UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date:
3/31/2010

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SUBJECT : Phthalates and Phthalate Substitutes in Children's Toys[1]

Introduction

On August 14th 2008, the Consumer Product Safety Improvement Act of 2008 (Public Law 110-314; herein referred to as "CPSIA") was signed into law. Section 108 of the CPSIA imposed a permanent ban on dibutyl phthalate, benzyl butyl phthalate, and di-(2-ethylhexyl) phthalate (DBP, BBP, and DEHP, respectively) in any children's toy or child care article in concentrations greater than 0.1%. Additionally, an interim ban was placed on di-*n*-octyl phthalate, di-isononyl phthalate, and di-isodecyl phthalate (DNOP, DINP, and DIDP, respectively) in any children's toy that can be placed in a child's mouth, and child care articles in concentrations greater than 0.1% each. Furthermore, Section 108 required the U.S. Consumer Product Safety Commission (CPSC) to appoint a Chronic Hazard Advisory Panel (CHAP) to examine the potential health effects on children due to phthalates or phthalate alternatives in children's toys and child care articles.

In December 2008, CPSC staff purchased 63 various children's toys and child care articles to be analyzed. The resulting data will be used to support exposure and risk assessments of phthalates

[1] This memo was prepared by CPSC staff, has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

and phthalate substitutes by the CHAP. Specifically, the test plan solicited the following information:

1. Identify the plastic used in all component parts.
2. Identify the plasticizer(s), if present.
3. Determine the mass % of plasticizer(s) where present.
4. Measure migration of plasticizers for the estimated oral exposure from mouthing.
5. Measure migration of plasticizers for the estimated dermal exposure from handling.

This memorandum presents the methods used for the analysis and the resulting data. Each sample was given an identification number from 1 through 63. Any component parts that merited separate analysis from the larger item were identified by descriptive text (e.g., Sample 3, Doll Head).

Methods

1. Identification of plastic(s) used in component parts:

   All component parts of each sample were screened using a Thermo 6700 FTIR Spectrometer. The resultant IR spectrum was searched against a library to identify the type of polymer present. In cases where a strong library match did not occur, the plastic was then analyzed by a Thermo NITON XL3X XRF analyzer. The XRF results classified a plastic as polyvinyl chloride (PVC) due to the strong presence of chlorine, or, as a non-PVC plastic, in which case the sample was labeled "unknown".

2. Identification of plasticizer(s) present:

   Each component part was qualitatively analyzed using an adapted version of the CPSC staff test method CPSC-CH-C1001-09.2 – Standard Operation Procedure for Determination of Phthalates[2]. The analysis portion of the method was performed by a Thermo FOCUS Gas Chromatograph/DSQ II Mass Spectrometer (GC-MS), running in full scan ion mode. Identifications were made based on the resulting mass spectra.

3. Determination of the mass % of plasticizer(s):

   A set of calibration standards was prepared containing approximately 30, 60, 120, and 240 µg/ml of the plasticizers found during the qualitative assessment in cyclohexane. Calibration curves were constructed and used to quantify the amount of plasticizer in solution, and in turn the plasticizer concentration (mass %) in the sample.

4. Migration testing of plasticizers to estimate oral exposure from mouthing:

[2] http://www.cpsc.gov/about/cpsia/CPSC-CH-C1001-09.2.pdf

Head-over-heels (HoH) migration testing was performed using the adapted JRC[3] method previously followed by the CPSC[4]. A punch press was used to cut three test disks from each sample. Typically, the surface areas of the test disks were between 10 and 13 cm^2. Many disks featured irregular surfaces; in these cases the surface areas were approximated.

The three disks from each sample were extracted two times each in 50 ml of simulated saliva in a 250 ml Schott Duran bottle for 30 minutes. The two volumes of simulated saliva[5] were combined, and then extracted with 50 ml of cyclohexane. Samples were analyzed using a modified GC-MS injection parameter: 2 µl sample, plus 1 µl standard using a splitless injection. The standard was a solution of 2 µg/ml BBP in cyclohexane, a compound not found in any of the 63 samples.

Calibration standards containing approximately 0.25, 1, 2.5, 5, and 12 µg/ml plasticizer in cyclohexane were prepared and analyzed. Any samples that contained more than 12 µg/ml of plasticizer were reanalyzed, injecting only 1 µl of sample solution.

