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Plastics — Determination of the degree of disintegration of plastic materials under defined composting conditions in a pilot-scale test

Plastiques — Détermination du degré de désintégration des matériaux plastiques dans des conditions de compostage définies lors d'un essai à échelle pilote

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 14, *Environmental aspects,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 16929:2019), which has been technically revised.

The main changes compared to the previous edition are as follows:

— in 6.1.1, the minimum amount of biowaste has been changed to 15 kg from 30 kg due to the smaller size of composting bins;

— in 6.2.2.3, a separate temperature profile has been added to cover tests including also production of compost for ecotoxicity tests.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The biological treatment of biodegradable plastic materials includes aerobic composting in well-operated, municipal or industrial biological waste treatment facilities. Determining the degree of disintegration of plastic materials in a pilot-scale plant is an important step within a test scheme to evaluate the industrial compostability of such materials.

To claim industrial compostability, a material not only has to disintegrate in a composting system, it also has to biodegrade in a composting system (as can be shown by standard test methods) and has to complete its biodegradation during the end-use of the compost. Furthermore, the compost has to meet the relevant quality criteria, including low content of regulated metals, no ecotoxicity, and no obviously distinguishable residues.

Plastics — Determination of the degree of disintegration of plastic materials under defined composting conditions in a pilot-scale test

1 Scope

This document defines a test method used to determine the degree of disintegration of plastic materials in a pilot-scale aerobic composting test under defined conditions. It forms part of an overall scheme for the evaluation of the industrial compostability of plastics as outlined in ISO 17088.

The test method laid down in this document is also used to determine the influence of the test material on the composting process and the quality of the compost obtained. This test method cannot be used to determine the aerobic biodegradability of a test material.

NOTE Other methods are available for this test (for example, see ISO 14851, ISO 14852 or ISO 14855-1 and ISO 14855-2).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
degradation
irreversible process leading to a significant change in the structure of a material, typically characterized by a loss of properties (e.g. integrity, molecular mass or structure, mechanical strength) and/or by fragmentation, affected by environmental conditions, proceeding over a period of time and comprising one or more steps

3.2
biodegradation
degradation (3.1) caused by biological activity especially by enzymatic action leading to a significant change in the chemical structure of a material

3.3
disintegration
physical breakdown of a material into very small fragments

3.4
compost
organic soil conditioner obtained by *biodegradation* (3.2) of a mixture principally consisting of various vegetable residues, occasionally with other organic material, and having a limited mineral content

3.5
composting
aerobic process designed to produce *compost* (3.4)

3.6
compostability
property of a material to be biodegraded in a *composting* (3.5) process

3.7
maturity of compost
assignment of the maturity of a *compost* (3.4) based on the measurement of the maximum temperature in a self-heating test using Dewar vessels

Note 1 to entry: It is expressed in terms of the so-called "Rottegrad" (see 6.2.3.1).

3.8
total dry solids
amount of solids obtained by taking a known volume of test material or *compost* (3.4) and drying at about 105 °C to constant mass

3.9
volatile solids
amount of solids obtained by subtracting the residues of a known volume of test material or *compost* (3.4) after incineration at about 550 °C from the *total dry solids* (3.8) content of the same sample

Note 1 to entry: The volatile solids content is an indication of the amount of organic matter present.

4 Principle

The disintegration test is performed under defined and standardized composting conditions on a pilot-scale level.

The test material is mixed with fresh biowaste in a precise concentration and introduced into a defined composting environment. A natural ubiquitous microbial population starts the composting process spontaneously and the temperature increases. The composting mass is regularly turned over and mixed. Temperature, pH-value, moisture content and gas composition are regularly monitored. They should fulfil certain requirements to ensure sufficient and appropriate microbial activity. The composting process is continued until a fully stabilized compost is obtained. This is usually the case after 12 weeks.

The compost is visually observed at regular time intervals to detect any adverse effect of the test material on the composting process. At the end of the test, the maturity of compost is determined, and the mixture of compost and test material is sieved through 2 mm and 10 mm mesh sieves. The disintegration of the test material is evaluated based on the total dry solids by comparing the fraction of test material retained by the 2 mm sieve and the amount tested. The compost obtained at the end of the composting process may be used for further measurements, such as chemical analyses and ecotoxicity tests.

