Bioplastics and Managing Post-Consumer Feedstock Streams

USCC – 19th Annual Conference Santa Clara
January 24-26, 2011
Debra Darby, Director of Marketing Communications

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

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.mirelplastics.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.mirelplastics.com

Biobased

Starting with corn.

Corn Sugar

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

Fermentation

A patented process, transforms the sugar into Mirel bioplastics.

Formulation

Mirel is compounded into plastic pellets.

Applications

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

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Solutions Toward Zero Waste

Waste Diversion

- Packaging reduction and organics diversion from landfills
- Compost bags enable diversion of waste: food, yard waste, and pet waste to closed loop reuse systems

Soil Biodegradable

- Mulch films tailored to the local market
- New horticulture products

Marine Biodegradable

- Coastal restoration of sea-grass; rebuilding natural wetlands habitats (injection molded parts)
- Address soil erosion (injection molded parts)

Working with ASTM on new standards

- Home compost, soil and anaerobic digestion

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Certifications

All commercial grades are in the process of further certifications

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

*

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 seawater

Ball Horticultural Company Launches Bottomless Plantable Pot

"The intention was to design a pot that can be planted in the ground. We chose Mirel because it is biodegradable in soil. When you introduce it into the soil, it is seen by microbes as a food source."

-- Greg Trabka, product development manager for Ball Horticulture

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10 Compounded Products Available in 2011

Differentiation – Biodegradable and Performance

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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Mirel P1003 / F1005

Injection Molding Grades

- F1005 is FDA cleared for food-contact applications
- Suitable for a wide 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
- Suitable for a wide 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
  - Similar extrusion costs

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Mirel P3001 / F3002
Thermoforming Grade

- F3002 is FDA food compliant
  - Suitable for a wide range of food service and packaging applications
  - EFSA (EU food compliant) is underway
- High melt strength
  - Suitable for 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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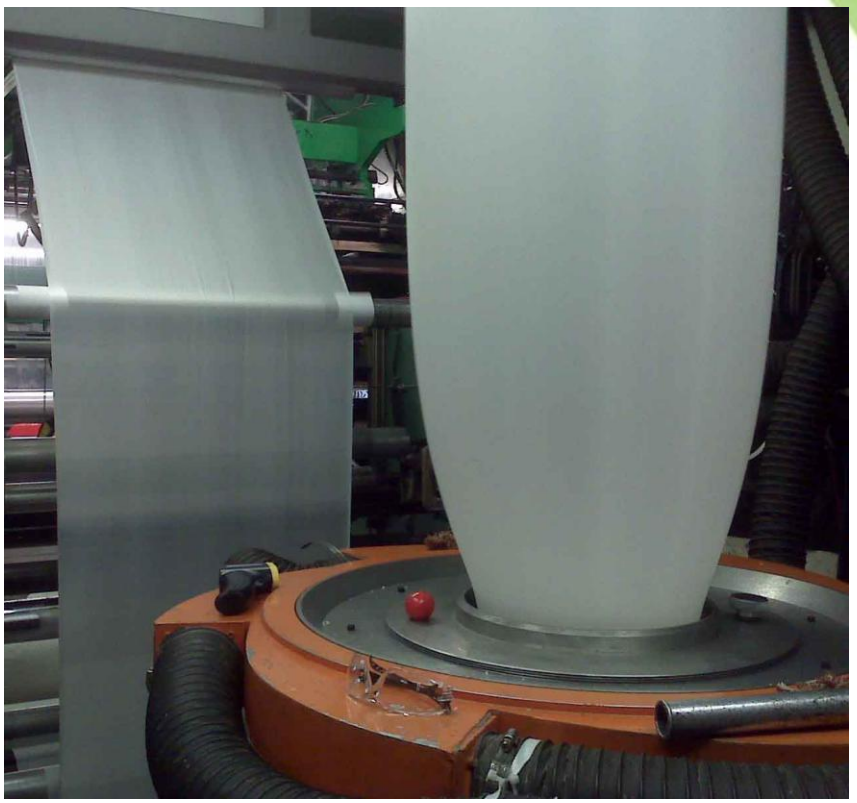
Mvera™ B5002 Compostable Film Grade

