POLYMATERIAL LTD.
LMPERIAL COLLEGE LONDON I-HUB WHITE CITY CAMPUS,84 WOOD LANE, LONDON W12 0BZ
UNITED KINGDOM

样品描述	:	BPE
Ploymateria 样品 ID	:	JJ1200(+)
材料类型	:	BPE
材料成分	:	BPE
供应商	:	深圳市恒昌泰科技有限公司
		**********
到样日期	:	2023 年 07 月 05 日
测试周期	:	2023 年 07 月 05 日至 2023 年 08 月 28 日

测试项目	PAS 9017 测试要求	样品	结论
聚烯烃产品类别	附录 B	BPE	/
羰基指数	>1	1.54	符合
数均分子量（M_n）	<5000 Da	1560 Da	符合
Z均分子量（M_z）	<30000 Da	9009 Da	符合
重均分子量（M_w）损失百分比%	>90%	95.0%	符合
幼苗出苗和幼苗生长试验[1]	OECD 208	-	有效
大型溞繁殖试验[1]	OECD 211	-	有效
蚯蚓繁殖试验[1]	OECD 222	-	有效
土壤生物降解测试[2]	>90%	94.28%	符合

备注：

1. 测试结果符合 OECD 208，222 和 211 标准的生态毒性要求，测试在 RECETOX 完成，详见报告后附的生态毒性声明文件，该声明文件遵循 PAS9017 相关要求。
2. 测试结果符合 PAS9017 相关要求，依据 ISO 17556 方法并在 AIMPLAS 完成测试，测试样品在 278 天内实现了 94.28%的生物降解。测试数据详见附件“AIMPLAS 报告 AST-21-097-06”。
3. GB/T 22047-2008 等同采用 ISO 17556-2003《土壤中塑料材料最终需氧生物分解能力的测定 通过测定密闭呼吸计中需氧量或测定释放的二氧化碳的方法》，技术性内容完全相同。

通标标准技术服务（上海）有限公司
授权代表签署

张晓宁
授权签字人

详情如下：

测试项目	报告编号	发布日期	实验室名称	测试标准	测试结果
土壤生物降解测试	AST-21-097-06	07/02/2023	AIMPLAS	ISO 17556	有效

测试步骤：

UV 老化测试参数应符合 PAS 9017:2020 规定，参照 ASTM D4329 / ISO 4892-3。

测试条件：
灯管： UVA-340
循环条件：黑板温度（60±2）℃，1 小时光照，黑板温度（60±2）℃，23 小时冷凝
辐照度：（0.80±0.02） W/（m^2•nm） @340nm
总测试时间：336h

采样频率：
采样频率以小时计，与 UV 老化设备的测试时间有关。见下表。

每个采样间隔，从 UV 老化设备中取出一个样品（2.5”x 5.5”）并放入袋子中，用来进行后续分析。装有样品的袋子上应贴上包含样品 ID 和采样时间信息的标签。

频率（小时）	材料
	B
0	红外 & 凝胶渗透色谱
72	红外
168	红外
240	红外
336	红外 & 凝胶渗透色谱

样品分析：

1. 傅立叶红外

配备衰减全反射（ATR）附件的 Thermo Nicolet IS10 FTIR，用于样品的红外分析。

ATR 是一种与红外光谱结合使用的采样技术，可以直接在固态或液态下检查样品而无需进一步制备，可在预处理后立即对样品进行测试。FTIR 设备每年由赛默飞世尔工程师进行校准、维修和维护。
每种材料、每个采样时间点测试三个平行样。FTIR 测试参数如下：

- 波数范围：550 cm^{-1} 至 4000 cm^{-1}
- 扫描分辨率：4 cm^{-1}
- 扫描次数：32 次
- 后台扫描次数：每次采样前 32 次

根据 FTIR 测试中采集的光谱，羰基峰，并计算羰基指数，羰基指数 CI 计算方式如下：

$$羰基指数 = \frac{波数\ 1714\ cm^{-1}\ 周围的羰基峰面积}{波数\ 1470\ cm^{-1}\ 周围的CH_2\ 剪刀峰面积}$$

在计算羰基指数时，使用以下峰区域：

羰基峰：1650 cm^{-1} to 1850 cm^{-1}

CH_2 峰：1420 cm^{-1} to 1500 cm^{-1}

2. 凝胶渗透色谱

通过将 10 mL 溶剂加入 20 mg 样品来制备溶液，将制备的溶液加热并在 160℃下震荡 4 小时，或直至样品溶解。将试样放置在自动进样器中，自动进样每个小瓶的部分内容物。本节中的所有质量、体积、时间和温度都只是近似值。

