APPENDIX- II ASTM TEST METHODS

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D6692-01 Standard Test Method for Determining the Biodegradability of Radiolabeled POLYMERic Plastic Materials in Seawater

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This test is used to determine the degree of aerobic biodegradation of **POLYMER**ic compounds utilized in plastic materials by determining the level of respiration of such radiolabeled carbon compounds to radiolabeled carbon dioxide.

1.2 The test is designed to utilize the naturally occurring microbes in seawater as the inoculum for the enrichment and subsequent mineralization (biodegradation) of the test **POLYMER** using it as a carbon and energy source resulting in a carbon dioxide as an end product.

1.3 The test method requires that the **POLYMER**s to be assayed are synthesized using the radioisotope, carbon-14, and that the compound or plastic material be uniformly labeled with carbon-14.

1.4 As controls, known **BIODEGRADABLE** compounds, such as glucose or starch, also uniformly labeled with carbon-14, are run in order to determine the biological activity of the natural population.

1.5 The concentration of added **POLYMER**s shall be kept low so as not to cause limitation by oxygen, and the seawater inoculum is amended with nitrogen and phosphorus compounds to ensure that growth in not limited by these nutrients.

1.6 The safety problems and regulations associated with working with radioactive materials are not addressed in the method. It is the responsibility of the individual users to establish and ensure adherence the proper safety, health, monitoring and all regulatory practices associated with the use of radioactive compounds.

1.7 There is no similar or equivalent ISO standard.

2. Referenced Documents

D5296 Test Method for Molecular Weight Averages and Molecular Weight Distribution of Polystyrene By High Performance Size Exclusion Chromatography
D6340 Determining Aerobic Biodegradation of Radiolabeled Plastic Materials in an A) Aqueous or B) Compost Environment
D883 Terminology Relating to Plastics

Index Terms

polymeric compounds; radio labeled; carbon; dioxide; 19.040; 83.080.01

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D6954-04 Standard Guide for Exposing and Testing Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This guide provides a framework or road map to compare and rank the controlled laboratory rates of degradation and degree of physical property losses of **POLYMERs** by thermal and photooxidation processes as well as the biodegradation and ecological impacts in defined applications and disposal environments after degradation. Disposal environments range from exposure in soil, landfill, and compost in which thermal oxidation may occur and land cover and agricultural use in which photooxidation may also occur.

1.2 In this guide, established ASTM International standards are used in three tiers for accelerating and measuring the loss in properties and molecular weight by both thermal and photooxidation processes and other abiotic processes (Tier 1), measuring biodegradation (Tier 2), and assessing ecological impact of the products from these processes (Tier 3).

1.3 The Tier 1 conditions selected for thermal oxidation and photooxidation accelerate the degradation likely to occur in a chosen application and disposal environment. The conditions should include a

range of humidity or water concentrations based on the application and disposal environment in mind. The measured rate of degradation at typical oxidation temperatures is required to compare and rank the **POLYMER**s being evaluated in that chosen application to reach a molecular weight that constitutes a demonstrable **BIODEGRADABLE** residue (using ASTM International biometer tests for CO_2 evolution appropriate to the chosen environment). By way of example, accelerated oxidation data must be obtained at temperatures and humidity ranges typical in that chosen application and disposal environment, for example, in soil (20 to 30°C), landfill (20 to 35°C), and composting facilities (30 to 65°C). For applications in soils, local temperatures and humidity ranges must be considered as they vary widely with geography. At least one temperature must be reasonably close to the end use or disposal temperature, but under no circumstances should this be more than 20°C away from the removed that temperature. It must also be established that the **POLYMER** does not undergo a phase change, such as glass transition temperature (*Tg*) within the temperature range of testing.

1.4 The residues resulting from the oxidations are then exposed to appropriate disposal or use environments in standard biometric test methods to measure the rate and degree of biodegradation (Tier 2).

1.5 The data generated under Tier 1 evaluation and the determined time for the biodegradation in the chosen environment (Tier 2) allow ranking relative to other **POLYMER**s evaluated under similar environmental conditions with this guide. The degree and time for biodegradation should be consistent with ASTM International methods, and any residues from the intermediate oxidation stage and from biodegradation must be shown to be environmentally benign and not persistent (Tier 3).

Note 1—The intended use of this guide is for comparison and ranking of data to aid in the design and development and the reduction of environmental impacts of **POLYMER**s that require no more than 24 months to oxidize and biodegrade in the intended use and disposal options and create no harmful or persistent residues under the appropriate disposal conditions (for example, two seasons of crop-growing conditions in soil).

1.6 It is cautioned that the results of any laboratory exposure in this guide cannot be directly extrapolated to actual disposal environments; confirmation to real world exposure is ultimately required as with all ASTM International standards.

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

Note 2—There is no ISO standard that is the equivalent of this standard guide.

1.8 *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 requirements prior to use.*

2. Referenced Documents

D3826 Practice for Determining Degradation End Point in Degradable Polyethylene and Polypropylene Using a Tensile Test
D3987 Test Method for Shake Extraction of Solid Waste with Water
D5071 Practice for Exposure of Photodegradable Plastics in a Xenon Arc Apparatus
D5208 Practice for Fluorescent Ultraviolet (UV) Exposure of Photodegradable Plastics
D5272 Practice for Outdoor Exposure Testing of Photodegradable

Plastics

D5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions

D5510 Practice for Heat Aging of Oxidatively Degradable Plastics

D5526 Test Method for Determining Anaerobic Degradation of Plastic Materials Under Accelerated Landfill Conditions

D5951 Practice for Preparing Residual Solids Obtained after Biodegradability Standard Methods for Plastics in Solid Waste for Toxicity and Compost Quality Testing

D5988 Test Method for Determining Aerobic Biodegradation in Soil of Plastic Materials or Residual Plastic Materials after Composting

D6002 Guide for Assessing the Compostability of Environmentally Degradable Plastics

D6400 Specification for Compostable Plastics

D883 Terminology Relating to Plastics

E1440 Guide for an Acute Toxicity Test with the Rotifer

EPA TITLE 40 CFA 40CFR62, 40CFR50-189, 40CFR260-299, 40CFR300-399, 700-799, and 49CFR100-180

OECD Guideline 207 Earthworm, Acute Toxicity Tests

OECD Guideline 208 Terrestrial Plants, Growth Test

ORCA Guidelines for the Evaluation of Feedstock for Source Separated Biowaste Composting and Biogasification

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Index Terms

biodegradation; ecotoxicity; environmental biodegradation; oxidation; photooxidation; thermal; 83.080.01

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D6691-01 Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials in the Marine Environment by a Defined Microbial Consortium

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This test method is used to determine the degree and rate of aerobic biodegradation of plastic materials (including formulation additives) exposed to pre-grown population of at least ten aerobic marine microorganisms of known genera. The test method is conducted under controlled laboratory conditions.

1.2 This test method is designed to index **POLYMER** materials that are possibly **BIODEGRADABLE**, relative to a positive reference material, in an aerobic environment.

1.3 This test method is applicable to all **POLYMER** materials containing at least 20 % carbon that are not inhibitory to the microorganisms present in a marine environment.

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

1.5 There is no similar or equivalent ISO standard.

1.6 *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.

