Mobile Laboratory Screening Method for Phthalate Esters in Children’s Toys by Gas Chromatography/Mass Spectrometry

ECL REPORT 2008-03

September 2008
Environmental Chemistry Laboratory Report

Mobile Laboratory Screening Method for Phthalate Esters in Children's Toys by Gas Chromatography/Mass Spectrometry

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2/11/09
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EXECUTIVE SUMMARY

Phthalate esters are commonly added into PVC as softeners to make plastic material flexible. Phthalates are suspected cancer causing agents and possible teratogens which have been linked to liver and kidney damage, and the underdevelopment of reproductive organs in humans and animals. Public health concerns of human exposure to phthalates are on the rise as they do not chemically bond to PVC and may leach out over time.

Following in the European Union’s and Japan’s footsteps in restricting certain phthalates usage, a regulatory limit of 0.1% in children’s toys was established by the California State Legislature (AB-1108). The Department of Toxic Substances Control (DTSC) has been delegated the role of lead agency for consumer product safety.

To support DTSC’s Green Chemistry activities, ECL’s Mobile Laboratory Team has developed an on-site screening method to monitor phthalates in children’s toys. The method was first tested in a collaborative study with the San Francisco Department of the Environment who provided the samples. This method is simple, fast and effective with ample sensitivity to quantify the 6 phthalates in children’s toys at 100 ppm (LOQ=100 ug/g) which is 10 times lower than the regulatory threshold of 0.1%. Additionally, this method has a high throughput capability and enables testing of approximately 6 to 10 samples per day depending on the complexity of the sample matrix and concentration. This method is designed to survey the 6 phthalates in children’s toys and other consumer products for compliance with the threshold of 0.1% (1,000 ppm).
TABLE OF CONTENTS

EXECUTIVE SUMMARY ........................................................................................................... 3
TABLE OF CONTENTS ............................................................................................................ 4
ABBREVIATIONS AND ACRONYMS .................................................................................... 5
LIST OF TABLES AND FIGURES ............................................................................................ 6
INTRODUCTION ....................................................................................................................... 7
METHOD ................................................................................................................................... 7
  Materials and Reagents ..................................................................................................... 7
  Apparatus ......................................................................................................................... 7
  Standard and Sample Preparation .................................................................................... 8
RESULTS AND DISCUSSION ................................................................................................. 8
REFERENCES ......................................................................................................................... 11
ACKNOWLEDGMENTS ........................................................................................................... 11
ABBREVIATIONS AND ACRONYMS

BBP = Benzyl butyl phthalate  
DBP = Dibutyl phthalate  
DEHP = Bis(2-ethylhexyl) phthalate  
DIDP= (Di-isodecyl) phthalate  
DINP = (Di-isononyl) phthalate  
DNO = Di-n-octyl phthalate  
GC/MS = Gas Chromatography/Mass Spectrometer  
ISTD = internal standard  
ML = Mobile Laboratory  
PVC = Polyvinyl chloride [(CH2-CHCl)n]  
STD = standard
LIST OF TABLES AND FIGURES

Table 1: Phthalate esters, quantitation ions and qualifiers.
Table 2: Recovery data of phthalate esters in PVC matrix.
Table 3: Phthalate esters found in 11 children’s toy samples purchased by the San Francisco Department of the Environment.

Figure 1: Phthalate structures, molecular weights and CAS numbers.
Figure 2: Group-1 phthalate esters including surrogate (diethyl phthalate), dibutyl phthalate, internal standard (Bis [2-butoxyethyl] phthalate), di-n-octyl phthalate, and di-isodecyl phthalate.
Figure 3: Group-2 phthalate esters including surrogate (diethyl phthalate), benzybutyl phthalate, internal standard (bis [2-butoxyethyl] phthalate), Bis[2-ethylhexyl] phthalate, and di-isononyl phthalate.
Figure 4: Chromatograms of PVC matrix blank, Group-1 phthalate matrix spike, and Group-2 phthalate matrix spike.
Figure 5: Sample and standard target ions overlay, a) DINP and b) DIDP.
INTRODUCTION

Polyvinyl chloride or PVC [(CH2-CHCl)n] is widely used in toys, children’s products and many other household items. PVC is generally hard and brittle, and different percentages of phthalate esters are commonly added to make the plastic material flexible. As a result, many soft PVC children’s toys, chewing teethers, feeding and care products contain high concentrations of phthalate esters.