- 仪器：安捷伦 PL GPC220
- 色谱柱：混合 B
- 溶剂 µm：1，2，4-三氯苯（含抗氧化剂）
- 流速：1.0 毫升/分钟（标称），
- 温度：160°C （标称），
- 检测器：示差折光和光散射

数据采集和后续数据处理均使用安捷伦科技公司的“Cirrus”软件进行。
GPC 系统使用一系列已知分子量的安捷伦/聚合物实验室 EasiVial PS-H 聚苯乙烯标准品进行校准，应用 Mark-Houwink 参数校正线性聚乙烯或聚丙烯均聚物的结果（使用的 Mark Houwink 参数见下表）。

Mark Houwink 参数	聚苯乙烯（标准品）	聚丙烯
Alpha	0.65	0.725
K x 10^{-5} dL/g	19	19

样品是完全可溶的。溶液过滤或色谱都没有明显的问题。

测试结果：

1. 羰基指数均值（CI）

样品	UV 光老化后羰基指数均值（CI）				
时间	0h	72h	168h	240h	336h
样品	0.05	0.04	0.78	0.97	1.54
标准方差	0.01	0.01	0.02	0.01	0.03

附录 – 红外测试数据

		样品		
		峰面积 1850-1650 cm^{-1}	峰面积 1500-1420 cm^{-1}	羰基指数 (CI)
初始样品	1	0.18	3.02	0.06
	2	0.12	3.01	0.04
	3	0.13	3.08	0.04
	均值	0.14	3.04	0.05
	标准方差	0.03	0.04	0.01
UV 老化 72h	1	0.10	3.21	0.03
	2	0.14	3.24	0.04
	3	0.16	3.20	0.05
	均值	0.13	3.22	0.04
	标准方差	0.03	0.02	0.01
UV 老化 168h	1	2.23	2.81	0.79
	2	2.19	2.87	0.76
	3	2.37	2.98	0.80
	均值	2.26	2.89	0.78
	标准方差	0.09	0.09	0.02
UV 老化 240h	1	2.70	2.79	0.97
	2	2.40	2.47	0.97
	3	2.90	2.95	0.98
	均值	2.67	2.74	0.97
	标准方差	0.25	0.24	0.01
UV 老化 336h	1	4.76	3.02	1.58
	2	4.45	2.93	1.52
	3	4.71	3.07	1.53
	均值	4.64	3.01	1.54
	标准方差	0.17	0.07	0.03

2. 分子量测试

	Mw 初始	Mw 336h	Mn original	Mn 336h	Mz original	Mz 336h	Mw 损失百分比 (%)	Mw/Mn (PD) 初始	Mw/Mn (PD) 336h
样品	89995	4476	26372	1560	218627	9009	95.0%	3.41	2.87
标准方差	1473	143	4282	277	16919	600	/	/	/

