Designation: D 5988 – 96

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 D 5988; 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.

NOTE 1—There is no ISO standard that is equivalent to this test method.

2. Referenced Documents

2.1 *ASTM Standards:*

D 425 Test Method for Centrifuge Moisture Equivalent of Soils[2]

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[3]

D 883 Terminology Relating to Plastics[3]

D 1193 Specification for Reagent Water[4]

D 1293 Test Methods for pH of Water[4]

D 1898 Practice for Sampling of Plastics[3]

D 2980 Test Method for Volume Weights, Water-Holding Capacity, and Air Capacity of Water-Saturated Peat Materials[2]

D 2989 Test Method for Acidity-Alkalinity of Halogenated Organic Solvents and Their Admixtures[5]

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

D 4972 Test Method for pH of Soils[7]

D 5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions[8]

D 5511 Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under High-Solids Anaerobic-Digestion Conditions[8]

2.2 *APHA-AWWA-WPCF Standards:*[9]

2540 D Total Suspended Solids Dried at 103°–105°C

2540 G Total, Fixed, and Volatile Solids in Solids and Semi-Solid Samples

3. Terminology

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

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 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.

5. Significance and Use

5.1 The degree and rate of aerobic biodegradability of a plastic material in the environment determines the extent to

[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 04.08.

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

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

[5] *Annual Book of ASTM Standards*, Vol 15.05.

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

[7] *Annual Book of ASTM Standards*, Vol 04.09.

[8] *Annual Book of ASTM Standards*, Vol 08.03.

[9] Standard Methods for the Examination of Water and Wastewater, 17th Edition, 1989, American Public Health Association (APHA), 1015 Fifteenth Street NW, Washington, DC 20005.

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 D 5338) is therefore also an appropriate matrix for evaluation of the biodegradability of plastics.

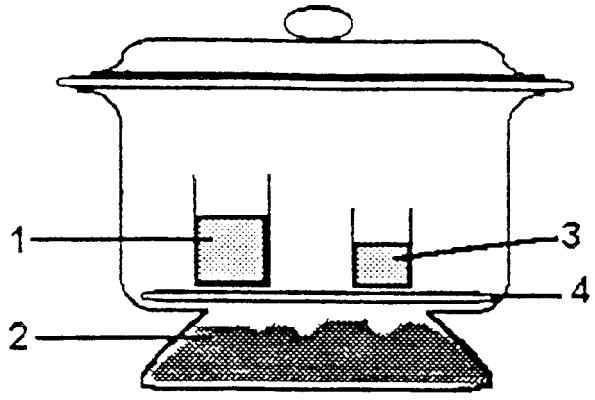
6. Apparatus

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.

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



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

FIG. 1 Soil-Contact Incubation Apparatus

6.1.4 *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*.

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.[10] 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 $BaCO_3$ does not form on the surface of the solution in the beaker, which would inhibit CO_2 diffusion into the absorbing medium. Alternatively, potassium hydroxide solution (KOH, 0.5 N) could be used and is prepared by dissolving 28 g of anhydrous KOH/L of distilled water and proceeding in the same way as for the KOH.

7.4 *Hydrochloric acid*, 0.05 N HCl when using 0.025 N $Ba(OH)_2$, or 0.25 N HCl when using 0.5 N KOH.

8. Hazards

8.1 This test method includes the use of hazardous chemicals. Avoid contact with chemicals and follow the manufacturer's instructions and material safety data sheets.

9. Soil

9.1 The soil can be a laboratory mixture of equal parts (by weight) of sand, topsoil, and composted manure or a natural soil sample. The soil should not be handled in any way that would inhibit the activity of the soil microorganisms. In the case of a natural soil, it is advisable to avoid soils that have been exposed to pollutants that may cause a significant perturbation of the microbial population. The source of the soil

[10] *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.