Due to public health concerns, the EU has set regulations to limit phthalates to 0.1% in toys (1). The City of San Francisco has also recently passed City Health Code Sections 34.1 to 34.6 to follow the EU standard in regulating children’s products containing phthalates.

To support the Department of Toxic Substance Control (DTSC) in measurement of toxic chemicals in consumer products, this screening method was developed for use in the DTSC Mobile Laboratory (ML) to conduct on-site monitoring of toxic phthalates in consumer products. This method relies upon a streamlined sample preparation procedure, adjusted to accommodate smaller equipment, fewer apparatus and less manpower due to the ML’s workspace limitations; however, the method is also suitable to be used in fixed laboratories.

Simple, quick and effective, this method enables the screening of phthalate esters in consumer products on site. The limit-of-detection (LOD) or detection limit (DL) is 100 ppm which is sensitive enough for screening purpose at the regulatory action level of 1,000 ppm or 0.1%.

MATERIALS AND METHODS

Materials and Reagents
2. Standards: dibutyl phthalate (DBP), di-n-octyl phthalate (DNOP) and diisodecyl phthalate (DIDP), Benzyl butyl phthalate (BBP), bis(2-ethylhexyl) phthalate (DEHP) and di-isononyl phthalate (DINP), Restek Corporation, 110 Benner Circle, Bellefonte, PA 18823.
3. Internal Standard: bis(2-butoxyethyl) phthalate (DBEP), Restek Corporation, 110 Benner Circle, Bellefonte, PA 18823.

Apparatus
The ML consists of one vehicle (Ford F-555), a satellite communication system and two gas chromatograph/mass spectrometers (GC/MS) specifically designed for detecting toxic industrial chemicals in air, soil and water. The advanced analytical instruments are complemented by a series of field instruments for the quick detection of volatile compounds, metals and other chemicals.
The GC/MS system used in this study was:
1. GC/MSD: Agilent 6850/5973 GC/MSD with ChemStation computer system.
2. Column: HP-5MS (5% phenyl methyl siloxane), 30m x 0.25mm x 0.25um.
3. Temperature program: rate 100°C/min., initial temperature 80°C for 1 min., temperature 250°C for 1 min., rate 10°C, temperature 320°C for 1 min., and run time 11.70 min. Injector temperature 250°C.
4. MSD setup: DFTPP tune, full scan mode (50-480 amu).
5. Valley-to-valley integration for DBEP (ISTD), DEP (surrogate), DBP, BBP, DNOP and DEHP and area-sum integration for DINP (8.5-9.9 min) and DIDP (9.6-10.6 min).

**Standard and Sample Preparation**

The following standards were prepared:
1. Internal standard – DBEP (Bis[2-butoxyethyl] phthalate), 1,000 ug/mL in dichloromethane.
2. Surrogate – DEP (Diethyl phthalate), 1,000 ug/mL in dichloromethane.
3. Standard mixture Group-1 – DBP (dibutyl phthalate), DNOP (di-n-octyl phthalate) and DIDP (diisodecyl phthalate), 1,000 ug/mL in dichloromethane.
4. Standard mixture Group-2 - BBP (Benzyl butyl phthalate), DEHP (bis(2-ethylhexyl) phthalate) and DINP (di-isononyl phthalate), 1,000 ug/mL in dichloromethane.
5. Standard linear curve quantitative levels –10, 50 100, 150 and 200 ug/mL in hexane.

**Sample Preparation**

Samples were ground or cut into pieces sized at less than 2 mm². Approximately 1g (0.9-1.1g) of the cut pieces were placed into a 40 mL VOC bottle and 8 mL of DCM (dichloromethane, CH2Cl2), 1mL of surrogate (DEP, conc. 1,000 ug/mL) and 1 mL of internal standard (DBEP, 1,000 ug/mL) were added. The sample bottle was shaken for 1 hour. Approximately 1 mL of the top layer of this extract was transferred into a vial for GC/MSD injection to measure low concentration (0.1-0.2%) phthalates (1:10 dilution).

Alternatively, for anticipated high phthalate concentrations, 1 g of the cut pieces were placed into a 40 mL VOC bottle and 10 mL DCM were added into the bottle. After the sample bottle was shaken for 1 hour, 1 ml of the extract was transferred into another 40 mL VOC bottle and then, 1 mL of internal standard (DBEP, 1,000 ug/mL), 1 mL surrogate and 7 mL DMC were added into the VOC bottle, mixing well. Approximately 1 mL of the top layer of this extract was transferred into a vial for GC/MSD injection to measure high concentration (1-2%) phthalates (1:100 dilution). Further dilution may be needed to bring the sample concentration level into the calibration range (10 to 200 ug/mL) for some samples having very large content of phthalates (e.g. 45%).

