Compostability and biodegradability of the bio-based materials

Deliverable 6.2

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Acronyms	Description
BOD	biological oxygen demand
BPC	Bioprocess Control
D	Deliverable
D_t	Biodegradation percentage
EN	European Standard
EoL	End of Life
EVA	Ethylene vinyl acetate
GA	Grant agreement
ISO	International Organisation for Standardization
MP	Microparticle
PES	Polyester
PHA	Polyhydroxyalkanoate
PHB	Polyhydroxybutyrate
PLA	Polylactic Acid
ThOD	Theoretical Oxygen demand of sample
TOC	Total Organic Carbon
UNE	Asociación Española de Normalización
W2BC	**Waste2BioComp**
ρT	Concentration of the test material in the reaction mixture
WP	Work Package

1. Introduction

This report relates the results achieved in Task 6.2 - Compostability and Biodegradability of the bio-based materials.

The main objective of this task was to check the biodegradability and/or compostability of the prototypes prepared from PHAs developed in Task 1 of the **W2BC** project, for the three value chains (footwear, textiles and packaging). For this purpose, aerobic biodegradation analysis in soil was done according to UNE-EN ISO 17556:2019 specifications to these prototypes. Toxicity analysis of the soil remaining from the biodegradability tests was assessed in Task 6.1 (see Deliverable 6.1) in order to check the possibility to compost.

Due to time constraints, it was not possible to test the biodegradability of the prototypes in other media.

This task is part if WP6 - Toxicity and sustainability assessment – where the study of toxicity and sustainability (biodegradability and LCSA) aspects were studied for the **W2BC** materials.

As part of Milestone 6 (Sustainable EoL for the **W2BC** materials), this report shows the biodegradability (and possibility to compost) of the materials develop din the project.

2. Work carried out in Task 6.2

The aim of this task was to assess the biodegradability of the bio-based demonstrators developed in the **W2BC** project (WP3 and WP4) for each value chain (footwear, textile and packaging). Different media were initially proposed to perform these biodegradability tests: soil and aqueous media as sea water/marine sediments and/or fresh water. However, as the biodegradability analysis are long in time (usually they take between 2 and 6 months, depending on the biodegradation rate of each material) only test in soil media could be attempted and completed.

2.1. Biodegradability test description

All the analysis were performed according to the following standard method: UNE-EN ISO 17556:2019, where the biodegradability data are obtained by oxygen demand determination.

An automatic Gas Flow measuring System (Gas Endeavour) from Bioprocess Control (BPC) Systems (Figure 1) was set up to carry out the biodegradation tests on the **W2BC** prototypes as soon as some promising materials from WP3 and WP4 were ready to be tested.

Figure 1 Biodegradability test ongoing in soil under the standard UNE-EN ISO 17556:2019.

The soil used for performing the analysis was analysed. Soil composition is described on Table 1.

Table 1 Soil composition used in the biodegradability tests

Weight (mg)	N %	C %	H %	S %	Total Organic Carbon-TOC %
1.581	1.44	42.59	4.83	0.26	
1.587					36.14

Biodegradation analyses in soil were made under the following conditions:

- T = 25.0 ± 0.1 ºC
- 3 replicates of each sample
- Powder form -> Obtained by cryogenic grinding by using a sieve with a pore size of 3 mm.

The biodegradability calculations were made by using the following equation:

$$D_t = \frac{B_{Tt} - B_{Bt}}{T \times \rho_T} \times 100$$

Where:

D_t: percentage biodegradation of test material over time

B_{Tt}: biological oxygen demand (BOD) of the sample

B_{Bt}: biological oxygen demand (BOD) of the inoculum

ρ_T: concentration of the test material in the reaction mixture: 1 grams/0.1 kg soil

T: ThOD Theoretical Oxygen demand of sample: mg/g sample

2.2. First trials on biodegradation analysis

First trials on the analysis of aerobic biodegradation in soil were made to the following samples:

- **Three-layer film** made by blown extrusion received from PROPAGROUP. The composition of these films was:

Layer A	PLA Ingeo 4032 D (from NatureWorks)	33 %
Layer B	PHA.K.3.3.1.4 (from task 1 W2BC)	33 %
Layer C	PLA Ingeo 4032 D (from NatureWorks)	33 %

- **Foam** samples received by NORA, with a composition (in weight%) of 55% PHB, 25% bio-based EVA and 15% Silica as filler, the remaining 5% were several additives.
- **Rigid plastic** samples made in UDC lab from PHA.B.2.2.0.4 + 2 wt.% MP (made from PHB Power Biomer)

Results of these first trials are shown in Figure 2 and the biodegradation percentage numerical values achieved for each sample at the end of the analysis are reported in Table 2.