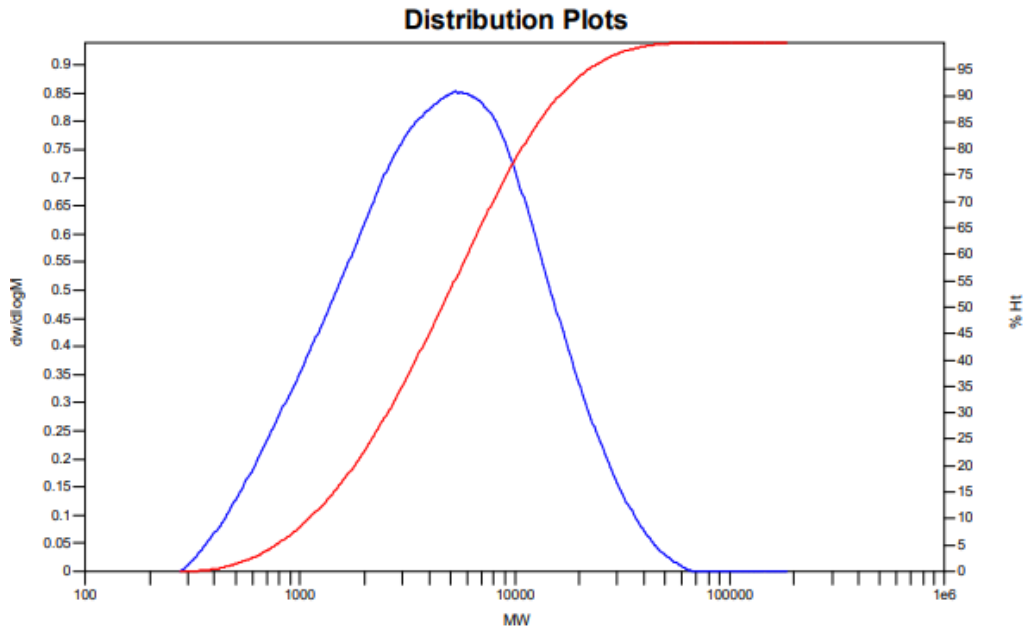
备注：Mw：重均分子量；Mn：数均分子量；Mz：Z 均分子量

附录 – 凝胶渗透色谱测试数据

条件		样品
Mw, 初始样品	1	90137
	2	88456
	3	91392
	均值	**89995**
	标准方差	1473
Mw, UV 老化 336h	1	4552
	2	4311
	3	4564
	均值	**4476**
	标准方差	143
Mn, 初始样品	1	21578
	2	29816
	3	27721
	均值	**26372**
	标准方差	4282
Mn, UV 老化 336h	1	1241
	2	1697
	3	1741
	均值	**1560**
	标准方差	277
Mz, 初始样品	1	231793
	2	199544
	3	224543
	均值	**218627**
	标准方差	16919
Mz, UV 老化 336h	1	9521
	2	8349
	3	9156
	均值	**9009**
	标准方差	600

备注：GPC测试分包广州特种承压设备检验研究所

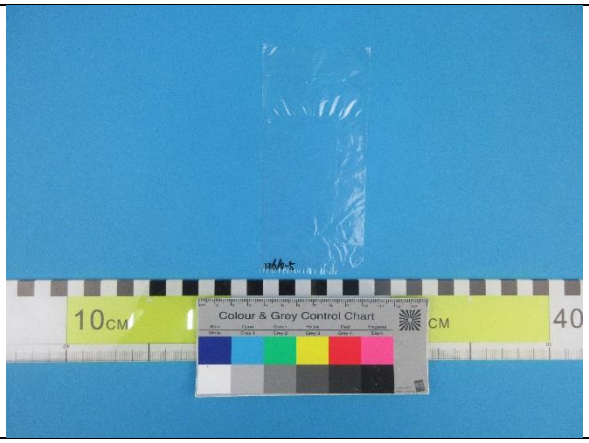
GPC分布图：



测试样品：样品 B

测试前

测试 72h 后（样品 ）



测试 168h 后（样品 ）

测试 240h 后（样品 ）

测试 336h 后（样品 ）

Research Centre for Toxic Compounds in the Environment

1

Ecotoxicity Statement

This statement confirms that plastic products biotransformed by Polymateria's additive technologies, specified hereunder, have met all ecotoxicity criteria set out by BS PAS 9017:2020 for:

- **Freshwater aquatic and;**
- **Soil invertebrates and;**
- **Plant eco-toxicity**

And can thus be considered safe for contact in these environments.

The testing and reporting were conducted at RECETOX, a third-party laboratory ISO17025: 2005 accredited for chemical trace analysis and conducting the research, development and utilization of environmental eco-toxicity testing.

Persons responsible for the ecotoxicological testing and reporting – Mgr. Jana Vašíčková, Ph.D. & Mgr. Marek Šudoma, Ph.D.

Study dates: 22nd December 2020 - 20th February 2021

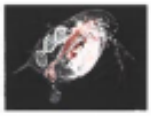
Place of study - Research Centre for Toxic Compound in the Environment (RECETOX), Faculty of Science, Masaryk University, Brno, Czech Republic.