**RESULTS AND DISCUSSION**

Phthalates in plastics are suspected cancer causing agents and possible teratogens which have been linked to liver and kidney damage, and the underdevelopment of reproductive organs in humans and animals (2). Public health concerns about the safety
of human exposure to phthalates are on the rise. PVC and other types of plastics pollution in the California coastline, ocean and waterways are also increasingly prevalent. The Governor’s ocean Protection Council adopted a new resolution to reduce and prevent marine debris on February 8, 2007 (3).

Following in the European Union’s (1) and Japan’s footsteps (4) in restricting phthalates usage in toys, the City and County of San Francisco passed an ordinance in April 2007 to regulate phthalates in toys, child care products and child feeding products. The health code limits six phthalates, including DBP (dibutyl phthalate), DNOP (di-n-octyl phthalate), DINP (di-isodecyl phthalate), BBP (benzylbutyl phthalate), DEHP (Bis [2-ethylhexyl] phthalate) and DINP (di-isononyl phthalate), to concentration levels of 0.1% or lower in all child-related products. Consequently, the DTSC has become increasingly interested in the matter due to its mission to protect public health and the environment from toxic harm. To this end, a quick and effective screening method was developed by the Mobile Laboratory Team to monitor the presence of toxic products on-site and to provide rapid information to the various government agencies (city, county and state) for necessary corrective action.

The structures of the 6 phthalates are presented in Figure 1. During method development two challenging aspects in testing the six phthalates were identified. The first unusual aspect encountered was that while DBP, BBP, DNOP and DEHP appeared as single peaks in the chromatogram, DIDP and DINP each appeared as multiple peaks due to isomeric congeners. The solution was to use traditional valley-to-valley integration to obtain area counts for quantitative calculation of the single-peak phthalates, and then subsequently change to area summation integration for the late eluting multi-peak phthalates. The second difficulty was that DEHP, DIDP and DINP eluted closely together and could not be easily separated by gas chromatograph temperature programming. The overlapping retention time presented challenges in identification and quantitation. Fortunately, these three phthalates are not commonly used together as mixture ingredients in a single product based on reported findings (2, 5). Using an innovative approach this method divided six phthalates into 2 groups and used 2 separate calibration schemes to process data consecutively after the GC/MSD data acquisition was completed. The autosampler data processing for 2 calibration programs was linked by a few macro commands in the method software. Chromatograms in Figure 2 present the 2 groups of phthalates.

The additional benefit of dividing the 6 phthalates into 2 groups was that the GC program time was reduced to less than 12 minutes per sample without sacrificing peak-to-peak resolution. Consequently, the throughput doubled that of other methods (5, 6). This improvement positively impacted turnaround time, enabling large sample loads to be rapidly analyzed in a short period of time.

Target ion selection for data processing is critical in quantitative analysis, with the base ion usually being the most favorable candidate to be chosen because it holds the highest abundance value in the spectrum. In this case, the predominant ion or base ion for all phthalates is m/z 149 (C₈H₅O₃), with S/N ratio approximately 10 to 100 fold higher.
than other ions in the spectrum. Furthermore, this ion is extremely sensitive. The stable m/z 149 ion, corresponding to a protonated phthalic anhydride, can be expected from the formation of any phthalate ester by charge of the two ester bonds during the ionization process (7). In order to eliminate matrix interferences from unwanted phthalates for quantitation, this method had to select less intense ions as application ions. Table 1 presents the selected target ion and two qualifying ions for each phthalate. Phthalate identification was confirmed by probability based match (PBM) logarithm with the NIST library data base, as all spectra were acquired in full scan mode by this method. Additionally, overlay target ion of sample peak and standard peak is a useful tool to identify and differentiate DINP and DIDP because both phthalates have slightly different retention times with distinguishing multiple peak shapes. Peak shape overlays are presented in Figure 5.

This method is simple, fast and effective; the recovery data and their statistics were based on a set of 5 replicates of PVC matrix spikes with 6 target phthalate esters and 1 surrogate at 100 ppm level, the recovery means, SD and RSD are presented in Table 2. The ranges of recovery mean, SD and RSD were 98%-108%, 6.42-15.58 and 5.92%-15.25% respectively. The chromatograms of PVC matrix blank and matrix spikes are presented in Figure 4. As a pilot trial, a total of 11 children’s toy samples purchased by the City of San Francisco Department of the environment for this collaborative study were tested by this method, 54% were found to contain large amounts of the six regulated phthalate esters. Examples of 4 toy samples are presented in Figure 6. Duplicate results with relative percent difference (RPD) are presented in Table 3. The range of RPD was 0.32 to 18.79%. All of these data demonstrate that this is a valid and effective method.