2. Referenced Documents

D1193 Specification for Reagent Water

D3593 Test Method for Molecular Weight Averages/Distribution of Certain **POLYMERs** by Liquid Size-Exclusion Chromatography (Gel Permeation Chromatography GPC) Using Universal Calibration

D4129 Test Method for Total and Organic Carbon in Water by High-Temperature Oxidation and Coulometric Detection

D618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing

D883 Terminology Relating to Plastics

Index Terms

aerobic; biodegradation; marine environment; plastics; 13.030.99

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D6002-96(2002)e1 Standard Guide for Assessing the Compostability of Environmentally Degradable Plastics

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This guide covers suggested criteria, procedures, and a general approach to establish the compostability of environmentally degradable plastics.

1.2 *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.*

Note 1—There is no similar or equivalent ISO standard.

2. Referenced Documents

D3593 Test Method for Molecular Weight Averages/Distribution of Certain **POLYMERs** by Liquid Size-Exclusion Chromatography (Gel Permeation Chromatography (GPC)) Using Universal Calibration
D5152 Practice for Water Extraction of Residual Solids from Degraded Plastics for Toxicity Testing
D5209 Test Method for Determining the Aerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewer Sludge

D5247 Test Method for Determining the Aerobic Biodegradability of Degradable Plastics by Specific Microorganisms

D5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions

D5509 Practice for Exposing Plastics to a Simulated Compost Environment

D5512 Practice for Exposing Plastics to a Simulated Compost Environment Using an Externally Heated Reactor

D5951 Practice for Preparing Residual Solids Obtained After Biodegradability Standard Methods for Plastics in Solid Waste for Toxicity and Compost Quality Testing

D5988 Test Method for Determining the Aerobic Biodegradation in Soil of Plastic Materials or Residual Plastic Materials after Composting

D638 Test Method for Tensile Properties of Plastics

D882 Test Methods for Tensile Properties of Thin Plastic Sheeting

D883 Terminology Relating to Plastics

E1440 Guide for an Acute Toxicity Test with the Rotifer Brachionus

E1720 Test Method for Determining Ready, Ultimate, Biodegradability of Organic Chemicals in a Sealed Vessel CO_2 Production Test

G22 Practice for Determining Resistance of Plastics to Bacteria

Guidelines for the Evaluation of Feedstock for Source Separated Biowaste Composting and Biogasification

OECD Guideline 207 Earthworm, Acute Toxicity Tests

OECD Guideline 208 Terrestrial Plants, Growth Test

Index Terms

biodegradation; compostable; composting; degradable; plastic; **POLYMER**; strategy; toxicity; 13.030.10; 83.080.01

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D6340-98(2007) Standard Test Methods for Determining Aerobic Biodegradation of Radiolabeled Plastic Materials in an Aqueous or Compost Environment

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 These test methods directly determine the rate and degree of biological oxidation of carbon in plastic materials when placed in a composting environment containing simulated municipal solid waste or an aqueous environment under laboratory conditions.

1.2 Test Method A utilizes a mixed culture derived from the target environment (waste water, sewage sludge, compost eluant, and other environmental sources). Temperature, mixing, and aeration are monitored and controlled.

1.2.1 This method has the sensitivity to determine biodegradation at concentrations commonly found in these environments.

1.3 Test Method B starts with fresh compost and proceeds through the normal composting process to an early mature stage. Temperature, aeration; and moisture are monitored and controlled.

1.3.1 This method can determine biodegradation at levels of the plastic commonly expected in municipal solid waste.

1.4 These test methods require that the target component of the plastic material be synthesized using the radioactive isotope carbon-14. Depending upon the objective, either a portion of the components of the plastic or all of the carbon can be uniformly labeled with carbon-14. The test method will determine how that labeled portion will be metabolized and biologically oxidized by the microorganisms in the system tested.

1.5 These test methods can be applied to any carbon-14 labeled compound as well as for plastic materials that have been formulated to biodegrade in a natural aerobic environment.

1.6 The synthesis and preparation of the radiolabled plastic is beyond the scope of these methods. Carbon-14 labeled **POLYMER**s may be purchased from a number of commercial labs.

1.7 There are no ISO test methods that are equivalent to the test methods in this standard.

1.8 The safety problems associated with compost and radioactivity are not addressed in this standard. It is the responsibility of the user of this standard to establish appropriate safety and health practices. It is also incumbent on the user to conform to all the regulatory requirements, specifically those that relate to the use of open radioactive sources.

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.

2. Referenced Documents

D5209 Test Method for Determining the Aerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewage Sludge

D5296 Test Method for Molecular Weight Averages and Molecular Weight Distribution of Polystyrene by High Performance Size Exclusion Chromatography

D5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions

D5512 Practice for Exposing Plastics to Simulated Compost Environment Using an Externally Heated Reactor

D883 Terminology Relating to Plastics

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5271-02 Standard Test Method for Determining the Aerobic Biodegradation of Plastic Materials in an Activated-Sludge-Wastewater-Treatment System

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This test method is designed to index plastic materials which are more or less biodegradable relative to a standard in aerobic activated-sludge-treatment systems.

1.2 This test method is designed to be applicable to all plastic materials that are not inhibitory to the bacteria present in the activated sludge. Compounds with toxic properties may delay or inhibit the degradation process.

1.3 This test method measures the degree and rate of aerobic biodegradation of plastic materials (including formulation additives which may be biodegradable) on exposure to activated-sludge biomass in the concentration range from 0.1 to 2.5 g/L mixed-liquor volatile suspended solids (MLVSS) under laboratory conditions.

1.4 The high MLVSS concentration relative to other biodegradation tests has the advantage of improved repeatability and increased likelihood of more rapid adaptation or acclimation of the biomass.

1.5 This test method allows for the determination of biological nitrification and the oxidation of other non-carbon components of the plastic.

1.6 This test method does not purport to determine whether or not a plastic material will pass through primary treatment to the aeration basin of an activated-sludge wastewater-treatment plant. The size or density of the plastic material may exclude it from the secondary-treatment stage of a treatment facility.

1.7 This test method is equivalent to ISO 14851.

1.8 *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.* For a specific hazards statement, see Section 8.

2. Referenced Documents

D1193 Specification for Reagent Water
D1898 Practice for Sampling of Plastics
D2579 Test Methods for Total and Organic Carbon in Water
D3593 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
D5209 Test Method for Determining the Aerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewer Sludge
D883 Terminology Relating to Plastics
2540D Total Suspended Solids Dried at 103-105C
2540E Fixed and Volatile Solids Ignited at 550C
ISO 14851 Determination of the Ultimate Aerobic Biodegradability of

Plastic Materials in an Aqueous Medium - Method by Measuring the Oxygen Demand in a Closed Respirometer

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Index Terms

aerobic; biodegradation; municipal; nitrification; plastics; sewage; sludge; waste treatment; 13.060.30

DOCUMENT SUMMARY

WITHDRAWN STANDARD: D5209-92 Standard Test Method for Determining the Aerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewage Sludge (Withdrawn 2004)

WITHDRAWN, NO REPLACEMENT

Developed by Subcommittee: D20.96

Withdrawn Rationale:

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.

Formerly under the jurisdiction of Committee D20 on Plastics, this test method was withdrawn in April 2001 in accordance with section 10.5.3.1 of the Regulations Governing ASTM Technical Committees, which requires that standards shall be updated by the end of the eighth year since the last approval date.