The plasticizer migration was calculated and expressed in µg/min per 10 cm^2 of surface area of the test disk:

$$Plasticizer\ Release\ (\mu g/min/10\ cm^2) = \frac{C_{plasticizer} \times 50\ ml \times 10\ cm^2}{60\ min \times A\ cm^2}$$

where $C_{plasticizer}$ is the concentration of the plasticizer in the extract; 50 ml is the amount of cyclohexane, 60 min is the total HoH time, and A is the actual surface area of the test disk.

5. Migration testing of plasticizers to estimate dermal exposure:

A wipe test method was developed by combining elements of the CPSC staff Test Methodology for Accessible Lead in Vinyl Products[6] and the ASTM method "Field Collection of Organic Compounds from Surfaces Using Wipe Sampling"[7]. Two ml of isopropanol was added to an Ahlstrom 7 cm glass microfiber filter. The wet filter was swiped across the surface 10 times inside a 100 cm^2 area. The filter was folded and placed into an open 20 ml vial and was allowed to air dry. This was repeated two additional times for the same 100 cm^2 surface, for a total of 30 swipes. Once the filters were dry, 15 ml of cyclohexane were added and the vials were sealed. Each vial was sonicated for 20 minutes. The cyclohexane solution was removed and analyzed by GC-MS (1 µl sample plus 1 µl ISTD injection, 20:1 split). The standard was a 100 µg/ml

[3] Catherine Simoneau, Standard Operation Procedure, "Determination of release of di-isononylphthalate (DINP) in saliva stimulant from toys and childcare articles", JRC, European Commission, Nov 11, 2000.
[4] Shing-Bong Chen, "Screening of Toys for PVC and Phthalates Migration", U.S. Consumer Product Safety Commission, June 20, 2002.
[5] Simulated saliva is water containing various salts; prepared using the JRC recipe.
[6] http://www.cpsc.gov/phth/vinyltest.html
[7] ASTM method D6661-01 (Reapproved in 2006).

solution of BBP in cyclohexane. Again, samples were quantified using a calibration curve of standards. Only samples with a large enough surface area were analyzed.

The results of the plasticizer wiped from the surface were summed to calculate the total mass extracted per 30 swipes.

Results

From the 63 samples collected, a total of 129 component parts were identified (Table 1). Of these:

- 38 items were composed of PVC.
- 9 items were acrylonitrile butadiene styrene (ABS).
- 7 items were polystyrene (PS).
- 26 items were polypropylene (PP).
- 18 items were polyethylene (PE), or a polyethylene co-blend like poly(ethylene-co-vinyl acetate).
- 7 items were polyester based.
- 3 items were polyurethane based.
- 21 items were classified as unknown (non-PVC containing), of which:
    - 5 items did not contain any plastic, or were likely a natural rubber.
    - 2 items were primarily silicone or siloxane-based.

Of these samples, plasticizers were only found and extracted from PVC samples (38 items total from 30 samples). Only 2 items were found to have any phthalate content. The phthalate alternatives found were common among the PVC samples (Tables 2 and 3):

- 14 items contained di-(2-ethylhexyl) terephthalate (DOTP, CAS # 6422-86-2) in concentrations between 3 and 60% weight by mass.
- 13 items contained 1,2-cyclohexanedicarboxylic acid, di-isononyl ester (DINCH, CAS # 474919-59-0) in concentrations between 3 and 25%.
- 20 items contained acetyl tributyl citrate (ATBC, CAS # 77-90-7) in concentrations between 5 and 43%.
- 9 items contained 2,2,4-trimethyl-1,3 pentanediol diisobutyrate (TXIB, CAS # 6846-50-0) in concentrations between 2 and 19%.
- 1 item contained DINP (42%). It should be noted that this item is *not* mouthable (no part smaller than 5 cm in any dimension).
- 1 item contained DEHP (6%).
- 1 item contained butyl citrate (TBC, CAS # 77-94-1).
- 1 item contained an additive that was unable to be identified. This additive contained one or more benzoate groups and phenyl rings.

A slight majority of the samples contained a combination of two or more plasticizers (20 of the 38 items). The plasticizer pairings were varied; the most common combination was DINCH and ATBC, found together in only 5 items.

