

CSIR Biodegradation Testing Laboratory



The CSIR hosts Africa's only laboratory equipped to test and verify the biodegradability of materials. These include imported and locally produced products that are being promoted as biodegradable and compostable.



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Biodegradability testing of materials

Biodegradation tests are used to determine the biodegradability of products in a given environment or intended use environment, such as in agricultural soil, landfill, compost (home and industrial), fresh water, marine water, aerobic and anaerobic conditions.

Biodegradation is a biochemical interaction between a material/product and microorganisms. A product's ability to biodegrade depends on the amount of carbon available for microbial consumption. It is generally measured by CO₂ (aerobic) and CH₄ (anaerobic) production.

To claim biodegradable materials, it must be defined by:

- The disposal system – composting, anaerobic digester, landfill, soil, marine water.
- The time required for complete microbial utilisation in the selected disposal environment – defined timeframe or less.
- Complete utilisation of the substrate carbon by the microorganisms as measured by the evolved CO₂ (aerobic) and CO₂ + CH₄ (anaerobic), and leaving no toxic residues.
- No negative effects on the disposal system, including the presence of high levels of regulated metals and other harmful components.

Disintegration, fragmentation, primary degradability, partial biodegradability, or will eventually biodegrade is not an option – serious health and environmental consequences can occur.

A number of standard methods have been published by various organisations, such as the Organisation for Economic Cooperation and Development (OCED), International Organization for Standardisation (ISO), American Society for Testing and Materials, (ASTM) and the European Normative (EN).

Services offered at the laboratory

Services offered ensure that a material/product claim can be tested in accordance with environmental labelling standards.

Challenges with biodegradation testing include the complexity of the biochemical interaction, the composition of the materials tested, and the specific needs of each biodegradation test. Materials that are made up of components known to biodegrade sometimes don't pass in certain environments, and materials made of inorganic components don't necessarily fail the various assessments of biodegradability. Therefore, knowing which biodegradation test method to use for a specific material is key.

Successful biodegradation demonstration can be managed through the selection of the appropriate method and preparation of the samples to fit the requirements of the specific test method. It is highly recommended to review testing requirements or alternatively contact the CSIR laboratory prior to testing to determine which methods are required for labelling claims and regulatory acceptance.

The CSIR Biodegradation Testing Laboratory can establish the conditions and timeframes for the biodegradation of materials. Tests can be performed under different conditions – compost, soil, freshwater, marine water and anaerobic digestate.

Compost biodegradation

The ASTM D6400 standard is equivalent to the ISO 14855 and EN 13432 and is the most requested for biodegradation testing under aerobic composting in municipal and industrial facilities, which is recognised by many municipalities and regulatory agencies for making biodegradability claims about a product or material.

The standard specifies procedures and requirements for materials and products (finished products) that are suitable for composting (home or industrial). Materials and products are considered as suitable for home composting (at 23°C ±2°C) and industrial composting (at 58°C ±2°C) as a complete product, including all the individual components, and should meet the requirements as such. The following aspects need to be addressed:

- (i) Disintegration during composting;
- (ii) Mineralisation – CO₂ emission during composting;
- (iii) Eco-toxicity test on the quality of the resulting compost, including the presence of high levels of regulated metals and other harmful components.

Soil biodegradation

Currently, the main international standards are ASTM D5988 and ISO 17556 for determining aerobic biodegradation of plastic materials in or on soil, and deal with the extent of biodegradation over a time period by the microorganisms present in the soil-mineralised plastics. This standard was recently superseded by the



new standard specification EN17033 for biodegradable mulch films for use in agriculture and horticulture, which specifies the necessary requirements and test methods.

EN 17033 specifies test methods and evaluation criteria regarding the biodegradation, ecotoxicity, film properties and constituents of the biodegradable mulch films. To use the pre-existing and well-established certification “OK biodegradable SOIL” the test materials and products require 90% CO₂ conversion within 24 months in a soil biodegradation test.

Additionally, the standard includes a new, more comprehensive ecotoxicity testing and evaluation scheme taking into account relevant terrestrial organism groups such as plants, invertebrates (e.g. earthworms), and microorganisms (e.g. nitrification inhibition test); important ecological processes that are critical due to their role in maintaining soil functions by breaking down organic matter and formulating soil structure and ecologically recycling of materials; and relevant exposure pathways of degradation products such as soil pore water, soil pore air and soil material.

Moreover, the standard strictly defines restrictions regarding different potentially harmful constituents, such as regulated metals and substances of very high concern.

Aqueous biodegradation test

OECD 301B is the most requested readily and inherent biodegradability method in a liquid environment. For marine biodegradability, OECD 306 is most requested by customers.

OECD 301B and OECD 306 are aerobic biodegradation tests that introduce a material to an inoculum in a closed environment and measure biodegradation of the material by CO₂ evolution.

