

*Adflex Z 101H: Adds value in Filler MB compounders and Raffia manufacturers*
Conclusion

PB-1

• Works as dispersion modifier by improving the homogenization & reduce agglomeration in various filled compound and masterbatch

• Masterbatch compounders can optimize the cost by increasing output and pigment dosage. End-users benefit from improved dispersion and reduced processing related issues

*Adflex*:

• Particularly helpful as modifier in filler masterbatch used in raffia, with broadening the stretching window and enhancing elongation post stretching.

• Provides high value-in-use by improving the properties of the raffia at higher filler loading
Thank You
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- This product(s) may not be used in:
  - (i) any U.S. FDA Class I, Health Canada Class I, and/or European Union Class I Medical Devices, without prior notification to Seller for each specific product and application; or
  - (ii) the manufacture of any of the following, without prior written approval by Seller for each specific product and application: (1) U.S. FDA Class II, Health Canada Class II or Class III, and/or European Union Class II Medical Devices; (2) film, overwrap and/or product packaging that is considered a part or component of one of the aforementioned Medical Devices; (3) packaging in direct contact with a pharmaceutical active ingredient and/or dosage form that is intended for inhalation, injection, intravenous, nasal, ophthalmic (eye), digestive, or topical (skin) administration; (4) tobacco related products and applications; (5) electronic cigarettes and similar devices; and (6) pressure pipe or fittings that are considered a part or component of a nuclear reactor.
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