

Biodegradation of Compostable Plastic Snack Bags with Metallized Coating in Green-Yard Waste and Food Waste Compost

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Topics

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Introduction

- Research project
 - Frito Lay corporation is interested in the biodegradation performance of their snack bag in different biodegradation environments, including:
 - Industrial compost
 - Home compost
 - Marine waters
- This presentation presents the biodegradation test results for PLA based snack package in green and food waste industrial compost facilities.

Biodegradable Plastics Definitions

- Biodegradable Plastics
 - Degraded by microorganisms in soil, compost, or marine environments.
 - Made from corn, potato, polylactic acid, sugar cane, polyester, or other organic materials.
- “Biodegradable plastics” is “INCOMPLETE” wording
- Necessary Requirements for Biodegradation
 - Environment
 - Industrial compost, marine water, anaerobic digester, home compost, landfill
 - Time
 - 6 months for industrial compost
 - 6 months for marine water
- “Biodegradable plastics in industrial compost in 6 months” is “COMPLETE” wording

Standards for Biodegradation

- Necessary standards for biodegradation require two things:
 - Test method
 - Provides procedures and equipment to properly simulate degradation environment and obtain experimental measurements to indicate biodegradation.
 - Example, ASTM D-5338 for laboratory testing of industrial compost
 - Provides a listing of procedures in the experimental set-up to simulate industrial compost environment in the laboratory.
 - Provides an experimental means of measuring the concentration of CO₂ in the biogas.
 - Biodegradation results interpretation
 - Provides criteria to establish biodegradation
 - Example, ASTM D-6400 for laboratory testing of industrial compost
 - Provides the method of converting biogas measurements to percentage biodegradation of carbon from the plastic sample.
 - Provides a minimum level of biodegradation for positive control.
 - Provides minimum level of biodegradation for plastic samples.

Standards for Biodegradation

- Biodegradation standards and the biodegradation conditions.

Environment	Test Method: Description of consistent testing	Biodegradation standard: Results interpretation	Measurement method	Can plastics claim biodegradation with this standard?
Industrial Compost	D5338	D6400	CO ₂ measurement	Yes
Marine	D6691	D7081	CO ₂ measurement	Yes
Home Compost	None	None	None	No
Anaerobic Digestion	D5511	None	Biogas measurement	No
Active Landfill	In development	None	Biogas measurement?	No

Biodegradation in Industrial Compost

- ASTM standards
 - **D5338: Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions**
 - 600 g of compost plus 100 g of plastic sample
 - Minimum 2-L containers at 58C and 50% moisture.
 - Biogas and oxygen measured with specific sensors or gas chromatographs
 - **D6400: Standard Specification for Compostable Plastics**
 - Disintegration after 12 weeks: < 10% of plastic sample remains.
 - Biodegradation after 6 months: > 90% conversion of carbon in sample to CO₂
 - Plant phytotoxicity after 6 months: cress or tomato plants grow in compost soil
 - Regulated metals after 6 months: less than 50% of those prescribed for sludges or composts.
 - **D6868: Biodegradable Plastics Used as Coatings on Paper and Other Compostable Substrates**

Where PLA Comes From

Reference: <http://www.natureworksllc.com/>



sugar → fermentation

↓ ... lactic acid

monomer production

↓ ... lactide

polymer production

↓

PLA

polymer
conversion



Ingeo Fibers



End-of-life for Consumable Snacks

- The Frito Lay compostable snack bag provides customers a way to reduce their waste generation by composting instead of sending the waste to landfill.
- Over 30% of the CA waste in landfill is organic including food waste.* * <http://www.ciwmb.ca.gov/Publications/?pubid=1097>
- The compostable PLA snack bag will be tested in:
 - Green yard waste facility
 - Food waste facility
 - Laboratory compost

Green Yard Waste Environment Results

Biodegradation Results

- City of Chico Green Yard Waste Compost Environment
 - Windrow compost facility
 - 10-acre site that produces 500,000 cubic yards of compost each year via aerobic windrow compost.
 - Disintegration tests
 - Materials
 - Cellulose paper
 - Frito Lay Snack package
 - PLA straws
 - Polyethylene plastic bag
 - Monitored how much the compostable samples disintegrated by the microbes in the compost soil.

Testing Methods

- Green Yard Waste Compost Environment



Figure 1. Samples plus Compost plus Bag Compost



Figure 2. City of Chico Green Yard Waste

Start Date: September 3, 2009
End Date: November 11, 2009 (69 Days)

Disintegration Test Results

- Green Yard Waste Compost Environment
 - Temperature varied from 130°F to 155°F
 - Moisture content was 50% +/- 5%
 - The compost was made from green grass, sticks, leaves, etc.
 - The compost was turned twice a week to aerate compost pile.
 - The compost was 2-months maturity at the start of the test.