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.

Index Terms

Aerobic/anaerobic biodegradation; Biodegradation; Carbon dioxide content; Degree (of biodegradation); Municipal sewer sludge; Plastics (general); Sewer sludge; Sludge; Soluble organic carbon (SOC) content; Synthetic plastic materials; aerobic biodegradation of plastic materials in presence of municipal; sewage sludge, test; 13.030.20

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5951-96(2002) Standard Practice for Preparing Residual Solids Obtained After Biodegradability Standard Methods for Plastics in Solid Waste for Toxicity and Compost Quality Testing

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This practice covers a standard procedure for preparing the residual solids obtained at the end of standard methods for biodegradability testing of plastics in solid waste, for subsequent toxicity and compost quality testing. The practice yields mixtures that can be used as such for terrestrial toxicity testing or that can be submitted to water extraction for further aquatic toxicity tests, in accordance with Practice D 5152, and in conjunction with Method D 4229, Guides E 729, E 1192, E 1295, and E 1440, or other currently accepted toxicity test methods (see OECD Guidelines 201, 202, 203, 207, and 208 or U.S. EPA 40FR797A, as well as other documents such as *A New Manual for Conducting Microtox Test with the Model 500 Analyzer* the work on cyst-based toxicity tests by Centeno, et al). The mixtures can also be used for further soil contact biodegradation testing.

1.2 This practice provides for storage and drying of the mixtures obtained at the end of the test methods for determination of the biodegradability of plastics under controlled composting conditions (Test Method D **5338**), and under high-solids anaerobic digestion (Test

Method D 5511). The mixtures contain the biologically decomposed residuals from solid waste and from the plastic materials. For the blanks, the residuals will be derived only from the biologically decomposed solid waste. In the event that a particular sample does not pass the toxicity test, chemical characterization of the degradation products can be performed on the sample to determine the source of the toxicity. Description of the performance of these analyses is beyond the scope of this practice.

1.3 There is no ISO standard that is equivalent to this practice.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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.*

2. Referenced Documents

D3987 Test Method for Shake Extraction of Solid Waste with Water
D4229 Method for Conducting Static Acute Toxicity Tests on Waste-Waters with Daphnia
D5152 Practice for Water Extraction of Residual Solids from Degraded Plastics for Toxicity Testing
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
D883 Terminology Relating to Plastics
E1192 Guide for Conducting Acute Toxicity Test on Aqueous Ambient Samples and Effluents with Fishes, Macroinvertebrates, and

Amphibians

E1295 Guide for Conducting Three Brood, Renewal Toxicity Tests with Ceriodaphnia Dubia

E1440 Guide for an Acute Toxicity Test with the Rotifer Brachionus

E729 Guide for Conducting Acute Tests on Test Materials with Fishes, Macroinvertebrates, and Amphibians

APHA 2540E Fixed and Volatile Solids Ignited at 550C

OECD Guideline 201 Alga, Growth Inhibition Test

OECD Guideline 202 Daphnia sp., 14-day Reproduction Test

OECD Guideline 203 Fish, Acute Toxicity Test

OECD Guideline 207 Earthworm, Acute Toxicity Tests

OECD Guideline 208 Terrestrial Plants, Growth Test

U.S. EPA 40FR797A A Variety of Toxicity Testing Procedures

Index Terms

biodegradation; compost; composting; digestion; plastics; toxicity; 13.030.10

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5338-98(2003) Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

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

D1293 Test Methods for pH of Water
D1888 Test Methods for Particulate and Dissolved Matter, Solids, or Residue in Water
D2908 Practice for Measuring Volatile Organic Matter in Water by Aqueous-Injection 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 Coulometric Detection
D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
E260 Practice for Packed Column Gas Chromatography
E355 Practice for Gas Chromatography Terms and Relationships
2540D Total Suspended Solids Dried at 103 to 105C
2540E Fixed and Volatile Solids Ignited at 550C
ISO14852 Plastics-Evaluation of the Ultimate Aerobic Biodegradability and Disintegration Under Controlled Composting Conditions-Method by Analysis of Released Carbon Dioxide

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Index Terms

aerobic biodegradation; biodegradation; composting; plastics

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D6400-04 Standard Specification for Compostable Plastics

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This specification covers plastics and products made from plastics that are designed to be composted in municipal and industrial aerobic composting facilities.

1.2 This specification is intended to establish the requirements for labeling of materials and products, including packaging made from plastics, as "compostable in municipal and industrial composting facilities."

1.3 The properties in this specification are those required to determine if plastics and products made from plastics will compost satisfactorily, including biodegrading at a rate comparable to known compostable materials. Further, the properties in the specification are required to assure that the degradation of these materials will not diminish the value or utility of the compost resulting from the composting process.

1.4 The following safety hazards caveat pertains to the test methods portion of this standard: *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 health and safety practices and to determine the applicability of regulatory limitations prior to use.*

Note 1—No equivalent ISO specifications exist for this standard.

2. Referenced Documents

D5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions
D6002 Guide for Assessing the Compostability of Environmentally Degradable Plastics
D883 Terminology Relating to Plastics
EN 13432: 2000, 2000-CEN/TC 261/SC 4 N 99 Packaging-Requirements for Packaging Recoverable through Composting and Biodegradation-Test Scheme and Evaluation Criteria for the Final Acceptance of Packaging (EN 13432)
40 CFR Part 503.13 Standards for the Use or Disposal of Sewage Sludge
EN 13432 Requirements for Packaging Recoverable through Composting and Biodegradation-Test Scheme and Evaluation Criteria for the Final Acceptance of Packaging
ISO 14855 Evaluation of the Ultimate Aerobic Biodegradability and Disintegration of Plastics under Controlled Composting Conditions-Method by Analysis of Evolved Carbon Dioxide
ISO 16929 Plastics-Determination of the Degree of Disintegration of Plastic Materials under Defined Composting Conditions in a Pilot-Scale Test
OECD Guideline 208 Terrestrial Plants, Growth Test
Trade Memorandum T-4-93 Standards for Metals in Fertilizers and Supplements

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Index Terms

biodegradable; compostable plastic; composting; degradable plastics; labeling; 83.080.01

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D7081-05 Standard Specification for Non-Floating Biodegradable Plastics in the Marine Environment

Developed by Subcommittee: D20.96

See Related Work by this Subcommittee

Adoptions:

Book of Standards Volume: 08.03

1. Scope

1.1 This specification covers products made from plastics (including packaging and coatings) that are designed to be biodegradable under the marine environmental conditions of aerobic marine waters or anaerobic marine sediments, or both. (Possible environments are shallow and deep salt water and brackish water.)

1.2 This specification is intended to establish the requirements for labeling materials and products, including packaging, as "biodegradable in marine waters and sediments."

1.3 The properties in this specification are those required to determine if products (including packaging) will biodegrade satisfactorily, including biodegrading at a rate comparable to known compostable materials. Further, the properties in the specification are required to assure that the degradation of these materials will not diminish the value or utility of the marine resources and habitat.

1.4 This specification does not describe contents or their performance with regard to biodegradability.

1.5 The following safety hazards caveat pertains to the test methods portion of this standard: 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 health and safety practices and to determine the applicability of regulatory limitations prior to use.

Note 1 – There is no known ISO equivalent to this standard.

