

Customer Report

Thursday, April 11, 2013

**C
O
N
T
A
C
T**

Entropy Solutions

151 Cheshire Lane

STE 400

Plymouth MN 55441

Chris Servais

952-374-6420

Chris.servais@entropysolutionsinc.com

Project Title

Biodegradation Test

ID **0912-AFG-01 -- 1 r.** Entry Date 9/21/2012

Project Summary

Overview:

The **ASTM D6400 - Standard Specification for Compostable Plastics** is designed to evaluate the biodegradation and selected environmental parameters of biodegradable products or materials. Biodegradation is determined by the evolution of carbon dioxide from the test material under laboratory compost conditions using the ASTM D5338. Disintegration of material (by sieving), and phytotoxicity (seed germination) are assessed on the test sample following the termination of the biodegradation testing.

Results:

A phase change product PureTemp 28 (Test Sample) was submitted for testing according to the ASTM D6400 Standard Specification for Compostable Plastics; excluding metals analysis.

Sample testing was conducted for 160 days. Control sample microcrystalline cellulose was tested as a positive control. Triplicate samples were tested in separate chambers containing a municipal composted inoculum. Control samples demonstrated 90% theoretical carbon dioxide (%ThCO₂) generation within 92 days of the biodegradability test. The test sample demonstrated 86% ThCO₂ within 159 days of biodegradation testing. Test sample graphs were analyzed by curve fit to establish that a plateau of the rate of biodegradation was achieved prior to termination of the analysis.

Sample List

Method Name

<i>Sample #</i>	<i>Sample Name</i>	<i>Sample Notes</i>
ASTM D6400 - Standard Specification for Compostable Plastics		
1	PureTemp 28	
2	Cellulose Control	
ASTM D6400 -Phytotoxicity		
1	PureTemp 28	
2	Cellulose Control	
ASTM D6400 Mesh Analysis of composted material		
1	PureTemp 28	
2	Cellulose Control	

Result Table

Contact	Entropy Solutions	Chris Servais	952-374-6420
Title	Biodegradation Test		
Project ID	0912-AFG-01 -- 1	r.	Entry Date 9/21/2012 Test Start Date 9/21/2012

Result Table *

Test Method	ASTM D6400 - Standard Specification for Compostable Plastics		
-------------	--	--	--

Sample #	1	PureTemp 28	
----------	---	-------------	--

	Interval	Result
Inoculum	Mixed Environmental Organisms ()	
	82 days	60 % ThCO ₂
	159 days	86 % ThCO ₂
Image:	Chart	
<p>Figure - Test chamber carbon dioxide (CO₂) measurement as the percent of theoretical maximum (% ThCO₂) derived from the test sample. Average values are plotted with the standard deviation (+/- SD) for the time course of the test. Curve fit is applied to calculate the statistical confidence for 95% (line) and predicted (red) curve fit.</p>		

Sample #	2	Cellulose Control	
----------	---	-------------------	--

	Interval	Result
Inoculum	Mixed Environmental Organisms ()	
	49 days	60 % ThCO ₂
	92 days	90 % ThCO ₂
Image:	chart	
<p>Figure - Test chamber carbon dioxide (CO₂) measurement as the percent of theoretical maximum (% ThCO₂) derived from the test sample. Average values are plotted with the standard deviation (+/- SD) for the time course of the test. Curve fit is applied to calculate the statistical confidence for 95% (line) and predicted (red) curve fit.</p>		

Test Method	ASTM D6400 -Phytotoxicity		
-------------	---------------------------	--	--

Sample #	1	PureTemp 28	
----------	---	-------------	--

	Interval	Result
Inoculum	None ()	
cucumber	10 days	0.39 grams
soy bean	10 days	0.41 grams

Result Table *

Sample #	2	Cellulose Control	Interval	Result
Inoculum <i>None ()</i>				
	cucumber		10 days	0.37 grams
	soy bean		10 days	0.4 grams

Test Method	ASTM D6400 Mesh Analysis of composted material
--------------------	--

