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**REPORT**

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**ISSUE DATE:** May 22, 2008

**ISSUED TO:** Al Poteat  
V2O Biocorp LLC

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**SUBJECT:** Evaluation of BioD Additive

**PROJECT NUMBER:** 458.001

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**EXECUTIVE SUMMARY**

BioD, an additive developed by Wells Plastics Limited to make the package 100% biodegradable, was evaluated in a generic carbonated soft drink (CSD) style bottle at PTI to determine the processability of the additive in a 2-stage injection stretch blow molding process.

Preforms were made using an industry standard 0.84dL/g PET resin, Invista 1101E, and 1.5% BioD masterbatch. The loading level of active BioD ingredient is not known at this time. Throughout the injection molding and blow molding portions of the study, there were no out of the ordinary processing conditions or anomalies that caused concern for the use of this BioD additive. Visually, the preform and bottle samples were very clear and free of any contamination, haze or other defects than can be caused by additive addition in PET. Bottle samples for biodegradability studies were shipped to an outside laboratory for testing.

**INJECTION MOLDING**

The Invista 1101E resin was dried in a desiccant bed dryer overnight at 300°F to a final moisture content of 5ppm prior to injection molding. The BioD masterbatches were dried in a vacuum oven overnight to moisture content less than 50ppm prior to injection molding. The incoming moisture of the masterbatches are listed in the table below.

<b>Batch#</b>	<b>Moisture (ppm)</b>
11964	2460
12628	1028

Preforms were injection molded using an Arburg unit cavity injection molding machine. The preforms that were made were 24.5g part designed to blow mold into a 20oz CSD container. Blends of the additive and colorant were prepared in aluminized Mylar bags that were sealed and tumbled for 10-15 minutes to ensure even blending of the resin, BioD masterbatch and colorant.

Two preform variables were injection molded; these variables are listed in the following table. The blue colorant was an addition to the trial; therefore, the colorant used was not optimal for the light blue color that was desired. The suggested loading level of this colorant was 0.35%, but the color produced at this loading level was much too dark; therefore, several steps down in this loading level were required to produce the desired color. The second variable produced contained only the BioD masterbatch to understand the level of yellowness that the additive causes in the preforms.

<b>Material Variables</b>		
<b>Injection Data for WR#</b>	<b>Colorant</b>	<b>Additive</b>
25899 A	0.005% ColorMatrix 85-1421-3	1.5% BioD
25899 B	N/A	1.5% BioD

**Preforms**



The injection molding machine was originally set up using virgin PET resin. This resin was used to determine the injection molding temperatures, pressures and speeds required to produce preforms with minimal injection molded stresses and good preform clarity. No changes were required to these standard PET conditions when the BioD additive was introduced. The processing parameters, including cavity fill time and cycle time remained the same even after the additive and colorant were introduced. These injection molding conditions are summarized in the following table.

### Injection Molding Conditions

<b>Injection Data for WR#</b>	25899 A & B
Injection Date	4/30/2008
Machine	#6 Arburg 420 M
Preform #	PRE-3987
Preform Weight (g)	24.7
Relative Humidity	51%
Dew Point (°F)	46.8
Mold Temp (°F)	50
Ambient Temp (°F)	65.5
Dryer Temp (°F)	300
<b>Barrel Temperatures</b>	
Feed (°C)	264
Zone 2 (°C)	265
Zone 3 (°C)	265
Zone 4 (°C)	265
Nozzle (°C)	265
<b>Injection</b>	
Injection Pressure 1 (bar)	500
Injection Time (sec)	2.5
1st Injection Speed (ccm/sec)	12.0
2nd Injection Speed (ccm/sec)	10.0
<b>Holding Pressure</b>	
Switch-Over Point (ccm)	9.0
1st Hold Pressure (bar)	350.0
2nd Hold Pressure (bar)	325.0
3rd Hold Pressure (bar)	300.0
1st Hold Pr. Time (sec)	2.5
2nd Hold Pr. Time (sec)	3.0
3rd Hold Pr. Time (sec)	2.0
Remain Cool Time (sec)	15.0
<b>Dosage</b>	
Circumf. Speed (m/min)	10.0
Back Pressure (bar)	15.0
Dosage Volume (ccm)	27.0
Meas. Dosage Time (sec)	3.6
Cushion (ccm)	4.9
<b>Adjustment Data</b>	
Cycle Time (sec)	29.4