Biotransformed products in study:

Sample ID	Description of the material tested	PAS 9017 Annex B category
Product 8	Plastic bottle (PP) containing Masterbatch formulation No. 1 of Cycle+	Polypropylene (+ BA)
Product 9	Plastic film (PE) containing Masterbatch formulation No. 1 of Cycle+	Polyethylene (+ BA)

Biotransformed products met criteria for:

- Chronic toxicity:

OECD 208	OECD 211	OECD 222
		
Terrestrial plants	*Daphnia* sp.	Earthworm

OECD 208: Terrestrial plant test (*Sinapis alba* and *Hordeum vulgare*): Terrestrial Plant Test: Seedling, Emergence and Seedling Growth Test
OECD 211: *Daphnia magna* Reproduction Test (freshwater aquatic eco-toxicity test).
OECD 222: Earthworm reproduction test (*Eisenia fetida*).

Conclusion: The trial concluded that the biotransformed plastic products (PP and PE) containing Polymateria's technologies (Cycle+) have met the criteria for all ecotoxicity tests required to reach BS PAS 9017 specfication and can thus be considered safe for contact in soil, plant and water environments.

Professor Luděk Bláha
Deputy Director of RECETOX

Signature.....

In Brno, CZ, on date 30th April, 2021

Stamp:

MASARYKOVA UNIVERZITA
Přírodovědecká fakulta
Centrum pro výzkum
toxických látek v prostředí
Kotlářská 2, 611 37 Brno

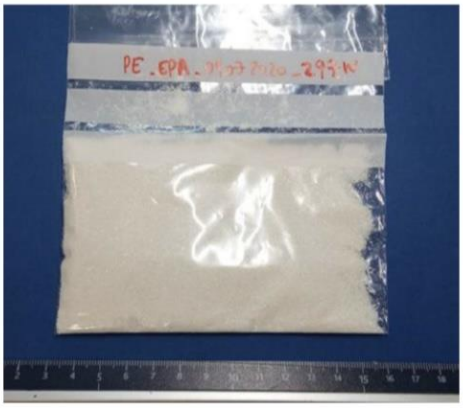
AIMPLAS
INSTITUTO TECNOLÓGICO DEL PLÁSTICO

ilac-MRA ENAC ENSAYO ISO 17025 Nº56 / LE156

** The marked activities are not covered by the ENAC accreditation.*

TEST CERTIFICATE	Number: AST-21-097-05 Date of tests: 22/12/2021-09/11/2022 Certificate issue: 07/02/2023
COMPANY	POLYMATERIA LTD Imperial College i-Hub White City Campus 80 Wood Lane W12OBZ LONDON UNITED KINGDOM
PETITIONER	Florence Huynh
PRODUCT NAME	PE_EPA_09072020_297_W *- Description: Polyethylene sample from a polyethylene product, containing Polymateria Technology at 2% loading rate (wt%) and white masterbatch at 6,5%, manufactured by* [redacted] *- Code: AST-21-097-05*
TESTS PERFORMED ACCORDING TO STANDARDS OR INTERNAL PROCEDURES	Determination of the ultimate aerobic biodegradability of plastic materials in soil under controlled soil conditions according to the UNE-EN ISO 17556:2019 standard.
RESULTS	According to reports: AST-21-097-5-EN/1

SAMPLE



Customer's reference
PE_EPA_09072020_297_W Polyethylene sample from a polyethylene product, containing Polymateria Technology at 2% loading rate (wt%) and white masterbatch at 6,5%, manufactured by [redacted]
AIMPLAS code
AST-21-097-05
Description
White powder
Reception date
08/09/2021

TEST CERTIFICATE	Number: AST-21-097-05 Date of tests: 22/12/2021-09/11/2022 Certificate issue: 07/02/2023