- 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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Mvera Film Properties - Provisional

	ASTM Method	B5002
General Description		General Purpose
*Physical and Thermal Properties^*		
Density, g/cm^3	D792	1.3
Apparent Melt Viscosity (180°C, 100 sec^{-1})	D3835	400 Pa-s
Mechanical Properties^ For Blown Film		
Coefficient of Friction	D1894	~0.25
Dart Impact Resistance	D1709	150 g/mil
Elmendorf Tear Resistance MD†	D1922	160 g/mil
Elmendorf Tear Resistance TD‡	D1922	650 g/mil
Tensile Strength MD	D882	25 MPa (3626 psi)
Tensile Strength TD	D882	22 MPa (3191 psi)
Tensile Modulus MD	D882	125 MPa (18130 psi)
Tensile Modulus TD	D882	675 MPa (97902 psi)
Tensile Elongation @ Break MD	D882	250%
Tensile Elongation @ Break TD	D882	450%
Tensile Toughness @ Break MD	D882	0.15 J
Tensile Toughness @ Break TD	D882	0.17 J
*Thermal Properties^*		
Melting Point	§	170°C (338°F)
Compostability		
Industrial compostable	D6400 / EN 13432	to 288 µm

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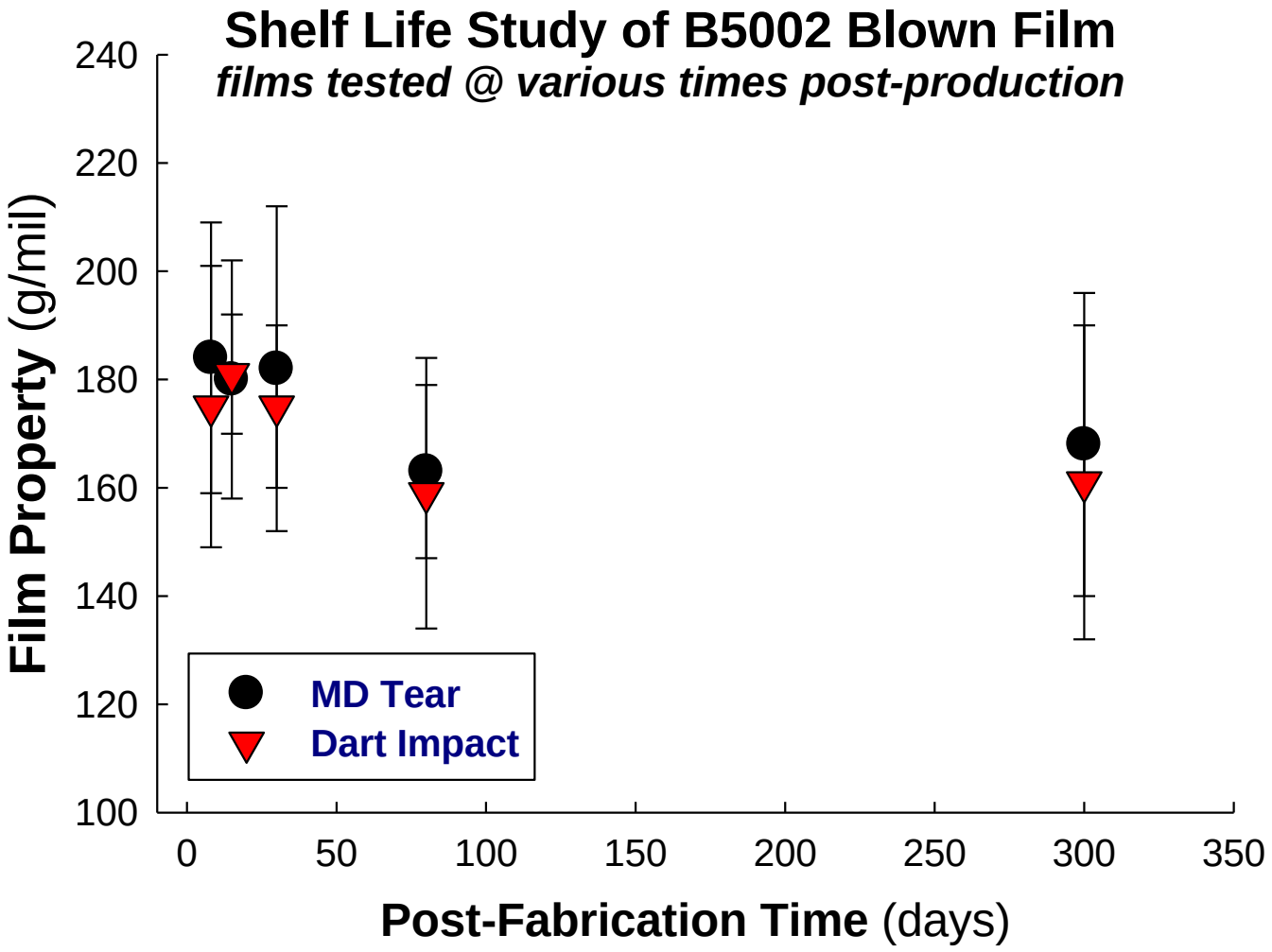
Aging - (About 1 year)



