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Plastics — Biodegradable mulch films for use in agriculture and horticulture —

Part 1: Requirements and test methods regarding biodegradation, ecotoxicity and control of constituents

Plastiques — Films de paillage biodégradables pour utilisation en agriculture et horticulture —

Partie 1: Exigences et méthodes d'essai concernant la biodégradation, l'écotoxicité et le contrôle des constituants

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

A list of all parts in the ISO 23517 series can be found on the ISO website.

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

Biodegradable mulch films are used worldwide in agriculture and horticulture for many years. They enhance growing conditions and contribute to increased yields and improved crop quality by, for example:

- inhibiting the development of weeds;
- reducing significantly the consumption of water and other resources;
- control of soil temperature;
- reduction in leaching of mineral elements and other fertilizer;
- reduction in soil compaction;
- protecting the crops from soil.

In addition, at the end of the intended service life it is no longer necessary for farmers to retrieve the biodegradable mulch film from the field for disposal or recycling after the harvest. Farmers can simply plow it under along with what remains from the plants.

This document defines the standard specification to be met for biodegradable mulch films to be used in agriculture and horticulture.

ISO 23517 consists of the following parts, under the general title *Plastics — Biodegradable mulch films for use in agriculture and horticulture*:

- *Part 1: Requirements and test methods regarding biodegradation, ecotoxicity and control of constituents*
- *Part 2: Requirements and test methods regarding product characteristics of mulch films*

Part 1 is suited to characterize both the plastic materials which are used to manufacture mulch films and the mulch films itself with respect to characteristics such as biodegradation, adverse effects on terrestrial organisms and control of constituents.

Part 2 is a product standard which can be used to characterize mulch films regarding relevant physical product characteristics including dimensional, mechanical and optical properties.

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Plastics — Biodegradable mulch films for use in agriculture and horticulture —

Part 1:

Requirements and test methods regarding biodegradation, ecotoxicity and control of constituents

1 Scope

This document is applicable to biodegradable plastic materials used to produce mulch films or biodegradable mulch films ready to be used for mulch applications in agriculture and horticulture.

Biodegradable mulch films are not designed to be recovered, but to be incorporated into soil at the end of the intended service life.

This document specifies test methods and evaluation criteria by addressing the following characteristics:

- a) Control of constituents
- b) Biodegradation
- c) Negative effects on terrestrial organisms

NOTE This document is construed in a way that it can be used to assess other soil biodegradable plastic products that do not qualify as mulch films. For example, drip tape, twine, clips, and plant pots.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10390, *Soil quality — Determination of pH*

ISO 11268-1, *Soil quality — Effects of pollutants on earthworms — Part 1: Determination of acute toxicity to Eisenia fetida/Eisenia andrei*

ISO 11268-2, *Soil quality — Effects of pollutants on earthworms — Part 2: Determination of effects on reproduction of Eisenia fetida/Eisenia andrei*

ISO 11269-2, *Soil quality — Determination of the effects of pollutants on soil flora — Part 2: Effects of contaminated soil on the emergence and early growth of higher plants*

ISO 11274, *Soil quality — Determination of the water-retention characteristic — Laboratory methods*

ISO 12846, *Water quality — Determination of mercury — Method using atomic absorption spectrometry (AAS) with and without enrichment*

EN 14582, *Characterization of waste — Halogen and sulfur content — Oxygen combustion in closed systems and determination methods*

EN 15408, *Solid recovered fuels — Methods for the determination of sulphur (S), chlorine (Cl), fluorine (F) and bromine (Br) content*

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ISO 15685, *Soil quality — Determination of potential nitrification and inhibition of nitrification — Rapid test by ammonium oxidation*

ISO 17294-2, *Water quality — Application of inductively coupled plasma mass spectrometry (ICP-MS) — Part 2: Determination of selected elements including uranium isotopes*

ISO 17556, *Plastics — Determination of the ultimate aerobic biodegradability of plastic materials in soil by measuring the oxygen demand in a respirometer or the amount of carbon dioxide evolved*

OECD, 2006), Test No. 208: *Terrestrial Plant Test: Seedling Emergence and Seedling Growth Test*, OECD Guidelines for the Testing of Chemicals, Section 2, OECD Publishing, Paris, <https://doi.org/10.1787/9789264070066-en>

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

mulch film

film made from thermoplastic material intended to be used in agriculture and horticulture to cover the ground in order to improve growing conditions of crops and depending on the colour to control weeds

Note 1 to entry: It is assumed that a transparent mulch film does not allow to control weeds.

[SOURCE: EN 17033:2018, 3.1.1]

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3.2

material

homogenous preparation of biodegradable polymer and additives, as necessary, such as carbon black and colour pigments

Note 1 to entry: Additives are usually introduced under the form of masterbatches using as carrier resin a biodegradable polymer.

