SLOVENSKI STANDARD
SIST-TP CEN/TR 15822:2010

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Polimerni materiali - Biorazgradljivi polimerni materiali v ali na tleh - Predelava, odlaganje in sorodna okoljska vprašanja

Plastics - Biodegradable plastics in or on soil - Recovery, disposal and related environmental issues

Kunststoffe - Bioabbaubare Kunststoffe in oder auf Böden - Verwertung, Entsorgung und verwandte Umweltthemen

Plastiques - Plastiques biodégradables dans et sur les sols - Valorisation, élimination et problèmes environnementaux associés

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Contents

Page

Foreword

This document (CEN/TR 15822:2009) has been prepared by Technical Committee CEN/TC 249 “Plastics”, the secretariat of which is held by NBN.

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Introduction

Biodegradable plastics are a broad class of materials, encompassing various types of very different polymers and final products, which have been classified in different ways.

CEN/TC 249/WG 9 has previously prepared a Technical Report [1], intended to harmonise the terminology to be used in the field of degradable and biodegradable polymers and plastic items. It is based on scientific considerations and on a technical analysis of the various stages and mechanisms involved in the degradation of plastics; its use should help to avoid misleading claims or statements and to increase the knowledge in the field.

It should be clear that, as for any other material, the overall environmental impact of using biodegradable plastics, and the related environmental issues, should be assessed on the basis of their entire life cycle in a given system, e.g. according to the requirements of EN ISO 14040 series of standards on Life Cycle Assessments. Furthermore, the communication of the results of such assessments is governed by other ISO standards (e.g. EN ISO 14020 series on Environmental Labels and Self-claims, ISO 14063 on environmental communication).

All of these standards aim to harmonise the approaches to environmental issues, and play an important role in preventing confusion in the mind of target audiences.

In the perspective of sustainability, it is also important to note that the environmental dimension and related issues are only one of the three dimensions which need to be considered, the others being social and economic dimensions.

1 Scope

This Technical Report is intended to summarise the current state of knowledge and experience in the field of biodegradable plastics which are used on soil or end up in soil. It also addresses the links between use, disposal after use, degradation mechanisms and the environment.

Therefore, this document is intended to provide a basis for the development of future standards. Its aim is to clarify the ideas and ensure a level playing field, without hiding possible needs for further research or areas of disagreement among experts.

2 General background

During the last decade several standardisation activities have been undertaken to characterise the behaviour of biodegradable polymers when exposed to composting conditions. A group particularly active in Europe was CEN/TC 261/SC 4/WG 2 (Packaging and environment/Organic recovery). The activity of this group was restricted to biodegradability and compostability of packaging. Other applications or other biodegradation environments were not addressed. This was due to the limits of the mandate given to CEN by the European Commission [2]. The standards to be developed were intended to give presumption of conformity with the essential requirements of the packaging and packaging waste directive [3] relating to biodegradability and compostability of packaging claimed to be "recoverable in the form of organic recovery" (i.e. composting and biogasification).

The resulting European Standard EN 13432 was finalized in 2000. This standard defines the requirements for composting of packaging; a new European Standard dealing with the evaluation of the compostability of plastics (EN 14995) has been completed recently.

In other applications of plastics, however, composting is not likely to be the final treatment. Several plastic materials and products have been designed for applications ending up in or on soil. They have been developed for applications where biodegradation is beneficial from a technical, environmental, social or economic standpoint. Examples can be found in agriculture (e.g. mulching film), horticulture (twines and clips, flower pots, pins, etc.), funeral items (e.g. body bags), recreation (e.g. plastic “clay” pigeons for shooting, hunting cartridges), etc. In many cases recovery and/or recycling of these plastic items is either difficult or not economically viable; various types of biodegradable plastics have been developed which have been designed to biodegrade and disappear in situ after their useful life.

So far, it has not been possible to reach a consensus on a single testing scheme to be applied to biodegradable plastics for such applications. The issue of "pre-treatment", i.e. exposure of specimens to light/heat realistically representing the field conditions, before testing the biodegradation in soil, has caused much discussion between involved parties.

Long-term effects, like the possible persistency and bio-accumulation of the remaining fragments or the release of harmful degradation species or of additives like heavy metals or metal compounds are also of concern.

However, there is general agreement that soil cannot be considered as a dumping location for plastic particles, no matter if they are proven safe, with no adverse effects on terrestrial or aquatic organisms, and if they are invisible.

Standards which define biodegradable plastics suitable for degradation in soil are important for industry, users and all stakeholders. It is important, for the development of such standards to refer to the findings of science and to robust evidence based on field experience as well as to identify the needs for further research and possible environmental improvement of products. This is a prerequisite for ensuring a “level playing field” for all biodegradable products. The only standard that currently exists is the French NF U 52-001:2005, *Biodegradable materials for use in agriculture and horticulture — Mulching products — Requirements and test methods*.