**Conclusion**

This screening method was developed for application in a space-limited mobile laboratory; however, the method is equally valid in all fixed laboratories. The method uses GC/MSD to screen six regulated phthalate esters with minimum sample preparation; as such, the reporting results could be lower than the actual amount in certain products (ca. 90-95%). If the amounts found are near the threshold level at 0.1%, longer extraction time (e.g. overnight) is recommended.

Simple, fast and effective, the method has a high throughput capability to meet the needs of providing information for on-site characterization purposes. This method is designed to survey the six phthalates in children’s toys and other consumer products for compliance with the regulatory threshold of 0.1% (1,000 ppm).

**Calculations and Reporting**

The concentration of each phthalate (as ppm or percent by weight) in the test sample is calculated according to the following equation:

\[
\text{Phthalates (ug/g or ppm)} = \frac{\text{Area Spl/Area ISTD in Spl} \times \text{Area ISTD in Std}}{\text{Area Std} \times \text{Std conc.} \times \text{Spl W (g)} \times \text{V (mL)}}
\]
Where:
Spl = sample
ISTD = internal standard
STD = standard
W = weight
V = volume (dilution)

Calculation for percent recovery

% Rec. = (Amount of cpd. Recovered / Amount of cpd. spiked) x 100

Calculation for relative percent difference (RPD)

RPD = (Value A – Value B / Average of A+B) x 100

REFERENCES


(2) Ruth Stringer, Irina Labounskaja, David Santillo, Paul Johnston, John Siddorn and Angela Stephenson, Determination of the Composition and Quantity of Phthalate Ester Additives in PVC Children’s Toys, Greenpeace Research Laboratories Technical Note 06/97, September 1997.


ACKNOWLEDGMENTS

The authors thank Dr. Bruce La Belle (ECL Manager) and Dr. Myrto Petreas (Branch Chief) for their support and encouragement of this research project. The authors also thank Ms. Deborah O. Raphael (Manager of San Francisco Environment) for providing all toy samples.
Table 1: Phthalate esters, CAS number, quantitation ions and qualifiers.

* Group-1 targeted phthalates.
** Group-2 targeted phthalates.

<table>
<thead>
<tr>
<th>Phthalate Esters</th>
<th>CAS No.</th>
<th>Type</th>
<th>Quantitation Ion</th>
<th>Qualify Ion 1</th>
<th>Qualify Ion 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bis(2-butoxyethyl) phthalate</td>
<td>000117-83-9</td>
<td>Internal std</td>
<td>193.1</td>
<td>249.2</td>
<td>294.2</td>
</tr>
<tr>
<td>DEP-Diethyl phthalate</td>
<td>000084-66-2</td>
<td>Surrogate</td>
<td>177.1</td>
<td>178.1</td>
<td>222.2</td>
</tr>
<tr>
<td>DBP-Dibutyl phthalate</td>
<td>000084-74-2</td>
<td>* Target</td>
<td>223.2</td>
<td>205.2</td>
<td>167.1</td>
</tr>
<tr>
<td>BBP-Benzyl butyl phthalate</td>
<td>000085-68-7</td>
<td>** Target</td>
<td>206.2</td>
<td>178.2</td>
<td>238.1</td>
</tr>
<tr>
<td>DEHP-Bis(2-ethylhexyl) phthalate</td>
<td>000117-81-7</td>
<td>** Target</td>
<td>167.1</td>
<td>279.2</td>
<td>390.3</td>
</tr>
<tr>
<td>DNOP-Di-n-octyl phthalate</td>
<td>000117-84-0</td>
<td>* Target</td>
<td>279.2</td>
<td>261.2</td>
<td>167.1</td>
</tr>
<tr>
<td>DINP (Di-isononyl) phthalate</td>
<td>020548-62-3</td>
<td>** Target</td>
<td>293.3</td>
<td>167.1</td>
<td>307.3</td>
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<tr>
<td>DIDP (Di-isodecyl) phthalate</td>
<td>026761-40-0</td>
<td>* Target</td>
<td>307.2</td>
<td>281.0</td>
<td>253.0</td>
</tr>
</tbody>
</table>
Table 2: Recovery of phthalate esters in PVC matrix.

