



Designation: D 5209 – 92

Standard Test Method for Determining the Aerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewage Sludge¹

This standard is issued under the fixed designation D 5209; 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 the determination of the degree and rate of aerobic biodegradation of synthetic plastic materials (including formulation additives that may be biodegradable) on exposure to activated-sewage sludge inoculum under laboratory conditions.

1.2 This test method is designed to index plastic materials that are more or less biodegradable 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 present in the activated sewage sludge.

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 problems, 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 hazards are given in Section 8.

2. Referenced Documents

2.1 ASTM Standards:

D 618 [Practice for Conditioning of Plastics and Electrical Insulating Materials for Testing](#)²

D 883 [Terminology Relating to Plastics](#)²

D 1193 [Specification for Reagent Water](#)³

D 1898 [Practice for Sampling of Plastics](#)²

D 2667 [Test Method for Biodegradability of Alkylbenzene Sulfonates](#)⁴

D 3593 [Test Method for Molecular Weight Averages and Molecular Weight Distribution of Certain Polymers by](#)

[Liquid Size-Exclusion Chromatography \(Gel Permeation Chromatography-GPC\) Using Universal Calibration](#)⁵

3. Terminology

3.1 Definitions:

3.1.1 Definitions of terms applicable to this test method appear in Terminology D 883 [D 883](#).

4. Summary of Test Method

4.1 The test method described consists of selection of plastic material for the determination of aerobic biodegradability, obtaining activated sewage sludge from a municipal-wastewater-treatment plant and preparing inoculum, exposing plastic material to the aerated inoculum, measuring carbon dioxide evolved as a function of time, soluble organic carbon (SOC) content and residual polymer weight, and assessing degree of biodegradability.

4.2 The percent of theoretical gas production based on 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 to what extent and in what time period that plastic may be eliminated from the environment. With increasing use of plastics, disposal is becoming a major issue and the results of this test method may permit an estimation of the degree of biodegradability and over what time period plastics will remain in an aerobic environment. This test method determines the degree of aerobic biodegradation by measuring evolved carbon dioxide, SOC, and residual polymeric material as a function of time, when the plastic is exposed to activated sewage-sludge.

5.2 Activated sewage-sludge from a sewage-treatment plant that treats principally municipal waste is considered an acceptable active aerobic environment available over a wide geographical area in which to test a broad range of plastic materials. Because of the enriched environment of activated

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

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

⁴ *Annual Book of ASTM Standards*, Vol 15.04.

⁵ *Annual Book of ASTM Standards*, Vol 08.02.

sewage-sludge, the inoculum may be more diverse in composition than a typical aerobic environment that plastics encounter in usual disposal methods.

6. Apparatus

6.1 *Carbon Dioxide Scrubbing Apparatus*—(See Fig. 1) for each specimen the following is required:

6.1.1 A series of twelve 4 L Erlenmeyer flasks (three test materials, and four Erlenmeyer flasks per test) requires the following

6.1.1.1 *Four 1-L plastic bottles*, containing 700 mL of 10N sodium hydroxide (NaOH),

6.1.1.2 *Two empty 1-L Erlenmeyer flasks*, to prevent liquid carry over, and

6.1.1.3 *One 1-L Erlenmeyer flask*, containing 700 mL of 0.025N barium hydroxide [Ba(OH)₂] solution.

6.1.2 Connect the bottles in series, using vinyl, or other suitable non gas-permeable tubing, to a pressurized air system, and purge air through the scrubbing solution at a constant rate.

6.1.3 For each additional set of four Erlenmeyer flasks add one additional 1-L glass bottle filled with 700 mL of 10N sodium hydroxide.

6.2 Carbon dioxide production and trapping apparatus for each test plastic material requires the following:

6.2.1 *Four 4-L Erlenmeyer flasks*,

6.2.2 *Stoppers*, flexible non-permeable to carbon dioxide (CO₂) plastic tubing,

6.2.3 *Several 100 mL bottles*, fitted with gas bubblers and containing 100 mL Ba(OH)₂ carbon dioxide scrubbing solution,

6.2.4 *Analytical equipment*, to measure total carbon content of the test specimen,

6.2.5 *Analytical balance*, to weigh test specimen before and after exposure,

6.2.6 *100-mL burette*, and

6.2.7 *0.05N hydrochloric acid*.

6.3 *Analytical instrument*, to measure soluble organic carbon content (SOC) before and after the experiment is concluded.