2. Referenced Documents

D5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions
D6002 Guide for Assessing the Compostability of Environmentally Degradable Plastics
D6400 Specification for Compostable Plastics
D6691 Test Method for Determining Aerobic Biodegradation of Plastic Materials in the Marine Environment by a Defined Microbial Consortium
D883 Terminology Relating to Plastics
40CFRPart 141 National Primary Drinking Water Regulations
40CFRPart 143 National Secondary Drinking Water Regulations
EN13432 Packaging-Requirements for Packaging Recoverable through Composting and Biodegradation-Test Scheme and Evaluation Criteria for the Final Acceptance of Packaging
ISO14851:1999 Determination of the Ultimate Aerobic Biodegradability of Plastic Materials in an Aqueous Medium-Method by Measuring the Oxygen Demand in a Closed Respirometer
ISO14852:1999 Determination of the Ultimate Aerobic Biodegradability of Plastic Materials in an Aqueous Medium-Method by Analysis of Evolved Carbon Dioxide
ISO14855:1999 Determination of the Ultimate Aerobic Biodegradability

and Disintegration of Plastic Materials under Controlled Composting Conditions-Method by Analysis of Evolved Carbon Dioxide

OPPTS850.1010 Aquatic Invertebrate Acute Toxicity Test, Freshwater Daphnids

OPPTS850.1075 Estuarine/Marine Fish Acute Toxicity Study

OPPTS850.5400 Algal Acute Toxicity Study

Index Terms

biodegradable plastic; marine biodegradable; microbial degradable plastics; packaging; 83.140.99

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D6954-04 Standard Guide for Exposing and Testing Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This guide provides a framework or road map to compare and rank the controlled laboratory rates of degradation and degree of physical property losses of polymers by thermal and photooxidation processes as well as the biodegradation and ecological impacts in defined applications and disposal environments after degradation. Disposal environments range from exposure in soil, landfill, and compost in which thermal oxidation may occur and land cover and agricultural use in which photooxidation may also occur.

1.2 In this guide, established ASTM International standards are used in three tiers for accelerating and measuring the loss in properties and molecular weight by both thermal and photooxidation processes and other abiotic processes (Tier 1), measuring biodegradation (Tier 2), and assessing ecological impact of the products from these processes (Tier 3).

1.3 The Tier 1 conditions selected for thermal oxidation and photooxidation accelerate the degradation likely to occur in a chosen application and disposal environment. The conditions should include a

range of humidity or water concentrations based on the application and disposal environment in mind. The measured rate of degradation at typical oxidation temperatures is required to compare and rank the polymers being evaluated in that chosen application to reach a molecular weight that constitutes a demonstrable biodegradable residue (using ASTM International biometer tests for CO_2 evolution appropriate to the chosen environment). By way of example, accelerated oxidation data must be obtained at temperatures and humidity ranges typical in that chosen application and disposal environment, for example, in soil (20 to 30°C), landfill (20 to 35°C), and composting facilities (30 to 65°C). For applications in soils, local temperatures and humidity ranges must be considered as they vary widely with geography. At least one temperature must be reasonably close to the end use or disposal temperature, but under no circumstances should this be more than 20°C away from the removed that temperature. It must also be established that the polymer does not undergo a phase change, such as glass transition temperature (*Tg*) within the temperature range of testing.

1.4 The residues resulting from the oxidations are then exposed to appropriate disposal or use environments in standard biometric test methods to measure the rate and degree of biodegradation (Tier 2).

1.5 The data generated under Tier 1 evaluation and the determined time for the biodegradation in the chosen environment (Tier 2) allow ranking relative to other polymers evaluated under similar environmental conditions with this guide. The degree and time for biodegradation should be consistent with ASTM International methods, and any residues from the intermediate oxidation stage and from biodegradation must be shown to be environmentally benign and not persistent (Tier 3).

Note 1—The intended use of this guide is for comparison and ranking of data to aid in the design and development and the reduction of environmental impacts of polymers that require no more than 24 months to oxidize and biodegrade in the intended use and disposal options and create no harmful or persistent residues under the appropriate disposal conditions (for example, two seasons of crop-growing conditions in soil).

1.6 It is cautioned that the results of any laboratory exposure in this guide cannot be directly extrapolated to actual disposal environments; confirmation to real world exposure is ultimately required as with all ASTM International standards.

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

Note 2—There is no ISO standard that is the equivalent of this standard guide.

1.8 *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 requirements prior to use.*

2. Referenced Documents

D3826 Practice for Determining Degradation End Point in Degradable Polyethylene and Polypropylene Using a Tensile Test
D3987 Test Method for Shake Extraction of Solid Waste with Water
D5071 Practice for Exposure of Photodegradable Plastics in a Xenon Arc Apparatus
D5208 Practice for Fluorescent Ultraviolet (UV) Exposure of Photodegradable Plastics
D5272 Practice for Outdoor Exposure Testing of Photodegradable

Plastics

D5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions

D5510 Practice for Heat Aging of Oxidatively Degradable Plastics

D5526 Test Method for Determining Anaerobic Degradation of Plastic Materials Under Accelerated Landfill Conditions

D5951 Practice for Preparing Residual Solids Obtained after Biodegradability Standard Methods for Plastics in Solid Waste for Toxicity and Compost Quality Testing

D5988 Test Method for Determining Aerobic Biodegradation in Soil of Plastic Materials or Residual Plastic Materials after Composting

D6002 Guide for Assessing the Compostability of Environmentally Degradable Plastics

D6400 Specification for Compostable Plastics

D883 Terminology Relating to Plastics

E1440 Guide for an Acute Toxicity Test with the Rotifer

EPA TITLE 40 CFA 40CFR62, 40CFR50-189, 40CFR260-299, 40CFR300-399, 700-799, and 49CFR100-180

OECD Guideline 207 Earthworm, Acute Toxicity Tests

OECD Guideline 208 Terrestrial Plants, Growth Test

ORCA Guidelines for the Evaluation of Feedstock for Source Separated Biowaste Composting and Biogasification

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Index Terms

biodegradation; ecotoxicity; environmental biodegradation; oxidation; photooxidation; thermal; 83.080.01

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D6868-03 Standard Specification for Biodegradable Plastics Used as Coatings on Paper and Other Compostable Substrates

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This specification covers biodegradable plastics and products (including packaging), where plastic film or sheet is attached (either through lamination or extrusion directly onto the paper) to substrates and the entire product or package is designed to be composted in municipal and industrial aerobic composting facilities.

1.2 This specification is intended to establish the requirements for labeling of materials and products, including packaging, using coatings of biodegradable plastics, as "compostable in municipal and industrial composting facilities."

1.3 The properties in this specification are those required to determine if products (including packaging) using plastic films or sheets will compost satisfactorily, including biodegrading at a rate comparable to known compostable materials. Further, the properties in the specification are required to assure that the degradation of these materials will not diminish the value or utility of the compost resulting from the composting process.

1.4 This standard does not describe contents or their performance with regard to compostability or biodegradability.

1.5 *The following safety hazards caveat pertains to the test methods portion of this standard: 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 health and safety practices and to determine the applicability of regulatory limitations prior to use.*

Note 1—No equivalent ISO specifications exist for this standard.