Test method

Standard:	Determination of the ultimate aerobic biodegradability of plastic materials in soil under controlled soil conditions according to the UNE-EN ISO 17556:2019 standard.
Method:	The determination of the aerobic biodegradability of the plastic material samples has been carried out under controlled soil conditions. The test method used is based on the method reflected in the UNE-EN ISO 17556:2019 standard and is based on the measurement of carbon dioxide generated by gravimetry. In the present test, the soil used is a standardized soil and the material to be analyzed is tested in a size of 20x20 mm. 2500 mg (dry solids) of sample are mixed with 300 g (dry solids) in each 3-liter capacity reactor and intensively maintained under optimum oxygen conditions, temperature 25 ± 2 ° C and humidity (optimum water content between 40% and 60% of the total water holding capacity) for a test period of six months, extendable to 2 years under specific circumstances. Air was supplied into the vessels to ensure aerobic conditions throughout the test. Furthermore, the test vessels were subjected to stir twice a week in order that the air distribution was homogeneous throughout the vessel. The test vessels were distributed as follows: - Three reactors for the blank (compost). - Three reactors for reference material (cellulose). - Three reactors for each test material. During the aerobic biodegradation of the material, the amount of carbon dioxide generated in each of the reactor is continuously recorded and analyzed by an IR detector and the flow rate is determined by an on-line flowmeter. The percentage of biodegradation is calculated as the ratio of the carbon dioxide generated from the test material to the theoretical maximum amount of carbon dioxide in the test material ($ThCO_2$). The amount of carbon dioxide generated is absorbed in a column and measured at intervals of time by weighing the grams of CO_2 retained using a precision electronic scale. The percentage of biodegradation is calculated by the relationship between the carbon dioxide generated from the test material and the maximum theoretical amount of carbon dioxide ($ThCO_2$) that can be produced from the test material.
Standard:	Determination of Total Nitrogen (Nt)[c]
Method:	- Compost matrix: Internal procedure PI-LTL-6.038. - Plastic matrix: Internal procedures B-N211 and B-N214 according to ASTM D5291

TEST CERTIFICATE	Number: AST-21-097-05 Date of tests: 22/12/2021-09/11/2022 Certificate issue: 07/02/2023

	Test method D for matrices: Biomass (wood, pruning residues, sludge, manure, residues from the agricultural, wood and paper industries), solid biofuels and for Petroleum Products
Standard:	Determination of Total Organic Carbon (COT)[d]
Method:	- Compost matrix: Internal procedure PI-LTL-6.081 (Oxid. Dichromate)
	- Plastic matrix: Internal procedures B-N211 and B-N214 according to ASTM D5291
	Test method D for matrices: Biomass (wood, pruning residues, sludge, manure, residues from the agricultural, wood and paper industries), solid biofuels and for Petroleum Products

[c] Subcontracted test covered by ENAC accreditation N° 121/LE1782 in compost matrix.
[d] Subcontracted test covered by accreditation RvA N° 135 in plastic matrix.

Results

Start date: 22/12/2021
Finish date: 09/11/2022

1) IDENTIFICATION AND CHARACTERIZATION OF PARAMETERS

- **Normalised soil composition**

Table 1

Normalised soil	Theoretical amount (g dry mass/reactor)
Amount of normalized soil/ reactor	200,000
Quartz sand	140,000
Clay	20,000
Natural soil	32,000
Compost	8,000
KH_2PO_4	0,040
$MgSO_4$	0,020
$NaNO_3$	0,024
Urea	0,012
NH_4Cl	0,024

TEST CERTIFICATE	Number: AST-21-097-05 Date of tests: 22/12/2021-09/11/2022 Certificate issue: 07/02/2023

2) TEST QUANTITIES

QUANTITY OF CARBON DIOXIDE AND CALCULATION OF THE PERCENT OF BIODEGRADABILITY

The following figures show the evolution of CO_2 production and degree of biodegradation of the vessels containing the blank, the reference material and the test sample, respectively.

