# Innovation Today:
# Biobased Plastics
## *with Performance and Biodegradability*

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**Bioplastics Processing & Properties**
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# Overview

" Dedicated to the development and expansion of the composting industry….sound science, principles of sustainability and economic viability."

- *US Composting Council*

- Cultural change, paradigm shift  from petroleum to biobased infrastructure
- Market drivers as indicators
- Core technology – a unique platform based on renewable resources enabling a wide opportunity for innovation



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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

Metabolix
Bio-industrial Evolution

Telles

ADM

**Commercial Grades:**

- Injection Molding
- Cast Sheet
- Cast & Blown Film
- Thermoforming

**Developmental Grades (not commercial):**

- Extrusion Coating
- Foam
- Non-woven, fibers
- Monofilament
- Blends and Alloys

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# 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.




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# 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





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# Certifications

## All commercial grades are in the process of further certifications

| Certifications | | Products / Grades Certified |
|---|---|---|
| **Compostable**<br>**EN 13432 / ASTM D6400** | OK compost VINÇOTTE<br>COMPOSTABLE | m·vera Bioplastics by Telles | **Film**<br>B5002 to 288 µm |
| **Compostable**<br>**EN 13432 / ASTM D6400** | OK compost VINÇOTTE | mirel Bioplastics by Telles | **Injection Molding**<br>P1003, P1004 to 480 µm<br>F1005, F1006 to 500 µm |
| **Home Compostable** | HOME OK compost VINÇOTTE | mirel Bioplastics by Telles | **Injection Molding**<br>P1003, P1004 to 480 µm |
| **Biodegradable in Soil**<br>**ASTM D5988-96 / ISO 17556**<br><br>**Biodegradable in Water**<br>**ASTM D5271 / ISO 14851** | SOIL OK biodegradable VINÇOTTE<br>WATER OK biodegradable VINÇOTTE | mirel Bioplastics by Telles | **Injection Molding**<br>P1003, P1004 F1005, F1006<br><br>**Extruded Sheet**<br>P4001, F4002 |
| **Biobased Content**<br>**ASTM D6866** | OK biobased VINÇOTTE | mirel Bioplastics by Telles | **Injection Molding**<br>P1003 >80% Biobased *Four Star Rating* |
| **Marine Biodegradable**<br>**ASTM D7081** | **OWS reviewed** | mirel Bioplastics by Telles | **PHA base resin** |

# Mirel
## Marine Biodegradability Study

## Cosmetic Case Sample

Whitney Laboratory, St. Augustine University Florida
2007

| 0 week | 1 month | 2 months | 5 months |
|---|---|---|---|




- Injection molded part
- Biodegrades in low or cold temperature environments
  - e.g. home backyard compost and marine water




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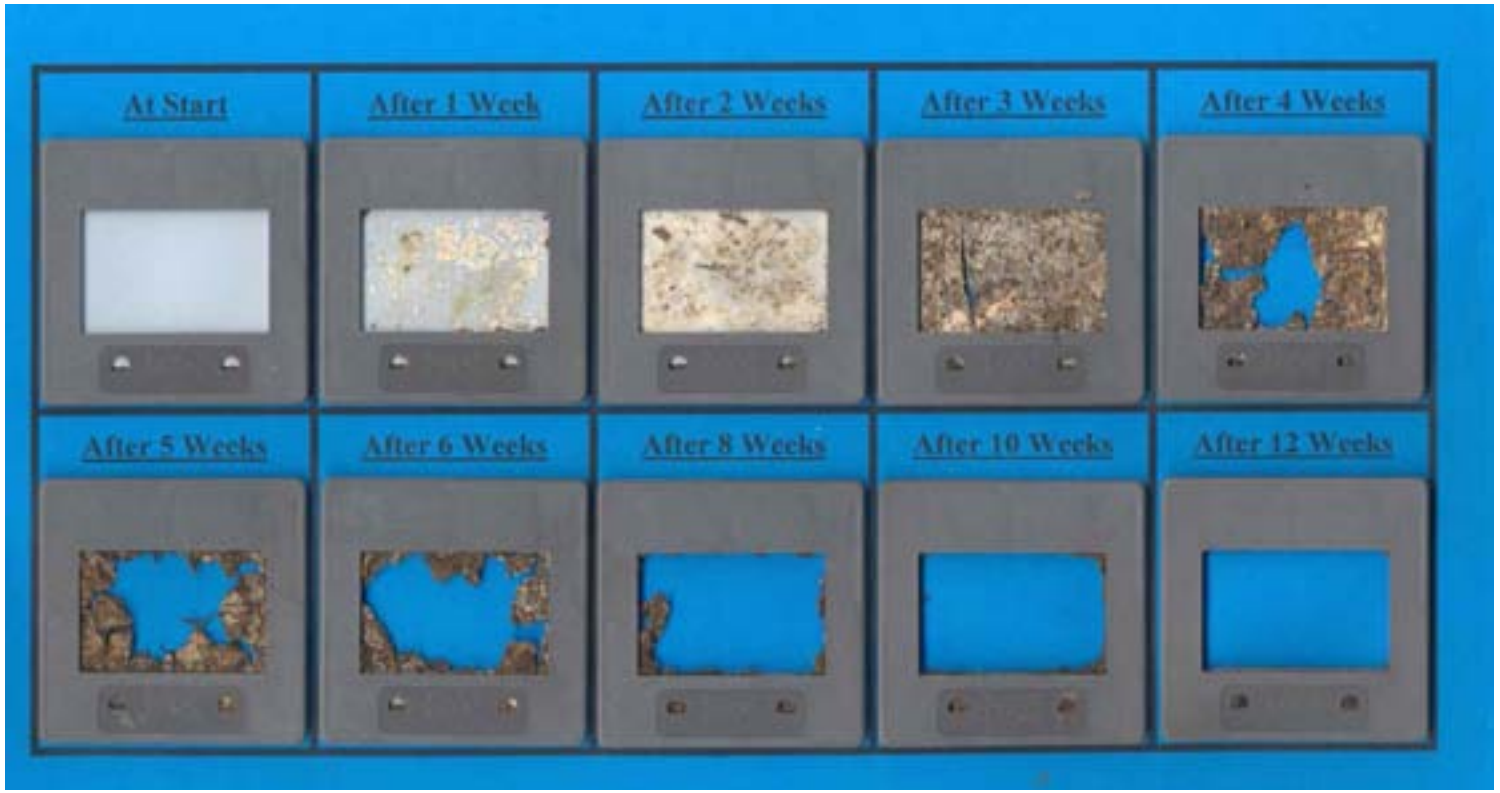
# OWS: Evolution of the Disintegration in a Compost Environment

