Southern Waters

TEST REPORT

Result: PASS **Report Date: 27.NOV.2013**

Customer Name: Enviplas (ENVI™)

Tested To: ASTM D6400-04

Description: Enviplas (ENVI™) added PE Films

Test Type: Disintegration, heavy metals, ecotoxicity, and FT-IR analysis

Job Number: 2013/09/305

Project Number: 2013/206

Project Manager: Johnny WILL

Thank you for having your product tested by Waters Agricultural Laboratories.

Report Authorization: Keith GREENE **Date: 27.NOV.2013**

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Contact your Project Manager if you have any questions or concerns pertaining to this report.

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Objective

The objective of this test is to evaluate PE Film samples to all requirements of ASTM 6400 sections 6.2 "Disintegration During Composting ", 6.4.1 "Regulated Heavy Metal Concentration ", and 6.4.2 "Germination and Ecotoxicity ':

Sample Description

Testing was performed on Enviplas (ENVI™) plastic PE Film Samples provided by Enviplas (ENVI™). The photograph in Figure 1 shows the prepared test specimen cut into 2 cm by 2 cm pieces for disintegration.

Figure 1

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Test Protocol

PE Film samples from Enviplas (ENVI™) were tested to selected requirements of ASTM D6400 including heavy metals analysis, disintegration while composting over a 12 week period, and germination and ecotoxicity to determine residual chemical influence upon plant germination and growth. A Fourier Transform Infrared Spectroscopy (FT -IR) spectra was also analyzed to verify sample composition.

Metal Analysis

Samples were subjected to microwave digestion and metal scan per the EPA 200.8 ICP-MS test method. The sample was evaluated for concentration of regulated heavy metals as prescribed in Table 3 of 40 CFR Part 503.13 (USA) and Table II of the Trade Memorandum T -4-93 (Canada).

12 Week Disintegration

Disintegration during composting was determined per section 6.2 of ASTM D6400 and D5338. Compost used in testing was obtained from the Municipal Solid Waste facility located on Camilla, Georgia. Prior to testing, the compost was passed through a 10mm sieve to remove any large particles. A sample of the compost was analyzed for pH, percent dry and volatile solids. Table 1 lists the results of this initial testing.

Table 1: Compost Property

Property	Requirement	Actual
pH Level	7-8.2	7.02
Dry Solids at 105 ^{0}C	N/A	45 %
Volatile Solids at 550 ^{0}C	N/A	50 %

Each vessel was charged with approximately 1401 grams of compost mixed with an additional 105 grams of dry solids. Approximately 20 grams of wood chips were added to each vessel to promote aeration. Table 2 lists the experimental charge of each test vessel.

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Table 2: Experimental Charge

	Vessel A	Vessel B	Vessel C
Compost (g)	1401.5	1401.8	1401.8
Wood Chips (g)	20.01	20.03	20.30
PE Film Samples (g)	105.3	105.4	105.5

Composting vessels were kept at 58°C and maintained under diffused light. Samples were exposed to a continuous moist air flow. Test vessels were temporarily removed from the incubator on a weekly basis to shake contents to promote aeration throughout the container. After 12 weeks of testing, all compost was removed from the testing vessels to determine the level of disintegration. The samples were separated from compost and passed through a 2 mm sieve. Plastic material that remained on the sieve was dried until a constant weight was achieved, and the percent disintegration was calculated based upon the remaining dry weight in comparison to the initial sample experimental charge for each vessel.

Germination Rate and Plant Biomass

Plant growth mediums were prepared with fresh potting soil in ratios of 25% w/w and 50% w/w by mixing compost from the test vessels after completion of 12 week disintegration. Similarly, control groups were prepared by mixing a 25% w/w and 50% w/w ratio of post-test blank control compost and potting soil. The compost was then distributed into 6" pots and labeled according to the mix ratio. Two species of seeds, winter rye and cress greens, were purchased from Jonny Seed's for testing. 100 seeds of the same species were planted in each pot. Each species of seed was tested in respect to both compost concentrations, in triplicate. Samples were placed under ultra violet growth lamps with a 16 hour photoperiod and watered and on a regular basis to maintain appropriate soil moisture levels. The plants were also rotated on occasion to ensure equal exposure under the growing lamps.

Samples were grown for 2 weeks after 50% emergence was observed in the blanks. At the end of the test, the percent emergence of each pot was determined and compared with its corresponding blank samples. Additionally, the amount of biomass was determined for each pot by removing the shoots at the soil level and then drying them in an oven at 60°C until a constant weight was attained. As with emergence, biomass of each sample was compared to its respective blank control. -This procedure is described in detail in OECD 208 Terrestrial Plant Seedling Test, with the modifications found in Annex E of EN 13432.

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Test Results

Heavy Metals

The heavy metal analysis indicated that the samples concentration of heavy metals was well below the limits set by the American and Canadian guidelines. Table 3 provides a comparison of the heavy metal limits for the US and Canada with the actual PE film sample.

Table 3: Heavy Metal Analysis

Metal	Limit for US (ppm)	Limit for Canada (ppm)	Actual
Arsenic	21.5	37.5	0.05
Cadmium	19.5	10	0.01
Copper	750	NA	1.08
Lead	150	250	1.02
Mercury	8.5	2.5	0.02
Nickel	210	90	0.38
Selenium	50	7	0.12
Zinc	1400	925	3.19
Cobalt	NA	75	0.03
Chromium	NA	NA	0.85
Molybdenum	NA	10	0.08

Disintegration during Composting

All compost from each test vessel was passed through a 2 cm sieve after 12 weeks of testing to determine the percent degradation. This resulted in an average of 3 .55% of the original weight of material remaining on the sieve. This is within the allowable limits of less than 10% of the original dry weight to be retained on a 2 cm sieve, per ASTM D6400. Table 4 shows the results of the disintegration test for each vessel. Figure 2 shows the representative sample of material retained on the 2 mm sieve.