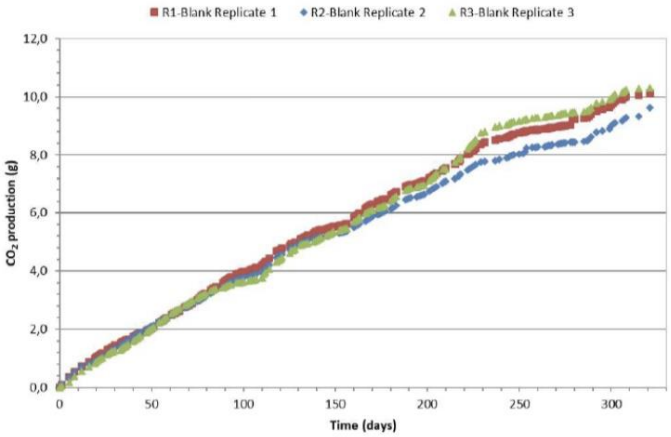


Figure 1. Evolution of CO_2 production (for each replica) of the blank

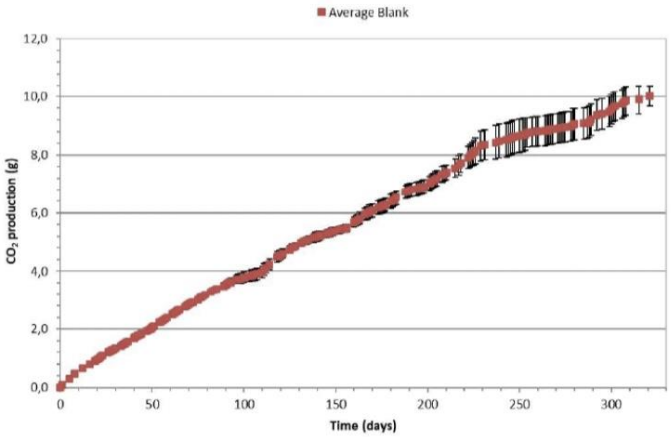


Figure 2. Evolution of CO_2 production (average value) of the blank

TEST CERTIFICATE	Number: AST-21-097-05 Date of tests: 22/12/2021-09/11/2022 Certificate issue: 07/02/2023

- **Reference (cellulose) results**

The graphical evolution of CO_2 production and the percentage of biodegradation (for each replica) and the average percentage of biodegradation of the reference material are shown below:

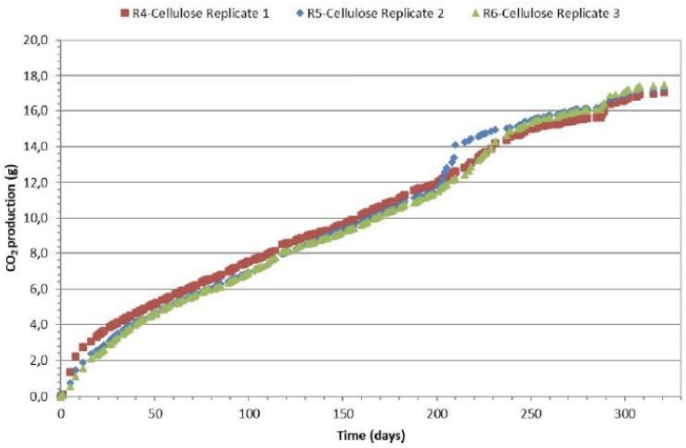


Figure 3. Evolution of CO_2 production (for each replica) of the reference material (cellulose)

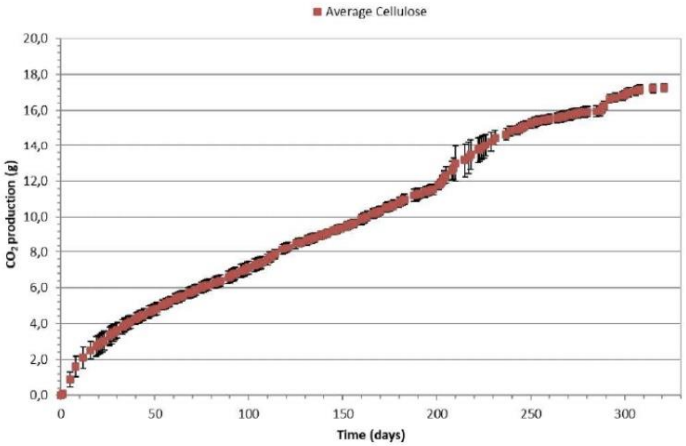


Figure 4. Evolution of CO_2 production (average value) of the reference material (cellulose)

TEST CERTIFICATE

Number: AST-21-097-05
Date of tests: 22/12/2021-09/11/2022
Certificate issue: 07/02/2023

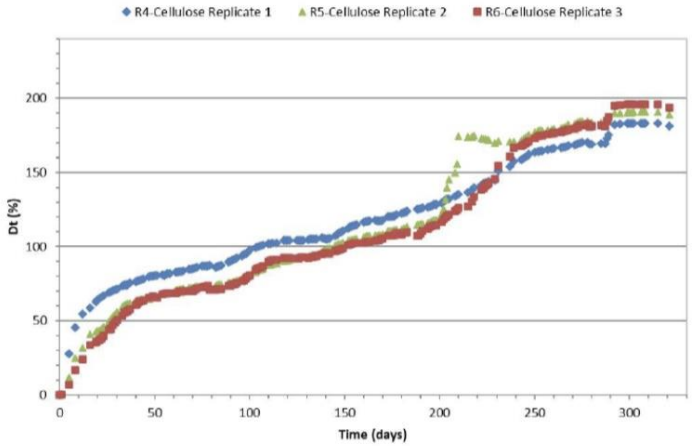


Figure 5. Evolution of the percentage of biodegradation (for each replica) of the reference material (cellulose)

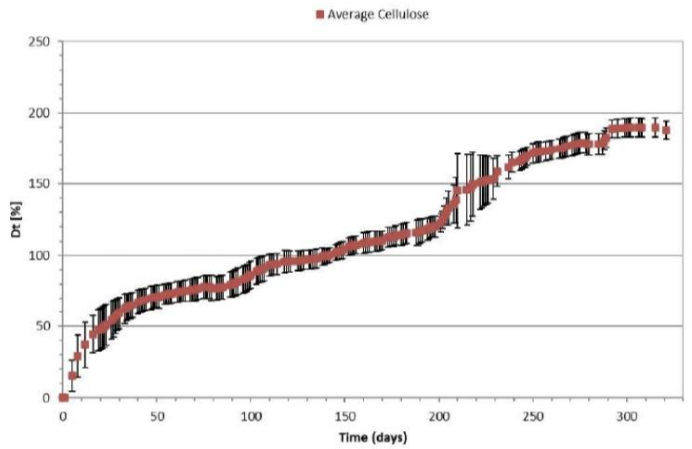


Figure 6. Evolution of the percentage of biodegradation (average value) of the reference material (cellulose)

TEST CERTIFICATE	Number: AST-21-097-05 Date of tests: 22/12/2021-09/11/2022 Certificate issue: 07/02/2023

- **Results sample AST-21-097-05**

The graphical evolution of CO_2 production and the percentage of biodegradation (for each replica) and the average percentage of biodegradation of the reference material are shown below:

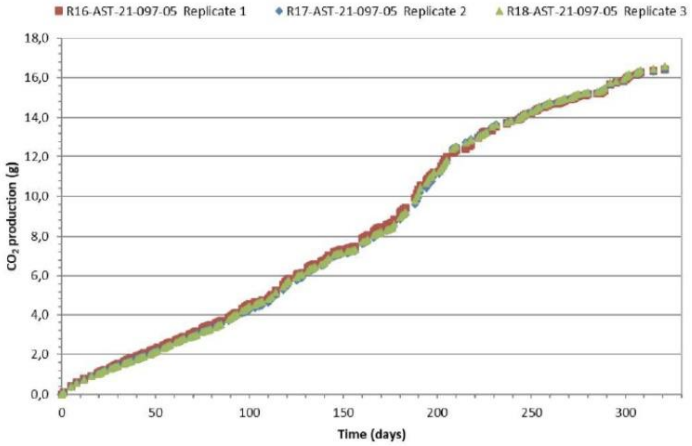


Figure 7. Evolution of CO_2 production (for each replica) of sample AST-21-097-05

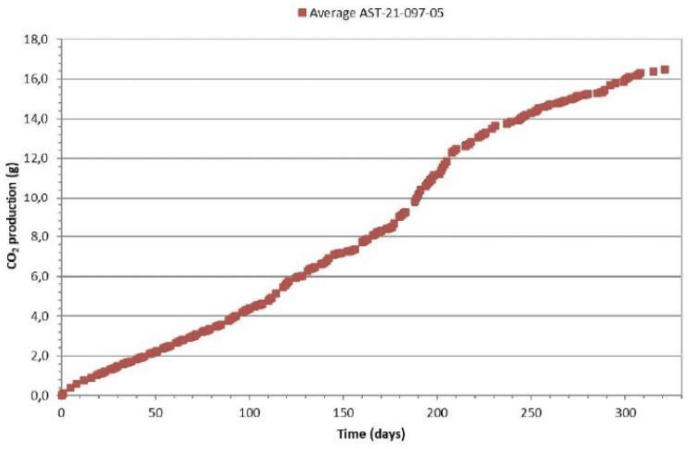


Figure 8. Evolution of CO_2 production (average value) of sample AST-21-097-05

TEST CERTIFICATE

Number: AST-21-097-05
Date of tests: 22/12/2021-09/11/2022
Certificate issue: 07/02/2023

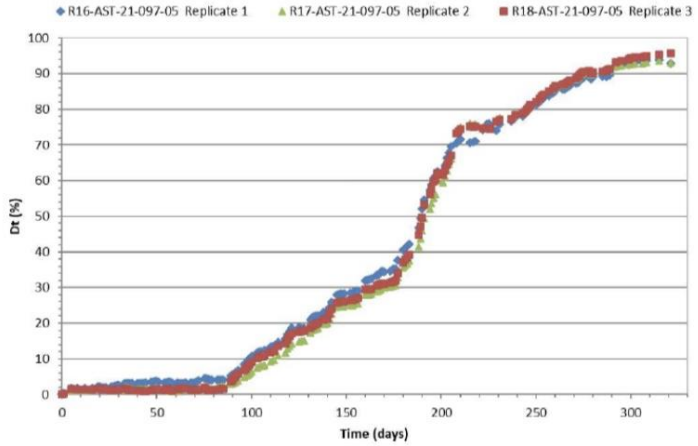


Figure 9. Evolution of the percentage of biodegradation (for each replica) of sample AST-21-097-05

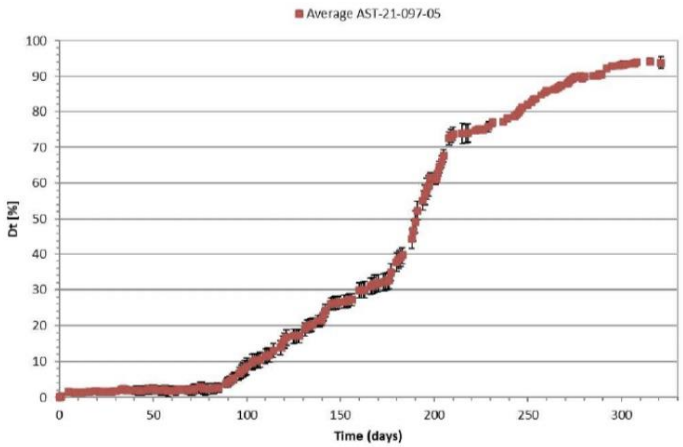


Figure 10. Evolution of the percentage of biodegradation (average value) of sample AST-21-097-05

3) MAINTENANCE OPERATIONS CARRIED OUT DURING THE TEST AND AT THE END OF THE TEST

- **Temperature control during the test**
- **Humidity control and other maintenance operations during the test**

Water is added to each reactor during the stirring process to maintain the total weight of the reactors, and thus, to maintain the optimum humidity in the mixture.

- **pH control**

4) VALIDITY OF THE TEST

In accordance with the UNE-EN ISO 17556:2019 standard, the test is considered valid if the following criteria are met:

(a) The degree of biodegradation of the reference material is greater than 60% in the plateau phase or at the end of the test.

(b) The DBO or carbon dioxide in three blanks are at 20% in the plateau phase or at the end of the test.

TEST CERTIFICATE	Number: AST-21-097-05 Date of tests: 22/12/2021-09/11/2022 Certificate issue: 07/02/2023

*CONCLUSIONS

Determination of the ultimate aerobic biodegradability of plastic materials in soil under controlled soil conditions according to the UNE-EN ISO 17556:2019 standard.

The percentage of biodegradation average value of the sample after 315 days of testing, is shown in the following table:

Sample	D_{tm} (%) 315 days
AST-21-097-05	94,28
Standard requirement	>90%

To demonstrate that a product is biodegradable under controlled soil conditions according to this standard, 90% biodegradation has to achieved within a minimum of 6 months and a maximum of 24 months.

Electronic signature of the authorized signatories:

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*** 报告结束 ***