The OECD 301B test method can be used for highly soluble, poorly

soluble, and even for materials with certain concentrations known to be insoluble. Common materials tested with OECD 301B include fuels, lubricants, oil, surfactants and personal care products. Formulations and other solutions can also be tested with the 301B.

Customers commonly request biodegradability and toxicology testing to simultaneously perform an environmental fate analysis on the test material to meet regulatory requirements for different product applications

Anaerobic biodegradation

ASTM D5511 is the most used standard test method for determining anaerobic biodegradation of plastic materials under high-solids anaerobic-digestion conditions.

Our respirometer system can measure both emission of CO₂ and CH₄ gases from the test samples during degradation. ASTM D5511 test method covers the rate and degree of anaerobic biodegradability of plastic products when placed in a high-solids anaerobic digester from municipal solid waste. The anaerobic process is operated at temperatures of 50 - 52°C resulting in the conversion of carbon in the sample to gaseous CO₂/CH₄ under these conditions.

According to this standard method, we monitor the biodegradation in three steps, namely:

- (i) Disintegration/fragmentation of the test sample over time (primary degradation),
- (ii) Percentage biodegradation based on CO₂/CH₄ gases evolved, and
- (iii) Eco-toxicity after biodegradation.

List of standards available for biodegradation testing

Standards	Title
OECD 301B	OECD 301B is a frequently requested aerobic biodegradation test for liquids. OECD 301B is a 28-day respirometry test that analyses CO ₂ evolution and is suitable for both poorly soluble and absorbing material samples.
OECD 302	This test is used for the determination of the biodegradability of a solution typically not readily biodegradable. Often used for materials that are known to be insoluble.
OECD 306	OECD 306 is used when a material needs to be specifically shown to biodegrade in sea water. It requires the use of a marine water inoculum. It is often used in conjunction with the OECD 301/302 sludge inoculum protocol.
ISO 14852	Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium; method by analysis of evolved carbon dioxide
ISO 17088 & 14855:1	Determination of the ultimate aerobic biodegradability and disintegration of plastic materials under controlled composting conditions; method by analysis of evolved carbon dioxide. Amendment 1: Use of activated vermiculite instead of mature compost
ISO 17088 & 14855:2	Determination of the ultimate aerobic biodegradability and disintegration of plastic materials under controlled composting conditions. Part 2: Gravimetric measurement of carbon dioxide evolved in a laboratory-scale test
ISO 14593	Evaluates the ultimate aerobic biodegradability of organic compounds in aqueous medium. ISO 14593 is a minimum 28-day biodegradation test.
ISO 17556	Plastics: Determination of the ultimate aerobic biodegradability in soil by measuring the oxygen demand in a respirometer or the amount of carbon dioxide evolved

Standards	Title
ISO 20200	Plastics: Determination of the degree of disintegration of plastic materials under simulated composting conditions in a laboratory-scale test
EN 13432	Packaging: Evaluation of the ultimate aerobic biodegradability of packaging materials under controlled composting conditions; method by analysis of released carbon dioxide
EN 14047	Packaging: Determination of the ultimate aerobic biodegradability of packaging materials in an aqueous medium; method by analysis of evolved carbon dioxide
EN 17033	Biodegradable mulch films for use in agriculture and horticulture; requirements and test methods
prCEN/TR 15822	Plastics: Biodegradable plastics in or on soil; recovery, disposal and related environmental issues
ASTM D5209	Standard test method for determining the aerobic biodegradation of plastic materials in the presence of municipal sewage sludge
ASTM D5272	Standard practice for outdoor exposure testing of photodegradable plastics
ASTM D5510	Standard practice for heat aging of oxidatively degradable plastics
ASTM D5511	Standard test method for determining anaerobic biodegradation of plastic materials under high-solids anaerobic-digestion conditions
ASTM D5526	Anaerobic biodegradation test of plastic materials under accelerated landfill conditions
ASTM D5864	Determining aerobic aquatic biodegradation of lubricants or their components
ASTM D5988	Standard test method for determining aerobic biodegradation in soil of plastic materials or residual plastic materials after composting
ASTM D6400	Standard specification for labelling of plastics designed to be aerobically composted in municipal or industrial facilities
ASTM D5338	Standard test method for determining the degree and rate of aerobic biodegradation of plastic materials in a controlled composting environment
ASTM D6954	Standard guide for exposing and testing plastics that degrade in the environment by a combination of oxidation and biodegradation
PAS 9017-2018	Biodegradation of polyolefins in an open-air terrestrial environment
ASTM D6691	Standard test method for determining aerobic biodegradation of plastic materials in the marine environment by a defined microbial consortium
NF T51-800	Plastics: Specifications for plastics suitable for home composting
AS 5810	Biodegradable plastics suitable for home composting

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