Designation: D5338 – 11

StandardTest Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions, Incorporating Thermophilic Temperatures[1]

This standard is issued under the fixed designation D5338; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 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.

NOTE 1—During composting, thermophilic temperatures are most readily achieved in large-scale, professionally-managed facilities. However, these temperatures may also be reached in smaller residential composting units, frequently referred to as "backyard" or "home" composting.

1.2 This test method is designed to yield a percentage of conversion of carbon in the sample to carbon dioxide. The rate of biodegradation is monitored as well.

1.3 This test method is designed to be applicable to all plastic materials, which are intended to be composted in facilities that achieve thermophilic temperatures.

1.4 The values stated in SI units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Specific hazard statements are given in Section 8.*

1.6 This test method is equivalent to ISO 14855.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
D1293 Test Methods for pH of Water
D2908 Practice for Measuring Volatile Organic Matter in Water by Aqueous-Injection Gas Chromatography
D3590 Test Methods for Total Kjeldahl Nitrogen in Water
D4129 Test Method for Total and Organic Carbon in Water by High Temperature Oxidation and by Coulometric Detection
E260 Practice for Packed Column Gas Chromatography
E355 Practice for Gas Chromatography Terms and Relationships

2.2 *APHA—AWWA—WPCF Standards:*

2540 D Total Suspended Solids Dried at 103 to 105°C[3]
2540 E Fixed and Volatile Solids Ignited at 550°C[3]

2.3 *ISO Standard:*

ISO 14855 Plastics—Evaluation of the Ultimate Aerobic Biodegradability and Disintegration Under Controlled Composting Conditions—Method by Analysis of Released Carbon Dioxide[4]

3. Terminology

3.1 *Definitions*—Definitions of terms applying to this test method appear in Terminology D883.

4. Summary of Test Method

4.1 This test method consists of the following:

4.1.1 Selection of plastic material for the determination of the aerobic biodegradability in a controlled-composting system,

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.19 on Film, Sheeting, and Molded Products.

Current edition approved . Published April 2011. Originally approved in 1992. Last previous edition approved in 2003 as D5338 - 98(2003). DOI: 10.1520/D5338-11.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] *Standard Methods for the Examination of Water and Wastewater,* 17th Edition, 1989, American Public Health Association, 1740 Broadway, New York, NY 19919.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

4.1.2 Obtaining an inoculum from composted municipal solid waste,

4.1.3 Exposing the test substances to a controlled aerobic composting process in conjunction with the inoculum,

4.1.4 Measuring carbon dioxide evolved as a function of time, and

4.1.5 Assessing the degree of biodegradability.

4.2 The percentage of biodegradability is obtained by determining the percentage of carbon in the test substance that is converted to CO_2 during the duration of the test. This percentage of biodegradability will not include the amount of carbon converted from the test substance that is converted to cell biomass and that is not, in turn, metabolized to CO_2 during the course of the test.

4.3 The disintegration of a compact test material is visually determined at the end of the test. Additionally, the weight loss of the test material may be determined.

5. Significance and Use

5.1 Biodegradation of a plastic 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 large, 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.

5.2 *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.

6. Apparatus

6.1 *Composting Apparatus (see* Fig. 1*):*

6.1.1 A series of at least twelve composting vessels (one test substance, one blank, one positive and one negative control, all in three replicates) of 2 to 5 L of volume. For screening purposes, depending upon the test material, a smaller volume also may be used.

6.1.2 *Water Baths,* or other temperature controlling means capable of maintaining the temperature of the composting vessels at 58°C (±2°C).

6.1.3 *Pressurized-Air System,* that provides CO_2-free, H_2O-saturated air to each of the composting vessels at accurate aeration rates. If using a direct measurement of CO_2 (see 6.4), then normal air may be used.

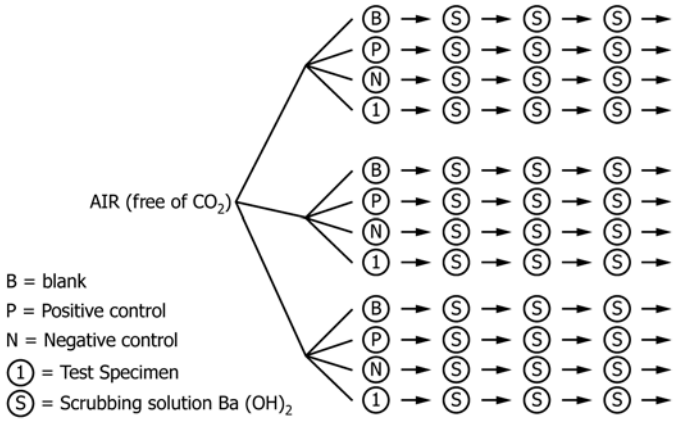

FIG. 1 Set-Up Using Carbon Dioxide-Trapping Apparatus

6.1.4 Suitable devices for measuring oxygen and CO_2 concentrations in the exhaust air of the composting vessels, such as specific sensors or appropriate gas chromatographs.

6.2 *Carbon Dioxide-Trapping Apparatus for Each Composting Vessel:*

6.2.1 At least three 5000-mL bottles fitted with gas sparging and containing $Ba(OH)_2$ carbon-dioxide scrubbing solution.

6.2.2 *Flexible Tubing,* nonpermeable to carbon dioxide.

6.2.3 *Stoppers,* equipped with gas-sampling parts.

6.3 *Miscellaneous:*

6.3.1 *Analytical Balance,* (±0.1 mg) to weigh test specimen.

6.3.2 *100-mL Burette.*

6.3.3 *0.05 N HCl.*

6.3.4 *pH Meter.*

6.3.5 Suitable devices and analytical equipment for measuring dry solids (at 105°C), volatile solids (at 550°C), volatile fatty acids by aqueous-injection chromatography, total Kjeldahl nitrogen and carbon concentrations.

6.4 *Optional*—The carbon dioxide-trapping apparatus and titration equipment can be replaced by a gas flow meter plus a gas-chromatograph, or other apparatus equipped with suitable detector and column(s), for measuring CO_2 and O_2 concentrations in the exhaust air of each vessel. Take care to analyze CO_2 concentration on a sufficiently frequent basis in order to produce a reliable cumulative CO_2 production over the course of the test (for example, every 3 to 6 h). A standard gas should be injected to internally standardize the gas-chromatograph on a continuous basis over the course of the test. Operate the gas chromatograph in conformance with Practices E260 and E355 (see Fig. 2).

6.5 Ensure that all glassware is cleaned thoroughly and free from organic matter.

7. Reagents and Materials

7.1 *Barium Hydroxide Solution,* approximately 0.024 N and then standardized, prepared by dissolving 4.0 g $Ba(OH)_2$ per litre of distilled water. Filter through filter paper and store sealed as a clear solution to prevent absorption of CO_2 from the air.