Designation: D 5338 – 98$^{\epsilon 1}$

Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions[1]

This standard is issued under the fixed designation D 5338; 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.

ε[1] NOTE—Corrections were made throughout in August 1999.

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. This test method is designed to yield reproducible and repeatable test results under controlled conditions that resemble composting conditions. 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.

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 that are not inhibitory to the microorganisms present in aerobic composting piles.

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 14852.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 883 Terminology Relating to Plastics[2]

D 1293 Test Methods for pH of Water[3]

D 1888 Test Methods for Particulate and Dissolved Matter, Solids, or Residue in Water[4]

D 2908 Practice for Measuring Volatile Organic Matter in Water by Aqueous-Injection Chromatography[5]

D 3590 Test Methods for Total Kjeldahl Nitrogen in Water[3]

D 4129 Test Method for Total and Organic Carbon in Water by High-Temperature Oxidation and Coulometric Detection[6]

E 260 Practice for Packed Column Gas Chromatography[7]

E 355 Practice for Gas Chromatography Terms and Relationships[7]

2.2 *APHA—AWWA—WPCF Standards:*

2540 D Total Suspended Solids Dried at 103 to 105°C[8]

2540 E Fixed and Volatile Solids Ignited at 550°C[8]

2.3 *ISO Standard:*

ISO 14852 Plastics—Evaluation of the Ultimate Aerobic Biodegradability and Disintegration Under Controlled Composting Conditions—Method by Analysis of Released Carbon Dioxide[9]

3. Terminology

3.1 Definitions—Definitions of terms applying to this test method appear in Terminology D 883.

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,

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

[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.96 on Environmentally Degradable Plastics.

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[2] *Annual Book of ASTM Standards,* Vol 08.01.

[3] *Annual Book of ASTM Standards,* Vol 11.01.

[4] Discontinued; see *1991 Annual Book of ASTM Standards,* Vol 11.01.

[5] *Annual Book of ASTM Standards,* Vol 11.02.

[6] *Annual Book of ASTM Standards,* Vol 11.04.

[7] *Annual Book of ASTM Standards,* Vol 14.02.

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

[9] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

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 will 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 solid-waste composting plants. 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 systems 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. 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.

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 E 260 and E 355 (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

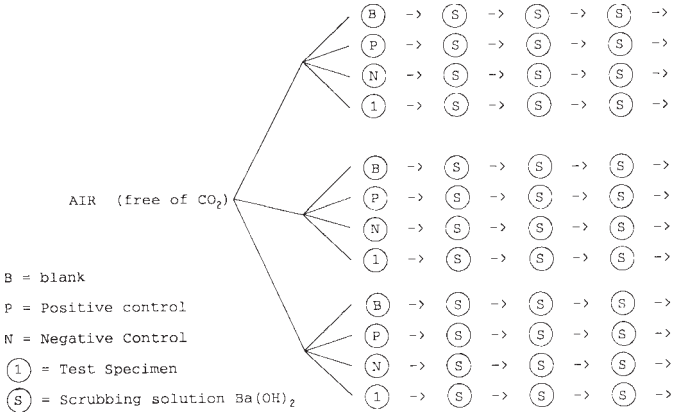

FIG. 1 Set-Up Using Carbon Dioxide-Trapping Apparatus

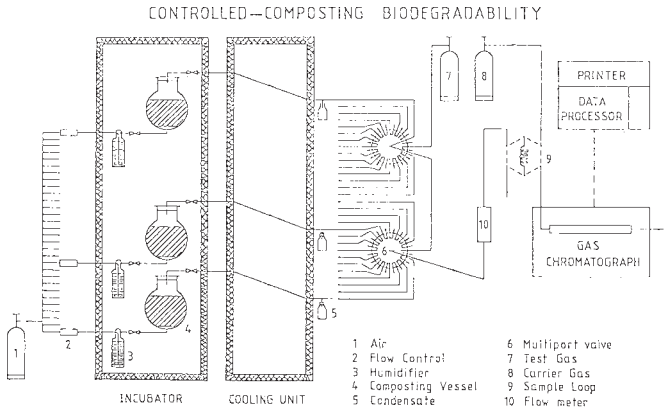

FIG. 2 Optional Set-Up Using a Gas Chromatograph