2. Referenced Documents

D5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions
D6002 Guide for Assessing the Compostability of Environmentally Degradable Plastics
D6400 Specification for Compostable Plastics
D883 Terminology Relating to Plastics
40 CFR Part 503.13 Standards for the Use or Disposal of Sewage Sludge
EN13432 Packaging-Requirements for Packaging Recoverable through Composting and Biodegradation-Test Scheme and Evaluation Criteria for the Final Acceptance of Packaging
ISO14851 Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium-Method by measuring the oxygen demand in a closed respirometer
ISO14852 Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium-Method by analysis of evolved carbon dioxide
ISO14855 Evaluation of the Ultimate Aerobic Biodegradability and Disintegration of Plastics under Controlled Composting Conditions-Method by Analysis of Evolved Carbon Dioxide
ISO16929 Determination of the degree of disintegration of plastic

materials under defined composting conditions in a pilot-scale test

OECD Guideline 208 Terrestrial Plants, Growth Test

Index Terms

biodegradable; compostable packaging; compostable plastic; composting; degradable plastics; labeling; 13.030.99

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D6094-97(2004) Standard Guide to Assess the Compostability of Environmentally Degradable Nonwoven Fabrics

Developed by Subcommittee: D13.90
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 07.02

1. Scope

1.1 This guide covers suggested criteria, procedures, and a general approach to establish the compostability of environmentally degradable nonwoven fabrics and products.

Note 1—The assessment of degradable plastics and nonwoven fabrics or products is considered similar. Consequently, this guide contains only minor changes in technical content from this guide developed by Subcommittee D20.96 on Environmentally Degradable Plastics of Committee D-20 on Plastics.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.3 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.

2. Referenced Documents

D123 Terminology Relating to Textiles

D1776 Practice for Conditioning Textiles for Testing

D3593 Test Method for Molecular Weight and Molecular Distribution of Certain Polymers by Liquid Size Exclusion Chromatography (GPC) Using Universal Calibration

D3776 Test Methods for Mass per Unit Area (Weight) of Woven Fabrics

D3786 Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics-Diaphragm Bursting Strength Tester Method

D5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)

D5152 Practice for Water Extraction of Residual Solids from Degraded Plastics for Toxicity Testing

D5209 Test Method for Determining the Aerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewer Sludge

D5247 Test Method for Determining the Aerobic Biodegradability of Degradable Plastics by Specific Microorganisms

D5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions

D5509 Practice for Exposing Plastics to a Simulated Compost Environment

D5512 Practice for Exposing Plastics to a Simulated Compost Environment Using an Externally Heated Reactor

D5734 Test Method for Tearing Strength of Nonwoven Fabrics by Falling-Pendulum (Elmendorf) Apparatus

D5951 Practice for Preparing Residual Solids Obtained After Biodegradation Standard Methods for Plastics in Solid Waste for Toxicity and Compost Quality Testing

D5988 Test Method for Determining the Aerobic Biodegradation In Soil of Plastic Materials or Residual Plastic Materials After Composting

D6002 Guide to Assess the Compostability of Environmentally Degradable Plastics

D883 Terminology Relating to Plastics

E1440 Guide for an Acute Toxicity Test with the Rotifer Brachionus (and with Microcrustacean Thamnocelphalus)

E1720 Test Method for Determining Ready, Ultimate, Biodegradability of Organic Chemicals in a Sealed Vessel CO Production Test

G22 Practice for Determining Resistance of Synthetic Polymeric Materials to Bacteria

Guidelines for the Evaluation of Feedstock for Source Separated Biowaste Composting and Biogasification, 1994

Compost Facility Operating Guide, 1995

Guidelines for the Use of Environmental Marketing Claims, 1992

OECD Guideline 207, Earthworm, Acute Toxicity Tests

OECD Guideline 208, Terrestrial Plants, Growth Test

Recommended Test Methods for the Examination of Compost and Composting Towards Common Ground, The International Workshop on Biodegradability, 1992 U.S. Solid Waste Composting Facility Profiles-Volume II, 1993

Index Terms

biodegradation; composting; ecotoxicity; nonwoven fabric; 59.080.30

DOCUMENT SUMMARY

WITHDRAWN STANDARD: D5509-96 Standard Practice for Exposing Plastics to a Simulated Compost Environment (Withdrawn 2002)

WITHDRAWN, NO REPLACEMENT

Developed by Subcommittee: D20.96

1. Scope

1.1 This practice covers the exposure of plastics to a specific test environment. The test environment is a laboratory-scale reactor that simulates a self-heating composting system and that uses aeration to control maximum temperature. Plastic exposure occurs in the presence of a media undergoing aerobic composting. The standard media simulates a municipal solid waste from which inert materials have been removed. This practice allows for the use of other media to represent particular waste streams. This practice provides exposed specimens for further testing and for comparison with controls. This test environment does not necessarily reproduce conditions that could occur in a particular full-scale composting process.

1.2 Changes in the material properties of the plastic and controls should be determined using appropriate ASTM test procedures. Changes could encompass physical and chemical changes such as disintegration and degradation.

1.3 This practice may be used for different purposes. Therefore, the interested parties must select the following: exposure conditions from those allowed by this practice; criteria for a valid exposure, that is, minimum or maximum change requirements for the compost and

controls; and the magnitudes of material properties changes required for the plastic specimens.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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.

Note 1-There is no similar or equivalent ISO standard.

Index Terms

aerobic; compost; degradation; plastic; practice; solid waste; 13.030.99

DOCUMENT SUMMARY

WITHDRAWN STANDARD: D5512-96 Standard Practice for Exposing Plastics to a Simulated Compost Environment Using an Externally Heated Reactor (Withdrawn 2002)

WITHDRAWN, NO REPLACEMENT

Developed by Subcommittee: D20.96

1. Scope

1.1 This practice covers the exposure of plastics to a specific test environment. The test environment is an externally-heated laboratory-scale reactor that simulates a composting system. Plastic exposure occurs in the presence of a media undergoing aerobic composting. The standard media simulates a municipal solid waste from which inert materials have been removed. This practice allows for the use of other media to represent particular waste streams. This practice provides exposed specimens for further testing and for comparison with controls. This test environment does not necessarily reproduce conditions that could occur in a particular full-scale composting process.

1.2 Changes in the material properties of the plastic and controls should be determined using appropriate ASTM test procedures. Changes could encompass physical and chemical changes such as disintegration and degradation.

1.3 This practice may be used for different purposes. Therefore, the interested parties must select: exposure conditions from those allowed by this practice; criteria for a valid exposure, that is, minimum or maximum change requirements for the compost and controls; and the

magnitudes of material properties changes required for the plastic specimens.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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.

Note 1-There is no similar or equivalent ISO standard.

Index Terms

aerobic; compost; degradation; plastic; practice; solid waste; 13.030.99

DOCUMENT SUMMARY

WITHDRAWN STANDARD: D6003-96 Standard Test Method for Determining Weight Loss From Plastic Materials Exposed to Simulated Municipal Solid-Waste (MSW) Aerobic Compost Environment (Withdrawn 2005)

WITHDRAWN, NO REPLACEMENT

Developed by Subcommittee: D20.96

Withdrawn Rationale:

This test method was used to determine the degree and rate of aerobic biodegradation of plastic materials exposed to a controlled composting environment. Aerobic composting takes place in an environment where temperature, aeration, and humidity are closely monitored and controlled.