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OWS Pilot-Scale Composting Test

Materials Tested	Thickness
Mvera B 5002	288 µm (11 mil)

- Quantitative evaluation of materials for 12 weeks of composting
- Testing to ASTM D6400

Organic Waste Systems

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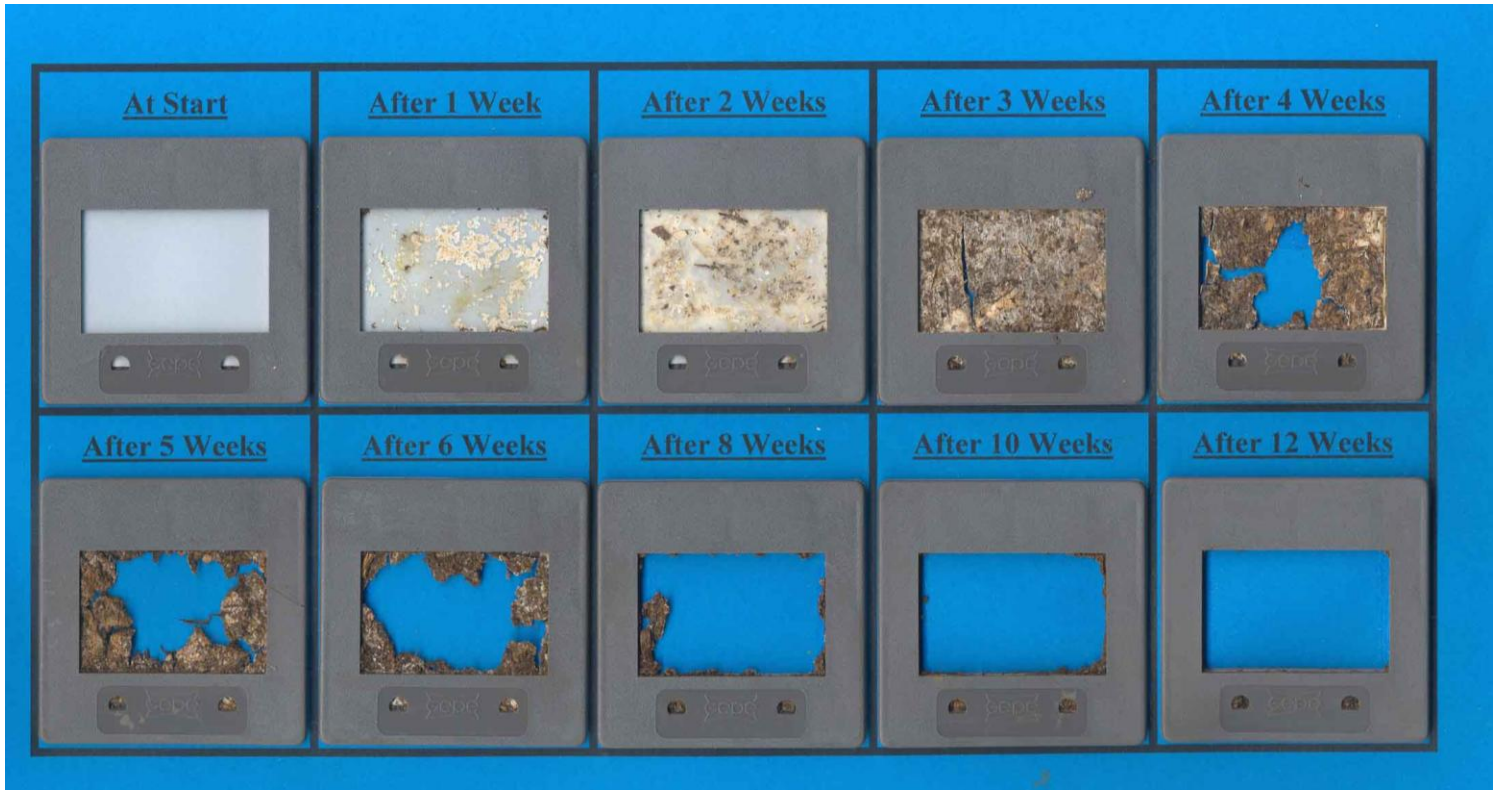
OWS: Evolution of the Disintegration in a Compost Environment

