



Plastics Forming Enterprises, LLC

Plastics Consulting, Research and Engineering

Danimer Scientific

Hot Melt Adhesive Evaluation

Recyclability Evaluation:

Objectives:

- Determine the solubility and/or degradation ability of the test adhesive

Materials:

- PET Sheet
- Hot Melt Adhesive - 92721

Equipment:

- Recycle System
 - Pilot Plant Wash System
 - Convection Ovens (Surface Drying)
 - GARDCO Milled Adhesive Applicator
 - Grinder with 3/8" Screen
 - Konica Minolta Spectrophotometer

Procedure

- Cut PET sheet to appropriate size for adhesive and label application
- Apply approximately 1.3g of hot melt adhesive to 5 pieces of PET sheet using recommended application temperatures per MSDS sheet supplied by Danimer and a GARDCO milled adhesive applicator (.5 mils)
- Secure Clear, unprinted OPP wrap label to surface of adhesive. Label size is calculated to be approximately .3% by weight of total test batch material (5lbs.)
- Allow adhesive and label to cure for 72 hours
- Grind un-labeled control materials and test adhesive sheet materials separately to 3/8" flake size
- Process through pilot scale recycle process
- Allow materials to air dry
- Perform color measurements on processed flakes to view any variation between the control materials and test materials
- Oven test control and test materials to reveal any deposited adhesives or left over label that did not release from the PET flakes

GARDCO Milled Adhesive Applicator



Pilot Scale Wash System

Test material flakes were washed according to APR standard protocol. This includes washing the material with caustic wash (see described below). The material was then rinsed and dried in ambient air flow. The process conditions for all variables were identical.

Caustic Wash: The flakes are exposed to a caustic wash of 1% NaOH and 0.3% Triton X-100 (surfactant) at 185°F (85° C) for 15 minutes. The liquid to solids ratio is 4:1 by weight and an agitator was used at 880 rpm. These conditions represent a standard wash process used to remove dirt and label adhesive during the typical reclamation process.

Rinse: Flakes are drained of caustic wash solution and are rinsed with room temperature water for 2 minutes at 880 rpm of agitation in order to remove the caustic solution.

Sink/Float: Flakes are submitted to a sink/float process to remove any label materials that float during the wash process.

Drying: Flakes were ambient air dried with no heat or vacuum.

Wash and Rinse Waters

Settled

Shaken

CTRL



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Flake Color Analysis



WASHED FLAKE COLOR DATA

Plastics Forming Enterprises, LLC

Date:

Project #: 383

Operator: JG

Equipment: Konica Minolta CM-3600d

Conditions: CIE Lab, 10 degrees, D65

Run #	Description	L * Values	a* Values	b* Values	L* Average	a* Average	b* Average
Control	Control	65.23	-0.04	0.33	66.12	-0.03	-0.03
		66.86	-0.04	-0.02			
		66.13	-0.06	-0.37			
		65.53	-0.01	-0.01			
		66.85	-0.02	-0.08			
383-1	Test Adhesive	70.97	-0.09	0.20	70.28	-0.10	0.20
		68.19	-0.10	0.26			
		71.01	-0.10	0.28			
		70.77	-0.12	0.04			
		70.47	-0.08	0.20			



COOKED FLAKE COLOR DATA

Plastics Forming Enterprises, LLC

Date:

Project #: 383

Operator: JG

Equipment: Konica Minolta CM-3600d

Conditions: CIE Lab, 10 degrees, D65

Run #	Description	L * Values	a* Values	b* Values	L* Average	a* Average	b* Average
Control	Cooked Flake	69.78	-0.53	0.94	70.14	-0.55	0.53
		69.92	-0.57	0.09			
		68.71	-0.54	0.33			
		70.58	-0.50	0.84			
		71.70	-0.63	0.47			
383-1	Cooked Test Flake	73.77	-0.64	1.53	71.77	-0.62	1.40
		71.34	-0.59	1.31			
		70.71	-0.64	1.64			
		71.93	-0.63	1.10			
		71.10	-0.58	1.42			

Flake Color Analysis

The flakes for both the control and test adhesive materials were analyzed for color with specific focus on the b^* values which can show yellowing in the positive range. Although there is some variation between the control and test materials it is not considered a significant amount of increase in b^* value.

Oven Tested Sample Photos

Samples of control and test label flake were oven tested in order to produce a visual representation of remaining label and/or adhesives in the flake material. This test submits the flakes to a temperature of 450°F for a period of 30 minutes. As can be seen,

Label 1



Control Flake

Test Flake

Conclusions

The overall results of the testing do not show a negative effect on the flake materials from the adhesives. Though this study is preliminary, it is evident that the adhesive releases the label and degrades in the caustic wash. It should also be noted that a larger than normal amount of adhesive was used in this study in order to get an idea of a potential “worst” case scenario.

In summary:

- Adhesive releases labels during the caustic wash
- Adhesive appears to degrade and go into solution
- Adhesive does not appear to impact the flake materials negatively
- Further study of this adhesive is recommended for full recyclability analysis