Sample #	1	PureTemp 28	Interval	Result
Inoculum <i>None ()</i>				
	no residual material		150 days	See Note

Sample #	2	Cellulose Control	Interval	Result
Inoculum <i>None ()</i>				
	no residual material		92 days	See Note

Result Table *

This test method determines the degree and rate of aerobic biodegradation of plastic materials on exposure to a controlled-composting environment under laboratory conditions, at thermophilic temperatures. This test method is designed to yield reproducible and repeatable test results under controlled conditions that resemble composting conditions, where thermophilic temperatures are achieved. The test substances are exposed to an inoculum that is derived from compost from municipal solid waste. The aerobic composting takes place in an environment where temperature, aeration and humidity are closely monitored and controlled.

Biodegradation of a plastic material within a composting unit is an important phenomenon because it may affect the decomposition of other materials enclosed by the plastic and the resulting quality and appearance of the composted material. Biodegradation of plastics will also allow the safe disposal of these plastics through professionally managed composting plants and well run residential units, where thermophilic temperatures are achieved. This procedure has been developed to permit the determination of the rate and degree of aerobic biodegradability of plastic products when placed in a controlled composting process.

Limitations— Because there is a wide variation in the construction and operation of composting facilities and because regulatory requirements for composting systems vary, this procedure is not intended to simulate the environment of any particular composting system. However, it is expected to resemble the environment of a composting process operated under optimum conditions where thermophilic temperatures are achieved. More specifically, the procedure is intended to create a standard laboratory environment that will permit a rapid and reproducible determination of the aerobic biodegradability under controlled composting conditions.

Reference Information:

Equipment:

Continuous Respirometer

Percival Incubator and Eurotherm RTD temperature controller (58°C +/- 2°C)

Thermotec 283 condenser

Varian Spectra AA 880Z GTA

Compost inoculum derived from local waste or municipal facility

Method and Instrument Limits as defined by US: 40 CFR 503.13; or Canadian: 6.1 of BNQ 9011-911-I/2007 regulations

Elemental Analysis Method Detection Limits

(As) Arsenic- 20.5 ppm, Canada (19 ppm); (MDL 5.00 ppb)

(Cd) Cadmium - 17 ppm, Canada (5 ppm); (MDL 0.28 ppb)

(Cu) Copper - 750 ppm, Canada (189 ppm); (MDL 3.57 ppb)

(Pb) Lead - 150 ppm, Canada (125 ppm); (MDL 2.00 ppb)

(Hg) Mercury - 8.5 ppm, Canada (1 ppm); (MDL 30.22 ppb)

(Ni) Nickel - 210 ppm, Canada (45 ppm); (MDL 1.82 ppb)

(Se) Selenium - 50 ppm, Canada (4 ppm); (MDL 0.69 ppb)

(Zn) Zinc - 1400 ppm, Canada (463 ppm); (MDL 55.8 ppb);

(Cr) Chromium - 265 ppm (MDL 0.233 ppb); Canada only

(Co) Cobalt - 38 ppm (MDL 0.484 ppb); Canada only

(Mo) Molybdenum - 5 ppm (MDL 0.481 ppb); Canada only

Recorded values below the MDL (Method Detection Limit) are reported as <MDL

Recorded values below the IDL (Instrument Detection Limit) are reported as <IDL

Phytotoxicity Requirement

Average mass (+/- 10%) of germinated seed sample compared to the positive control compost material (cellulose).

Minimum of three seed samples must germinate for positive evaluation for each test sample.

Powers Scientific Inc. incubator, 14 hrs day/night light rotation 250 to 300 lux. 25C +/- 3C

Mesh Analysis

A plastic product is considered to have demonstrated satisfactory disintegration if after twelve weeks in a controlled composting test, no more than 10% of its original dry weight remains after sieving on a 2.0-mm sieve.