Mvera B5002 film @ 288 µm (11 mil) thickness



Source: Lab results from OWS

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Internal Test - Hot Composting

Materials Tested	Thickness
Mvera B5002	255 µm (10 mil)
Mvera B5002	25.5 µm (1mil)

- Quantitative evaluation of materials for 12 weeks of composting
- 255 µm (10 mil) is about the typical thickness of a bag seam
- 25.5 µm (1mil) slightly thicker than typical bags, disintegration in 2 weeks

- Film samples are against a black background

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Telles Composting Equipment
Bioplastics Lab, University of MA Lowell

Compact Compost Tumbler

- 90 gallon composter, 43” H x 42” W x 33”
- Combined aerator/drainage port on the door
- Screened endcap vents for oxygen
- Made of galvanized metal, rust-proof drum

- Located in a heat-controlled room
- Temperature controlled to above 40°C
- Turned 2x per week
- Maintained proper levels of moisture, temperature and oxygen

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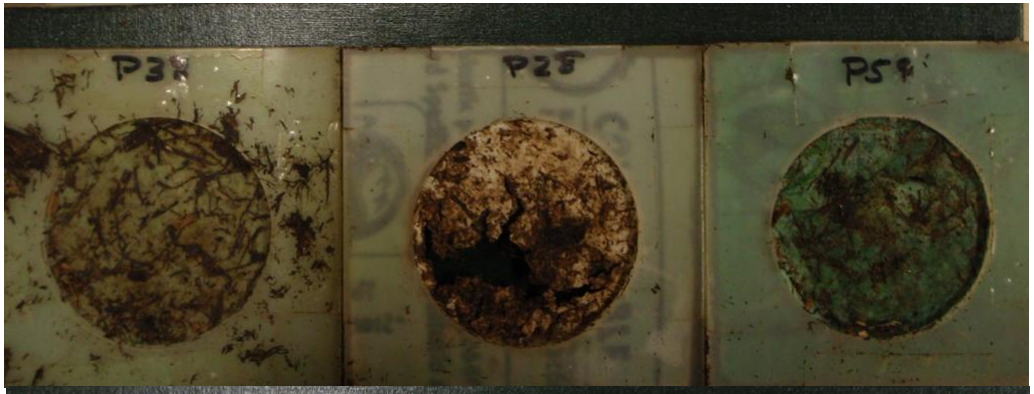
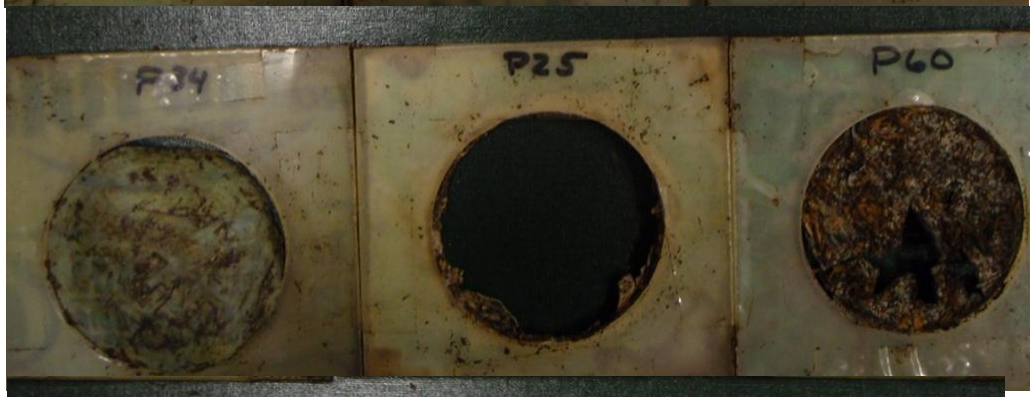
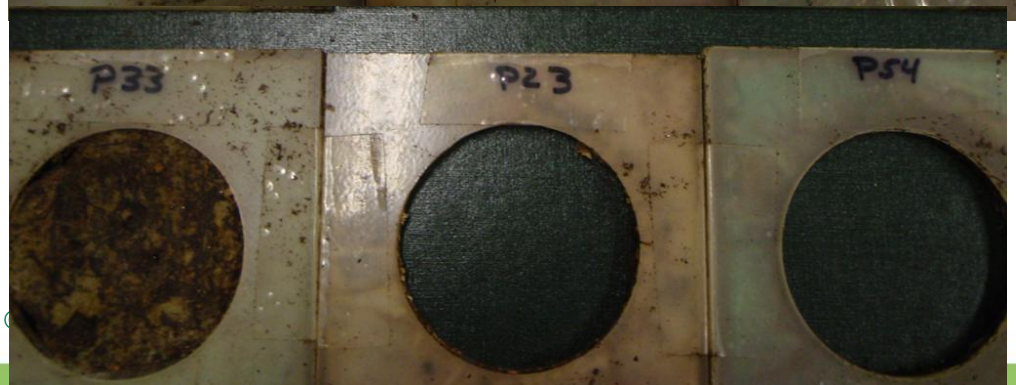
Internal Test: Evolution of Disintegration in Composting Environment at thickness of 255 µm (10 mil)

	Commercial Bag 1	Mvera B5002	Commercial Bag 2	
Week 2				• Bag 1 showed some disintegration • B5002 showed disintegration • Bag 2 showed disintegration
Week 4				• Bag 1 – showed some disintegration • B5002 disintegrated, only pieces remained present at borders of slide frame • Bag 2 showed more disintegration than Bag1
Week 7				• Bag 1 exhibits some disintegration • B5002 disintegrated, only small pieces remained present at borders of slide frame • Bag 2 disintegrated

