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Plastics — Carbon and environmental footprint of biobased plastics —

Part 2: Material carbon footprint, amount (mass) of CO_2 removed from the air and incorporated into polymer molecule

Plastiques — Empreinte carbone et environnementale des plastiques biosourcés

Partie 2: Empreinte carbone des matériaux, quantité (masse) de CO_2 captée dans l'air et incorporée dans les molécules de polymères

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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).

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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*.

A list of all parts in the ISO 22526 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

Increased use of biomass resources for manufacturing plastic products can be effective in reducing global warming and the depletion of fossil resources.

Current plastic products are composed of biobased synthetic polymers, fossil-based synthetic polymers, natural polymers and additives that can include biobased materials.

Biobased plastics refer to plastics that contain materials wholly or partly of biogenic origin.

Plastics — Carbon and environmental footprint of biobased plastics —

Part 2: Material carbon footprint, amount (mass) of CO_2 removed from the air and incorporated into polymer molecule

1 Scope

This document defines the material carbon footprint as the amount (mass) of CO_2 removed from the air and incorporated into plastic, and specifies a determination method to quantify it.

This document is applicable to plastic products, plastic materials and polymer resins that are partly or wholly based on biobased constituents.

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 472, *Plastics — Vocabulary*

ISO 16620-1, *Plastics — Biobased content — Part 1: General principles*

ISO 16620-2:2019, *Plastics — Biobased content — Part 2: Determination of biobased carbon content*

ISO 16620-3:2015, *Plastics — Biobased content — Part 3: Determination of biobased synthetic polymer content*

ISO 16620-4, *Plastics — Biobased content — Part 4: Determination of biobased mass content*

ISO 16620-5, *Plastics — Biobased content — Part 5: Declaration of biobased carbon content, biobased synthetic polymer content and biobased mass content*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472, ISO 16620-1, ISO 16620-2, ISO 16620-3, ISO 16620-4 and ISO 16620-5 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/

3.2 Symbols

m_{BSP} biobased synthetic polymer content, expressed as a percentage of the total mass

m_c fraction of carbon present in a product, in %

M_B biobased carbon content on a mass base (kg) per 1 kg of polymer

M_{CO_2} amount (mass) of CO_2 removed from the air and incorporated into 1 kg of the polymer

$M_{CO_2,x}$ amount (mass) of CO_2 removed from the air per 1 kg of each polymer

x_B^{TC} biobased carbon content by total carbon content, expressed as a percentage of the total carbon content

x_B^{TOC} biobased carbon content by total organic carbon content, expressed as a percentage of the total organic carbon content

3.3 Abbreviated terms

TC total carbon

TOC total organic carbon

4 Application

Material carbon footprint shall not be used for a communication on overall environmental superiority because the material carbon footprint covers only a single impact category.

5 Material carbon footprint

5.1 Principle

Material carbon footprint is based on the biobased carbon content of the biobased polymers, plastics or products. Therefore, material carbon footprint according to this document is applicable to plastic products, including semi-finished and finished plastic products, plastic materials, polymers, polymer resins, monomers or additives that are partly or wholly based on biobased constituents.

5.2 Determination of the biobased carbon content

Biobased carbon content of the product as % of the total organic carbon x_B^{TOC} or as % of the total carbon x_B^{TC} is experimentally determined using radiocarbon analysis as described in ISO 16620-2:2019, 8.3.1, 8.3.2 and 8.3.3.

5.3 Determination or calculation of biobased carbon content on a mass base

Biobased carbon content on a mass base (kg) per 1 kg of polymer (M_B) is determined or calculated using Formula (1):

$$M_B = \left(\frac{m_c}{100}\right) \times \left(\frac{x_B^{TOC} \text{ or } x_B^{TC}}{100}\right) \quad (1)$$

where m_c is the fraction of carbon present in a product, in %, and is

— experimentally determined with the elemental analysis, or

— calculated from the structural formulation.