Formerly under the jurisdiction of Committee D20 on Plastics, this test method was withdrawn in December 2004 in accordance with section 10.5.3.1 of the Regulations Governing ASTM Technical Committees, which requires that standards shall be updated by the end of the eighth year since the last approval date.

1. Scope

1.1 This test method is used to determine the degree and rate of aerobic biodegradation of plastic materials exposed to a controlled composting environment. Aerobic composting takes place in an environment where temperature, aeration, and humidity are closely monitored and controlled.

1.2 The test is designed to determine the biodegradability of plastic materials, relative to that of a standard material, in an aerobic environment. Aeration of the test reactors is maintained at a constant rate throughout the test and reactor vessels of a size no greater than 4-L volume are used to ensure that the temperature of the vessels is approximately the same as that of the controlled environment chamber.

1.3 Biodegradability of the plastic is assessed by determining the amount of weight loss from samples exposed to a biologically active compost relative to the weight loss from samples exposed to a "poisoned" control.

1.4 The test is designed to be applicable to all plastic materials that are not inhibitory to the bacteria and fungi present in the simulated Municipal Solid Waste (MSW).

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

1.6 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.

Note 1- There is no similar or equivalent ISO standard.

Index Terms

abiotic; aerobic; biodegradation; compost; 13.030.10; 83.040.01

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5510-94(2001) Standard Practice for Heat Aging of Oxidatively Degradable Plastics

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This practice is intended to define the exposure conditions of plastics at various temperatures when exposed solely to hot air for extended periods of time. Only the procedures for heat exposure are specified, not the test method or specimen. The effect of heat on any particular property may be determined by selection of the appropriate test method and specimen; however, it is recommended that Practice D 3826 be used to determine the embrittlement endpoint, which is defined as that point in the history of a material when 75 % of the specimens tested have a tensile elongation at break of 5 % or less at an initial strain rate of 0.1 mm/mm min.

1.2 This practice should be used as a guide for comparing the thermal-aging characteristics of materials as measured by the change in some property of interest (that is, embrittlement by means of loss of elongation). It is very similar to Practice D3045 but is intended for use in evaluating plastics designed to be oxidized easily after use. The exposure times used for this practice will be significantly shorter than those used for Practice D3045.

1.3 The type of oven used can affect the results obtained from this practice. The user can use one of two methods for oven exposure. The results based on one method should not be mixed with those based on the other.

1.3.1 *Procedure A: Gravity-Convection Oven*--Recommended for film specimens having a nominal thickness not greater than 0.25 mm (0.010 in.).

1.3.2 *Procedure B: Forced-Ventilation Oven*--Recommended for specimens having a nominal thickness greater than 0.25 mm (0.010 in.).

1.4 This practice recommends procedures for comparing the thermal aging characteristics of materials at a single temperature. Recommended procedures for determining the thermal aging characteristics of a material at a series of temperatures for the purpose of estimating time to a defined property change at some lower temperature are also described. This practice does not predict thermal aging characteristics where interactions between stress, environment, temperature, and time control failure.

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

1.6 *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.*

Note 1--There is no ISO standard that is equivalent to this standard.

2. Referenced Documents

D1870 Practice for Elevated Temperature Aging Using a Tubular Oven
D2436 Specification for Forced-Convection Laboratory Ovens for

Electrical Insulation

D3045 Practice for Heat Aging of Plastics Without Load

D3593 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

D3826 Practice for Determining Degradation End Point in Degradable Polyolefins Using a Tensile Test

D618 Practice for Conditioning Plastics for Testing

D883 Terminology Relating to Plastics

E145 Specification for Gravity-Convection and Forced-Ventilation Ovens

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Index Terms

age; degradable; embrittlement; oven; oxidation; 83.140.99

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5988-03 Standard Test Method for Determining Aerobic Biodegradation in Soil of Plastic Materials or Residual Plastic Materials After Composting

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

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

D1193 Specification for Reagent Water

D1293 Test Methods for pH of Water

D1898 Practice for Sampling of Plastics

D2980 Test Method for Volume Weights, Water-Holding Capacity, and Air Capacity of Water-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 Coulometric Detection

D425 Test Method for Centrifuge Moisture Equivalent of Soils

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

D618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing

D883 Terminology Relating to Plastics

2540 D Total Suspended Solids Dried at 103-105C

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

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

DOCUMENT SUMMARY

WK2756 Revision of D5988-96 Standard Test Method for Determining Aerobic Biodegradation in Soil of Plastic Materials or Residual Plastic Materials After Composting

Active Standard: D5988-03

Developed by Subcommittee: D20.96

See Related Work by this Subcommittee

Date Initiated: 09-03-2003

1. Rationale

Please find attached the changes to ASTM **D5988** that will harmonize it with the ISO equivalent method

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Keywords

aerobic; biodegradation; degree (of biodegradation); mineralization; plastics; soil; 13.030.10

DOCUMENT SUMMARY

WITHDRAWN STANDARD: D5247-92 Standard Test Method for Determining the Aerobic Biodegradability of Degradable Plastics by Specific Microorganisms (Withdrawn 2004)

WITHDRAWN, NO REPLACEMENT

Developed by Subcommittee: D20.96

Withdrawn Rationale:

This test method describes the procedures required to carry out a pure-culture study for evaluating the biodegradation of degradable plastics in submerged culture under aerobic conditions. Degradation will be evaluated by weight loss, tensile strength loss, percent-elongation loss and changes in molecular-weight distribution.

Formerly under the jurisdiction of Committee D20 on Plastics, this test method was withdrawn in April 2001 in accordance with section 10.5.3.1 of the Regulations Governing ASTM Technical Committees, which requires that standards shall be updated by the end of the eighth year since the last approval date.

1. Scope

1.1 This test method describes the procedures required to carry out a pure-culture study for evaluating the biodegradation of degradable plastics in submerged culture under aerobic conditions. Degradation will be evaluated by weight loss, tensile strength loss, percent-elongation loss and changes in molecular-weight distribution.

1.2 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.

Index Terms

Aerobic/anaerobic biodegradation; Bacterial biodegradation; Biodegradation; Degradable plastics; Fungal biodegradation; Molecular weight-distribution; Percent elongation; Pure culture; aerobic biodegradability-degradable plastics, by specific microorganisms; in submerged culture, test; 07.100.99; 83.080.01

DOCUMENT SUMMARY

WITHDRAWN STANDARD: D5437-93 Practice for Weathering of Plastics Under Marine Floating Exposure (Withdrawn 1999)

WITHDRAWN, NO REPLACEMENT

Developed by Subcommittee: D20.96

1. Scope

1.1 This practice covers the experimental conditions for exposure of plastics to marine environments. Although intended particularly for marine exposure, the methodology might be used with outdoor brackish water and fresh-water exposures as well. This practice is specifically intended for plastic materials of specific gravities lower than that of seawater that are therefore positively buoyant in seawater. Plastic products such as sections of fishing gear and packaging materials, as well as film or laminate samples of plastics, might be tested by this practice.

1.2 The exposure methodology in this practice is particularly applicable to enhanced-degradable plastics (or controlled-lifetime plastics) in which the environmental degradation under marine-floating exposure is expected to be accelerated relative to that of regular plastic materials.

