Designation: D7081 – 05

Standard Specification for Non-Floating Biodegradable Plastics in the Marine Environment[1]

This standard is issued under the fixed designation D7081; 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 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

2.1 *ASTM Standards:*[2]

D883 Terminology Relating to Plastics

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

2.2 *ISO Standards:*[3]

ISO 14851:1999 Determination of the Ultimate Aerobic Biodegradability of Plastic Materials in an Aqueous Medium—Method by Measuring the Oxygen Demand in a Closed Respirometer

ISO 14852:1999 Determination of the Ultimate Aerobic Biodegradability of Plastic Materials in an Aqueous Medium—Method by Analysis of Evolved Carbon Dioxide

ISO 14855:1999 Determination of the Ultimate Aerobic Biodegradability and Disintegration of Plastic Materials under Controlled Composting Conditions—Method by Analysis of Evolved Carbon Dioxide

2.3 *Comite European de Normalisation (CEN):*[3]

EN 13432 Packaging—Requirements for Packaging Recoverable through Composting and Biodegradation—Test Scheme and Evaluation Criteria for the Final Acceptance of Packaging

2.4 *Government Standards:*[4]

40 CFR Part 141 National Primary Drinking Water Regulations

40 CFR Part 143 National Secondary Drinking Water Regulations

OPPTS 850.1010 Aquatic Invertebrate Acute Toxicity Test, Freshwater Daphnids

OPPTS 850.1075 Estuarine/Marine Fish Acute Toxicity Study

OPPTS 850.5400 Algal Acute Toxicity Study

3. Terminology

3.1 For definitions of terms used in this specification, refer to Terminology D883.

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

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] *Code of Federal Regulations*, available from U.S. Government Printing Office, Washington, DC 20402.

3.1.1 *materials of natural origin*[5], *n*—chemically-unmodified packaging materials and constituents of natural origin, such as wood, wood fiber, cotton fiber, starch, paper pulp, jute, chitin, chitosan and cellulose.

3.1.2 *mesophilic phase*[6], *n*—temperature range from approximately 20°C to 40°C over which microorganisms adapted to moderate conditions maintain active metabolic rates.

3.1.3 *psychrophilic phase*[6], *n*—temperature range from approximately 2°C to 20°C over which microorganisms adapted to cold conditions maintain active metabolic rates.

4. Classification

4.1 This specification establishes requirements for identifying plastic products and materials that will biodegrade satisfactorily in the marine environment. Products meeting the requirements outlined below are appropriate for labeling as "marine disposable" in accordance with the guidelines issued by the Federal Trade Commission.[4]

5. Basic Requirements

5.1 *Disintegration During Marine Degradation*—A product or material will disintegrate during marine water exposure such that any remaining residuals (plastic or substrate) are not readily distinguishable from other organic materials or particulates normally present in this environment.

5.2 *Inherent Biodegradation*—A level of inherent biodegradation for the plastic shall be established by tests under controlled conditions that are comparable to known marine biodegradable materials (for example, Kraft paper).

5.3 *No Adverse Environmental Impacts*—The tested products or materials shall not adversely impact on the survival of marine organisms nor adversely affect the ecosystem, once placed in the marine environment. Additionally, the polymeric products or other materials must not introduce unacceptable levels of regulated metals or other toxic substances into the environment, upon sample decomposition.

6. Detailed Requirements

6.1 In order to be identified as marine biodegradable, products must pass the requirements of 6.2 and 6.3, using the appropriate laboratory tests, representative of the conditions found in aerobic/anaerobic marine waters and sediments.[7, 8, 9] Products and finished articles shall be tested in the same form as they are intended to be used. This specification is for products that have a density of greater than 1.05 gm/cc. Products shall have density greater than 1.05 g/cm^3. For products that are made in multiple thicknesses or densities, such as films, containers and foams, only the thickest or most dense products need to be tested as long as the chemical composition and structure remains otherwise the same. It is assumed that thinner gages and lower densities will also biodegrade satisfactorily. Similarly, if additives are present in test samples that pass testing, lower levels of the same additives are similarly passed.

6.2 *Disintegration During Incubation/Disposal*—A monomaterial product (that is, made only with the test polymer), is considered to have demonstrated satisfactory disintegration if after twelve weeks in controlled testing described in Test Method D6691, no more than 30 % of its original dry weight remains after sieving on a 2.0-mm sieve. Laboratory mesophilic and psychrophilic conditions may be generated by performing Test Method D6691.

6.3 *Inherent Biodegradation*—A product is considered to have demonstrated inherent biodegradability if the criteria in sections 6.3.1 and 6.3.2 are met or exceeded. These criteria apply to plastics when used to make formed articles or when used as coatings on substrates or when used as binders.