Disintegration Test Results



1 oz. Frito Lay Compostable start



1 oz Frito Lay Compostable Bag: 22 days



1 oz Frito Lay Compostable Bag 35 days:
Completely mineralized and no fragments remaining

Disintegration Test Results



10.5 oz Frito Lay Compostable Bag: 22 days



10.5 oz Frito Lay Compostable Bag: 35 days

10.5 oz. Frito Lay Compostable start



10.5 oz Frito Lay Compostable Bag 69 days:
Completely mineralized and no fragments remaining

Disintegration Test Results



PLA straws start



PLA straws: 22 days



PLA Straws: 35 days:
Completely mineralized and no fragments remaining

Disintegration Test Results



Cellulose paper start



Cellulose Paper: 35 days:
Completely mineralized and no fragments remaining

Disintegration Test Results



Frito Lay negative control PP bag: start



Frito Lay negative control PP bag 69 days:

Recology Food Waste Compost Environment

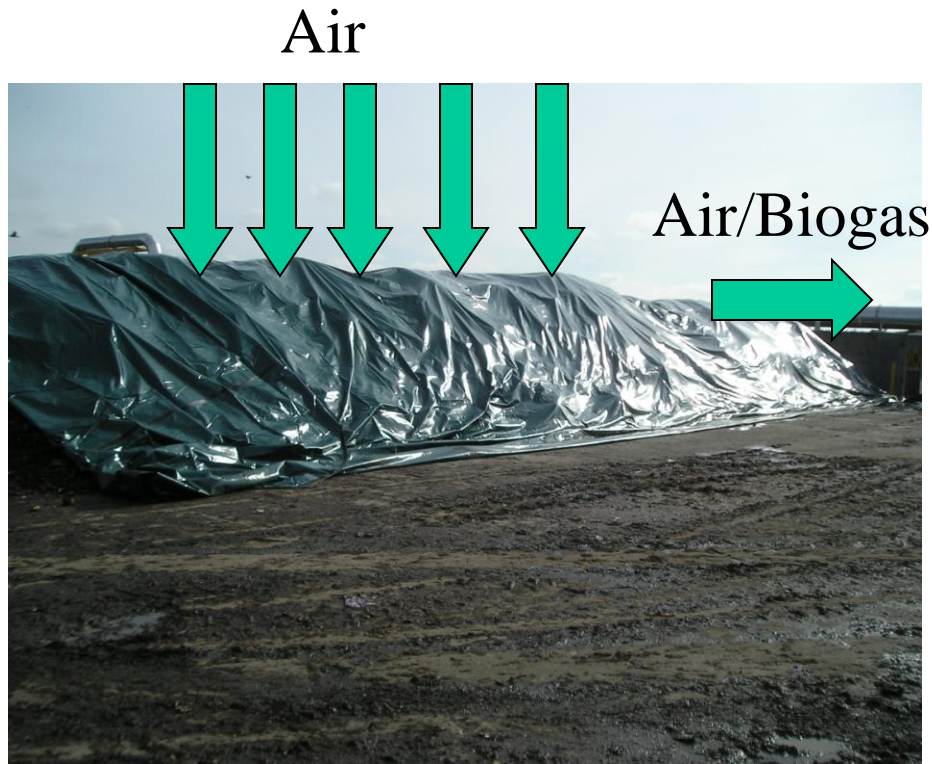
Disintegration Test Results

- Recology Food Waste Compost Environment
 - Temperature varied from 135°F to 160°F
 - Moisture content was 48% +/- 5%
 - The compost was made from food waste from San Francisco restaurants, hotels, schools, etc.
 - The compost was 1-month maturity at the start of the test.

Recology In-vessel Food Waste Compost

- Transforms food waste to 30,000 tons of organic compost a year.
- The compost facility utilizes in-vessel compost system for 45 days and then traditional static compost pile for 49 days.
- The samples were placed in plastic mesh sacks and mixed with solid waste.
- Engineered Compost System (ECS) in-vessel compost system
 - The MSW is placed on the ground with a plastic tarp placed on top.
 - Air is pulled through vent holes in the tarp and through the compost pile.
 - Biogases that are emitted from the compost pile are vented through a wood chip pile to collect the odors from the compost pile.
- PC based system control of temperature and pressure
 - The MSW materials are sent through a temperature regime that destroys pathogens in the first three days and then maximizes composting over the next 3 weeks with proper aeration, drainage, and temperature control.

Recology Dixon, CA In-vessel Compost



In-vessel composting with polyethylene cover



Compost pile after 45 days

Recology In-vessel Compost Pictures



Test materials on Start date: December 14, 2009



Placement on Food waste compost pile

Recology In-vessel Compost Pictures



Frito Lay compostable bag fragments after 45 days

No Frito Lay bag fragments left after 94 days



PLA straw fragments after 45 days

No fragments of PLA straws left after 94 days

Recology In-vessel Compost Pictures



Frito Lay negative control PP bag after 94 days



Static compost pile after 94 days

Recology In-vessel Food Waste Compost

- Results

- 45 days (In-vessel)

- Some degradation: Food waste, PLA-based bag and straws, and Kraft paper.
 - Complete disintegration: cellulose paper.
 - No disintegration: Frito Lay negative control PP bag.

- 94 days: (Windrow)

- Complete disintegration: Food waste, PLA-based bag and straws, cellulose paper, and Kraft paper.
 - No disintegration: Frito Lay negative control PP bag

Conclusions

- Frito Lay compostable plastic bags in 1 oz (gray) and 10.5 oz (blue) packages disintegrated very well in commercial green-waste and food-waste compost facilities.
- They disintegrate equally well in traditional windrow operations as with in-vessel composting operations.
- The Frito Lay compostable bags and other compostable plastic materials completely disintegrated in 94 days while in the in-vessel aerobic compost systems.
- The commercial Frito Lay chip bag made from polypropylene and LDPE plastic trash bags, used as negative control, did not demonstrate any disintegration during in-vessel nor windrow composting conditions.

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Questions?