5.4 Calculation of the amount (mass) of CO_2 removed from the air and incorporated into 1 kg of the polymer

5.4.1 Calculation from biobased carbon content on a mass base

The amount (mass) of CO_2 removed from the air and incorporated to 1 kg of biobased polymer (M_{CO_2}) is calculated using Formula (2):

$$M_{CO_2} = M_B \times \frac{44}{12} \tag{2}$$

5.4.2 Calculation from biobased synthetic polymer content

If the biobased synthetic polymer in the product is structurally determined, the amount (kg) of CO_2 removed from the air for 1 kg of each polymer can be calculated as described in Annex A. In this case, the amount (kg) of CO_2 removed from the air, M_{CO_2} , can be calculated using the biobased synthetic polymer content (m_{BSP}) as shown in Formula (3):

$$M_{CO_2} = M_{CO_2,x} \times m_{BSP} \tag{3}$$

where $M_{CO_2,x}$ is the amount (mass) of CO_2 removed from the air per 1 kg of each polymer.

Biobased synthetic polymer content (m_{BSP}) is determined as described in ISO 16620-3:2015, 6.2, Formula (1).

Annex A
(informative)

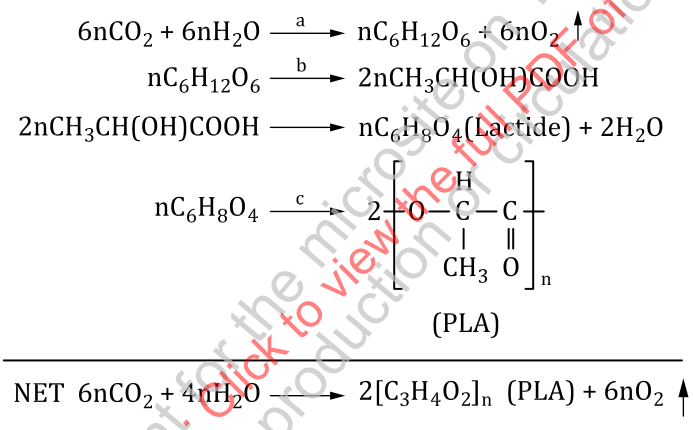
Calculation of the amount of CO_2 removed from the air for each polymer

A.1 General

Some examples are given in this annex for the calculation of the amount of CO_2 removed from the air from the chemical structure of each biobased polymer.

A.2 Polylactic acid (PLA)

In the case of PLA, 1,83 kg of CO_2 removed from the environment to manufacture 1 kg of PLA. See Figure A.1.

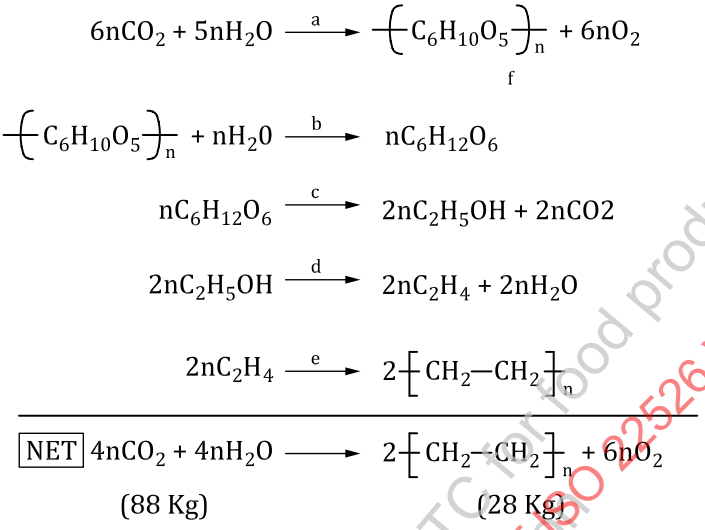


a Photosynthesis.
b Fermentation.
c Polymerization.

