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# Plastics — Carbon and environmental footprint of biobased plastics —

## Part 1: General principles



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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.



This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 14, *Enviromental 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 1: General principles

## 1 Scope

This document specifies the general principles and the system boundaries for the carbon and environmental footprint of biobased plastic products. It is an introduction and a guidance document to the other parts of the ISO 22526 series.

This document is applicable to plastic products and plastic materials, polymer resins, which are based from biobased or fossil-based 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 14020, *Environmental labels and declarations — General principles*

ISO 14040, *Environmental management — Life cycle assessment — Principles and framework*

ISO 14044, *Environmental management — Life cycle assessment — Requirements and guidelines*

ISO 14067, *Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification*

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

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

ISO 16620-3, *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 and definitions

For the purposes of this document, the terms and definitions given in ISO 472, ISO 14067, ISO 16620-1, ISO 16620-2, ISO 16620-3, ISO 16620-4, ISO 16620-5 and the following 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**
**carbon and environmental footprint**
life cycle assessment of biobased plastics products with considerations on the specific situations for biobased materials and products on the removal of $CO_2$ from the air in comparison with fossil-based plastics products

Note 1 to entry: The definition of the term "environmental footprint" used here is different from that of the one used in European Union, which is composed of "Product environmental footprint" and "Organization environmental footprint".

**3.2**
**material carbon footprint**
amount (mass) of $CO_2$ removed from the air and incorporated into 1 kg of polymer molecule

**3.3**
**process carbon footprint**
carbon footprint for the process of converting the starting feedstock/resource to product at factory gate

## 4 General principles

**4.1** The general principles for the development and use of environmental labels and declarations established in ISO 14020 shall be followed for modifications that will fit the special assessment linked to the origin of the material.

**4.2** The general principles for guidance for decisions relating to both the planning and the conducting of an LCA in ISO 14040 shall also be followed.



## 5 Carbon and environmental footprint of biobased plastics



### 5.1 Principle

Carbon is the major basic element that is the building block of all plastics, fuels, and even life itself. Therefore, discussions on sustainability and environmental responsibility centre on the carbon footprint of bioplastics using biocarbon content analysis and life-cycle assessment of biobased plastics, in which the fossil carbon is replaced by bio-based carbon, offer the intrinsic value of a reduced carbon footprint and are in complete harmony with the rates and time scale of the biological carbon cycle. Identification and quantification of bio-based content is based on the radioactive C-14 signature associated with (new) biocarbon. Using experimentally determined biocarbon content values, one can calculate the intrinsic $CO_2$ emissions reduction achieved by substituting petrocarbon with biocarbon — the material carbon footprint. The process carbon footprint arising from the conversion of feedstock to final product is computed using life-cycle assessment methodology. The issue is of managing carbon (carbon-based materials) in a sustainable and environmentally responsible manner. Indeed, the burning issue of today is concern over increasing human-made $CO_2$ emissions with no offsetting sequestration and removal of the released $CO_2$. Reducing our carbon footprint is a major challenge. Reduced $CO_2$ emissions translate to minimizing global warming-climate change problems.

### 5.2 Material carbon footprint

Switching the manufacturing base (the origins of the carbon) from fossil carbon feedstock to bio-based carbon feedstock offers an intrinsic zero material (i.e. referred to the feedstock of the product) carbon footprint potentiality. This can be seen by reviewing biological carbon cycle. Nature cycles carbon through various environmental compartments with specific rates and time scales, as shown in Figure 1. Carbon is present in the atmosphere as inorganic carbon in the form of $CO_2$. The current level of $CO_2$ in the atmosphere is around 380 ppm (parts per million) and is increasing. $CO_2$ and other greenhouse gases in the atmosphere trap the sun's heat from radiating back to space, thereby providing a life-sustaining average planet temperature of 7,2 °C (45 °F).

 

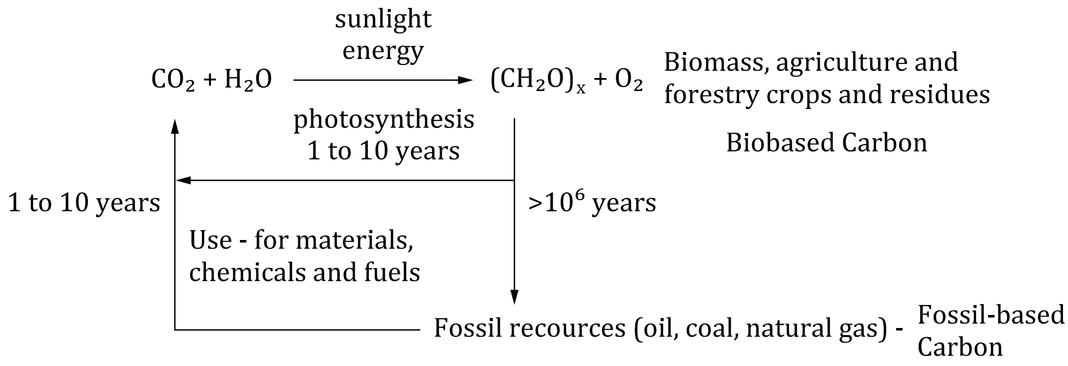


**Figure 1 — Biological carbon cycle-value proposition for using biorenewable carbon instead of fossil-based carbon feedstock**

Increasing levels of $CO_2$ and other greenhouse gas emissions to the atmosphere traps more of the sun's heat, thereby raising the average temperature of the planet. While one might debate the severity of the effects associated with this or any other target level of $CO_2$, there can be no disagreement that an uncontrolled, continued increase in levels of $CO_2$ in the atmosphere will result in a slow perceptible rise of the earth's temperature, global warming, and with it an associated severity of effects that will affect life on this planet as well known.

It is therefore prudent and necessary to try and maintain current $CO_2$ levels — the "zero carbon" approach. This can best be done by using renewable biomass crops to manufacture carbon-based products so that the $CO_2$ released at the end-of life of the product was that originally captured by the crops, so that no extra $CO_2$ is added to the atmosphere. Specifically, the rate of $CO_2$ release to the environment at end-of-life equals the rate of photosynthetic $CO_2$ fixation by the original crops planted — a zero material carbon footprint, in case of total oxidation into $CO_2$ of the feedstock. In the case of fossil feedstock, the rate of carbon fixation is measured in millions of years, while the end-of-life release rate into the air is in 1 to 10 years. The math is simple, and this is not sustainable. It causes more $CO_2$ release than fixation, resulting in an increased carbon footprint and, with it, attendant global warming and climate change problems.



Based on the previous carbon cycle discussion and using basic stoichiometry, it was calculated that for every 100 kg of polyolefin (polyethylene, PE; polypropylene, PP) manufactured, a net 314 kg $CO_2$ is released into the air at its end-of-life (100 kg of PE contains 85,7 % kg carbon and upon combustion will yield 314 kg of $CO_2$ (44/12) × 85,7). Similarly, PET (polyethylene terephthalate) contains 62,5 % carbon and would result in 229 kg of $CO_2$ released into the air at end-of life. However, if the carbon in the polyester or polyolefin comes from a biological feedstock, the net release of $CO_2$ into the air is zero, because the $CO_2$ released is fixed in a short time period by the next crop or biomass plantation (see Figures 2, 3 and 4). This is the intrinsic zero material carbon footprint for using a bio/renewable feedstock.