Table 4: Disintegration Test

	Vessel A	Vessel B	Vessel C
Initial Weight of the Film (g)	105.3	105.4	105.5
Final Weight of the Film collected on sieve (g)	2.175	3.928	5.100
Average Disintegration	**3.55 %**		

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Ecotoxicity and Germination Study

The following table below summarizes the results for the germination rate and plant biomass of winter rye and cress greens grown in the compost sample. The results are the averages for 25% and 50% compost concentrations.

Table 5: Ecotoxicity Results for Winter Rye

Concentration	Emergence % Compared to Blank	Biomass % Compared to Blank	Survival %
25 % test compost	141	143	96
50 % test compost	114	97	96

Percent emergence was measured for both varieties of seeds tested at concentrations of 25% and 50% disintegration compost. Winter rye seeds planted at concentrations of 25% and 50% met the minimum 50% emergence requirement per ASTM D6400. Cress green seeds planted at 25% and 50% concentrations did not met the minimum 50% emergence requirement for either the test or control samples. Therefore, no data has been included from the cress greens grass germination or ecotoxicity study as it was determined to be an invalid test, however it should be noted that a similar germination trend was observed and no detrimental effects were seen when the sample and control were compared. Based upon the results of the winter rye test sets, the residual chemicals remaining in the soil after disintegration do not hinder germination rates.

Biomass was measured by cutting the plants at soil level two weeks after 50% emergence. Plants were then dried in an oven at 60°C until a constant weight was attained. Winter rye grown at 25% and 50% compost concentrations had 87% and 123% plant biomass, respectively as compared with control samples. Based upon the satisfactory results of the germination and biomass analysis, it can be concluded that no harmful effects are evident in regards to plant growth from the disintegration of the PE film sample in compost.

FTIR Analysis

FTIR analysis was performed on the clear plastic of the PE Film. It was a near identical match to the spectrum known as poly (lactic acid) or PLA, a biodegradable plastic polymer. See Annex A for FT-IR spectrum.

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Conclusion

PE Film samples from Yapkim Yavuzlar Plastik ve Kimya San. Tic. A.S. were tested to select requirements of ASTM D6400 including heavy metals analysis, disintegration while composting over a 12 week period, and ecotoxicity to determine if residual chemicals negatively affect plant germination and growth. **Based on the results of testing, the PE film samples provided by Enviplas (ENVI™) passes the select requirements of ASTM D6400 for disintegration (6.2), heavy metals concentration (6.4.1), and ecotoxicity (6.4.2).** The composition of the film was verified by the FT-IR scan, as it was determined that the film is composed of a cellulosic material lined with PLA, a known biodegradable plastic.

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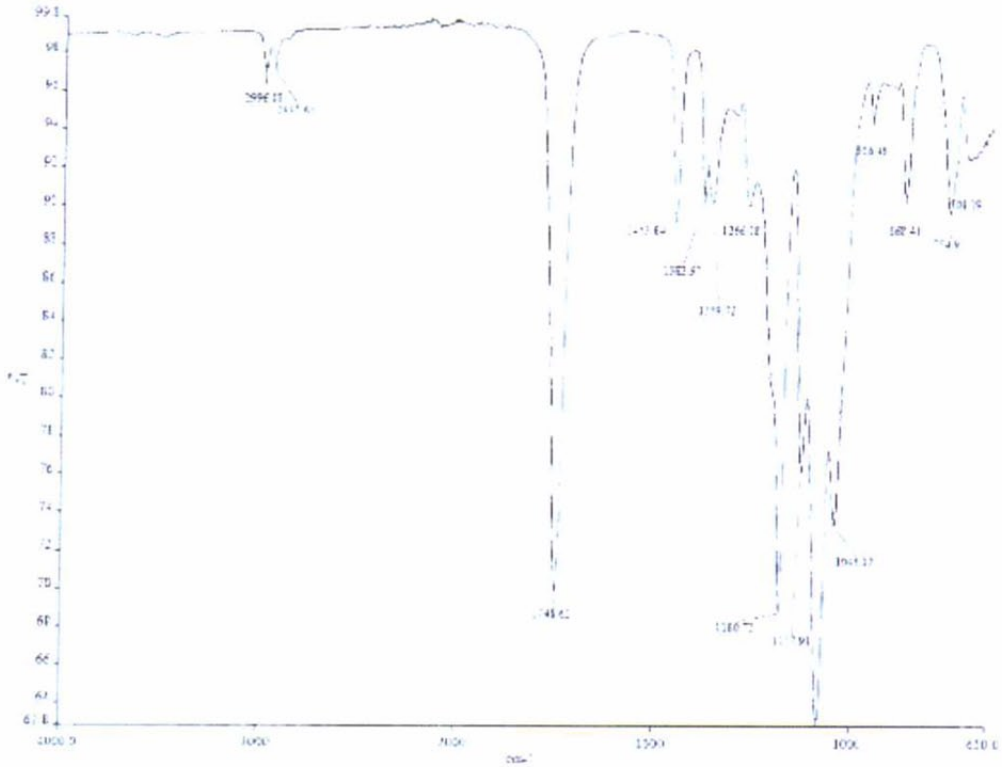
ANNEX A

FT-IR analysis was performed on between the regions 4000-650 cm^{-1}. The following plot shows the resulting spectra.



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