**Mvera B5002 film @ 288 µm (11 mil) thickness**




**Source: Lab results from OWS**

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# 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

| | Mirel P5001 | Mirel A5004 | Mvera B5002 |
|---|---|---|---|
| Biobased Content | High | Medium | Low |
| Biodegradability | Broad | Soil<br>Industrial compost | Industrial compost |
| Melt Strength | Good | Excellent | Excellent |
| Tensile Strength | Good | High | High |
| Tear | Good | Good | High |
| Puncture | Good | High | High |
| Applications | Packaging, reusable retail carrier bags, compostable bags | Mulch film, bale wrap drip irrigation, stretch and shrink wrap | Industrial can liners, compostable bags |

# 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

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# 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

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# 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 concluded100% 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




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# 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





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# 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




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# Anaerobic Digestion of Mirel™ Lab Study by OWS

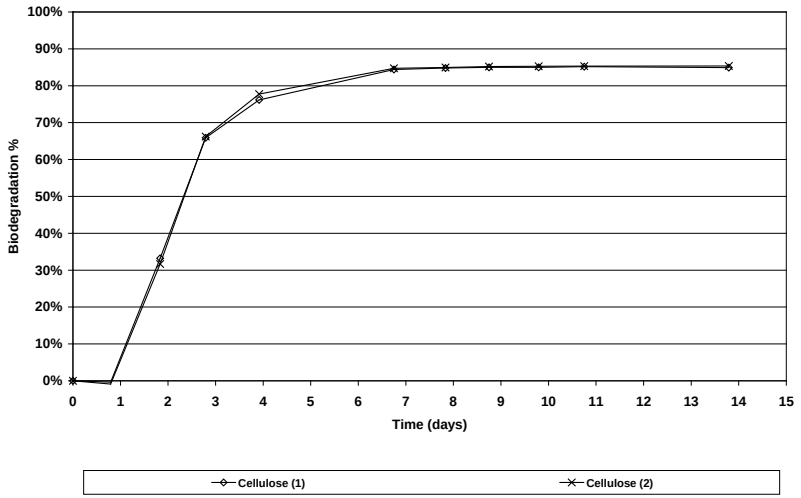
| Materials Tested | |
|---|---|
| Mirel P1003 | Injection molding grade compound |
| Mirel F5003 | Film grade resin |

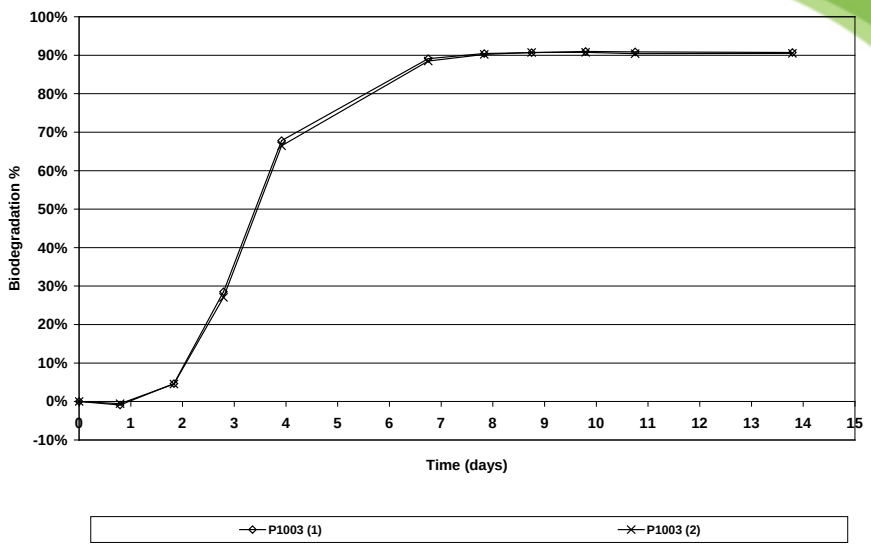
D5511-02 Standard test method for determining anaerobic biodegradation of plastic materials under high solids anaerobic digestion conditions.

ISO 15985 Plastics - Determination of the ultimate anaerobic biodegradability and disintegration under high solids anaerobic digestion conditions method by analysis of released biogas.

# Anaerobic Digestion -Organic Waste Systems (OWS) Testing

# Anaerobic Degradation of Mirel – Thermophilic 52C




## 13.8 day test data

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

**Typically out of 1 ton of biowaste, about 120 $m^3$ of biogas can be produced**
**5% Mirel increase biogas production by 30% - 40%**

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# Enabling Alternative Disposal Options

## Thank you.

www.mirel.com

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




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