Analytical Summary

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ASTM D 5511 – 02
Standard Test Method to Determine Anaerobic Biodegradation of Plastic Materials Under High-Solids Anaerobic-Digestion Conditions

The degree and rate of anaerobic biodegradability of a plastic type material may be predictive of the period required to reduce the proposed plastic from the environment depending on the given conditions. Where disposal is considered a major issue, this test method may be useful to estimate the degree and persistence of biodegradable plastic in a biologically active anaerobic disposal situation. ASTM method D5511-02 determines the degree of anaerobic biodegradation of plastic materials in a high-solids anaerobic conditions. The test sample is exposed to methanogenic inoculum cultivated from a wastewater treatment facility's anaerobic digesters operating on household waste. Anaerobic decomposition in this case employs a high solids environment. High solids conditions are usually considered to be greater than 20% solids. The sample conditions remain static.

This test method is designed to yield a percentage of conversion of carbon in the sample to carbon in the gaseous form under conditions found in high-solids anaerobic digesters, treating municipal solid waste. This can be validated using change in mass of the original sample. This test method is also designed to resemble many conditions in a biologically active landfill. This method is applicable to all plastic materials that are not toxic to microorganisms present in wastewater treatment facility's anaerobic digesters that are operating on household waste.

ASTM Method D5511 determines the rate and degree of anaerobic biodegradation by measuring the volume of carbon dioxide (CO_2) and methane (CH_4), or change in mass as a function of time (days) of exposure to anaerobic-digester sludge. This method is considered an accelerated representation with respect to anaerobic environments. Landfill sites that plastics encounter in usual disposal methods are a prime example of this environment.

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Experiment:

1. Inoculum
   1.1. Isolation of an inoculum is the primary step.
   1.2. The dependability of the inoculum is determined by the positive control sample test.
   1.3. Sludge Characteristics and Preparation
      1.3.1. Sludge from Organic Compost – McEnroe Organic Farms, Millerton, NY
      1.3.2. Fifteen day hold period observed @ 53 ± 2°C
      1.3.3. Solid Content - 24%
      1.3.4. pH - 7.9
      1.3.5. Volatile Fatty Acids - 0.9 g/kg
      1.3.6. Ammonium Nitrogen 1.3 mg/kg
2. Sample characteristics are observed and recorded.
   2.1. Carbon Content - 61.2%
   2.2. Structure - PETE
   2.3. Sample Form – PETE Bottles
   2.4. Temperature Range During Study - 52 ± 2°C
   2.5. Duration of study - 29 days
3. Experiment commences in an appropriate apparatus to verify gas evolution and sample isolation for final mass analysis.
   3.1. Incremental mass and gas evolution is measured for sample, control and positive control by considering mass loss.
   3.2. The experiment is continued for a given period of time.
      3.2.1. Twenty-nine days in this case.
      3.2.2. If gas production of actual sample reduces to that of the control sample the experiment is terminated.

Results:

After consideration of gas production of all samples, there appears to be no gross inconsistencies that would deem this experiment unusable. There is excellent continuity among the three samples.

	Average		Methane (CH_4)			Carbon Dioxide (CO_2)			Total Carbon (C)		Biodegradation	
	Wt (g)	Total Vol (ml)	%	Vol (ml)	Wt CH_4 (g)	%	Vol (ml)	Wt (g)	Total Wt (g)	Theoretical (g), C_i	%	Adjusted %
PETE	12.3	12,010.0	50.9	6113	4.37	1.90	228	0.45	3.40	7.53	13.81	16.93
Positive	10.0	20,967.0	51.2	10735	7.68	1.98	416	0.82	5.98	4.44	81.54	100.00
Inoculum	250.0	8671.0	48.8	4231	3.03	2.00	173	0.34	2.36			

There was indication that the inoculum was viable, because the positive and sludge control results indicated biodegradation when gas production is considered.