## BLOW MOLDING

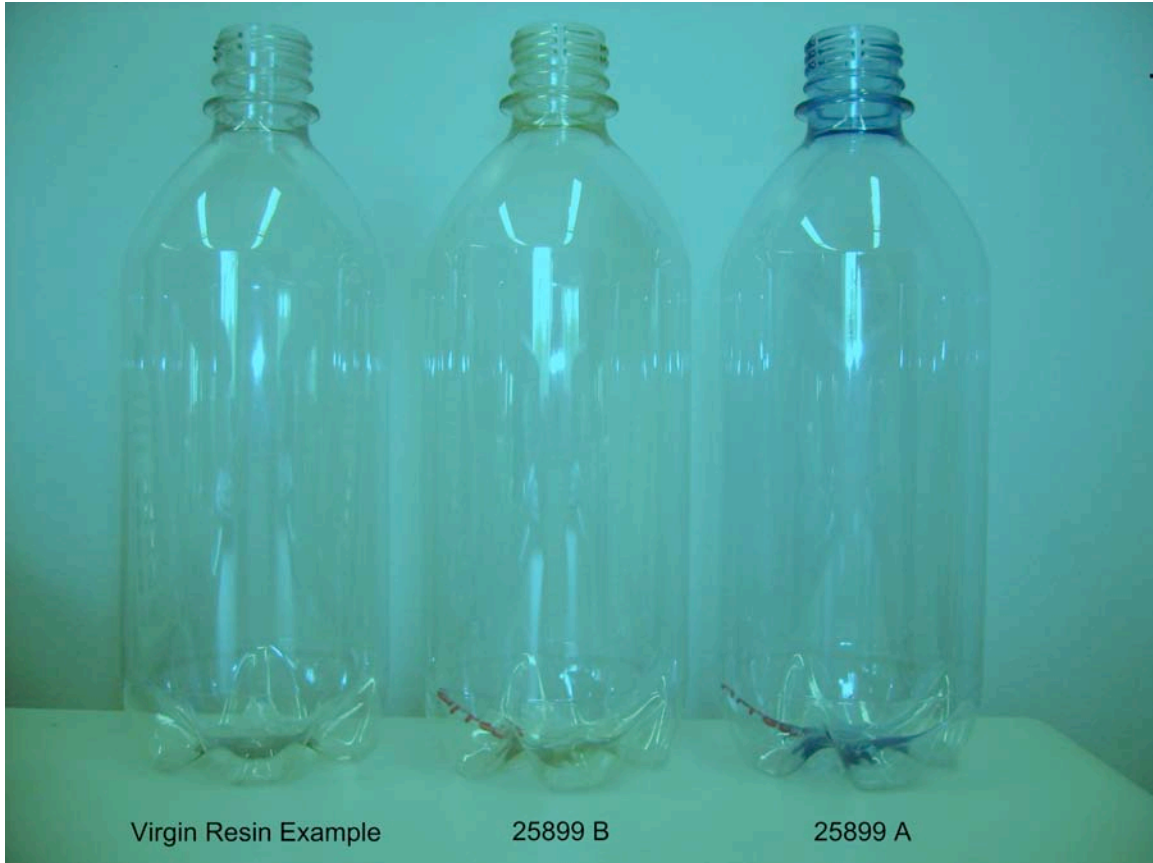
The preforms were blow molded into a 20oz straightwall CSD style container using a Sidel SBO1/2 blow molding machine. The blow molding conditions were set up to produce bottles with even material distribution and clarity throughout the bottle.

Processing began with a generic flat oven profile where each oven lamp was set to 50% of its power. From this starting point, only small changes in the oven heating profile and low blow air pressure were required. The final conditions used to produce samples for testing are very similar to typical conditions used to make standard PET bottles. The conditions that were used are summarized in the following table.

<b>Blow Molding Conditions</b>	
<b>Work Request</b>	<b>25899 A &amp; B</b>
Date Molded	5/1/2008
	1101 1.5% BioD + 0.005%
Resin	Blue
Speed (bph)	900
Overall	67
Oven Lamp Settings	
Zone 6	95
Zone 5	85
Zone 4	20
Zone 3	30
Zone 2	20
Zone 1	40
Low Blow Position (mm)	170
Low Pressure (bar)	11
High Blow Position (mm)	275
High Blow Pressure (bar)	40
Preblow Flow (bar)	3
Body Mold Temp (°F)	45
Base Mold Temp. (°F)	45
Preform Temp. (°C)	96
Top Weight (g)	9.7
Panel Weight (g)	9.7
Base Weight (g)	5.2

The following picture illustrates the color of the bottles that were produced. The bottle on the left of the picture was not produced during this trial; it is a bottle that was produced from the same preform/bottle combination using virgin 1101E resin. The picture shows that it is difficult to detect the slight yellowness of the 25899B variable in the sidewall of the bottle. The yellowness is mostly noticeable in the thicker finish and base areas of the bottle.