<table>
<thead>
<tr>
<th>Phthalate Esters</th>
<th>Spike Amount ppm or ug/g</th>
<th>Number of Replicates</th>
<th>Recovery Mean, %</th>
<th>SD</th>
<th>RSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEP-Diethyl phthalate (surrogate)</td>
<td>100</td>
<td>5</td>
<td>104</td>
<td>8.40</td>
<td>8.07</td>
</tr>
<tr>
<td>DBP-Dibutyl phthalate</td>
<td>100</td>
<td>5</td>
<td>107</td>
<td>8.61</td>
<td>8.04</td>
</tr>
<tr>
<td>BBP-Benzyl butyl phthalate</td>
<td>100</td>
<td>5</td>
<td>98</td>
<td>6.50</td>
<td>6.65</td>
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<tr>
<td>DEHP-Bis(2-ethylhexyl) phthalate</td>
<td>100</td>
<td>5</td>
<td>107</td>
<td>7.52</td>
<td>7.04</td>
</tr>
<tr>
<td>DNOP-Di-n-octyl phthalate</td>
<td>100</td>
<td>5</td>
<td>108</td>
<td>6.42</td>
<td>5.92</td>
</tr>
<tr>
<td>DINP (Di-isononyl) phthalate</td>
<td>100</td>
<td>5</td>
<td>103</td>
<td>7.69</td>
<td>7.44</td>
</tr>
<tr>
<td>DIDP (Di-isodecyl) phthalate</td>
<td>100</td>
<td>5</td>
<td>102</td>
<td>15.58</td>
<td>15.25</td>
</tr>
</tbody>
</table>
Table 3: Phthalate esters found in 11 children’s toy samples purchased by the San Francisco Department of the Environment

<table>
<thead>
<tr>
<th>ECL Lab No.</th>
<th>Product Description</th>
<th>Surrogate Recovery (%)</th>
<th>Phthalate found</th>
<th>Amount in Duplicate ( % W/W)</th>
<th>RPD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR05613</td>
<td>White horse</td>
<td>102, 99.6</td>
<td>DINP</td>
<td>27.99</td>
<td>27.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DIDP</td>
<td>10.22</td>
<td>9.98</td>
</tr>
<tr>
<td>AR05614</td>
<td>Pink horse</td>
<td>85.3, 90.0</td>
<td>DINP</td>
<td>25.91</td>
<td>26.41</td>
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<td></td>
<td></td>
<td></td>
<td>DIDP</td>
<td>10.51</td>
<td>11.71</td>
</tr>
<tr>
<td>AR05615</td>
<td>Pink Doll</td>
<td>74.0, 64.6</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>AR04536</td>
<td>Yellow duck</td>
<td>101, 109</td>
<td>DINP</td>
<td>0.13</td>
<td>0.12</td>
</tr>
<tr>
<td>AR04538</td>
<td>Bath Jelly</td>
<td>170, 162a</td>
<td>DINP</td>
<td>44.50</td>
<td>44.23</td>
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<tr>
<td>AR04544</td>
<td>Plastic man</td>
<td>129, 121</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>AR04545</td>
<td>White doll</td>
<td>132, 140</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>AR00131</td>
<td>Squeez a bubble</td>
<td>104, 108</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>AR00132</td>
<td>Bendable pokey</td>
<td>163, 168a</td>
<td>DINP</td>
<td>46.00</td>
<td>38.10</td>
</tr>
<tr>
<td>AR00133</td>
<td>My little pony</td>
<td>103, 103</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>AR00134</td>
<td>Bath sticker</td>
<td>160, 169a</td>
<td>DEHP</td>
<td>16.66</td>
<td>17.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DINP</td>
<td>7.96</td>
<td>7.86</td>
</tr>
</tbody>
</table>

a. Matrix interference by high concentration of phthalates.
Figure 1: Phthalate structures, molecular weights and CAS numbers.