1.3 This practice is limited to a description of the method by which the exposure and sampling is conducted and the general precautions to be observed in conducting such exposures. Depending on the objective of the exposure study and the end-use of the plastic material in question, suitable means for evaluating the extent of degradation must be selected.

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.

Index Terms

Exposure tests-plastics; Marine floating exposure; Plastics (general); Stability-plastics; Weathering-plastics; weathering-plastics, under marine floating exposure, practice; 83.080.01

DOCUMENT SUMMARY

WITHDRAWN STANDARD: D5525-94a Standard Practice for Exposing Plastics to a Simulated Active Landfill Environment (Withdrawn 2002)

WITHDRAWN, NO REPLACEMENT

Developed by Subcommittee: D20.96

1. Scope

1.1 This practice covers the exposure of plastics to a specific test environment. The test environment is a laboratory-scale reactor that simulates a landfill with enhanced biological activity. Biological activity is enhanced by adding moisture, recirculating leachate, and heating to 35°C. Plastic exposure occurs in the presence of a media undergoing anaerobic degradation. The standard media used in the practice simulates a municipal solid-waste stream. The practice allows for the use of other media to represent particular waste streams. This practice provides exposed specimens for further testing and for comparison with controls. This test environment does not necessarily reproduce conditions that could occur in a particular landfill.

1.2 Changes in the material properties of the plastic and controls should be determined using appropriate ASTM test procedures. Changes could encompass physical and chemical changes such as disintegration and degradation.

1.3 This practice may be used for different purposes. The interested parties therefore must select the following: exposure conditions from those allowed by this practice; criteria for a valid exposure, that is, minimum or maximum change requirements for the simulated landfill

environment and controls; and magnitudes of material properties changes required for the plastic specimens.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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 hazards statements are given in Section 8.

Note 1-There is no similar or equivalent ISO standard.

Index Terms

Anaerobic degradation; Biodegradation; Degradation-plastics; Disintegration; Exposure tests-plastics; Landfill; Leachates/leaching; Simulated landfills; Solid waste; Waste materials/processing; exposing plastics-simulated landfill environment, practice; 13.030.40

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5526-94(2002) Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under Accelerated Landfill Conditions

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This test method covers determination of the degree and rate of anaerobic biodegradation of plastic materials in an accelerated-landfill test environment. This test method is also designed to produce mixtures of household waste and plastic materials after different degrees of decomposition under conditions that resemble landfill conditions. The test materials are mixed with pretreated household waste and exposed to a methanogenic inoculum derived from anaerobic digesters operating only on pretreated household waste. The anaerobic decomposition occurs under dry (more than 30 % total solids) and static nonmixed conditions. The mixtures obtained after this test method can be used to assess the environmental and health risks of plastic materials that are degraded in a landfill.

1.2 This test method is designed to yield a percentage of conversion of carbon in the sample to carbon in the gaseous form under conditions that resemble landfill conditions. This test method may not simulate all conditions found in landfills, especially biologically inactive landfills. This test method more closely resembles those types of landfills in which the gas generated is recovered or even actively promoted, or

both, for example, by inoculation (codeposition of anaerobic sewage sludge and anaerobic leachate recirculation), moisture control in the landfill (leachate recirculation), and temperature control (short-term injection of oxygen and heating of recirculated leachate) **(1-7)**.

1.3 This test method is designed to produce partially degraded mixtures of municipal solid waste and plastics that can be used to assess the ecotoxicological risks associated with the anaerobic degradation of plastics after various stages of anaerobic biodegradation in a landfill.

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 hazards statements are given in Section 8.

Note 1—There is no similar or equivalent ISO standard.

2. Referenced Documents

D1293 Test Methods for pH of Water
D1888 Test Methods for Particulate and Dissolved Matter, Solids, or Residue in Water
D2908 Practice for Measuring Volatile Organic Matter in Water by Aqueous-Injection Gas Chromatography
D3590 Test Method for Total Kjeldahl Nitrogen in Water
D4129 Test Method for Total and Organic Carbon in Water by High-Temperature Oxidation and Coulometric Detection
D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics

E260 Practice for Packed Column Gas Chromatography

E355 Practice for Gas Chromatography Terms and Relationships

212 Nitrogen Ammonia

2540D Total Suspended Solids Dried at 103-105C

2540E Fixed and Volatile Solids Ignited at 550C

Index Terms

accelerated landfill; anaerobic biodegradation; biodegradation; dry digestion; ecotoxicity; landfill; metabolites; plastics; test method; 13.030.40

DOCUMENT SUMMARY

WK9579 Revision of D5526-94(2002) Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under Accelerated Landfill Conditions

Active Standard: D5526-94(2002)
Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Date Initiated: 11-23-2005

1. Rationale

Landfills begin as aerobic environments and transform into anaerobic environments over time and as they are filled. Hence a need to have a biodegradation standard for both environments. Also, there is a need to measure the degree of degradation / disintegration in the aerobic phase over time which will correlate with the packing of landfill sites and volume availability.

Keywords
accelerated landfill; anaerobic biodegradation; biodegradation; dry digestion; ecotoxicity; landfill; metabolites; plastics; test method; 13.030.40

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5511-02 Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under High-Solids Anaerobic-Digestion Conditions

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This test method covers the determination of the degree and rate of anaerobic biodegradation of plastic materials in high-solids anaerobic conditions. The test materials are exposed to a methanogenic inoculum derived from anaerobic digesters operating only on pretreated household waste. The anaerobic decomposition takes place under high-solids (more than 30 % total solids) and static non-mixed conditions.

1.2 This test method is designed to yield a percentage of conversion of carbon in the sample to carbon in the gaseous form under conditions found in high-solids anaerobic digesters, treating municipal solid waste **(1, 2, 3, 4)**. This test method may also resemble some conditions in biologically active landfills where the gas generated is recovered and biogas production is even actively promoted, for example, by inoculation (codeposition of anaerobic sewage sludge, anaerobic leachate recirculation), moisture control in the landfill (leachate

recirculation), and temperature control (short-term injection of oxygen, heating of recirculated leachate) **(5, 6, 7)**.

1.3 This test method is designed to be applicable to all plastic materials that are not inhibitory to the microorganisms present in anaerobic digesters operating on household waste.

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

1.5 This test method is equivalent to ISO DIS15985.

1.6 *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 hazards are given in Section 8.

2. Referenced Documents

D1293 Test Methods for pH of Water
D1888 Test Methods for Particulate and Dissolved Matter, Solids, or Residue in Water
D2908 Practice for Measuring Volatile Organic Matter in Water by Aqueous-Injection 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
D618 Practice for Conditioning Plastics for Testing
D883 Terminology Relating to Plastics
E260 Practice for Packed Column Gas Chromatography
E355 Practice for Gas Chromatography Terms and Relationships
212 Nitrogen Ammonia
2540 D Total Suspended Solids Dried at 103-105C

2540 E Fixed and Volatile Solids Ignited at 550C

ISO DIS 15985 Plastics- Determination of the Ultimate Anaerobic Biodegradability and Disintegration Under High-Solids Anaerobic-Digestion Conditions- Method by Analysis of Released Biogas

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Index Terms

anaerobic biodegradation; anaerobic digestion; biodegradation; high-solids digestion; landfill; plastics test method; 13.030.99

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5210-92(2000) Standard Test Method for Determining the Anaerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewage Sludge

Developed by Subcommittee: D34.03
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 11.04

1. Scope

1.1 This test method determines the degree and rate of anaerobic biodegradation of synthetic plastic materials (including formulation additives) on exposure to anaerobic-digester municipal sewage sludge from a waste-water plant, under laboratory conditions.