5 Apparatus

5.1 Composting environment.

5.1.1 General

The composting environment may be either a pilot-scale composting bin or nets buried in a pilot-scale composting bin. The volume of each bin shall be high enough for natural self-heating to occur. Sufficient and even aeration shall be provided by an appropriate air supply system. To standardize conditions for the test, the composting trials can be run in bins which are placed in a climatic chamber with a constant chamber temperature or in insulated bins.

If during the spontaneous thermophilic phase the compost reaches temperatures higher than 65 °C, the diversity of microbial species can be reduced. To restore a full array of thermophilic bacteria, the compost can be re-inoculated with mature compost (about 10 g/kg initial biowaste mass) of recent origin (maximum 3 months old).

5.1.2 Composting bins

5.1.2.1 Volume and material

The bins shall:

— have a minimum volume of 35 l;

— consist of a sturdy, heat-resistant and non-biodegradable material;

— not affect the composting process or the quality of the compost.

5.1.2.2 Drainage

The drainage shall consist of a layer of drains with a thickness of at least 5 cm at the bottom of the bins.

5.1.3 Sample nets, if used, shall consist of mesh-like material with a mesh size of 1 mm made of non-degradable plastic which is resistant to temperatures up to 120 °C. The minimum volume shall be 20 l.

5.2 Apparatus for temperature measurement.

5.3 pH-meter.

5.4 Apparatus for oxygen measurement.

5.5 Sieves, of suitable shape with screens of 2 mm and 10 mm mesh (as specified, for example, in ISO 3310-2).

6 Test procedure

WARNING — Compost can contain potentially pathogenic organisms. Therefore, appropriate precautions should be taken when handling it. Aspergillosis, farmer's lung, histoplasmosis, Legionnaire's disease, paronychia and tetanus are some of the more common physical ailments that can result from unprotected contact with compost. The following general safety precautions should be followed in order to avoid transmission of dangerous fungi, bacteria and other pathogens found in compost.

— **Always wear gloves to avoid direct contact with the skin.**

— **Always wear protective footwear that covers your skin adequately.**

— **When stirring and tilling the compost, which is required on a regular basis in order for it to process and break down, always wear a nose and mouth guard or dust mask to avoid inhaling the various spores that will become airborne during tilling and turning.**

— **Do not store compost in fully closed or airtight containers.**

— **Always wash your hands after dealing with compost.**

6.1 Actions before and during incubation

6.1.1 Start-up of the test

6.1.1.1 Preparation of biowaste

As a carrier matrix, use biowaste, if possible from the input material of a composting plant treating predominantly municipal waste, or, less satisfactorily, biowaste directly from households or grocery stores for example.

NOTE Alternatively, a representative artificial biowaste with, for example, the following ingredients can be used:

— freshly mixed fruit and vegetable waste;

— rabbit feed (seeds and extruded dried-vegetable pellets);

— mature compost;

— sufficient water to attain a good moisture content;

— a bulking agent (such as wood chips or bark).

It is important that for all test series a homogeneous biowaste of the same age and origin is used. Reduce the biowaste to particle sizes of maximum 50 mm, for example by shredding or sieving. Depending on the type of waste, add about 100 g/kg to 600 g/kg of bulking agent (structurally stable components such as wood chips or bark with a particle size between 10 mm and 50 mm).

To ensure a good composting process, the biowaste shall meet the following criteria:

— the C:N ratio of the fresh biowaste/bulking agent mixture shall be between 20 and 30;

— the moisture content shall be above 50 % mass fraction, with no free water present;

— the volatile solids content of the total dry solids shall be above 50 % mass fraction;

— the pH shall be above 5.

Adjust the C:N ratio with urea, if required.

6.1.1.2 Preparation of the test material

a) If the purpose of the test is to measure the degree of disintegration of the test material and to determine the effects on the composting process and the compost quality, use the test material in an identical form (e.g. shape, thickness) as for the intended final use. Reduce large materials in size to 10 cm × 10 cm for films and 5 cm × 5 cm for other products.

   NOTE 1 As an option, a colouring agent (e.g. TiO_2 or Fe_2O_3) can be added to the test material for easier re-isolation.

b) If the (optional) purpose of the test includes production of compost for ecotoxicity tests, use in addition to a) the test material in the form of fine powder or granules. The fine form is intended to prevent the mixture of biowaste and test material from getting too bulky.

   It is recommended that the test material be used as a powder with a particle size <500 µm.

   NOTE 2 The fine powder or granulates is added with the sole purpose to increase the input concentration at start of the composting test (see 6.1.1.4). The fine powder or granulates, if reduced in particle size to <500 µm, will not affect the disintegration of the test material.