### Bottles



### ANALYTICAL TESTING

Preforms from the 25899A variable were submitted for intrinsic viscosity measurement using the solution viscosity method ASTM D4603. This testing was performed to ensure that the BioD masterbatch did not have a significant negative impact on the IV loss of the preforms; significant IV loss can have a negative impact on the physical strength and performance of PET containers. The IV of the preform submitted was 0.81dL/g, as shown in the table below, this results is very typical of Pet preforms made on PTI's unit cavity Arburg systems. The initial resin IV was 0.84dL/g, as quoted in the specification sheet from the supplier, so the loss in IV through the injection molding process was 0.03dL/g.

### Preform SIV Result

<b>Injection Data for WR#</b>	<b>IV (dL/g)</b>
25899 A	0.81

The color and haze of the preforms and bottles from the 25899A variable were also measured at PTI to understand the clarity of the containers produced. One of the negative impacts that additives typically have in PET containers is the loss of clarity in the bottle. The amount of haze in the bottle is less than 1% which is very good for a PET bottle.

### Preform and Bottle Color and Haze Results

		<b>L*</b>	<b>a*</b>	<b>b*</b>	<b>Haze(%)</b>
<b>Preform</b>	<b>Average</b>	<b>56.67</b>	<b>-11.44</b>	<b>-15.62</b>	<b>60.69</b>
	<b>St. Dev.</b>	0.31	0.16	0.35	0.18
<b>Bottle</b>	<b>Average</b>	<b>93.56</b>	<b>-0.99</b>	<b>-0.85</b>	<b>0.94</b>
	<b>St. Dev.</b>	0.10	0.07	0.14	0.02

### CONCLUSIONS AND NEXT STEPS

Overall, the trial was very successful; there were no processing issues caused by the BioD additive that cause any concern at this time with the processability of this material. The injection molding press was actually set up with the same virgin material that was used to create the blends and no further processing was required to produce the BioD preforms. There were no virgin preforms available to set up the blow molding machine; however, the conditions that were determined to produce good bottles are very similar to conditions used to produce standard PET bottles in the past. The IV and color testing also produced results that were typical of a standard PET.

Once the biodegradation testing results are complete, further physical testing or recyclability testing should be considered to rule out the possibility of poor container performance on the store shelves or a negative impact on the recycle stream.

- A. **Confidentiality.** It is recognized that both PTI and V2O BIOCORP LLC may have access to information considered confidential by the other party. The terms of Confidentiality have been previously agreed to by parties, which cover this agreement.
- B. **Warranty.** It is expressly understood and agreed that the services required of PTI hereunder involve research and development, and PTI cannot represent, warrant or guarantee the success of its efforts. PTI is only able to represent, and hereby does represent and warrant, that it will use its best efforts to perform the services requested of it in a workmanlike and professional manner consistent with industry standards. Except as provided herein, PTI makes no other express or implied warranties, including but not limited to warranties of merchantability and fitness for a particular purpose, with respect to the services to be provided hereunder. V2O BIOCORP LLC's sole and exclusive remedy in the event PTI does not perform the services required under this Agreement is to require PTI to employ its best efforts to correct any work or services improperly performed and/or to terminate this Agreement. In no event shall PTI be liable for damages of any sort, including special, indirect, incidental, consequential or punitive damages (including lost revenues or profit) other than for intentional misconduct or gross negligence of PTI. PTI shall not be responsible for claims alleging infringement or other violation of intellectual property rights with respect to services performed or technology and other intellectual property created at V2O BIOCORP LLC's request, nor shall PTI be responsible for any claims, losses or damages arising from V2O BIOCORP LLC's future use or commercialization of any of the methods, technologies, designs, or products identified or developed by PTI.
- C. **Indemnity.** It is understood and agreed that PTI is a service business providing consulting services of the type described in this Agreement for an hourly rate of pay for Customers who are capable of evaluating and testing PTI's work and who expect to utilize PTI's work product in commercial applications. As a result, except as otherwise provided herein, V2O BIOCORP LLC agrees to indemnify and hold harmless PTI and Agents of PTI from and against any and all damages, losses, liabilities, costs and expenses (including without limitation, consequential and incidental damages, attorney and paralegal fees and disbursements in reasonable amounts) incurred directly or indirectly by PTI or by any of the indemnified parties arising out of or resulting from the services to be performed by PTI hereunder and any alleged defect in or nonperformance of the same, except where due to the intentional misconduct or gross negligence of PTI.
- D. **Governing Law and Choice of Jurisdiction.** This Agreement and the obligations of the parties hereunder will be interpreted, construed and enforced in accordance with the laws of the State of Ohio, without regard to principles governing conflicts of law. Any action or proceeding with respect to this Agreement shall be instituted only in the courts of Lucas County, Ohio, or the United States District Court for the Northern District, Western Division, of Ohio. PTI and V2O BIOCORP LLC hereby submit to the jurisdiction of each such court and waive any objection to venue in any such court whether based upon inconvenient forum or otherwise.