Figure A.1 — Polylactic acid (PLA)

A.3 Biobased polyethylene (bio-PE)

In the case of bio-PE, 3,14 kg of CO_2 removed from the environment to manufacture 1 kg of bio-PE. See Figure A.2.

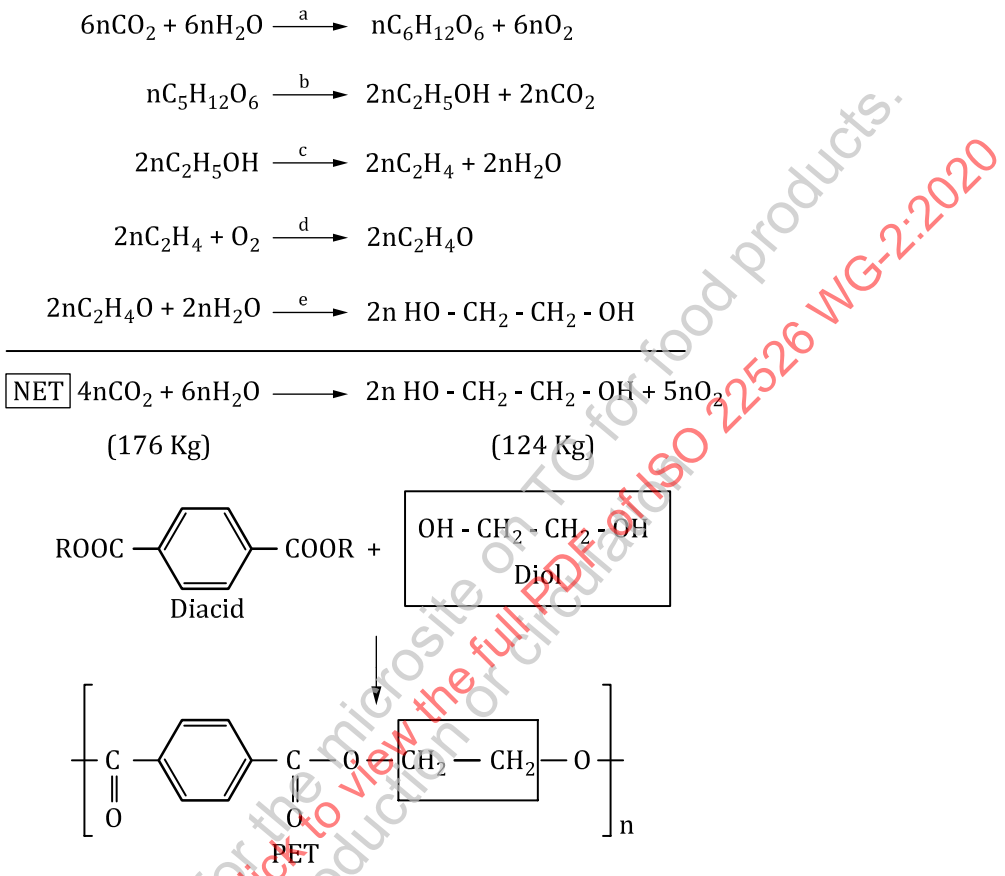


a Photosynthesis.
b Hydrolysis.
c Fermentation.
d Dehydration.
e Polymerization.

Figure A.2 — Bio-polyethylene (PE)

A.4 Biobased polyethylene terephthalate (bio-PET)

In the case of bio-PET, which is partially (about 30 %) biobased, 1,42 kg of CO_2 is removed from the air per kg of bio-mono ethylene glycol (bio-MEG). Further, 0,46 kg of CO_2 is removed from the air per kg of bio-PET.



Terephthalic acid = 8C; Ethylene glycol = 2C; biocontent is 20 % on total carbon or total organic carbon

Acid component = 68,75 %; glycol component = 31,25 % on total mass basis

a Photosynthesis.

b Fermentation.

c Dehydration.

d Oxidation.

e Hydrolysis.

Figure A.3 — Biobased polyethylene terephthalate (bio-PET)