Mirel PHB – Bio based Plastics with Performance and Biodegradability

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Telles Overview

- Joint venture between Metabolix and ADM
- Breakthrough biotechnology that is strongly patent protected covering resin, product formulation and process
- Global applications to be sourced from a new plant: 110 million pound (50,000 metric tons) designed capacity

Commercial Grades:
- Injection Molding
- Cast Sheet
- Cast & Blown Film
- Thermoforming

Developmental Grades (not commercial):
- Extrusion Coating
- Foam
- Non-woven, fibers
- Monofilament
- Blends and Alloys
World-Class Polymer Production Facility

- Design capacity of 50,000 tons per year of Mirel biopolymer in Clinton, Iowa
  - Now in operation
  - Commercial quantities available for customers located worldwide
  - European sales office and warehouse
  - Experienced technology and industry specialists
  - Focus on biobased and biodegradable solutions

Learn more about Mirel
www.mirel.com
How Mirel is Made

Biodegradable*
Mirel is biodegradable in natural soil and water environments, home and industrial composting facilities, where available.

Learn more at www.mirel.com

Biobased
Starting with corn.

Corn Sugar
One of many products made from each kernel of corn, used as feedstock for Mirel ™.

Applications
Mirel can be processed on conventional equipment and used in everyday products.

Fermentation
A patented process, transforms the sugar into Mirel bioplastics.

Formulation
Mirel is compounded into plastic pellets.
Mirel Bioplastics
General Properties

• Semi-crystalline thermoplastic
• Ranging from flexible to rigid
• Toughness ranging from PS to PP or better
• Withstands hot liquids, HDT > 120°C
• Chemical resistance similar to PET
• Oxygen barrier properties similar to PP
• Good printability
• Shelf Stable
10 Compounded Products Available in 2011

Differentiation – Performance and Biodegradation properties

**Injection Molding**
- Impact resistance
- High use temperature
- Range of stiffness and modulus

**Thermoforming**
- High use temperature
- Mold replication

**Sheet Extrusion**
- Print quality = marketability
- Shelf stability

**Film Extrusion (Blown & Cast)**
- Toughness
- Puncture and tear resistance
## Certifications

All commercial grades are in the process of further certifications

<table>
<thead>
<tr>
<th>Certifications</th>
<th>Products / Grades Certified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compostable EN 13432 / ASTM D6400</td>
<td>Film</td>
</tr>
<tr>
<td></td>
<td>B5002 to 288 µm</td>
</tr>
<tr>
<td>Compostable EN 13432 / ASTM D6400</td>
<td>Injection Molding</td>
</tr>
<tr>
<td></td>
<td>P1003, P1004 to 480 µm</td>
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<tr>
<td></td>
<td>F1005, F1006 to 500 µm</td>
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<tr>
<td>Home Compostable</td>
<td>Injection Molding</td>
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<tr>
<td></td>
<td>P1003, P1004 to 480 µm</td>
</tr>
<tr>
<td>Biodegradable in Soil ASTM D5988-96 / ISO 17556</td>
<td>Injection Molding</td>
</tr>
<tr>
<td></td>
<td>P1003, P1004, F1005, F1006</td>
</tr>
<tr>
<td>Biodegradable in Water ASTM D5271 / ISO 14851</td>
<td>Extruded Sheet</td>
</tr>
<tr>
<td></td>
<td>P4001, F4002</td>
</tr>
<tr>
<td>Biobased Content ASTM D6866</td>
<td>Injection Molding</td>
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<tr>
<td></td>
<td>P1003 &gt;80% Biobased Four Star Rating</td>
</tr>
<tr>
<td>Marine Biodegradable ASTM D7081</td>
<td>PHA base resin</td>
</tr>
<tr>
<td></td>
<td>OWS reviewed</td>
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</tbody>
</table>
Cosmetic Case Sample
Whitney Laboratory, St. Augustine University Florida
2007

- Injection molded part
- Biodegrades in low or cold temperature environments
  - e.g. home backyard compost and marine water
Mvera B5002 film @ 288 µm (11 mil) thickness

Source: Lab results from OWS
Mirel Film Products

• Range of applications

• Wide range of biodegradability:
  – soil, marine, industrial compost and home compost, anaerobic digestion

• Cast and blown film lines

• Heat sealable

• Range of color concentrates

• Thickness ranging from 8 μm to 125 μm

• Range of biobased content
## Film Products Comparison

<table>
<thead>
<tr>
<th></th>
<th>Mirel P5001</th>
<th>Mirel A5004</th>
<th>Mvera B5002</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biobased Content</strong></td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Biodegradability</strong></td>
<td>Broad</td>
<td>Soil</td>
<td>Industrial compost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Industrial compost</td>
<td></td>
</tr>
<tr>
<td><strong>Melt Strength</strong></td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>Tensile Strength</strong></td>
<td>Good</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Tear</strong></td>
<td>Good</td>
<td>Good</td>
<td>High</td>
</tr>
<tr>
<td><strong>Puncture</strong></td>
<td>Good</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Applications</strong></td>
<td>Packaging, reusable retail carrier bags, compostable bags</td>
<td>Mulch film, bale wrap drip irrigation, stretch and shrink wrap</td>
<td>Industrial can liners, compostable bags</td>
</tr>
</tbody>
</table>
Mvera™ B5002 Compostable Film Grade

