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Editorial corner – a personal view

Let's talk about the definitions: Bioplastics, biopolymers, biodegradable polymers and others

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Definitions form the basis of our knowledge and are intended to provide clarity. They help us break down complex ideas. Without clear definitions, concepts have different meanings to different people, leading to confusion and misunderstanding. However, definitions are not static; over time, as society and science develop, so do definitions. As 'green' polymers emerge, their scientific field and related knowledge are also developing and evolving. Communication related to the field can lead to misunderstandings in different segments of society, which affects our views and decisions. The terms such as bio-based, biopolymer, bioplastic, degradable, biodegradable, etc. might seem similar, but their meanings can differ considerably. This editorial corner aims to compare the various definitions of the most important terms related to the field and to make suggestions for their use.

As we build a circular society and economy, two important aspects of polymeric materials are usually left open. Where are they coming from (fossil-based or biobased) and what are the possible interactions with the environment?

The feedstock can be fossil-based or bio-based. Fossil-based polymers are called 'conventional', while according to International Union of Pure and Applied Chemistry (IUPAC), a **bio-based polymer** is: 'composed or derived in whole or in part of biological products issued from the biomass (including plant, animal, and marine or forestry materials)' (https://doi.org/10.1351/PAC-REC-10-12-04). The European Bioplastics association defines the term bio-based similarly: '»biobased« means that the material or product is (partly) derived from biomass (plants)'. The authors simply suggest that a **bio-based polymer** is: 'A significant part of the material is created from biomass'. The definition of **bio-based plastics** is covered, for example, in 'Council regulation 2025/40': 'plastics made from biological resources, such as biomass feedstock, organic waste or by-products, regardless of whether they are biodegradable or non-biodegradable plastics' (https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri= OJ:L_202500040).

Considering the interactions with the environment, a polymer can be biodegradable or non-biodegradable. IUPAC has a definition for **biodegradation:** 'Breakdown of a substance catalysed by enzymes *in vitro* or *in vivo*' (https://goldbook.iupac.org/terms/view/B00656). According to ISO 472:2013, **biodegradation** is 'caused by biological activity especially by enzymatic action, leading to a significant change in the chemical structure of the material'. Also a definition from Mastropetros *et al.*: 'Biodegradation is a term that refers to a collection of biological processes that break down and convert organic matter to inorganic matter. Biodegradation is carried out by degraders, which are microorganisms (fungi, bacteria, and protozoa) that proliferate on decomposing organic matter, which is formed by ecosystems' (https://doi.org/10.1016/j.biotechadv.2022.107999). (Note

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that this description is a modified version of what was provided by Razza and Degli Innocenti (https://doi.org/10.1002/apj.1648)). If we really consider the circularity of the economy in the case of polymers and plastics, we suggest a more straightforward definition for **biodegradation**: 'a biological process during which microorganisms that can be found in the medium break down the (plastic) material into natural substances, *e.g.* water, carbon dioxide, compost (artificial additives are not required)'. Partial and full biodegradation can be achieved via composting, industrial composting, home composting, etc., depending on the type of polymer, the properties of the product produced and other factors.

Based on the definitions mentioned above, we can now determine the definition of a biopolymer. According to IUPAC, biopolymers are 'macromolecules (including proteins, nucleic acids and polysaccharides) formed by living organisms'. In contrast, the term **bioplastics** is more complex. European Bioplastics defines **bioplastic** as 'a plastic material is defined as a bioplastic if it is either biobased, biodegradable, or features both properties' (https://www.european-bioplastics.org/bioplastics/). The authors suggest using a similar, standard-based definition: 'A plastic material can be called bio if it is biobased, biodegradable, or both bio-based and biodegradable' (EN 16575:2015).

To ensure transparent and non-misleading communication with consumers, the prefix 'bio' should be replaced with precise terminology that refers to a European or international standard. By applying these definitions and referring to standards, we can clearly distinguish between different material types and their characteristics. The accurate use of terminology and its integration into everyday life brings clear communication. Such knowledge is essential for the proper utilisation of these new materials.