Open-BIO

Opening bio-based markets via standards, labelling and procurement

Work package 5

In situ biodegradation

Deliverable N° 5.9:

Draft test methods and specifications on marine degradation of bio-based materials

Public summary

Version: 1

Novara, October 2016

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The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° KBBE/FP7EN/613677.

1 Public summary

Open-Bio is a research project funded by the European Commission within FP7 (*7th Framework Programme for Research and Technological Development*). The goal is to investigate how bio-based products can be integrated into the market, using standardisation, labelling and procurement. One part of the project (WP5: In situ biodegradation) investigated the biodegradation performance of bio-based polymers in natural environments: soil, freshwater and the marine environment. A part of this research concerned the marine environment aiming to develop a methodology and a testing scheme for marine (bio)degradation.

The biodegradation and disintegration in marine environment of bio-based plastic materials were studied, the results and the test methods proposed and developed are described in deliverable 5.7 and 5.8, while the validation and the correlations between the different test scales (laboratory, mesocosm and field) are discussed in deliverable 5.6. Three laboratory tests for the determination of biodegradation, a full scale installation for the determination of disintegration in three marine habitats in real conditions (field tests) and finally a mesocosm test to assess the degradation of polymers under controlled marine conditions, were developed. This activity can be considered as **pre-normative research**. Different problems were identified and improvements were developed during the project. The variability of the results is the principal problem. The marine environment comprises 70% of our planet's surface and is composed of a set of many different micro- and macro-environments. It is difficult to standardize such a huge complexity and variety and a certain variability of results is expected. During the preparation phases of the project, in order to clarify "the system boundaries" it was decided to reproduce three specific marine habitats: the pelagic (free seawater), the eulittoral (wet coastal sediment) and the benthic (interface seawater/sediment to represent the seafloor conditions). These three environmental settings represent the most typical coastal marine habitats. For the laboratory experiments, matrices (seawater and sediments) from two different locations (Elba Island in Italy and Salamis Island in Greece) were used. The field experiments were carried out in the same two sites while the mesocosm test was performed only at Elba Island.

The laboratory methods determine **the inherent biodegradability** under optimal conditions while the field (or mesocosm) test analyses the **environmental fate** of a polymer when it is accidentally littered into the sea. The inherent biodegradability is a specific property of a material biodegraded under controlled laboratory conditions using inocula (microorganism from seawater or sediments) collected directly in natural environment. Therefore, a high biodegradation rate in the laboratory proves that in the real environment there are microorganisms able to attack the chemical structure of the material and transform it to CO_2, water and biomass. The laboratory test is by definition an accelerated test (optimal temperature, nutrients) so the link with the disintegration under real conditions (field test) or on a smaller scale (mesocosm) gives an idea of the minimum time necessary for an item

made from an inherently biodegradable material, to reach total disintegration, under real conditions.

To complete the characterization of a material, a control of hazardous substances and an ecotoxicological impact should be perform. Different ecotoxicity test methods applicable to a sediment or seawater are already published at ISO or ASTM level. About the examination of constituents a control of heavy metals and fluorine of the bio-based materials is advisable. The limits inserted in the harmonised standard EN 13432 *"Packaging: requirements for packaging recoverable through composting and biodegradation"* reported also in Open-Bio Deliverable 6.8 "Validated biogasification test" could be accepted also for materials biodegradable in marine environment.

The three laboratory test methods proposed in deliverable 5.7 were able to determine the biodegradation of plastic films under marine conditions. A series of improvements were proposed and incorporated in the final test methods. These cannot be considered ready for standardization at this stage as further refinements are necessary. Especially the reliability and reproducibility of the results should be improved. The biodegradation trends were similar, the plastic materials chosen for the inter-laboratory experimentation biodegraded (except LDPE negative control) but a high standard deviation was observed. Compared to the biodegradation results, it is not observed a clear difference between the two inocula (collected at Elba and Salamis).

The field test was developed for the determination of the disintegration of plastic materials. Although these materials were exposed in nature it was possible to recover the samples at different time points and to carry out the characterization. No sample has been lost during the trials. The results were different between the experiments in Elba Island and in Salamis Island. A fast disintegration was observed in the Greek location, where the test materials were totally disintegrated in some months in good agreement with the laboratory results. In contrast, a slow disintegration was observed in Elba Island. This difference is probably due to the different environmental conditions and physico-chemical composition of the sediments and seawater at the two sites. This different activity in natural environments can also occur in e.g. soil, another typical natural environment, where different degradation processes are expected if a plastic material is released in an acidic soil as compared to alkaline or neutral soil or soils with different organic matter contents and composition (sandy, loamy, desert or fertilized etc).

The extensive and coordinated research work carried out by the participating laboratories is expected to help the standardization process. About the test methods a lot of technical information came out from Open-Bio WP5, and these data and information could support future follow-up research and standardization projects on biodegradation in marine environment. All the activities and results reported in deliverables 5.6, 5.7 and 5.8 are considered pre-normative research and could be submitted to the interested CEN technical committee i.e. CEN/TC 249, Plastics, or CEN/TC 411, Bio-based products, for further

consideration. A possible wider validation procedure of the test methods may lead to an official standardisation procedure in the medium/long term.

It is premature to talk about specifications of biodegradable plastic material in marine environment. The focus at this moment should be on improving the testing methods. From a general point of view it is an accepted standard that the time limit for complete biodegradation under natural conditions is 90% of biodegradation (absolute or relative to positive control) in 2 years:

- Mulch films for organic farming: "The film demonstrates at least 90% biodegradation absolute or relative to microcrystalline cellulose in less than two years in soil, according to ISO 17556 or ASTM D5988 testing methods." *Federal Register / Vol. 78, No. 163 / Thursday, August 22, 2013 / Proposed Rules PART 205—NATIONAL ORGANIC PROGRAM page 52106*

- "When tested in accordance with EN ISO 17556, it achieves a minimum biodegradation percentage as specified hereunder within a test period no longer than 24 months. 90 % of the organic carbon shall have been converted to CO_2 by the end of the test period (relative to a reference material).
  CEN TC249 - prEN 17033. Plastics - Biodegradable mulch films for use in agriculture and horticulture - Requirements and test methods.

The marine environment is also a natural environment just like soil or freshwater. To keep the same requirement would help for a horizontal standardization approach. The only standard specification for biodegradable plastics exposed to natural sea water is ASTM 7081:2005 "Standard Specification for Non-Floating Biodegradable Plastics Exposed to Natural Sea Water". This standard specification was withdrawn in 2014 and is under consideration within an ASTM International technical committee.

Finally, a control of the material constituents (i.e. heavy metals, fluorine and hazardous substances) and an evaluation of the ecotoxicity after degradation, are advisable to complete the characterization.