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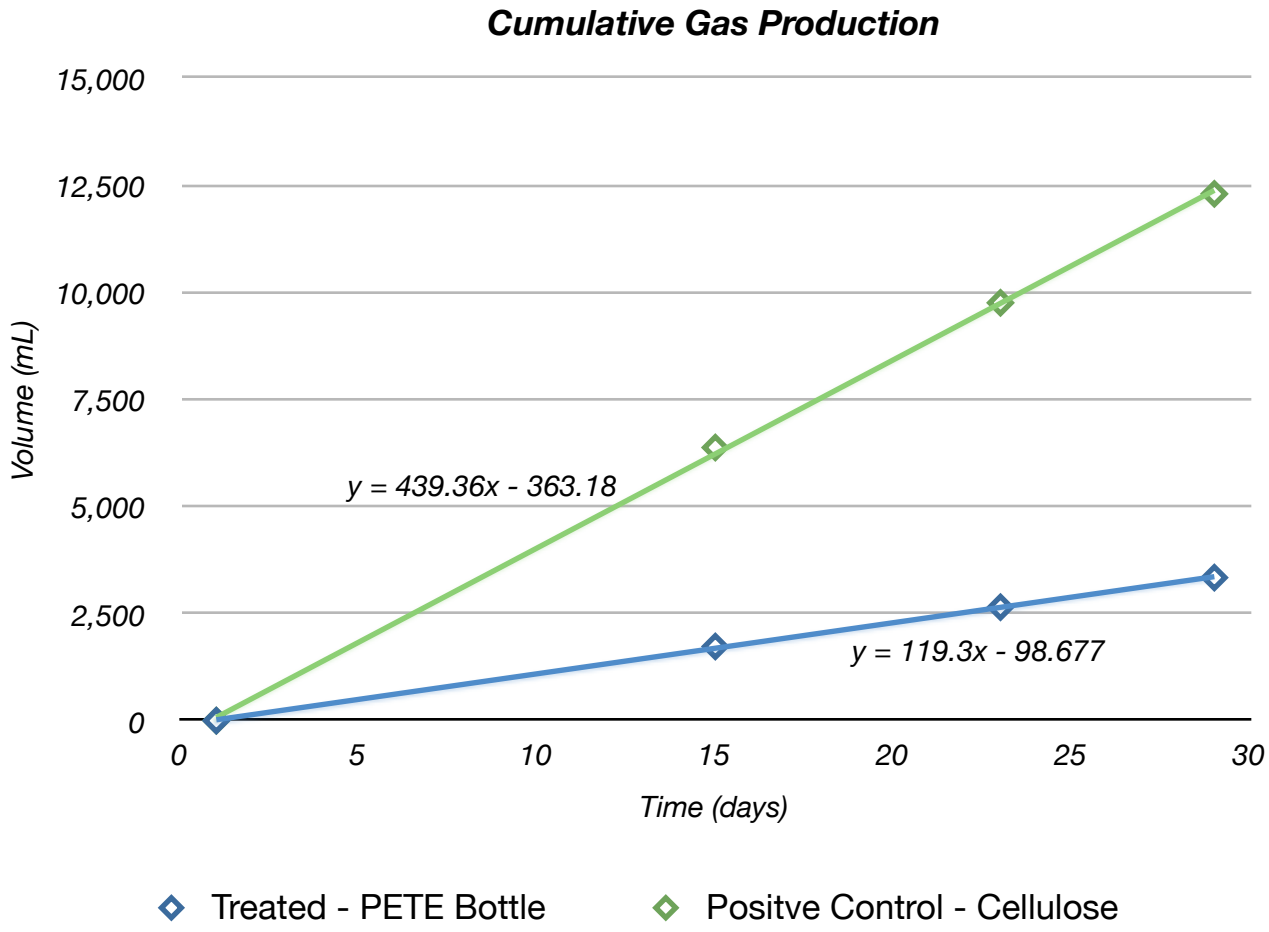
Conclusion & Analysis:
Upon consideration of gas production analysis, it becomes obvious that biodegradation has occurred. Biodegradation appears to be linear. There is no significant deceleration of degradation at the end of the first 15 day test period. The degradation will apparently continue in a linear fashion.



Prediction of time to total biodegradation is difficult. It is unknown if the slope of biodegradation will continue to be linear. Over a 29 day period there is a 13.8% carbon conversion. To accurately estimate the time of degradation two simultaneous samples would have to be run for varying times (30 and 90 days). This would help define an equation of degradation. It is worth noting that the degradation figures in the original test are likely skewed when considering the bottle shape. The neck - top and the bottom sprue contain the majority of the mass and they are the thickest portion. It is likely the thinner wall of the bottle side has likely degraded much more efficiently the thicker portions present in the first test. This should be quantified to determine the rate of degradation of these sections separately.

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These conditions are optimized. These results are very good. If your products were disposed of in a bioreactor landfill the biodegradation rate would be very fast. In this test, temperature and moisture are optimized as in a bioreactor. In a standard landfill these parameters are not optimized so biodegradation would not be as accelerated. To determine an accurate time to total degradation additional testing would be required.

At present rate of biodegradation, treated PETE biodegrades at least 99% faster than untreated PETE in a D5511-02 simulated landfill situation. For instance, if the Untreated PETE took 500 years to biodegrade the Treated PETE would only take 5 years.