6.3.1 The plastics and substrates (if used) are to individually demonstrate that 30 % or more of the organic carbon is converted to carbon dioxide using Test Method D6691 within a 180 days at 30 ± 2°C), when compared to the positive control. The testing method shall be D6691 unless it is inappropriate for the type and properties of the material. Also, 90 % biodegradation in an active environment like compost in accordance with Test Method D5338 must be demonstrated. As an alternative test, which conclusively demonstrates biodegradability by means of microbial assimilation of the test materials shall be used, in particular ISO 14851:1999, ISO 14852:1999, and ISO 14855:1999. Compliance to Specification D6400 shall be a necessary, but not a sufficient prerequisite.

6.3.2 To demonstrate that the entire material is inherently biodegradable, it must demonstrate a satisfactory rate of biodegradation in a test method designed to optimize microbial activity. The test method shall be Test Method D5338 as outlined in 7.3.1 and 7.3.3 of Guide D6002. To fulfill the requirements of this section plastics shall achieve one of the following ratios of conversion to carbon dioxide found in 6.3.2.1-6.3.2.3, within the time periods specified in 6.3.2.4 or 6.3.2.5. If the plastic is used as a coating or binder, then the substrates shall be tested separately and shall meet the requirements of 6.3.2.2, within the time periods specified in 6.3.2.4 or 6.3.2.5.

6.3.2.1 For products consisting of a single polymer (homopolymers), 60 % of the organic carbon must be converted to carbon dioxide by the end of the test period (see 6.3.2.4 and 6.3.2.5), when compared to the positive control.

6.3.2.2 For all other polymers and substrates, 90 % of the organic carbon must be converted to carbon dioxide by the end of the test period (see 6.3.2.4 and 6.3.2.5) when compared to the positive control.

6.3.2.3 For products consisting of more than one polymer, each individual polymer component, present at more than 1 % concentration, must achieve the 60 % specification for homopolymers, as described in 6.3.2.1.

6.3.2.4 For materials that are not radiolabeled, the test period shall be no greater than 180 days.

[5] EN 13432 Available from CEN

[6] Microbial World, (Eds: Stanier, Doudoroff and Adelberg), 1963.

[7] Ratto, J, Wirsen, C., Herbert, J. Allen A., Russo, J., 2001 pp. 320-335 *In* R.A. Gross and C. Scholz (eds.) *Biopolymers from Polysacharides and Agroproteins*, ACS Symposium Series 786. American Chemical Society, Washington, DC.

[8] Wirsen, C., Jannasch, H., 1976, Envrionmental Science and Technology, Vol 10, p880-886.

[9] Wisen, C. Jamasch, H. 1998, pp78-85 In Herbert, J. and D. Kaplan (eds) Biodegradable Polymers.

6.3.2.5 If radiolabeled materials are used, then the test period shall be no greater than 365 days.

NOTE 2—"Materials of Natural Origin" are accepted as being biodegradable without testing and are exempt from meeting the requirements found in 6.3. However, products utilizing materials of natural origin shall meet the requirement of 6.1, 6.2 and 6.4. Also they shall be characterized to identify their chemical composition, presence of heavy metals or other hazardous substances, organic carbon content and total dry and volatile solids.

6.4 *Toxicity*

6.4.1 The plastic product shall undergo toxicity testing with one of the following tests: Polytox (microbial oxygen absorption), Microtox (microbial bioluminescence) test, fish Acute Toxicity (static conditions) OPPTS 850.1075, Daphnia Acute Toxicity (static conditions) OPPTS 850.1010, or Static Algal Toxicity Test OPPTS 850.5400.

6.4.2 The plastic or product shall have concentrations of regulated heavy metals less than 25 % of those prescribed for in the country where the product is sold. This restriction is to insure the safety of the marine life and environment. Specifically in the United States, the regulated metal concentrations are 40 CFR Part 141 and 40 CFR Part 143. In Canada, the regulated metals concentrations are found DORM-2, National Research Council of Canada, Marine Analytical Chemistry Standards Program. In Europe, the United Nations Economic Commission for Europe, is currently addressing heavy metal issues and monitoring heavy metals in the ocean.

7. Sampling

7.1 Sampling shall be conducted as indicated in Test Method D6691.

8. Specimen Preparation

8.1 Specimen preparation shall be in accordance with Test Method D6691.

9. Marking and Labeling

9.1 Cartons or products meeting the requirements of this specification may be labeled as suitable for disposal in a marine environment.

10. Keywords

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