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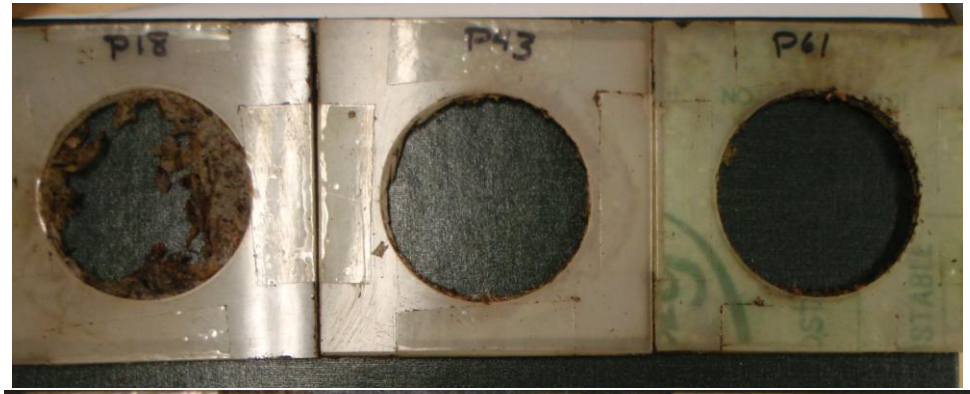
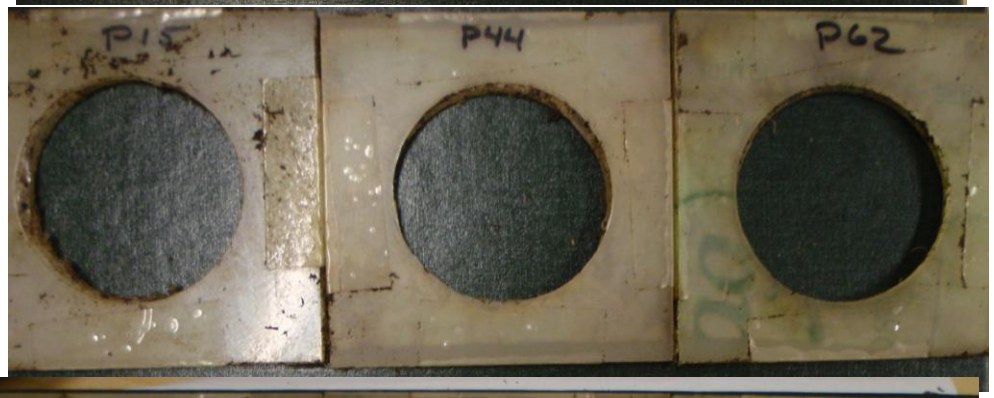
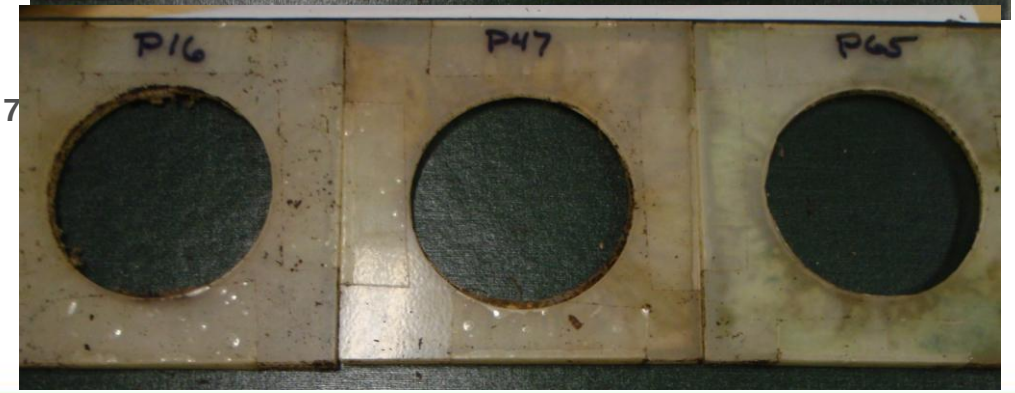
Internal Test: Evolution of Disintegration in Composting Environment at thickness of 25.5 µm (1 mil)

	Commerical Bag 1	Mvera B5002	Commercial Bag 2
Week 2			
Week 4			
Week 7			

- Bag 1 showed disintegration
- B5002 was disintegrated, only small pieces remained present at borders of slide frame
- Bag 2 was disintegrated, tiny pieces remained present at borders of slide frame

- Bag 1 was disintegrated, only small pieces remained present at borders of slide frame
- B5002 was disintegrated, only small pieces remained present at borders of slide frame
- Bag 2 was disintegrated

- Bag 1 was disintegrated, only small pieces remained present at borders of slide frame
- B5002 was disintegrated, only small pieces remained present at borders of slide frame
- Bag 2 was disintegrated

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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.

