Designation: D5988 – 03

Standard Test Method for Determining Aerobic Biodegradation in Soil of Plastic Materials or Residual Plastic Materials After Composting[1]

This standard is issued under the fixed designation D5988; 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 covers determination of the degree and rate of aerobic biodegradation of synthetic plastic materials (including formulation additives that may be biodegradable) in contact with soil, or a mixture of soil and mature compost, under laboratory conditions.

1.2 This test method is designed to rate the biodegradability of plastic materials relative to a standard in an aerobic environment.

1.3 This test method is designed to be applicable to all plastic materials that are not inhibitory to the bacteria and fungi present in soil and compost.

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.* A specific hazard statement is given in Section 8.

1.6 This ASTM test method is equivalent to ISO 17556:2003.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D425 Test Method for Centrifuge Moisture Equivalent of Soils
D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
D1193 Specification for Reagent Water
D1293 Test Methods for pH of Water
D1898 Practice for Sampling of Plastics
D2980 Test Method for Volume Mass, Moisture-Holding Capacity, and Porocity of Saturated Peat Materials
D2989 Test Method for Acidity-Alkalinity of Halogenated Organic Solvents and Their Admixtures
D4129 Test Method for Total and Organic Carbon in Water by High Temperature Oxidation and by Coulometric Detection
D4972 Test Method for pH of Soils
D5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions
D5511 Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under High-Solids Anaerobic-Digestion Conditions

2.2 *APHA-AWWA-WPCF Standards:*[3]

2540 D Total Suspended Solids Dried at 103°–105°C
2540 G Total, Fixed, and Volatile Solids in Solids and Semi-Solid Samples

2.3 *ISO Standard:*

ISO 17556:2003 Plastics—Determination of the Ultimate Aerobic Biodegradability of Plastic Materials in Soil by Measuring the Oxygen Demand in a Respirometer or the Amount of Carbon Dioxide Evolved

3. Terminology

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

4. Summary of Test Method

4.1 The test method described consists of the selection of plastic material or compost containing residual plastic material after composting for the determination of aerobic biodegradability, obtaining soil as a matrix and source of inoculum, exposing the plastic materials or the compost containing residual plastic material to the soil, measuring the carbon

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

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[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 (APHA), 1015 Fifteenth Street NW, Washington, DC 20005.

***A Summary of Changes section appears at the end of this standard.**

dioxide evolved by the microorganisms as a function of time, and assessing the degree of biodegradability.

4.2 The CO_2 production measured for a material, expressed as a fraction of the measured or calculated carbon content, is reported with respect to time, from which the degree of biodegradability is assessed.

4.3 Alternatively, the consumption of oxygen, or biochemical oxygen demand (BOD), can be determined, for example, by measuring the amount of oxygen required to maintain a constant gas volume in the respirometer flask, or by measuring the change in volume or pressure (or a combination of the two) either automatically or manually. The level of biodegradation expressed in percent is determined by comparing the BOD with the theoretical oxygen demand (ThOD). The influence of possible nitrification processes on the BOD has to be considered.

5. Significance and Use

5.1 The degree and rate of aerobic biodegradability of a plastic material in the environment determines the extent to which and time period over which plastic may be mineralized. Disposal is becoming a major issue with the increasing use of plastics, and the results of this test method may permit an estimation of the degree of biodegradability and the time period over which plastics will remain in an aerobic soil environment. This test method determines the degree of aerobic biodegradation by measuring evolved carbon dioxide as a function of time that the plastic is exposed to soil.

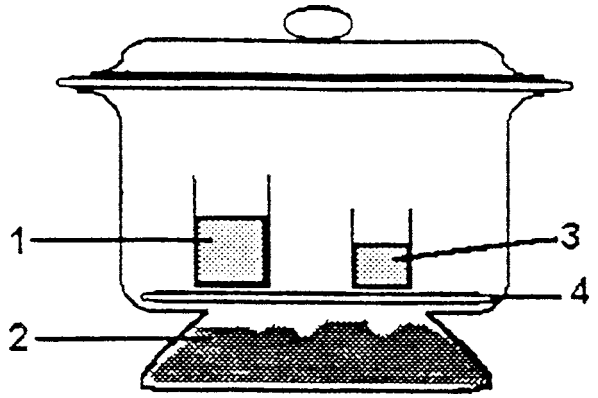
5.2 Soil is an extremely species-rich source of inoculum for evaluation of the biodegradability of plastics in the environment. When maintained appropriately with regard to moisture content and oxygen availability, the biological activity is quite considerable, although lower than other biologically active environments, such as activated sewage-sludge or compost. Soil is also the application target for composted materials, and therefore the biodegradability of such materials should be evaluated in the soil environment after the materials have been composted. A mixture of soil and mature compost containing composted plastic material (as obtained after performing Test Method D5338) is therefore also an appropriate matrix for evaluation of the biodegradability of plastics.

6. Apparatus

6.1 *Soil-Contact Incubation Apparatus* (see Fig. 1; biometer flasks are also appropriate):

6.1.1 *Vessels*, a set of approximately 2 to 4-L internal volume that can be sealed air-tight, such as 150-mm desiccators. For testing a plastic material in soil: three vessels for soil only controls, three for a positive control material, and three per test material. For testing a compost containing residual plastic material: three for soil only controls, three for a positive control material in soil, three for the compost-soil control, and three per compost containing test material (optional: three for the compost containing the positive reference from the previous composting test). In either case, three vessels may also be included as technical controls, containing only the absorbing solution and no soil.

6.1.2 *Beakers*, sets of 150 and 100-mL, equal in number to the soil incubation vessels.



NOTE 1—(1) Barium hydroxide solution or potassium hydroxide solution, (2) soil, (3) water, and (4) perforated plate.

FIG. 1 Soil-Contact Incubation Apparatus

6.1.3 *Perforated Plates or Other Support*, a set to hold the beakers above the soil inside each vessel.

6.1.4 *Darkened Chamber or Cabinet*, in which the temperature is maintained at 21 ± 2°C.

6.2 *Analytical Equipment*:

6.2.1 *Analytical Equipment*, to measure the total carbon content of the test specimen.

6.2.2 *Analytical Balance*, to weigh the test specimen.

6.2.3 *Burette*, 100 mL.

6.2.4 *Bench-Top Centrifuge*, for moisture-holding capacity (MHC) determination.

6.2.5 *Oven*, set to 104 ± 1°C for moisture determinations.

6.2.6 *Muffle Furnace*, set to 550°C for ash determinations.

6.2.7 *pH Meter*.

6.3 Alternatively, a flow-through apparatus or manometric apparatus as described in ISO 17566 may be used.

7. Reagents and Materials

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.[4] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Ammonium phosphate*, $((NH_4)_2HPO_4)$, 4.72 g/L.

7.3 *Barium Hydroxide Solution* (0.025 N), prepared by dissolving 4.0 g anhydrous $Ba(OH)_2$/L of distilled water. Filter free of solid material, confirm normality by titration with standard acid, and store sealed as a clear solution to prevent absorption of CO_2 from the air. It is recommended that 5 to 20 L be prepared at a time when running a series of tests. When using $Ba(OH)_2$, however, care must be taken that a film of

[4] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.