The HoH method was performed on 3 test disks (when available) from 47 different component parts for a total of 140 measurements (Tables 4 and 5). The results from the 3 disks were averaged to give one migration value per sample. DOTP had the lowest measured migration, with a range from 0.61 to 3.59 µg/min/10 cm^2. The other plasticizers had a migration range at least twice as large: DINCH, from 0.38 to 7.34; ATBC from 0.75 to 14.04; and TXIB from 0.90 to 11.3 µg/min/10 cm^2. A correlation between mass % of the plasticizer and the migration rate was poor, at best (Figure 1). Neither DOTP nor DINCH displayed any correlation; whereas ATBC and TXIB showed a very week correlation, largely driven by a few samples on the higher end of the mass % range also giving high migration rates. If these data points are removed, then any semblance of a trend disappears. These results largely mirror those for DINP reported in 2002[3].

The wipe testing was performed on 6 different samples. Each sample was wiped 10 times with three different filters, totaling 30 swipes per sample. The total amounts of extracted plasticizer collected from the 3 wipes were summed to give the total µg of plasticizer per 3 wipes over a 100 cm^2 area. The concentrations and migrations of plasticizers from the 6 samples were as follows:

- From samples containing 25 and 33% DOTP, 1700 and 2500 total µg per 3 wipes were extracted, respectively.
- From samples containing 14 and 26% ATBC, 490 and 2300 total µg per 3 wipes were extracted, respectively.
- From a sample containing 42% DINP, 32000 total µg per 3 wipes were extracted.

The majority of samples featured small, diverse surfaces, preventing uniform sampling over a 100 cm^2 area.

Conclusions

The results from the analytical screening of 63 children's toys and child care articles show a substantial use of phthalate alternatives, notably ATBC, DOTP, DINCH and TXIB. Only 2 items contained phthalates. The concentrations of plasticizers vary widely in these items: the mass % of each plasticizer varied from 2 to 60%, and combinations of 2 or 3 plasticizers in a single item were common.

Migration testing by HoH was performed to simulate oral exposure by mouthing. Nearly every item that contained a plasticizer released it in a quantifiable amount. The items containing the highest mass % of TXIB and ATBC also released the most during the migration test, however, these few items were the only samples that indicated any sort of correlation between % plasticizer and plasticizer migration. Overall, no trend was apparent.

Wipe testing was performed to simulate dermal exposure. Of those items tested, between 490 and 32000 µg of total plasticizer were extracted from 3 wipes, or 30 total swipes over a 100 cm^2 area. This test was limited in scope by the small size and varied surfaces of many samples, thus preventing the elucidation of any data trends.

Table 1. Plastic and plasticizer identification for each component part.

Sample #	Part Description	Main Plastic (FTIR, XRF Results)	Qualitative Analysis: Peaks Identified by GC-MS
1	Teething Ring	Poly(Ethylene-co-vinyl acetate)	No peaks observed
2	Baby Doll Limb	PVC	DOTP
	Baby Doll Face	PVC	DOTP
	Clothes	Polyester	Not analyzed
3	Baby Doll	PVC (XRF confirmed)	DINCH
4	Bib	Polyethylene	No peaks observed
5	Milk Bottle	Polyethylene	No peaks observed
	Bowling Ball	PVC (XRF confirmed)	ATBC
6	Teething Ring	Poly(Ethylene-co-vinyl acetate)	No peaks observed
7	Teething Ring	Poly(Ethylene-co-vinyl acetate)	No peaks observed
8	Stack Ring	Polypropylene	No peaks observed
9	Linking Beads	Poly(1-tetradecene), isotactic	No peaks observed
10	Star	ABS	No peaks observed
	Links	Polypropylene	No peaks observed
	Ring	Poly(1,4-Butylene Terephthalate)	No peaks observed
11	Ring	Polypropylene	No peaks observed
	Clackers	Polypropylene	No peaks observed
12	Teethers	Polypropylene	No peaks observed
13	Bee	Polypropylene	No peaks observed
	Wing/rings	Poly(ester urethane)	No peaks observed
14	Truck Yellow Plastic	Polypropylene	No peaks observed
	Tire	Polyethylene	No peaks observed
	Wheel	ABS	No peaks observed
15	Black Bag Surface	Polyester, terephthalic acid	No plasticizer peaks observed
	Blue Inside Liner	Polyester, terephthalic acid	DOTP