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, further lab testing with OWS is underway

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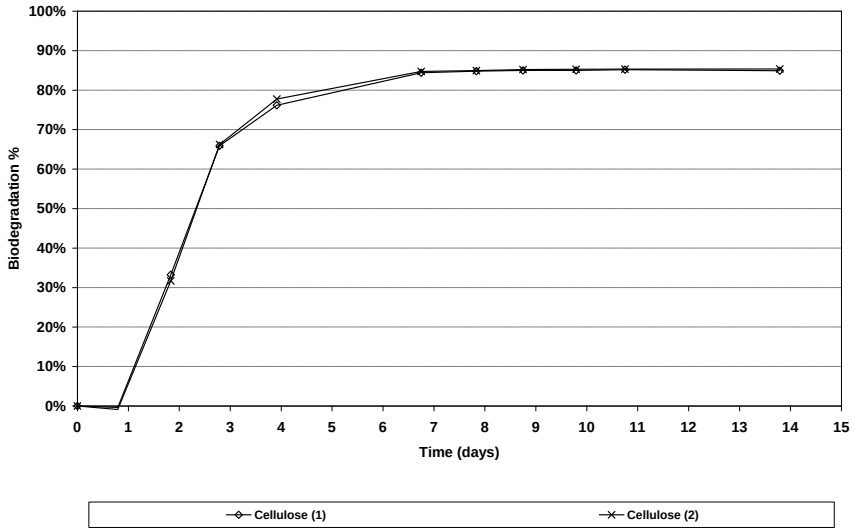
Anaerobic Digestion of Mirel™ Lab Study by OWS

Materials Tested	
Mirel P1003	Injection molding grade compound
Mirel F5003	Film grade compound

- 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

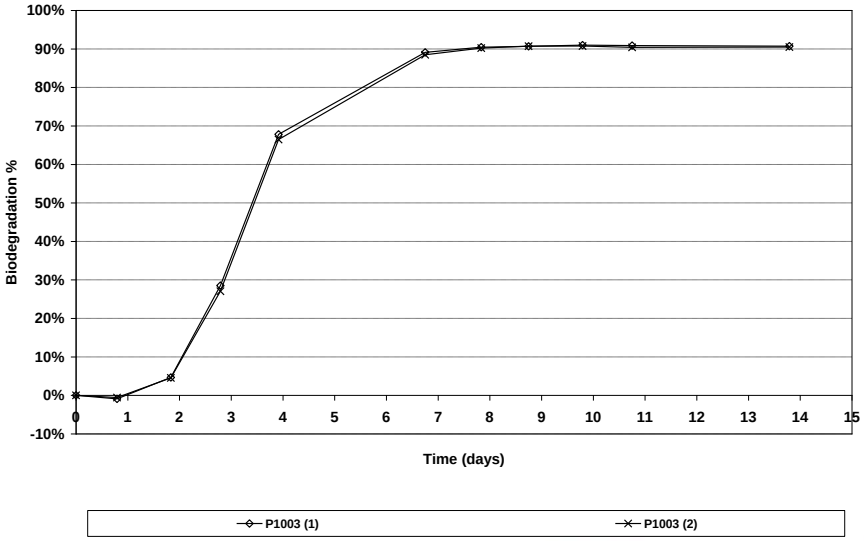
Anaerobic Degradation of Mirel - Thermophilic