- Blown film applications
  - Industrial can liners and retail bags, stretch wrap, and yard waste bags
- Durable and versatile like petroleum-based resins
  - BPI certified to meet ASTM D6400 standard for compostable plastics
- Processes on conventional equipment / infrastructure
  - Film properties similar to LDPE
  - Rheology similar to LLDPE
  - Run bubble like LLDPE
- Good dart and tear resistance
- Tensile strength
- Shelf stable
Why Compostable Bags made with Mvera

for Converters:
• Processes on existing equipment
• Easy start up, familiar operating conditions
• Mechanical properties; combination of tear and puncture strength

for Consumers:
• Durable and tougher, no breakage during movement
• Moisture and weather resistant
• Long shelf life; material maintains properties from production to retail shelf and consumer use
• Support municipal compostable bag programs

for Composters:
• Rapid composting - based on internal lab test data, 25.5 µm (1 mil) thickness disintegrated at about 2 weeks
• BPI certified to meet ASTM D6400 standard and Vinçotte certified to meet EN13432 to 288 µm (11mils) thickness - about the thickness of knots and bag seams that typically take longer to compost
• Works in anaerobic digestion, lab testing with OWS is completed
Mvera B5002 Hot Composting
Conclusions

Based on OWS test:

• Mvera at thickness of 288 µm (11 mil) completely disintegrated after 10 weeks
  – At end of composting test after 12 weeks, no film was found after sieving contents, therefore concluded 100% disintegration was achieved.

Based on Internal test:

• Mvera at thickness 255 µm (10 mil) disintegrated between weeks 4 and 7
• Mvera at thickness of 25.5 (1 mil) disintegrated in about 2 weeks

Key take-away:

• Films made with Mvera composts fast enough to not be a contaminant in the compost pile when it matures.
Mirel P1003 / F1005
Injection Molding Grades

• F1005 is FDA cleared for food-contact applications

• Range of food service and packaging applications
  High modulus
  High strength
  High temperature resistance
  Moisture resistance

• Surface energy suitable for printing and post-decorating
  High gloss finish

• Converts on conventional equipment
  Ability to mold in a range of colors
  Wide processing range
  Fast cycle time
  Similar conversion costs
Mirel P1004 / F1006
Injection Molding Grades

• F1006 is FDA cleared for food-contact applications

• Range of food service and packaging applications
  High toughness
  High flexibility (e.g. hinges and clips)
  High temperature resistance
  Moisture resistance

• Surface energy suitable for printing and post-decorating
  High gloss finish

• Converts on conventional equipment
  Ability to mold in a range of colors
  Wide processing range
  Fast cycle time
  Similar conversion costs
Mirel P4001
Cast Sheet Grade

• Good feel
  Like PVC, stands up to multiple uses

• Similar processing to extruded PET
  Good surface finish and printability for branded products

• Temperature and moisture resistance
  Vicat Softening > 130°C

• Converts on standard equipment
  Wide processing range
  Similar extrusion rates and costs
Mirel P3001 / F3002
Thermoforming Grade

• F3002 is FDA food compliant
  Range of food service packaging applications
  EFSA (EU food compliant) is underway

• High melt strength
  Sheet extrusion and thermoforming

• Processing similar to polypropylene
  Cycle times, form release

• Property balance like high impact polystyrene

• Good heat resistance

• Good resolution of mold detail
### Materials Tested

<table>
<thead>
<tr>
<th>Material</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirel P1003</td>
<td>Injection molding grade compound</td>
</tr>
<tr>
<td>Mirel F5003</td>
<td>Film grade resin</td>
</tr>
</tbody>
</table>

D5511-02 Standard test method for determining anaerobic biodegradation of plastic materials under high solids anaerobic digestion conditions.

ISO 15985 Plastics - Determination of the ultimate anaerobic biodegradability and disintegration under high solids anaerobic digestion conditions method by analysis of released biogas.
Anaerobic Degradation of Mirel – Thermophilic 52C

13.8 day test data

<table>
<thead>
<tr>
<th>Test item</th>
<th>Total Nl (Nl/kg)</th>
<th>Net biogas production (Nm³/g test item)</th>
<th>Biodegradation (%) AVG ± STD</th>
<th>Relative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blank</td>
<td>4.3</td>
<td>-</td>
<td>85.2 ± 0.3</td>
<td>100.0</td>
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<tr>
<td>Cellulose</td>
<td>14.5</td>
<td>676.0</td>
<td>90.4 ± 0.4</td>
<td>106.2</td>
</tr>
<tr>
<td>M2100</td>
<td>18.4</td>
<td>939.8</td>
<td>87.8 ± 1.0</td>
<td>103.2</td>
</tr>
<tr>
<td>M4100</td>
<td>18.1</td>
<td>914.7</td>
<td>90.6 ± 0.2</td>
<td>106.4</td>
</tr>
<tr>
<td>P1003</td>
<td>16.0</td>
<td>776.7</td>
<td>80.3 ± 4.2</td>
<td>94.3</td>
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<tr>
<td>F5003</td>
<td>15.8</td>
<td>764.9</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Typically out of 1 ton of biowaste, about 120 m³ of biogas can be produced
5% Mirel increase biogas production by 30% - 40%
Enabling Alternative Disposal Options

Thank you.

www.mirel.com

• Industrial Composting
• Home Composting
• Anaerobic Digestion
• Biodegradable in Soil & Water