INTERNATIONAL STANDARD

ISO 5148

First edition
2022-06

Plastics — Determination of specific aerobic biodegradation rate of solid plastic materials and disappearance time (DT50) under mesophilic laboratory test conditions

Plastiques — Détermination du taux de biodégradation aérobie spécifique des matières plastiques solides et du temps de disparition (DT50) dans des conditions d'essai de laboratoire mésophile

Reference number
ISO 5148:2022(E)

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Published in Switzerland

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Foreword

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This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 14, *Environmental aspects*.

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

Several test methods have been developed by ISO to measure the biodegradation degree of plastics. Under aerobic conditions, the biodegradation reaction of a material is described by the following reaction:

$$C_M + O_2 \rightarrow C_{CO_2} + H_2O + C_B$$

where

C_M is the organic carbon present in the test material (e.g. a polymer or a plastic material);

C_{CO_2} is the carbon evolved as carbon dioxide;

C_B is the carbon assimilated by microorganism and incorporated in the microbial biochemistry.

The test methods follow the biodegradation reaction by measuring either the oxygen uptake (disappearance of the reactant) or the CO_2 evolution (formation of the product). The test methods return a biodegradation percentage (which, strictly speaking, is a "mineralization" percentage). This value is the reaction yield percentage, i.e. the mass of carbon oxidised to CO_2 during the reaction (actual yield) in comparison with the maximum possible yield (theoretical yield). This is expressed as evolved CO_2/theoretical CO_2, the latter value being the amount of CO_2 obtained in case of total oxidation of the original carbon present in the test substance.

A reliable test method for the determination of the C_B, i.e. the amount of C_M that has been assimilated in the biomass is not available at the date of publication.

The test methods are suitable for measuring the final degree of biodegradation but are not suitable for measuring the biodegradation rate, because they do not take into account the surface area of the tested sample. On the other hand, this document provides a guidance on how to measure the biodegradation rate using existing test methods.

Biodegradation of solid, non-water soluble polymers and plastics is a heterogeneous reaction because the polymer is in the solid state while microbes and enzymes are in the liquid phase. Even when the tested material is exposed to solid matrices (e.g. compost, soil, marine sediment) the microbes are in the liquid phase present within the solid matrix (e.g. micropores, macropores). Thus, the reaction of biodegradation happens in the liquid/solid interphase and the available surface area can become a limiting factor. It is a common knowledge that milling increases the biodegradation rate of a plastic sample. The biodegradation speed, i.e. the CO_2 evolution and the O_2 uptake rates, is controlled by the surface area of the tested sample. Therefore, biodegradation rate must be expressed as a function of the available surface area, otherwise the information is pointless and paradoxical results can be obtained.

There is an increasing interest in determining the biodegradation rate and related parameters (such as the disappearance time 50, DT50, i.e. the time within which the initial concentration of the test substance is reduced by 50 %) in order to assess the risk in the case of accidental or deliberate leakage of biodegradable plastics into the environment. Degradation of organic substances in the environment influences exposure and, hence, it is a key parameter for estimating the risk of long-term adverse effects on biota.

This document enables to determine the specific aerobic biodegradation rate i.e. the amount of carbon mineralized per unit time per unit surface area, under the conditions defined by the applied test method.

The approach showed in this document is aimed to measure mineralization rate. It differs from ISO 23832 that describes a test method for the determination of the physical degradation rate and disintegration degree of plastic materials. On the other hand, ISO 22403 identifies the plastic materials that show intrinsic biodegradability when exposed to marine inocula under mesophilic aerobic laboratory conditions.