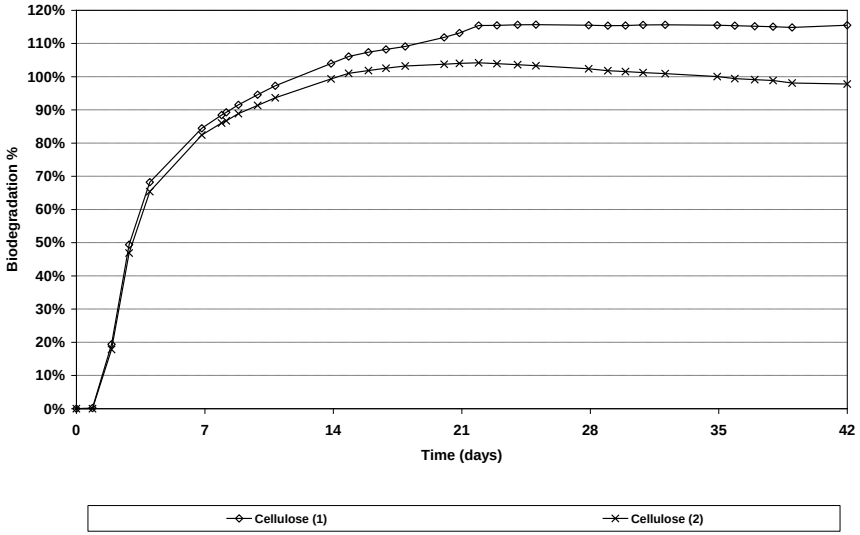
Thermophilic – 52C

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



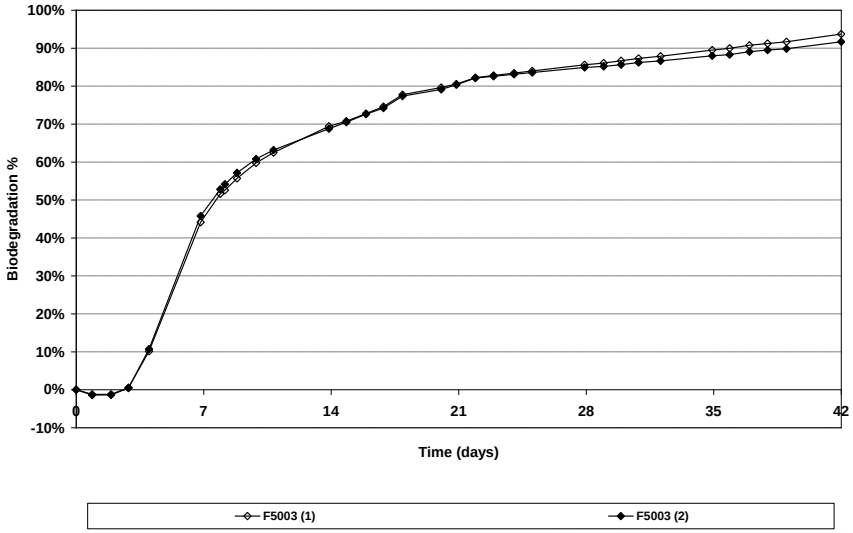
Anaerobic Degradation of Mirel - Mesophilic



Mesophilic – 37C

42 day test data

Test item	Total Nl (Nl/kg)	Net biogas production (Nml/g test item)	Biodegradation (%) AVG ± STD	Relative
Blank	24.3	-	-	-
Cellulose	36.9	846.6	106.6 ± 12.5	100.0
M2100	39.7	1031.2	99.2 ± 3.1	93.0
M4100	38.3	937.2	90.0 ± 3.0	84.4
P1003	34.3	670.6	78.2 ± 9.3	73.3
F5003	37.5	882.9	92.7± 1.4	86.9



Conclusion of Lab Test

After 15 days of testing:

- Mirel materials reached about 85% absolute biodegradation to methane and CO_2, which is 100% biodegradation relative to the cellulose reference.
- Concluded: Mirel materials are biodegradable under the test conditions.
- Early indicators: Mirel PHA 5-6x biogas production relative to typical food waste.

Anaerobic Digestion: a Viable Alternative

State of Wisconsin Office of Energy Independence (OEI) Working toward Zero Waste and Energy Development

Project General Overview:

- Launching Anaerobic Digestion project: demonstrate the feasibility of manures, food wastes and bioplastics to study bio-energy and compost contributions.
- Consortium involving key stakeholders: government and agencies with industry, certification test laboratory, retailers & consumer groups with subtly differing interest
  - University of Wisconsin at Platteville: conduct the study
  - UL Environment: generate data, testing and reporting
  - Telles: provide Mirel™ (PHA) bioplastics material, technical support and marketing/pr
  - other Wisconsin participants (tbd)
  - other bioplastics manufacturers (tbd)

OFFICE OF OEI ENERGY INDEPENDENCE

UL Environment℠ YOUR PARTNER IN SUSTAINABILITY

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Enabling Alternative Disposal Options

Thank you.

Please visit the Mirel bioplastics booth
www.mirelplastics.com

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

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