
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



COPYRIGHT PROTECTED DOCUMENT

© ISO 2022

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword.....	iv
Introduction.....	v
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	1
4 Principle.....	3
5 Apparatus.....	3
5.1 Sieves.....	3
5.2 Sieve shaker.....	4
5.3 Laser particle size analyser (i.e. laser diffraction instrument).....	4
5.4 Micropore and chemisorption analyser.....	4
6 Determination of the specific surface area (SSA) of test sample.....	4
6.1 General.....	4
6.2 Powder test sample.....	4
6.2.1 Sample preparation.....	4
6.2.2 Specific surface area determination.....	4
6.3 Film/sheet test sample.....	6
6.3.1 Sample preparation.....	6
6.3.2 Specific surface area determination.....	6
7 Determination of the net CO₂ evolution.....	7
8 Determination of the specific aerobic biodegradation rate and disappearance time.....	8
8.1 Determination of C_R disappearance.....	8
8.2 Determination of specific aerobic biodegradation rate.....	9
8.3 Determination of DT50.....	9
9 Test report.....	10
Annex A (informative) Example for the determination of r_{SAB} and DT50.....	11
Bibliography.....	16

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

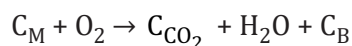
For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

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:



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.