6.4 *Agitation or stirrers*, for each 4-L Erlenmeyer flask.

7. Reagents and Materials

7.1 Prepare synthetic stock solutions by dissolving each of the following in distilled water to 1 L:

7.1.1 *Ferric Chloride (FeCl₃·6H₂O)*—0.25 g.

7.1.2 *Magnesium Sulfate, (MgSO₄·7H₂O)*—22.5 g.

7.1.3 *Calcium Chloride (CaCl₂)*—27.5 g.

7.1.4 *Phosphate Buffer*—KH₂HPO₄ 8.5 g, K₂HPO₄ 21.75 g, Na₂HPO₄·7H₂O 33.4 g, and NH₄Cl 1.7 g, for a total of 65.35 g.

7.1.5 *Ammonium Sulfate, ((NH₄)₂SO₄)*—40.0 g.

7.2 The test medium will contain the following reagents diluted to 1 L with high-quality distilled water:⁶

7.2.1 *Magnesium Sulfate Solution*, 1 mL,

7.2.2 *Calcium Chloride Solution*, 1 mL,

7.2.3 *Phosphate Buffer Solution*, 2 mL,

7.2.4 *Ferric Chloride Solution*, 4 mL, and

7.2.5 *Ammonium Sulfate Solution*, 1 mL.

7.3 Barium Hydroxide Solution, 0.025N, is prepared dissolving 4.0 g Ba(OH)₂ per litre 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 CO₂ from the air. It is recommended that five L be prepared at a time when running a series of tests.

8. Hazards

8.1 This test method includes the use of hazardous chemicals. Avoid contact with chemicals and follow manufacturers instructions and Material Safety Data Sheets.

NOTE 1—**Precaution:** This test method includes the use of hazardous material from a waste treatment plant. Avoid contact with the sludge by using gloves and other appropriate protective equipment. Use good personal hygiene to minimize exposure to harmful microbial agents.

9. Inoculum Test Organisms

9.1 The source of the test organisms is activated sludge freshly sampled from a well-operated municipal-sewage treatment plant. This sewage treatment plant should receive no or minimal effluent from industry.

9.2 Aerate sludge in the laboratory for 4 h. Five hundred mL of the mixed liquor is sampled and homogenized for 2 min at medium speed in a blender⁷ or equivalent high speed mixer. Allow to settle for 30 min.

9.3 If the supernatant still contains high levels of sludge-suspended matter at the end of 30 min, allow to settle for a further 30 to 40 min or adapt laboratory conditions to obtain better settling.

9.4 Decant sufficient volume of the supernatant to provide a 1 % inoculum for each carbon dioxide (CO₂) test Erlenmeyer flask. Avoid carry-over of sludge which would interfere with the measurement of carbon dioxide production.

9.5 Optionally, it is useful to perform counts on the supernatant fraction to determine microbial numbers. The inoculum should contain 10⁶ to 20 × 10⁶ colony-forming units per

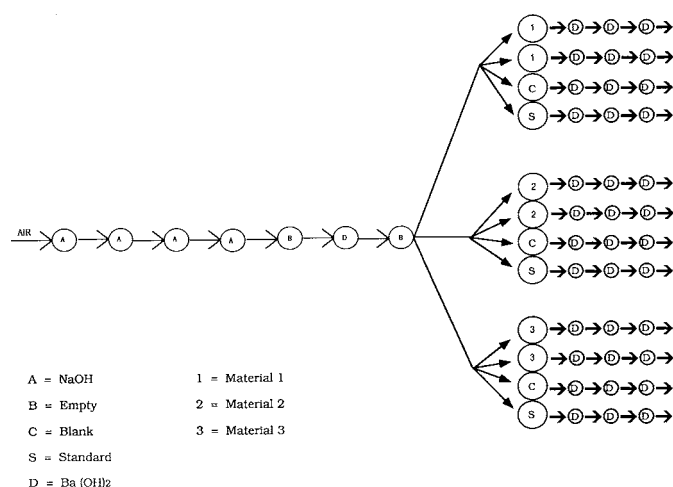


FIG. 1 Aerobic Testing Schematic

⁶ High-quality distilled water, free of toxic substances (copper in particular) with low carbon content (< 2.0 mg/L SOC) and with resistivity > 18 megohms/cm. (Distilled water must never contain more than 10 % of the organic carbon introduced by the test material.)

⁷ A Waring blender has been found suitable for this purpose.