Sample #	Part Description	Main Plastic (FTIR, XRF Results)	Qualitative Analysis: Peaks Identified by GC-MS
15	Blue plastic case	Polypropylene	No peaks observed
16	Clay	Unknown; Non-PVC (no plastic expected)	No peaks observed
17	Letter Tiles	Polyethylene	No peaks observed
18	Fake Teeth	Polyester, terephthalic acid	DOTP
19	Spoon Cover	Poly(dimethylsiloxane)	No peaks observed
20	Pencil Grips	Polystyrene/Polyethylene-butylene	No plasticizer peaks observed (broad hydrocarbon peaks)
21	Action Figure	PVC (XRF confirmed)	DINCH, DOTP, ATBC
	Accessories	Unknown; Possibly Siloxane/Silicon	Siloxane Peaks
	Horse	Polystyrene	No peaks observed
22	Animal	Poly(ethylene-co-propylene)	No peaks observed
	Tree	Polyethylene	No peaks observed
	Rock	Polyethylene	No peaks observed
23	Doll Head	PVC (XRF confirmed)	ATBC, DINCH, tributyl aconitate
	Limbs	PVC (XRF confirmed)	ATBC, DINCH, tributyl aconitate
	Torso	Unknown; Non-PVC	No peaks observed
24	Pony	PVC (XRF confirmed)	ATBC, DINCH, tributyl aconitate
	Hair	Polypropylene	Not analyzed
	Doll	PVC (XRF confirmed)	ATBC, DINCH, tributyl aconitate, TXIB
	Comb	Polypropylene	No peaks observed
	Clothes	Polyester	Not analyzed
25	Letters	Polyethylene	No peaks observed
26	Body	Polyester	Not analyzed
	Face	PVC (XRF confirmed)	ATBC, DINCH, tributyl aconitate
27	Building Blocks	Polypropylene	No peaks observed
28	Model Clay	Unknown; Non-PVC (no plastic expected)	No peaks observed
29	Body	ABS	No peaks observed

Sample #	Part Description	Main Plastic (FTIR, XRF Results)	Qualitative Analysis: Peaks Identified by GC-MS
29	Face	PVC (XRF confirmed)	ATBC, DINCH, tributyl aconitate
	Clackers/Clacker Ring	Polypropylene	No peaks observed
30	Bottle	Polypropylene	No peaks observed
	Spout	Polypropylene	No peaks observed
31	Building Blocks	Polyethylene	No peaks observed
32	Ball	PVC	DINP
33	Modeling Dough	None (Starch/Salt/Water based with some polyethylene glycol)	No peaks observed
34	Eraser	Unknown; likely natural rubber	No peaks observed
35	Ring Stand	Polyethylene	No peaks observed
	Ring	Polyethylene	No peaks observed
	Translucent Ring	Polypropylene	No peaks observed
36	Modeling Clay	Unknown; Non-PVC (no plastic expected)	No plasticizer peaks observed; alkane series
37	Oven Bake Clay	PVC (XRF confirmed)	ATBC, tributyl aconitate
38	Ball	Polycarbonate Urethane	No peaks observed
39	Sticky Ball	Unknown; Mineral Oil like substance	No plasticizer peaks observed
	Slime	Unknown; Water-based (likely polyvinyl alcohol)	No peaks observed
40	Linking Beads	Polyethylene	No peaks observed
41	Spoons	Polyethylene	No peaks observed
42	Superhero Figure	Unknown; Non-PVC	ATBC, tributyl aconitate, DOTP
	Streetlight	PVC (XRF confirmed)	ATBC, tributyl aconitate, DOTP
	Streetlight Base	ABS	No peaks observed
43	Boat Handle	Polypropylene	No peaks observed
	Boat	ABS	No peaks observed
	Octopus	PVC (XRF confirmed)	ATBC, DINCH, tributyl aconitate