The following is a short summary of the most relevant published scientific evidence concerned with the degradation of biodegradable plastics in the environment. The discussion is based, at least in part, on many years of field experience of the use of plastics in agriculture (see bibliography for fuller information).

3 Polymer degradation in the environment – a reminder

3.1 General

The ultimate fate of a biodegradable plastic in the environment depends on the intrinsic properties of the material, in particular:

a) the chemical structure of the polymer; and

b) the way in which it has been converted to an industrial product and the nature of that product (e.g. thickness, incorporation of additives, etc.).

It also depends upon external factors, in particular:

c) the conditions to which the material is exposed in the environment before its final disposal or degradation into final residues; and

d) the final disposal option.

It is worth mentioning that the biodegradability of a plastic is directly related to the chemical structure of the polymer molecules, and not to the origin of the raw materials (petrochemical or biomass).

3.2 Degradation in outdoor conditions

There are two main routes that can lead from a plastic product to the ultimate stage, mineralisation and biomass formation, as shown in Figure 1 below (see also CEN/TR 15351 [1]). These are:

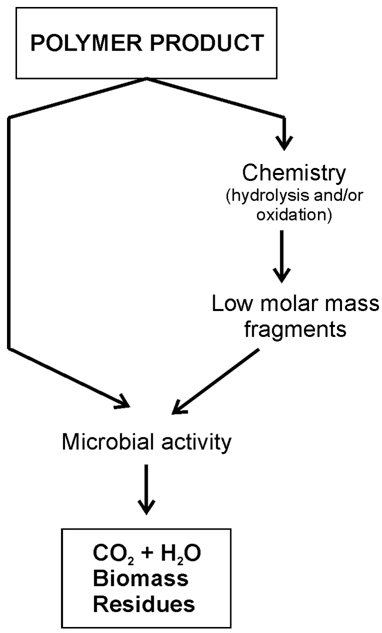

Figure 1 — Schematic of routes to biomineralisation

a) Cell-mediated degradation

The left-hand route corresponds to the attack of cellular enzymes on a polymeric substrate, followed by biochemical processing of the degradation products as a result of enzymatic reactions. This route requires the presence of appropriate enzymes and thus of specific cells under viable conditions (atmosphere, water, nutrients). In nature, enzymes cannot be found without the presence of living cells. In other words there is no degradation by living systems under conditions which do not support living organisms.

b) Chemically-mediated degradation

The right hand route differs from that of the left side in the sense that the breakdown of the polymer depends on abiotic chemical processes. Subsequently, only the small molecules generated by chemical degradation have to be eliminated through biochemical pathways. Here the conditions required to trigger chemical degradation are necessary (light, water, oxygen, heat, etc.). Without these influences there is no degradation. On the other hand, living cells have to be present to ensure the biochemical processing of the low molar mass molecules formed from the original polymer.

The most important abiotic factors are water, oxygen, temperature and sunlight. All may be significant for any given plastic, though their relative importance depends on the polymer structure and the intended use (e.g. application in/on soil). For example, plastics containing ester groups are more sensitive to hydrolysis (with or without the promoting effect of extracellular enzymes) than are polyolefins, but all plastics are affected to some extent by all three factors.

Sunlight is a source of both UV light and heat. The rate of photochemical reactions is also influenced by the temperature and an increase of temperature generally causes acceleration, with the degree depending upon the particular material. The overall effect of this combination of heat and light and humidity is normally referred to by polymer technologists as “weathering”. The combination of different environmental influences often produces a greater effect than either would produce alone, an effect known as synergism.

All plastics are affected by the synergistic effects of UV light, heat and water, leading to significant change in mechanical properties (e.g. elongation at break, Eb). In the case of saturated hydrocarbon polymers (e.g. polyethylene), this normally results in chain scission, due to peroxidation, followed by fragmentation. In the case of hydrolytically-degrading polymers, chain scission occurs by hydrolysis, again leading to fragmentation. However, hydrolytically-degrading polymers also photo-degrade. For example, polyesters, such as poly(lactic acid) (PLA) initially show molecular enlargement (cross-linking) on exposure to UV, but extended exposure leads to a rapid decrease in molecular weight..

4 Starting point and possible developments

EN 13432, applicable to packaging waste in the framework of the European directive on packaging and packaging waste, was developed with the main purposes of

- setting up a testing procedure to provide reliable and quantifiable results;
- preventing misleading claims of biodegradability under composting conditions;
- preventing negative effects of packaging residues on compost quality and their accumulation in or on soil;

whilst targeting two "organic recycling" options for packaging waste treatment as defined in the Directive, namely industrial composting and biomethanisation (or anaerobic digestion).

The above objectives remain valid for any biodegradable plastic at the end of its life. However, generalisation to all types of applications (mulching films, body bags, hygiene products, agricultural items, etc.), in all types of environmental conditions, has to take into account scientific findings and field experience.

The following principles should always govern the development of standards as well as the related communication on biodegradable plastics: