Final Report

Aerobic Biodegradation of Low Density Polietilene (LDPE) film with WRP's proprietary oxobiodegradable additive-Sample PDQ-H Under Controlled Composting Conditions

According to "Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions. (ASTM D5338 – 11).

ASTM D5338 is a part of ASTM D6954 – "Standard Guide for Exposing and Testing Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation"

Study number:	2343-BPCAE-525-11
Test substance:	Low Density Polietilene (LDPE) film with WRP's proprietary oxobiodegradable additive-Sample PDQ-H.
Number of test substance:	2343
Date of manufacture:	31 July 2011
Sponsor:	Willow Ridge Plastic Inc. Dixie Highway 3208 Erlanger – KY - USA
Test facility:	Bioensaios Análises e Consultoria Ambiental. Palermo Street, 257 – Santa Isabel 94480-775 - Viamão - RS – Brazil
Study director :	Alexandre Brandelli
Quality assurance manager :	Aline Garcia dos Santos
Test facility maneger:	Suzana Barros de Souza

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DECLARATION OF GLP CONFORMITY

Study: Aerobic Biodegradation of Low Density Polietilene (LDPE) film with WRP's proprietary oxobiodegradable additive-Sample PDQ-H Under Controlled Composting Conditions.

Study number: 2343-BPCAE-525-11

I declare that Study Plan objectives were successful reached and concluded. I declare that Raw Data are valid and that Final Report reflects the methods used and obtained raw data.

I declare that the study was conducted in accordance to the Good Laboratory Practice - GLP guidelines INMETRO-NIT-DICLA-035 to 041 (Sep. 2011), according to OECD-Principles on Good Laboratory Practice (1997).

I declare that the GPL principles were completely complied.

Viamão, 24 / Sep. / 2012 .

Alexandre Brandelli
Study director
Palermo Street, 257 - Viamão - RS - Brazil

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QUALITY ASSURANCE STATEMENT

Study: Aerobic Biodegradation of Low Density Polietilene (LDPE) film with WRP's proprietary oxobiodegradable additive-Sample PDQ-H Under Controlled Composting Conditions.

Study number: 2343-BPCAE-525-11

I declare that the Final Report was revised and it reflects the Raw Data.

I declare that the Study Director has signed the declaration that this Study was conducted according to GLP principles on September 24, 2012.

I declare that audits were conducted as specified in the table below. No protocol deviations and nonconformities that could affect the quality of the results were found.

Object of the Audit	Audit date	Report date to the Study Director	Report date to the Manager
*Study phase**			
Preparation of test solutions	16 Sep 2011	24 Oct 2011	24 Oct 2011
Assay	30 Sep 2011	24 Oct 2011	24 Oct 2011
Raw Data	18 Sep 2012	21 Sep 2012	21 Sep 2012
Final Report	18 Sep 2012	21 Sep 2012	21 Sep 2012

* Process audits based in the study 2318-BSS-444-11 audit.

Viamão, 24 / Sep. / 2012.

Franciele Avila Silveira
Franciele Avila Silveira
Setor de Garantia da Qualidade
Rua Palermo, 257 - Viamão - RS – Brazil

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Summary

1. EXECUTIVE SUMMARY

1.1 Experimental design

A biodegradation study with 121 days in length was conducted under composting conditions in laboratory to determine the biodegradation of a Low Density Polietilene (LDPE) film with PDQ-H, a Willow Ridge Plastics Inc. proprietary oxobiodegradable additive.

The study followed the method "Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions. (ASTM D5338 - 11).

The test system was an active organic compost collected in the Ecological Cooperative of Citrus - Ecocitrus.

The degradation was followed by determining the CO_2 produced during 121 days of exposure. The biodegradation rate was calculated based on the amount of carbon biodegraded in relation to the total organic carbon incorporated in the soil by the test substance.

1.2 Results

The biodegradation of LDPE+PDQ-H was between 3% and 8% with an average of 5%.

Replica	Description	% of biodegradation after 121 days of composting
Negative control	LDPE	1%
Positive control	Cellulose	83%
Positive control	Cellulose	87%
Test substance	LDPE + PDQ-H	3%
Test substance	LDPE + PDQ-H	4%
Test substance	LDPE + PDQ-H	8%

In the present work, we have studied the potential biodegradability of PE films containing oxobiodegradable additives. The objective was to compare the influence of the pro-oxidant additive on the biotic transformations. In this study the biodegradation was determined during 121 days, a relative short-term duration study if one consider that these materials will almost completely biodegrade in soil within two years (Jakubowicz et al, 2011).

These authors observed that the LDPE containing pro-oxidant showed a relatively high biodegradation in the introductory eight weeks. After that, the rate was reduced exhibiting an almost linear increase of biodegradability with exposure time but at a lower rate. After 470 days, the rate of biodegradation was reduced even more, reaching about 43% mineralization after 607 days. The mineralization profile of the remaining test material did not change significantly during the time to complete 2 years.

In a similar way, but in a different exposition conditions from our study, Chiellini et al (2003; apud Jakubowicz et al, 2011) also obtained a plateau at about 4–7% mineralization during about 200 days and thereafter a significant increase in the rate of biodegradation, reaching 63% biodegradation after 600 days and still increasing. Chiellini at all (2003) added some water and fresh soil inoculum after five months of incubation and ascribed the subsequent increase in the rate and extent of mineralization to this step.

Fontanella (2010) had appointed the link between the efficiency of polymer biodegradation and the formation of a biofilm at the polymer surface. It is important for bacteria to adhere to the PE film to be able to metabolize it. These authors also obtain a percentage of carbon mineralization from 5 to 20% in 20 days.

1.3 Conclusion

Based on these results the sample of low density polyethylene (LDPE) containing PDQ-H, an additive oxobiodegradable, property of Willow Ridge Plastic Inc, showed a similar biodegradation behavior as observed in the initial phase of the studies from others authors and has the potential to biodegradation in composting conditions.

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2. INTRODUTION

This report describes the procedure and presents the results of the biodegradation study under aerobic composting conditions of a sample of low density polyethylene (LDPE) containing PDQ-H, an oxobiodegradable additive, property of Willow Ridge Plastic Inc.

The study was conducted in the laboratory under controlled conditions in a 2-liter bottles containing 600 grams of active compost. The CO_2 produced by biodegradation was captured in an alkaline solution which was titrated periodically. The biodegradation was expressed as percentage and was calculated as the ratio between carbon evolved as CO_2 and the initial organic carbon introduced by the aliquot of test substance incorporated into the composting substrate.

2.1. Study dates

Study plan	: 05 July 2011
Experiment start	: 10 Jan. 2012
Experiment end	: 24 July 2012
Final report	: 24 Sep. 2012

3. MATERIAL AND METHODOS

3.1. Test substance

Name of test substance	: PEBD with PDQ-H aditive
Description of test substance	: Low density polyethylene (LDPE) containing PDQ-H, an oxobiodegradable additive, property of Willow Ridge Plastic Inc.
Batch	: 31 July 2011
Laboratory identification number	: 2343
Expiration date	: Not applicable because the sample was termically treated to activate the additive and trigger the oxidation process.
Date of opening the package	: 06 October 2011
Stability	: Not applicable because the sample was termically treated to activate the additive and trigger the oxidation process.
Homogeneity	: Visually homogeneous
Elemental composition[1]	: 82.29% carbon, 15.14% hydrogen, 0.03% nitrogen.

3.2. Methodology

The study followed the method "Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions. (ASTM D5338 - 11).

Summary of test conditions:

The test system was an active organic compost collected in the Ecological Cooperative of Citrus Producers from Cai River Valley – Ecocitrus[2] in January 09, 2012.

Test chamber...2000 mL glass bottles
Aeration system...continuous aeration with free CO_2 air

[1] Análise realizada pela Bioensaios Análises e Consultoria Ambiental por analisador CHN.
[2] Ecocitrus: Localizada na estrada RST 287, Km 10, Passo da Serra. Montenegro - Rio Grande do Sul – Brasil.

Light .... dark
Temperature .... 58 ± 2° C
Moisture .... 60% of MWHC
Exposition Length .... minimum 120 days
Result .... % of biodegradated carbon
System of CO_2 adsorption .... 0.2 N KOH solution
CO_2 analysis .... Titration with HCl 0,1 N
Sample amount incorporated to 600g of compost .... 100 g
Amount of organic carbon in the test substance .... 0.8229 g/g
Gel fraction percentage in the test substance 3%
Initial amount of organic carbono (total applied) .... 79821 mg
Theoretical initial amount of CO_2 (CI = 100%) 6652mMOL

4. CALCULATIONS

The CO_2 produced was calculated for each time interval. The production of CO_2 inherent to the soil respiration (CO_2 produced BY the respirometer control) was subtracted from the CO2 produced in each treatment.

CO_2 produced = CO_2 from treated respirometer – CO_2 from control respirometer

The biodegradation percentage is calculated by dividing the CO2 produced by the equivalent amount of CO2 applied to the soil by the test substance:

$$EB\% = \frac{Cb \times 100}{CI}$$

$$CI(CO2) = \frac{[MST \times COT(ST)] \times 1000}{12}$$

where:

EB% = Biodegradation efficiency (%)
Cb = amount of CO2 produced (mMOL)
CI(CO2) = initial amount of CO_2 (mMOL).
MST = mass of test substance applied to 600 g of compost (g)
$COT_{(ST)}$ = Total organic carbon in the test substance (g/g).

5. RESULTS

5.1 Temperature

The vials were kept at controlled temperature in a water bath. The exposure temperature ranged from 21.6 to 54.1 °C with average of 40.7 °C

5.2 Biodegradability

The titrations results, the CO_2 produced in the control respirometer and treated respirometers, the conversion of carbon biodegraded and the percentage of biodegradation are presented in Appendix I.

After 120 days of composting the biodegradability of LDPE-H + PDQ (test substance) was 5% in average.

The biodegradability of microcrystalline cellulose (reference substance) was 111%.

The production of CO_2 from LDPE without additive, the negative control, was 1%.

A graph showing the cumulative percentage of CO_2 production is presented in Appendix II.

5.3 Visual appearance after composting.

After 120 days of composting LDPE + PDQ-H (test substance) was in small fragments of, approximated size, 20 to 300 mm ^{2}. The color, which at the beggining was already yellow became more intense and the material lost transparency (Figure 10). Under the microscope, the fragments of LDPE + PDQ-H presented clearly points of biofilm attached to their surface (Figures 12 and 13).

In comparison, LDPE without additives remained the same in size, shape and color (Figure 11). Biofilm was not observed on the surface of LDPE (Figures14 and 15).

5.4 Toxicity after composting.

After 120 days, the toxicity to plants of samples from the biodegradability study was tested according to the method OECD 208 "Test Plant Terrestrial : Seedling Emergence and Seedling Growth Test. The toxicity test was performed with three types of plants: radish, rice and lettuce.

This test evaluates the effects on germination and initial growth of higher plants subjected to the test substance by exposure through the soil. Seeds are placed in contact with the soil treated and evaluated after 14 to 21 days when 50% of seeds germinate in the control group. The response of the study is the germination percentage, weight and root length. Other effects in different parts of the plant are also recorded when observed. The measurements and observations are compared to those of untreated control. The figures 16 and 17 show a view of the overall appearance of plants in the last day exposure toxicity test.

Whereas the germination of seeds, the results showed no significant difference (95% confidence) between the compost treated (sample 2343, positive control and negative control) and untreated compost for the three species: rice, lettuce and radish. Likewise, there was no significant difference in germination of the three types of seed comparing samples made with the control of toxicity test (washed sand).

Whereas the growth of root, the results indicated that there was a statistically (95% confidence) significant reduction in root growth radish exposed to the compost containing sample 2343 as compared with the growth of root radish of the no treated compost from biodegradation study and control of the toxicity test (washed sand). For other species, rice and lettuce, no statistically significant difference in root growth was observed among all treatments and controls.

6. CONCLUSION

In the present work, we have studied the potential biodegradability of PE films containing oxobiodegradable additives. The objective was to compare the influence of the pro-oxidant additive on the biotic transformations. In this study the biodegradation was determined during 121 days, a relative short-term duration study if one consider that these materials will almost completely biodegrade in soil within two years (Jakubowicz et al, 2011).

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Based on these results the sample of low density polyethylene (LDPE) containing PDQ-H, an additive oxobiodegradable, property of Willow Ridge Plastic Inc, showed a similar biodegradation behavior as observed in the initial phase of the studies by others authors and has the potential to biodegradation in composting conditions.

7. ARCHIVES

The Study Plan, Raw Data and Final Report will be archived for, at least, the next five years and the test substance for, at least, 60 days after the conclusion of all studies at Bioensaios Análises e Consultoria Ambiental dependencies.

8. REFERENCES

ASTM D5338-11. Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions.

OECD 208 - Terrestrial Plant Test: Seedling Emergence and Seedling Growth Test

Jakubowicz I, Yarahmadi N, Arthurson V. Kinetics of abiotic and biotic degradability of low-density polyethylene containing prodegradant additives and its effect on the growth of microbial communities, Polymer Degradation and Stability (2011), doi: 10.1016/j.polymdegradstab.2011.01.031

Husarova L, Machovsky M, Gerych P, Houser J, Koutny M. Aerobic biodegradation of calcium carbonate filled polyethylene film containing pro-oxidant additives, Polymer Degradation and Stability (2010), doi: 10.1016/j.polymdegradstab.2010.05.009.

Stéphane Fontanella a,b, Sylvie Bonhomme a, Marek Koutny c, Lucie Husarova c, Jean-Michel Brusson e, Jean-Paul Courdavault i, Silvio Pitteri f, Guy Samuel g, Gérard Pichon h, Jacques Lemaire a, Anne-Marie Delort. Comparison of the biodegradability of various polyethylene films containing pro-oxidant additives. Polymer Degradation and Stability (2010), Polymer Degradation and Stability 95 (2010) 1011e1021.

Viamão, 24 / Sep. / 2012.

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ANNEX I - Assay results

Cumulative production of CO_2 (mMOL)											
Data	11 Jan. 2012	12 Jan. 2012	13 Jan. 2012	14 Jan. 2012	17 Jan. 2012	19 Jan. 2012	24 Jan. 2012	26 Jan. 2012	30 Jan. 2012	01 Feb. 2012	03 Feb.2012
Positive control A	0	0	54	82	139	147	464	805	991	1174	1330
Positive control B	0	0	0	67	124	147	337	540	705	916	1142
Negative control	0	0	23	23	41	41	41	41	41	47	47
2343 A	0	2	2	11	51	80	102	125	125	136	140
2343 B	0	0	32	88	135	135	156	178	178	194	208
2343 C	0	0	58	114	169	181	230	252	263	298	316

Cumulative production of CO_2 (mMOL)											
	06 Feb.2012	08 Feb.2012	10 Feb.2012	13 Feb.2012	15 Feb.2012	17 Feb.2012	20 Feb.2012	23 Feb.2012	27 Feb.2012	02 Mar. 2012	05 Mar. 2012
Positive control A	1460	1589	1722	1833	1920	1970	1996	2020	2074	2146	2219
Positive control B	1363	1593	1791	1924	2026	2103	2156	2196	2224	2246	2266
Negative control	47	47	47	68	77	77	79	79	79	79	79
2343 A	140	140	140	156	163	163	175	182	182	188	193
2343 B	219	230	230	230	230	230	230	230	230	230	230
2343 C	346	379	405	424	435	435	446	446	451	456	459

Cumulative production of CO_2 (mMOL)											
	09 Mar. 2012	12 Mar. 2012	16 Mar. 2012	19 Mar. 2012	23 Mar. 2012	26 Mar. 2012	30 Mar. 2012	02 April 2012	05 April 2012	08 April 2012	13 April 2012
Positive control A	2305	2395	2410	2416	2416	2418	2427	2438	2456	2471	2472
Positive control B	2283	2322	2352	2373	2388	2413	2437	2460	2502	2530	2543
Negative control	79	79	79	79	79	79	79	79	79	79	79
2343 A	198	198	198	198	198	198	198	198	205	208	209
2343 B	230	230	230	230	230	230	230	231	236	243	250
2343 C	461	469	469	469	469	469	470	479	482	485	485

Cumulative production of CO_2 (mMOL)								
	16 April 2012	20 April 2012	23 April 2012	23 April 2012	30 April 2012	04 May 2012	07 May 2012	11 May 2012
Positive control A	2472	2472	2472	2479	2479	2479	2480	2506
Positive control B	2545	2549	2557	2561	2573	2576	2597	2619
Negative control	79	79	79	79	79	79	79	79
2343 A	209	209	209	215	215	215	215	215
2343 B	258	261	261	261	261	261	261	261
2343 C	485	485	485	499	504	504	504	504

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ANNEX I - Assay results

	Cumulative production of CO2 (% of biodegradation)										
Exposition length (Days)	0	1	2	3	6	8	13	15	19	21	23
Positive control A (Celullose)	0%	0%	2%	3%	5%	5%	15%	27%	33%	39%	44%
Positive control B (Celullose)	0%	0%	0%	2%	4%	5%	11%	18%	23%	30%	38%
Negative control (LPDE)	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%
Sample 2343 A (LDPE+PDQ-H)	0%	0%	0%	0%	1%	1%	2%	2%	2%	2%	2%
Sample 2343 B (LDPE+PDQ-H)	0%	0%	0%	1%	2%	2%	2%	3%	3%	3%	3%
Sample 2343 C (LDPE+PDQ-H)	0%	0%	1%	2%	3%	3%	3%	4%	4%	5%	5%

	Cumulative production of CO2 (% of biodegradation)										
	26	28	30	33	35	37	40	43	47	51	54
Positive control A (Celullose)	48%	53%	57%	61%	64%	65%	66%	67%	69%	71%	73%
Positive control B (Celullose)	45%	53%	59%	64%	67%	70%	71%	73%	74%	74%	75%
Negative control (LPDE)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Sample 2343 A (LDPE+PDQ-H)	2%	2%	2%	2%	2%	2%	3%	3%	3%	3%	3%
Sample 2343 B (LDPE+PDQ-H)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Sample 2343 C (LDPE+PDQ-H)	5%	6%	6%	6%	7%	7%	7%	7%	7%	7%	7%

	Cumulative production of CO2 (% of biodegradation)										
	58	61	65	68	72	75	79	82	85	88	93
Positive control A (Celullose)	76%	79%	80%	80%	80%	80%	80%	81%	81%	82%	82%
Positive control B (Celullose)	76%	77%	78%	79%	79%	80%	81%	81%	83%	84%	84%
Negative control (LPDE)	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Sample 2343 A (LDPE+PDQ-H)	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Sample 2343 B (LDPE+PDQ-H)	3%	3%	3%	3%	3%	3%	3%	4%	4%	4%	4%
Sample 2343 C (LDPE+PDQ-H)	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%

	Cumulative production of CO2 (% of biodegradation)							
	96	100	103	103	110	114	117	121
Positive control A (Celullose)	82%	82%	82%	82%	82%	82%	82%	83%
Positive control B (Celullose)	84%	84%	85%	85%	85%	85%	86%	87%
Negative control (LPDE)	1%	1%	1%	1%	1%	1%	1%	1%
Sample 2343 A (LDPE+PDQ-H)	3%	3%	3%	3%	3%	3%	3%	3%
Sample 2343 B (LDPE+PDQ-H)	4%	4%	4%	4%	4%	4%	4%	4%
Sample 2343 C (LDPE+PDQ-H)	7%	7%	7%	7%	8%	8%	8%	8%

ANNEX I - Assay results

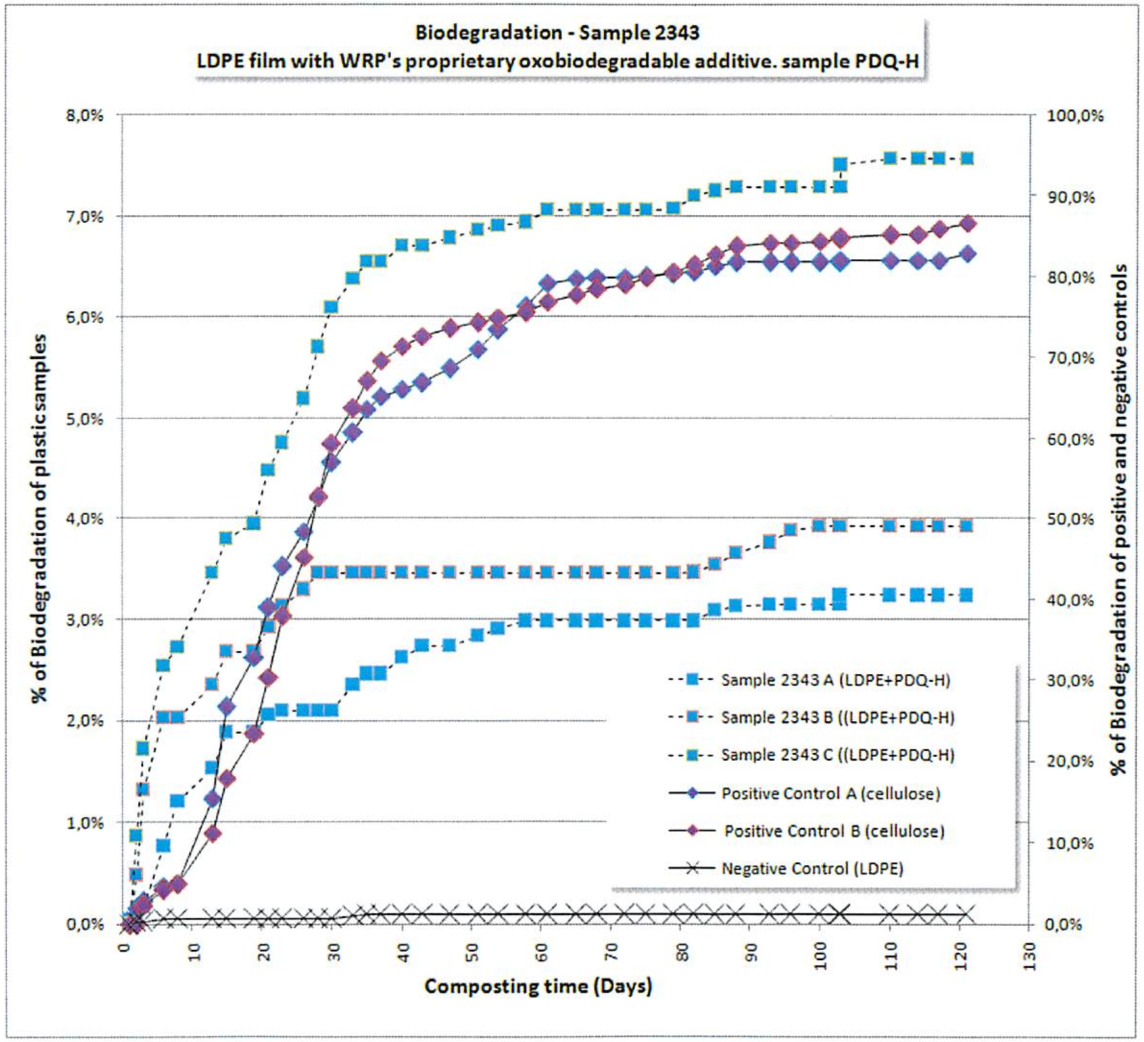

Figure 1. Graph of CO_2 evolution from the sample 2343, positive and negative controls during 121 days of exposure.

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ANNEX II - Images

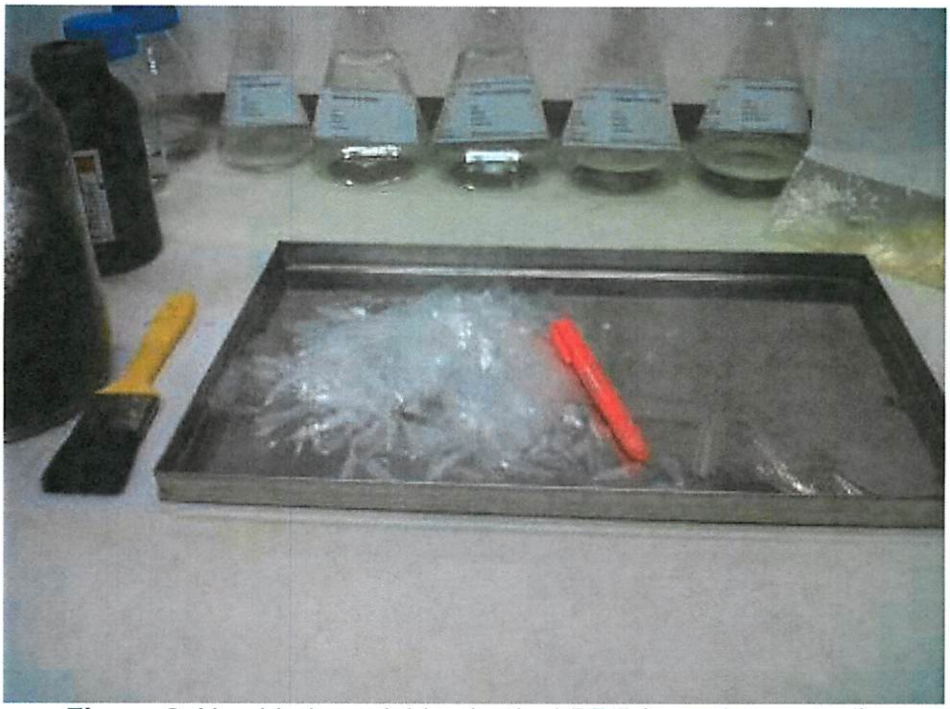

Figure 2: Non biodegradable plastic. LDPE (negative control).

Figure 3: Plastic oxobiodegradable. LDPE+PDQ-H (Sample 2343).

ANNEX II – Images (continuation)

Figure 4: Flasks containing 100 g of LDPE + PDQ-H (Sample 2343) and 600g of organic compost.

Figure 5: Flasks containing 100g of microcrystalline cellulose (Positive Control) and 600g of organic compound.

ANNEX II – Images (continuation)

Figure 6: Set of containers after the homogenization at the beginning of the study.

Figure 7: Set of flasks after 121 days of exposure.

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ANNEX II – Images (continuation)

Figure 8: General appearance of the compound after 121 days of exposure at 58 °C (Untreated compost - Study Blanck).

Figure 9: General appearance of compost containing cellulose (Positive Control) after 121 days of exposure.

ANNEX II – Images (continuation)

Figure 10: General appearance of the compost containing PDQ-H + LDPE (Sample 2343) after 121 days of exposure.

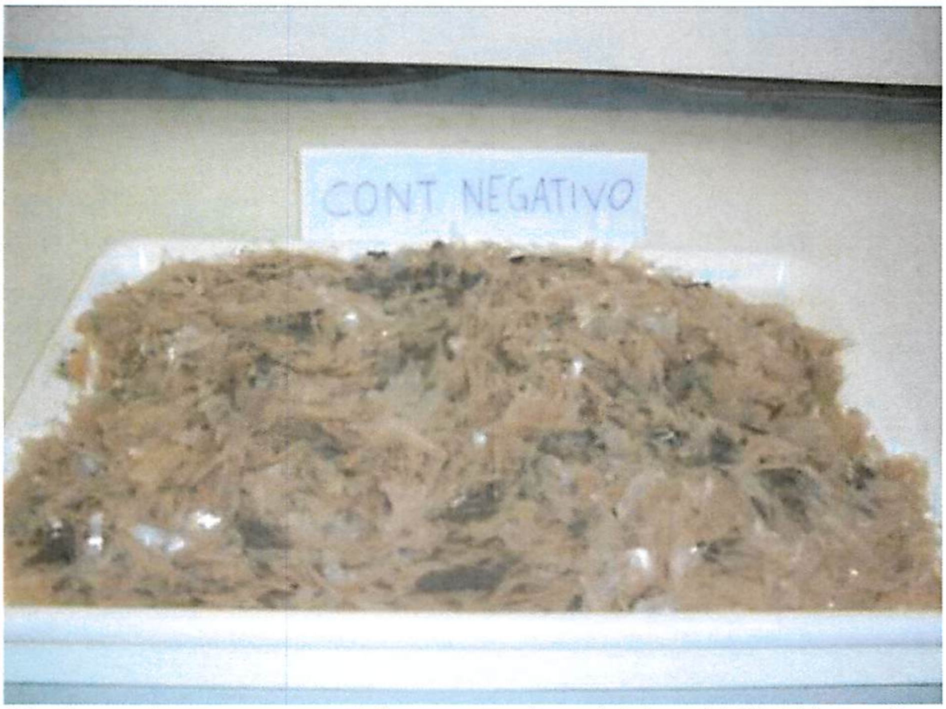

Figure 11: General appearance of the compost containingof LDPE (negative control) after 121 days exposure.

ANNEX II – Images (continuation)

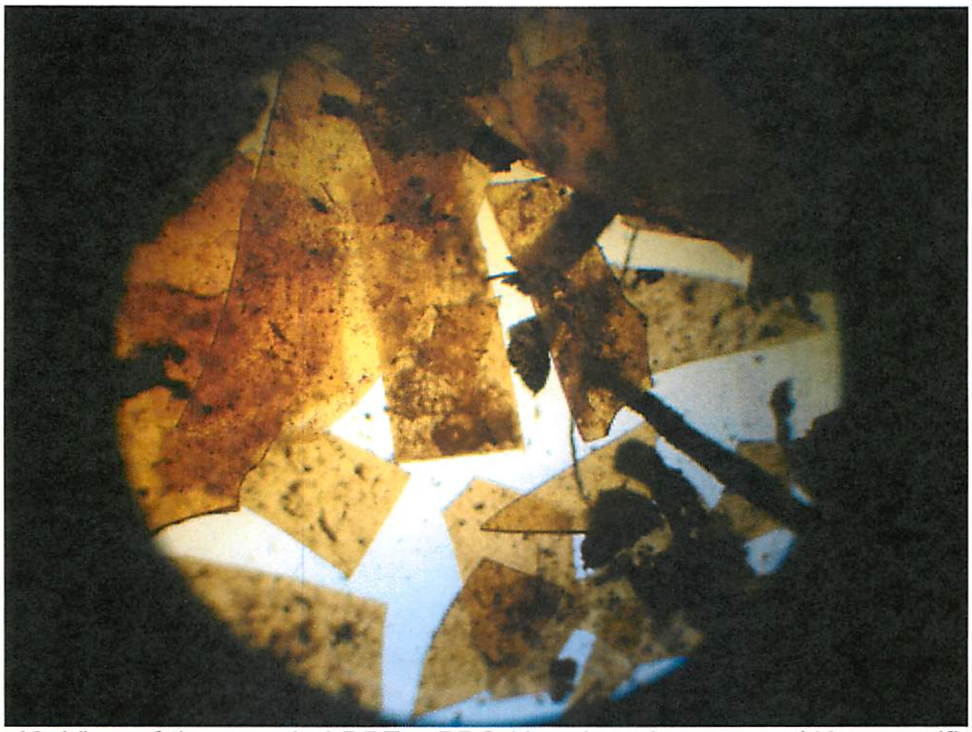

Figure 12: View of the sample LDPE + PDQ-H under microscope (40x magnification). Appearance after 121 days of exposure.

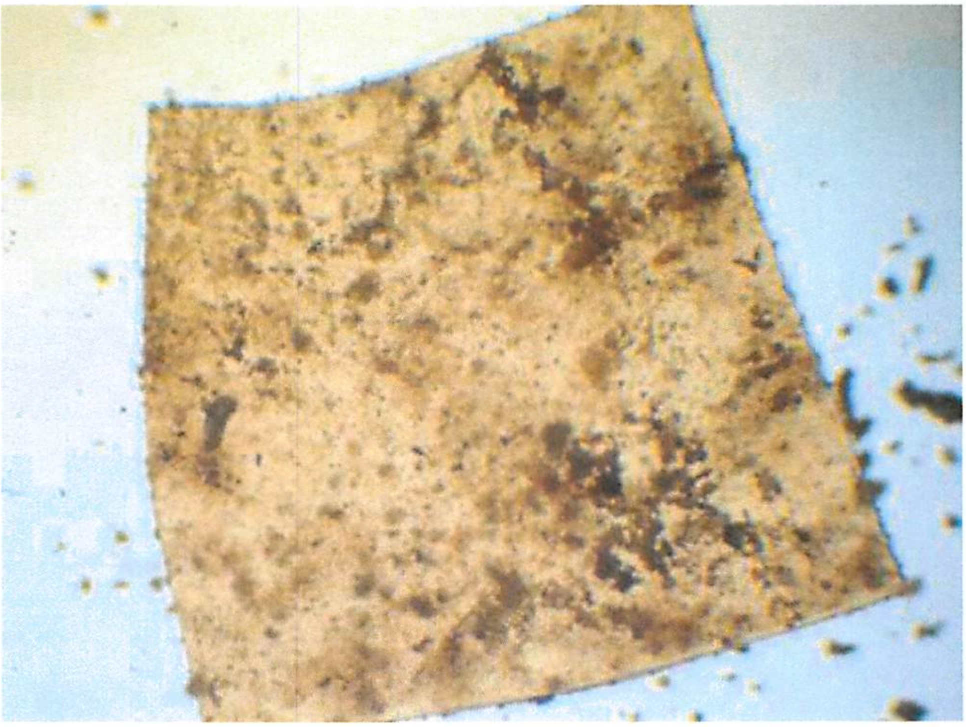

Figure 13: View of sample LDPE + PDQ-H under a microscope (100x magnification). Detail with evidence of biofilm formation on the surface.

ANNEX II – Images (continuation)

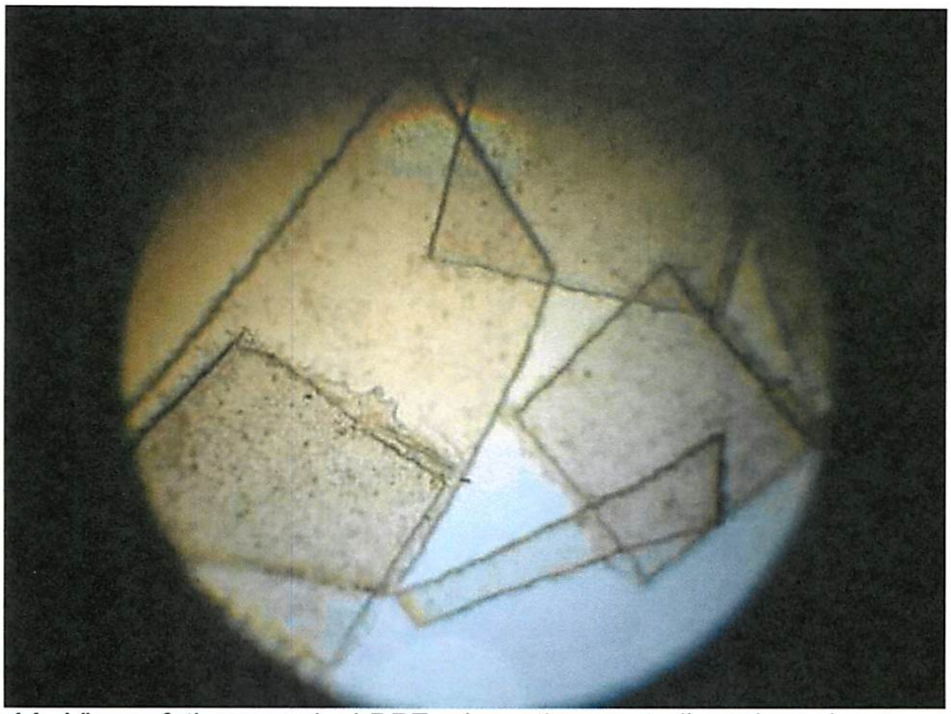

Figure 14: View of the sample LDPE (negative control) under microscope (40x magnification). Appearance after 121 days of exposure.

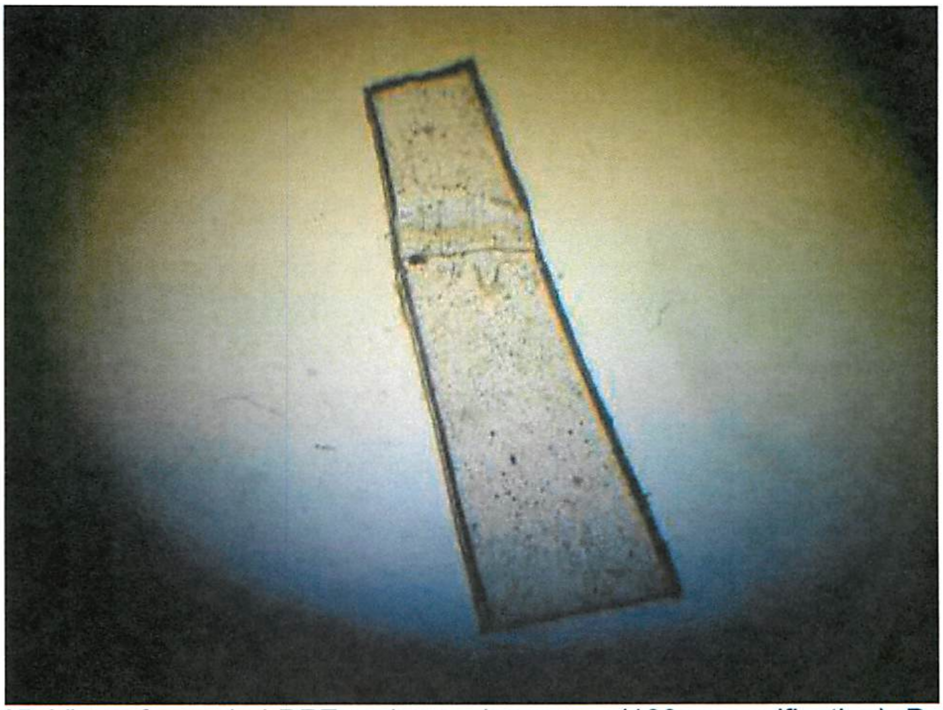

Figure 15: View of sample LDPE under a microscope (100x magnification). Detail with no biofilm formation on the surface.

ANNEX II – Images (continuation)

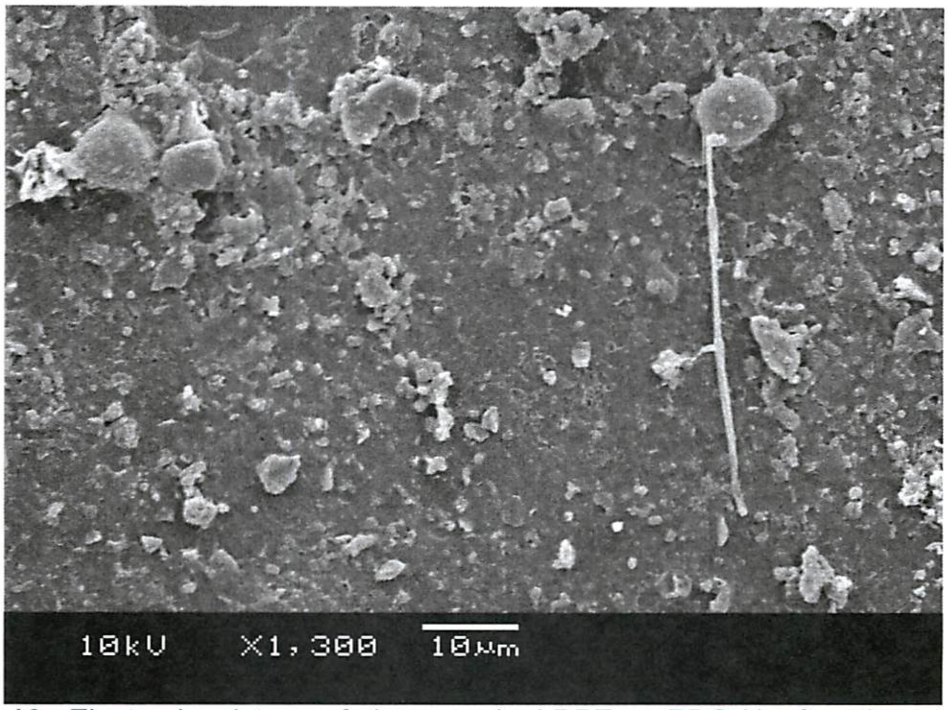

Figure 16: Electronic picture of the sample LDPE + PDQ-H after the period of composting (1300x magnification).

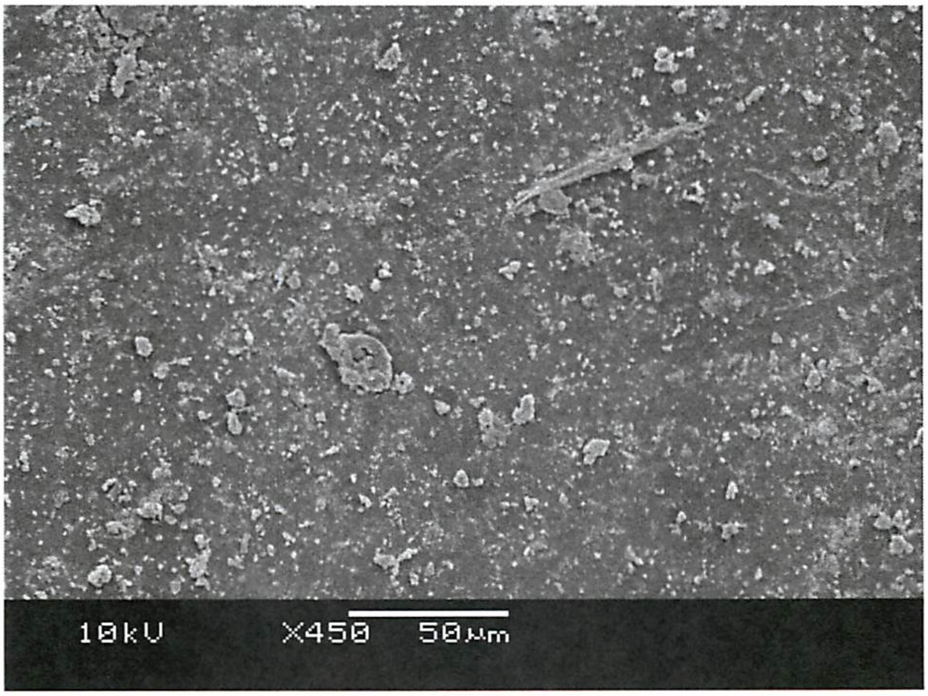

Figure 17: Electronic picture of the sample LDPE (negative control) after the period of composting (450x magnification).

ANNEX II – Images (continuation)

Figure 18: Radish (left) and lettuce (right) germinated and grown in the organic compost containing LDPE + PDQ-H (Sample 2343) obtained from the degradation test.

Figure 19: Radish (left) and lettuce (right) germinated and grown in washed sand (control of the toxicity study).

ANNEX II – Images (continuation)

Figure 20: Rice germinated and grown in the organic compost containing LDPE + PDQ-H (Sample 2343) obtained from the degradation test.

Figure 21: Rice germinated and grown in washed sand (control toxicity study).

ANNEX II – Images (continuation)

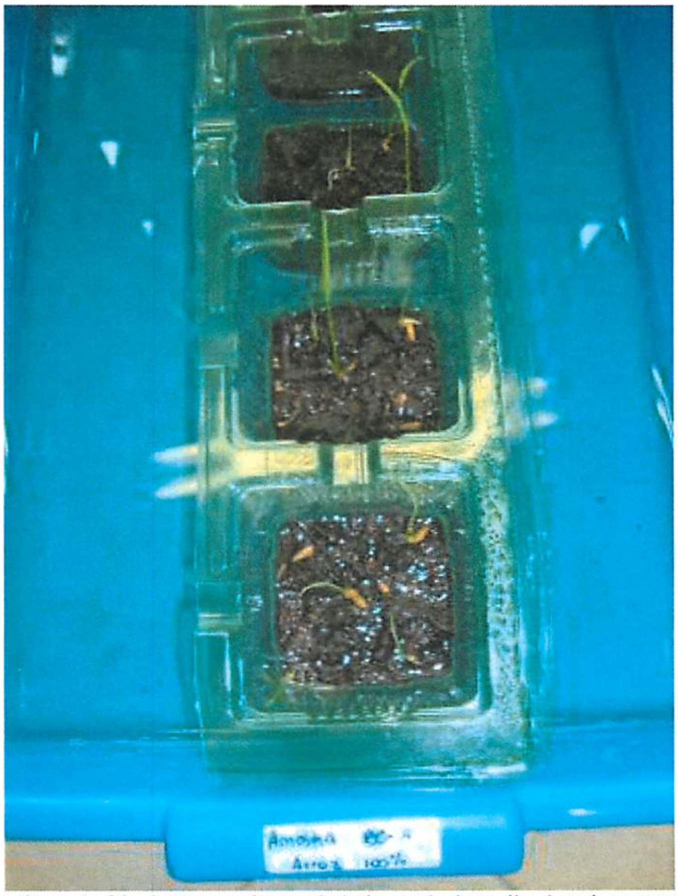

Figure 22: Radish (top left), lettuce (top right) and rice (below) germinated and grown in the organic compost (blank of the biodegradability study).

ANNEX III – GLP certificate

Federal Republic of Brazil
Ministry of Development, Industry and Foreign Trade
National Institute of Metrology, Standardization and Industrial Quality - INMETRO

General Coordination for Accreditation – CGCRE

Recognition of Compliance with the OECD Principles on Good Laboratory Practice

Statement of Compliance No. GLP 0006 **Initial Recognition: May 14th, 2001**

LABORATÓRIO DE ENSAIOS EM AGROTÓXICOS E PRODUTOS QUÍMICOS - BPL
BIOENSAIOS ANÁLISES E CONSULTORIA AMBIENTAL LTDA.
RUA PALERMO, 257 – SANTA ISABEL
VIAMÃO – RS

The test facility was inspected within the Brazilian GLP Monitoring Program of General Coordination for Accreditation of INMETRO and was considered in compliance with the OECD Principles on Good Laboratory Practice, for the conduct of non-clinical health and environmental safety studies, in the scope below:

Areas of expertise	***Categories of Test Items***
Physical-chemical testing; Toxicity studies, Mutagenicity studies, Environmental toxicity studies on aquatic and terrestrial organisms, Studies on behavior in water, soil and air and bioaccumulation, Residue studies.	*- Pesticides, Their Components and Suchlike; - Pharmaceutical Products; - Wood Preservative; - Veterinary Products; - Disinfectants; - Industrial Chemical Products; - Remedial for treatments of effluents and natural ecosystems*

Note: Categories of test items "pesticides" and "industrial chemical" are covered by Brazil´s full adherence to the OECD Council Acts related to the Mutual Acceptance of Data (MAD) on Good Laboratory Practice.

Marcos Aurélio Lima de Oliveira
General Coordinator for Accreditation

Issue: June 27th, 2011

Expiration date: May 14th, 2013