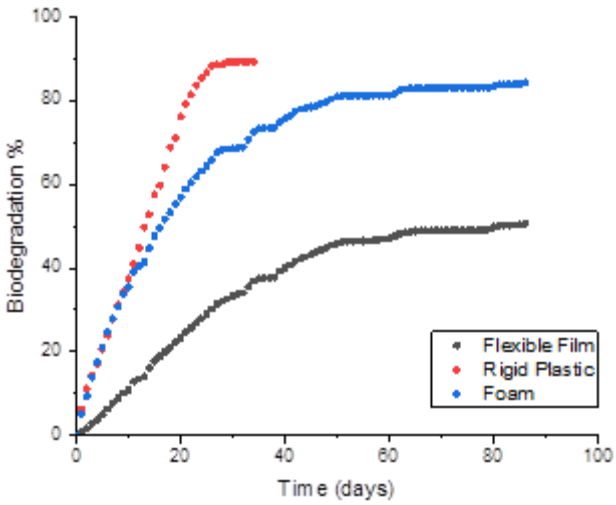

Figure 2 Biodegradation in soil under aerobic conditions curves for the first trials.

Table 2 Biodegradation percentage achieved for different biomaterials

Biomaterial	% Biodegradation achieved	Duration of analysis (days)
Three-layer film 33% PHA	50.6	86
Foam	84.2	86
Rigid plastic	89.3	34

2.3. Second trials on biodegradation analysis

The second trials on the analysis of aerobic biodegradation in soil were made to the following samples:

- **Three-layer film** made by blown extrusion received from PROPAGROUP. The composition of these films was:

Layer A	PLA Premium TecnoBi 26 (from ADBioplastics)	15 %
Layer B	PHA.K.3.3.1.4 (from task 1 W2BC)	70 %
Layer C	PLA Premium TecnoBi 26 (from ADBioplastics)	15 %

- **Textile** fabrics received by CITEVE with a composition of 100% PES
- **Textile** fabrics received by CITEVE which a composition of 100% PES and coated with 2% PHB.E.0

The results of these second trials, in the same conditions as the first trials, are shown in Figure 3 and the biodegradation percentage numerical values achieved for each sample at the end of the analysis are reported in Table 3.

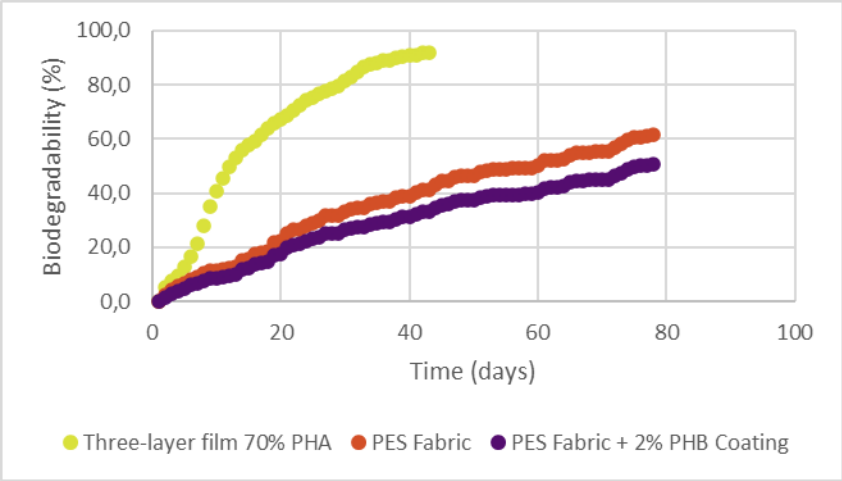

Figure 3 Biodegradation in soil under aerobic conditions curves for the second trials.

Table 3 Biodegradation percentage achieved for different biomaterials

Biomaterial	% Biodegradation achieved	Duration of analysis (days)
Three-layer film 70% PHA	92.1	42
PES Fabric	61.5	77
PES Fabric + 2% PHB coating	50.7	77

To analyze the compostability of the materials, the soil resulting from the finished biodegradability tests carried out at the UDC facilities were sent to CITEVE to study their toxicity and observe the plant growth in them (Task 6.1, see deliverable 6.1).

Finally, third trials on analysis of aerobic biodegradation in soil to textile samples are currently underway. Results will be showed in the final review meeting and in the final technical report.

3. Conclusions

Biodegradability tests performed on the different **W2BC** materials (insole foams, flexible plastics, rigid plastics, coated textiles) have all sown some aerobic degradation.

In the case of the foam, rigid plastic, and flexible film (70% PHA) prototypes, this was very high (84, 89 and 92%, respectively, after 86, 34 or 42 days), indicating their biodegradability according to the standard.

As for the textile samples, it is observed that the PHB coating treatment hardly affects the biodegradability of the fabric, which was expected given its very low percentage.

These results contributed to the accomplishment of milestone 6, in relation to the biodegradability of the **W2BC** materials.

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