[SOURCE: EN 17033:2018, 3.1.2]

3.3

ultimate aerobic biodegradation

breakdown of an organic compound by microorganisms in the presence of oxygen into carbon dioxide, water and mineral salts of any other elements present (mineralization) plus new biomass

[SOURCE: ISO/DIS 17088:2019, 3.9]

3.4

mineralization

decomposition of organic matter or organic substances into carbon dioxide, water and the hydrides, oxides or other mineral salts

[SOURCE: ISO 11074:2015, 3.3.19]

3.5

disintegration

physical breakdown of a material into fragments

[SOURCE: ISO 18606:2013, 3.3]

3.6**degradation**

irreversible process leading to a significant change in the structure of a material, typically characterized by a change 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

[SOURCE: ISO 472:2013, 2.262]

3.7**total dry solids**

amount of solids obtained by taking a known volume of test material or compost and drying at about 105 °C to constant mass

[SOURCE: ISO/DIS 17088:2019, 3.8]

3.8**volatile solids**

amount of solids obtained by subtracting the residue of a known volume of test material or compost after incineration at about 550 °C from the total dry solids of the same sample

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

[SOURCE: ISO/DIS 17088:2019, 3.10]

3.9**organic constituent**

chemical constituent that contains carbon covalently linked to other carbon atoms and to other elements, most commonly hydrogen, oxygen or nitrogen

Note 1 to entry: Inorganic carbonates, carbides, cyanides and simple oxides such as carbon monoxide and carbon dioxide are not considered as organic constituent.

Note 2 to entry: Allotropes of carbon, such as diamond, graphite, carbon black, fullerenes, and carbon nanotubes are also not considered as organic constituent.

[SOURCE: ISO/DIS 17088:2019, 3.15]

3.10**natural soil**

soil collected from the surface layer of fields and/or forests

[SOURCE: EN 17033:2018, 3.3.1]

3.11**per- and poly-fluorinated compound****PFC**

organofluorine compounds containing only carbon-fluorine bonds and carbon-carbon bonds but also other heteroatoms

4 Basic requirements**4.1 General**

In order to be identified as a biodegradable mulch film in accordance with this document, the mulch film or the material of the mulch film under investigation shall fulfil all requirements specified in [Clause 4](#) and [Clause 5](#), respectively.

If not, all requirements are met, no reference to this document shall be made.

4.1.1 Control of constituents

The mulch film or the material of the mulch film shall be identified and characterized prior to testing including

- determination of the presence of regulated metals and other elements;
- determination of the presence of per- and poly-fluorinated compounds (PFC) (determined as fluorine);
- evaluation of the presence of other hazardous substance as specified in [Annex B](#);

taking legal compliance into consideration.

In addition, volatile solids shall be determined.

4.1.2 Ultimate aerobic biodegradation

The ultimate level of aerobic biodegradation shall be established by testing under controlled conditions as laid down in chapter [5.2.1](#).

4.1.3 Negative effects on terrestrial organism

The mulch film or the material of the mulch film shall have no adverse effects on terrestrial organisms.

5 Detailed requirements

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5.1 Control of constituents

5.1.1 Regulated metals and other elements

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The concentrations of regulated metals and other elements in a mulch film or material of the mulch film shall be less than 50 % of those prescribed for sludges, fertilizers and composts in the country where the final product will be placed on the market or disposed of (see [Annex A](#) for examples).

Regulated metals and other elements shall be determined and reported.

5.1.2 Per- and poly-fluorinated compounds (PFCs)

From a precautionary perspective, per- and poly-fluorinated compounds (PFCs) shall not be intentionally added to a mulch film or to a material of the mulch film.

The concentration of per- and poly-fluorinated compounds (PFCs) in the mulch or material of the mulch film shall be determined and reported as fluorine.

The concentration of per- and poly-fluorinated compounds (PFCs) shall be less than 100 mg fluorine/kg material (dry matter) (see [Annex B](#)).

NOTE 1 Most of per- and poly-fluorinated compounds (PFCs) are extremely persistent in the environment and in addition, certain PFCs are suspected to have bioaccumulative properties and adverse effects for environment and human health.

NOTE 2 Per- and poly-fluorinated compounds (PFCs) have been frequently used as surface-treatment agents in e.g. tableware in order to enhance grease resistance or to control water permeability.

5.1.3 Other hazardous substances

From a precautionary perspective, hazardous substances as specified in [Annex B](#) shall not be intentionally added to a mulch film or material of the mulch film.

Information on the use of hazardous substances shall be recorded and can be based on a self-declaration.

5.1.4 Volatile solids

A mulch film or material of a mulch film shall contain a minimum of 50 % of volatile solids.

Volatile solids shall be determined and reported.

5.2 Ultimate aerobic biodegradation

5.2.1 Test method and evaluation criteria

The ultimate aerobic biodegradability shall be determined for the whole material or for each organic constituent.

Test samples shall not be subjected to conditions or procedures, such as a pretreatment by heat and/or an exposure to radiation exposure, designed to accelerate biodegradation prior to testing according to ISO 17556.