Result Table *

* This report is governed by and incorporates by reference, the conditions of testing as posted on the date of issuance and is intended for your exclusive use. Any Copying or replication of this report to or for any other person or entity, or use of our company name or Service Mark is permitted only with our prior written consent. This report sets forth our findings solely with respect to test samples identified herein. The results set forth in this report are not indicative or representative of the quality or characteristics of the lot from which a test sample was taken or any similar identical product unless specifically and expressly noted. Our report includes all tests requested and the results there of based upon the information provided. You have 60 days from the date of issuance of this report to notify us of any material error or omission caused by our handling of the samples, provided however that such notice shall be in writing and shall specifically address the issue you wish to raise. A failure to raise such issue within the prescribed time shall constitute your unqualified acceptance of the completeness of this report, the test conducted and the correctness of the report contents.

Report Addendum

Thursday, April 11, 2013

Project ID **0912-AFG-01 -- 1** Entry Date 9/21/2012 Test Start Date 9/21/2012

Image Table

Sample # **1** PureTemp 28

Test Method ASTM D6400 - Standard Specification for Compostable Plastics

Inoculum *Mixed Environmental Organisms*

Image: Chart

ASTM D5338 Biodegradation - PureTemp 28

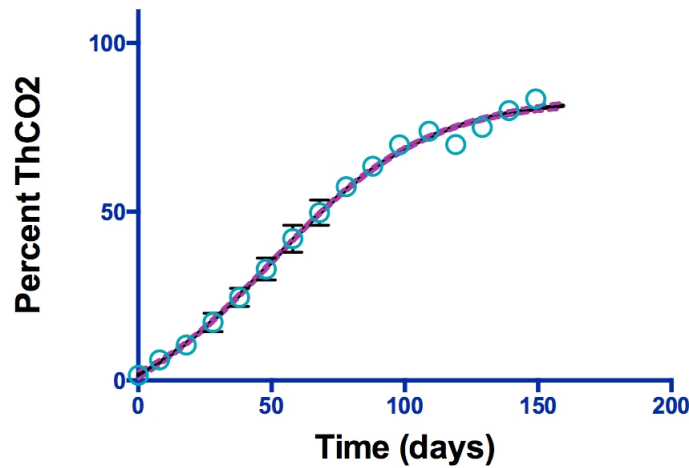


Figure - Test chamber carbon dioxide (CO₂) measurement as the percent of theoretical maximum (% ThCO₂) derived from the test sample. Average values are plotted with the standard deviation (+/- SD) for the time course of the test. Curve fit is applied to calculate the statistical confidence for 95% (line) and predicted (red) curve fit.

Image Table

Sample #	2	Cellulose Control
Test Method	ASTM D6400 - Standard Specification for Compostable Plastics	
Inoculum	Mixed Environmental Organisms	

Image: chart

ASTM D5338 Biodegradation - Cellulose Control

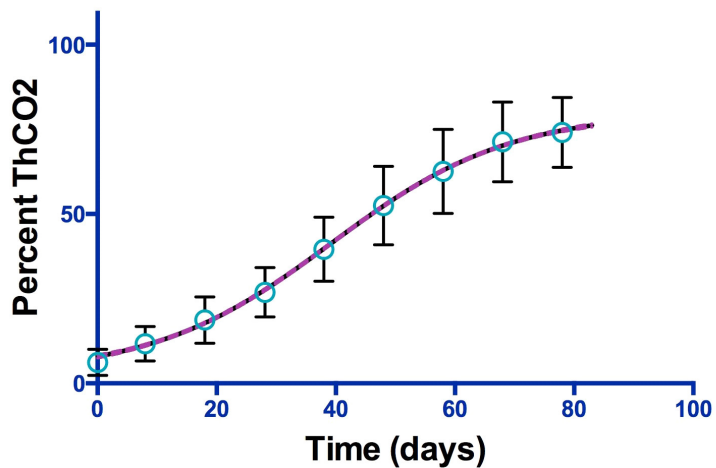


Figure - Test chamber carbon dioxide (CO₂) measurement as the percent of theoretical maximum (% ThCO₂) derived from the test sample. Average values are plotted with the standard deviation (+/- SD) for the time course of the test. Curve fit is applied to calculate the statistical confidence for 95% (line) and predicted (red) curve fit.