- **Benzylbutyl phthalate**
  - M.Wt. 312.14, CAS 000085-68-7

- **Diethyl phthalate**
  - M.Wt. 222.09, CAS 000084-66-2

- **Bis [2-butoxyethyl] phthalate**
  - M.Wt. 366.20, CAS 000117-83-9

- **Di-n-ocytyl phthalate**
  - M.Wt. 390.28, CAS 000117-84-0

- **Di-isononyl phthalate**
  - M.Wt. 418.31, CAS 020548-62-3

- **Dibutyl phthalate**
  - M.Wt. 278.15, CAS 000084-74-2

- **Di-isodecyl phthalate**
  - M.Wt. 446.34, CAS 026761-40-0

- **Bis[2-ethylhexyl] phthalate**
  - M.Wt. 390.28, CAS 000117-81-7
Figure 2: Group-1 phthalate esters including surrogate (diethyl phthalate), dibutyl phthalate, internal standard (bis [2-butoxyethyl] phthalate), di-n-octyl phthalate, and di-isodecyl phthalate.

![Figure 2](image)

Figure 3: Group-2 phthalate esters including surrogate (diethyl phthalate), benzybutyl phthalate, internal standard (bis [2-butoxyethyl] phthalate), bis[2-ethylhexyl] phthalate, and di-isononyl phthalate.

![Figure 3](image)
Figure 4: Chromatograms of PVC matrix blank, Group-1 phthalate matrix spike, and Group-2 phthalate matrix spike

Matrix blank with surrogate and ISTD

Group-1 DBP, DNOP and DIDP matrix spike
Group-2 BBP, DEHP and DINP matrix spike

Figure 5: Sample and standard target ions overlay, a) DINP and b) DIDP

a) DINP target ion, m/z 293.3 overlay
b) DIDP target ion, m/z 307.2 overlay
Appendix – Sample Pictures and Reports
AR00131 to AR00134
### Quantitation Limit

<table>
<thead>
<tr>
<th>Analyte</th>
<th>COL. NO</th>
<th>ECL NO.</th>
<th>PVC-16</th>
<th>PVC-17</th>
<th>PVC-18</th>
<th>PVC-19</th>
<th>Meth</th>
<th>Blank</th>
<th>Meth</th>
<th>Blank</th>
<th>Meth, Chloride</th>
<th>Chloride</th>
<th>mg/Kg</th>
<th>mg/Kg</th>
<th>mg/Kg</th>
<th>mg/Kg</th>
<th>mg/Kg</th>
<th>mg/Kg</th>
</tr>
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<tbody>
<tr>
<td>Di-n-butyl phthalate (DBP)</td>
<td>ND</td>
<td>AR00131</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>10</td>
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<td>100</td>
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<td>Benzylbutyl phthalate (BBP)</td>
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<td>AR00132</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td></td>
<td></td>
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<tr>
<td>Bis-2-ethylhexyl phthalate (DEHP)</td>
<td>ND</td>
<td>AR00133</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>179,000</td>
<td>ND</td>
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<td>ND</td>
<td>78,600</td>
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<td>25000*</td>
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**Notes:** ND = NOT DETECTED  
MG/KG - MILLIGRAM PER KILOGRAM

* = Multiply concentration of lowest std by dilution factor.

---

**Sample Preparation:**

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<th>Requester</th>
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**Quantitation Limit**

**Sample Prepared:**

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**Quantitation Limit**

**Sample Analyzed:**

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**Supervising Chemist:**

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**Sample Preparation:**

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**Analyst:**

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ECL Report 2008-03

Page 22 of 23
QC REPORT FOR

A: LABORATORY CONTROL SAMPLE
B: SAMPLE DUPLICATE ANALYSIS

<table>
<thead>
<tr>
<th>ANALYTE</th>
<th>LABORATORY CONTROL SAMPLE</th>
<th>FOUND</th>
<th>Actual Amount</th>
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<tr>
<td>Di-n-butyl phthalate (DBP)</td>
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<td>116</td>
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<tr>
<td>Benzylbutyl phthalate (BBP)</td>
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<td>90</td>
<td>100</td>
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<tr>
<td>Bis-2-ethylhexyl phthalate (DEHP)</td>
<td></td>
<td>112</td>
<td>100</td>
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<tr>
<td>Di-n-octyl phthalate (DNOP)</td>
<td></td>
<td>125</td>
<td>100</td>
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<tr>
<td>Diisononyl phthalate (DINP)</td>
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<td>80.2</td>
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<tr>
<td>Diisodecyl phthalate (DIDP)</td>
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<td>125</td>
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<th>RUN 1</th>
<th>RUN 2</th>
<th>RPD</th>
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<td>Di-n-butyl phthalate (DBP)</td>
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<td>ND</td>
<td>NA</td>
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<td>Benzyl butyl phthalate (BBP)</td>
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NOTES:

SAMPLE PREPARATION

Modan Gill

ANALYST

Orlando Garbin

SUPERVISOR

KC Ting