The material is considered to have demonstrated a satisfactory rate and level of biodegradation in soil if, when tested in accordance with ISO 17556, it achieves a minimum biodegradation percentage as specified hereunder;

- a) 90 % of the organic carbon shall have been converted to CO₂ by the end of the test period (relative to a reference material). Both the reference material and the test item shall be tested for the same length of time and the results compared at the same point in time;
- b) as an alternative, 90 % (in absolute terms) of the organic carbon shall have been converted to carbon dioxide by the end of the test period.

If the level of biodegradation exceeds 90 % (relative to a reference material or in absolute terms), then the biodegradation test can be terminated. However, the test period shall be no longer than 2 years.

The biodegradation test shall be performed at a temperature constant to within ± 2 °C in the range between 20 °C and 28 °C, preferably 25 °C.

Use as reference material a well-defined biodegradable polymer [microcrystalline-cellulose powder or ashless cellulose filters]. If possible, the physical form and size of the reference material should be comparable to that of the test material.

The validity criteria as stated in ISO 17556 shall be fulfilled.

NOTE Biodegradability is assessed by measuring the mineralization level i.e. the conversion of the organic carbon of a product or a material into CO₂ with the consumption of O₂ under aerobic conditions, or into CO₂ and CH₄ under anaerobic conditions. During biodegradation, part of the organic carbon is also assimilated as biomass. This biomass yield typically ranges from 10 % to 40 %, depending on the substrate. As a consequence, the mineralization level will rarely reach 100 % also when the biodegradation is 100 %, because of biomass formation. Standard test methods for the accurate determination of product's or material's carbon assimilated in biomass during biodegradation are not available yet.

5.2.2 Requirements regarding constituents

Organic constituents which are present at concentrations of less than 1 % (dry mass) do not need to demonstrate biodegradability. However, the sum of such constituents shall not exceed 5 % (dry mass).

For organic constituents which are present in the material at a concentration between 1 % and 15 % (by dry mass), the level of biodegradation shall be proven separately according to [5.2.1](#).

As an alternative, the level of biodegradation of an organic constituent may be determined using an artificial blend of the same material. This artificial blend shall consist of at least 15 % of the respective organic constituent (by total organic carbon (TOC) content). The chemical composition and the

structure of the material shall remain the same, but the amount of the organic constituent under consideration shall be increased to a minimum of 15 % (by total organic carbon (TOC) content). The artificial blend shall be produced following the same processing conditions (e.g. extrusion) as used for the production of the original material containing less than 15 % (by dry mass) of the respective constituent.

In case that the artificial blend meets the criteria specified in 5.2.1 (in absolute terms), then the constituent is considered biodegradable in the context of this document. The constituent can then be used at the same (15 %) or lower concentration (<15 %; by dry mass) in a material that also contains the same co-substrate as the tested material.

NOTE 1 The objective of testing an artificial blend is to verify a synergistic effect on biodegradation of a non or moderately biodegradable constituent in the presence of a biodegradable co-substrate in the same material.

NOTE 2 The concentration of the constituent in the artificial blend was set at a minimum of 15 % in order to avoid false positive results, as theoretically a material with e.g. 10 % of a non- or moderately biodegradable constituent may still reach the pass level for biodegradation specified in 5.2.1.

Constituents that turned out to be readily biodegradable in a ready biodegradation test according to an OECD test guideline (OECD 301, Methods A to F^[25]; OECD 310^[27]) are considered as biodegradable in the context of this document.

Carbon black which is frequently used in mulch film is an inert solid. Therefore, it is not considered as an organic constituent and shall not be accounted in the calculation of the degree of biodegradation.

5.3 Negative effects on terrestrial organism

5.3.1 Ecotoxicity testing scheme (standards.iteh.ai)

Ecotoxicity tests shall be performed in order to investigate possible adverse effects caused by degradation products resulting from the degradation of the material of a mulch film in soil at the end of the intended service life.

The test scheme takes into account:

- all relevant terrestrial organism groups as plants, earthworms (invertebrates) and microorganisms;
- important ecological processes critical due to their role in maintaining soil functions as breakdown of organic matter, formulation of soil structure and cycling of materials;
- all relevant exposure pathways as soil pore water, soil pore air and soil material.

The link between soil organism groups of major ecological importance covering all significant soil exposure pathways and suitable test methods for the evaluation of ecotoxicity of the materials of mulch films and their degradation products is shown in Table 1.

Table 1 — Test scheme for the assessment of ecotoxicity

Organism group	Ecological process	Soil exposure pathway	Test methods
plants: - higher plants	primary production	mainly soil pore water (by root uptake)	plant growth test according to OECD 208 or ISO 11269-2 with the modifications specified in Annex C
invertebrates: - earthworms	breakdown of organic matter; formation of soil structure	diverse and multiple up-take routes: - soil pore water; - ingestion of soil material; - soil air	acute earthworm test according to ISO 11268-1 with the modifications specified in Annex D or alternatively chronic earthworm toxicity test according to ISO 11268-2 with the modifications laid down in Annex E