1.2 This test method is designed to index plastic materials that are more or less biodegradable relative to a positive standard in an anaerobic environment.

1.3 This test method is applicable to all plastic materials that are not inhibitory to the microorganisms present in anaerobic 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

D1193 Specification for Reagent Water

D3593 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

D883 Terminology Relating to Plastics

Index Terms

anaerobic; biodegradation degree (biodegradation); municipal; plastics; sewer; sludge; 13.030.20

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D3826-98(2002) Standard Practice for Determining Degradation End Point in Degradable Polyethylene and Polypropylene Using a Tensile Test

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.02

1. Scope

1.1 This practice covers the determination of a degradation-end point *(a brittle point)* for degradable polyethylene/polypropylene films and sheeting less than 1.0 mm (0.04 in.) thick. This practice is not intended for determination of the rate of degree of degradation of a polyethylene/polypropylene film or sheet, but rather, to assess when in the course of its degradation under some condition, a brittle point is reached. If one wishes to monitor tensile elongation during the degradation process (such as when the tensile elongation is significantly greater than 5 %), Test Method D 882 is recommended. This practice should not be considered the only way of determining a degradation-end point.

1.2 Tensile properties of plastics 1.0 mm (0.04 in.) or greater in thickness shall be determined in accordance with Test Method D 638.

1.3 Use a static weighing-constant rate of grip separation test. This procedure employs a constant rate of separation of the grips holding the sample and a static load cell.

Note 1—This procedure is based on the use of grip separation as a measure of extension; however, the desirability of using extension indicators accurate to ±1.0 % or better as specified in Test Method D 638 is recognized, and a provision for the use of such instrumentation is incorporated in the procedure.

1.4 This procedure has been successful for determining the degradation end point of ethylene-carbon-monoxide copolymers and has screened successfully two other additive-type polyethylenes in a round robin test.

1.5 The values stated in SI units are to be regarded as the standard. The values in parentheses are for information only.

1.6 *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.*

1.7 There is no equivalent ISO standard.

2. Referenced Documents

D374 Test Methods for Thickness of Solid Electrical Insulation
D5208 Practice for Operating Fluorescent UV and Condensation Apparatus for Exposure of Photodegradable Plastics
D618 Practice for Conditioning Plastics and Electric Insulating Materials for Testing
D638M Test Method for Tensile Properties of Plastics [Metric]
D882 Test Methods for Tensile Properties of Thin Plastic Sheeting
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5272-92(1999) Standard Practice for Outdoor Exposure Testing of Photodegradable Plastics

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.03

1. Scope

1.1 This practice defines test conditions applicable when Practices D1435 and G7 are employed for the outdoor exposure testing of photodegradable plastics.

1.2 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.

Note 1-There is no ISO standard that is equivalent to this standard.

2. Referenced Documents

D1435 Practice for Outdoor Weathering of Plastics
D1898 Practice for Sampling of Plastics
D3593 Test Method for Molecular Weight Averages and Molecular Weight Distribution of Certain Polymers by Liquid Size-Exclusion Chromatography (Gel Permeation Chromatograph GPC) Using Universal Calibration
D3826 Practice for Determining Degradation End Point in Degradable

Polyolefins Using a Tensile Test

D882 Test Methods for Tensile Properties of Thin Plastic Sheeting

D883 Terminology Relating to Plastics

E772 Terminology Relating to Solar Energy Conversion

G7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials

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Index Terms

aging; degradable plastic; exterior exposure; outdoor exposure; photodegradation; ultraviolet radiation; weathering; 83.080.01

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5071-06 Standard Practice for Exposure of Photodegradable Plastics in a Xenon Arc Apparatus

Developed by Subcommittee: D20.96
See Related Work by this Subcommittee
Adoptions:
Book of Standards Volume: 08.02

1. Scope

1.1 This practice covers specific procedures and test conditions that are applicable for xenon arc exposure of photodegradable plastics conducted in accordance with Practices G 151 and G 155. This practice also covers the preparation of test specimens, the test conditions best suited for photodegradable plastics, and the evaluation of test results.

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.

Note 1

This practice is technically equivalent to ISO 4892-2 and Practice D 2565 which cover xenon arc exposures of plastics intended for long term use in outdoor applications.

2. Referenced Documents

D1293 Test Methods for pH of Water
D2565 Practice for Xenon-Arc Exposure of Plastics Intended for

Outdoor Applications

D3593 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

D3826 Practice for Determining Degradation End Point in Degradable Polyethylene and Polypropylene Using a Tensile Test

D3890 Test Method for Number of Strokes to Prime a Mechanical Pump Dispenser

D5870 Practice for Calculating Property Retention Index of Plastics

D882 Test Method for Tensile Properties of Thin Plastic Sheeting

D883 Terminology Relating to Plastics

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials

G141 Guide for Addressing Variability in Exposure Testing of Nonmetallic Materials

G147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests

G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources

G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

G169 Guide for Application of Basic Statistical Methods to Weathering Tests

DIN 53384 Testing of Plastics: Artificial Weathering or Exposure in Laboratory Exposure Weathering or Exposure in Laboratory Exposure Apparatus to UV Radiation

ISO 4892-2 Plastics-Method of Exposure to Laboratory Light Sources-

Part 2, Xenon Arc Sources

Publication C.I.E. No. 85 (1989)

DOCUMENT SUMMARY

ACTIVE STANDARD: ASTM D5208-01 Standard Practice for Fluorescent Ultraviolet (UV) Exposure of Photodegradable Plastics

Developed by Subcommittee: D20.96

See Related Work by this Subcommittee

Adoptions:

Book of Standards Volume: 08.03

1. Scope

1.1 This practice covers the specific procedures applicable for fluorescent Ultraviolet (UV) exposure of photodegradable plastics conducted in accordance with Practices G 151 and G 154. This practice also covers the preparation of test specimens and the evaluation of test results.

Note 1—Previous ersions of this practice referenced fluorescent UV devices described by Practice G 53, which described very specific equipment designs. Practice G 53 has been withdrawn and replaced by Practice G 151, which describes performance criteria for all exposure devices that use laboratory light sources and by Practice G 154, which gives requirements for exposing nonmetallic materials in fluorescent UV devices.

1.2 Practice D 4329 covers fluorescent UV exposures of plastics intended for long term use in outdoor applications.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *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.*

Note 2—There is no ISO standard equivalent to this practice.

2. Referenced Documents

D3826 Practice for Determining Degradation End Point in Degradable Polyolefins Using a Tensile Test D3980 Practice for Interlaboratory Testing of Paint and Related Materials
D5870 Practice for Calculating the Property Retention Index of Plastics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
G113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials
G141 Guide for Addressing Variability in Exposure Testing on Nonmetallic Materials
G147 Practice for Conditioning and Handling of Nonmetallic Materials for Natural and Artificial Weathering Tests
G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
G154 Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials
G169 Guide for Application of Basic Statistical Methods to Weathering Tests
G53 Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV/Condensation Type) for Exposure of Nonmetallic Materials