Sample #	Part Description	Main Plastic (FTIR, XRF Results)	Qualitative Analysis: Peaks Identified by GC-MS
43	Fish	PVC (XRF confirmed)	DINCH, TXIB
44	Weapon	PVC (XRF confirmed)	DINCH, ATBC, DOTP, TXIB
	Figure Body	Unknown; Non-PVC	No peaks observed
	Head	PVC (XRF confirmed)	DINCH, TXIB
	Feet/Hands	PVC (XRF confirmed)	DINCH, TXIB
	Weapon 2	Polystyrene	No peaks observed
	Projectile	Polypropylene	No peaks observed
45	Truck	PVC	ATBC, tributyl aconitate, TXIB
	Truck Bed	ABS	
	Truck Wheel	ABS	No peaks observed
46	Truck	PVC	ATBC, tributyl aconitate, TXIB
	Truck Wheel	ABS	No peaks observed
47	Toy Razor	PVC (XRF confirmed)	DINCH
48	Animals	PVC	ATBC, tributyl aconitate, TXIB
49	Green Hairball	Unknown; Non-PVC	No plasticizer peaks; lots of organic background
50	Design Beads	Poly(vinyl alcohol::2-benzyloxyethyl methacrylate)	No peaks observed
	Green Stand	Polystyrene	No plasticizer peaks
51	Accessories	Polypropylene	No peaks observed
	Pink Shoes	PVC (XRF confirmed)	ATBC, tributyl aconitate, DOTP
	Blue Shoes	PVC (XRF confirmed)	ATBC, TXIB, DOTP
	Doll Limbs	PVC (XRF confirmed)	ATBC, tributyl aconitate, DOTP
	Doll Torso	ABS	Not analyzed
	Doll Head	PVC	ATBC, TXIB
	Clothes	Polyester	Not analyzed
	Hat	Polycarbonate Urethane	No peaks observed
52	Jewelry	Polystyrene	No peaks observed

Sample #	Part Description	Main Plastic (FTIR, XRF Results)	Qualitative Analysis: Peaks Identified by GC-MS
52	Lipstick Case	Polystyrene	No peaks observed
	Gel Tube	Polyethylene	No peaks observed
	Gloss Case	Polystyrene	No peaks observed
	Nail Polish	Unknown	No peaks observed
	Lip Gloss	Unknown	No plasticizer peaks observed (alkane series, other hydrocarbons)
	Eye Shadow	Unknown	No plasticizer peaks observed (alkanes)
	Glitter Gel	Unknown	No peaks observed
53	Glove	PVC (XRF confirmed)	DOTP
	Ball	PVC (XRF confirmed)	DOTP
54	Monster	PVC (XRF confirmed)	TXIB, BTC, tributyl aconitate
	Car	Polypropylene	No peaks observed
55	Blocks	PVC (XRF confirmed)	Three unknown peaks. Likely benzoate; phenyl ring.
56	Boat	PVC (XRF confirmed)	DOTP
57	Pig	PVC (XRF confirmed)	DOTP
58	Book Pages	Polypropylene	No peaks observed
	Comb	Polypropylene	No peaks observed
	Food	PVC	ATBC, tributyl aconitate, DEHP
	Bowl	Polypropylene	No peaks observed
	Pen	Polypropylene	No peaks observed
	Ball	PVC (XRF confirmed)	TXIB, ATBC, tributyl aconitate
	Tag, Leash	Polypropylene	No peaks observed
59	Duck	PVC (XRF confirmed)	ATBC, tributyl aconitate
60	Cups	Polypropylene	No peaks observed
61	Duck	Unknown; Non-PVC	No peaks observed
62	Teether	Polyethylene/co-vinyl acetate	No peaks observed

Sample #	Part Description	Main Plastic (FTIR, XRF Results)	Qualitative Analysis: Peaks Identified by GC-MS
62	Photo book	PVC	DOTP
63	Hooking Ring	Polypropylene	No peaks observed

Table 2. Quantitative Analysis of Plasticizers. Sample preparation and calculated plasticizer concentration in solution.

Sample #	Part Description	Mass of Sample (mg)	Dilution Factor	DOTP Conc. (µg/ml)	DINCH Conc. (µg/ml)	ATBC Conc. (µg/ml)	TXIB Conc. (µg/ml)	Phthalate Conc. (µg/ml)
2	Baby Doll Limb	49.1	225	126.4				
	Baby Doll Face	49.9	75	245.8				
3	Baby Doll	49.5	75		166.8			
5	Bowling Ball	50.5	75			88.64		
15	Blue Inside Liner	48.3	75	156.9				
18	Fake Teeth	52.7	75	246.4				
21	Action Figure	52.4	75	70.71	81.30	43.37		
23	Doll Head	53.1	75		157.3	108.2		
	Limbs	49.2	75		94.25	51.66		
24	Doll	48.3	75		92.71	48.88	72.03	
26	Face	52.1	75		106.9	52.59		
29	Face	49.5	75		99.69	61.41		
32.1	Ball	49.0	75					282.9
32.2	(replicate)	49.1	75					257.0
32.3	(replicate)	50.3	75					289.6
37	Oven Bake Clay	47.9	75			105.8		
42	Superhero Figure	51.58	75	75.29		46.40		
	Streetlight	52.52	75	60.18		51.97		
43	Octopus	49.96	75		123.0	31.95		

Sample #	Part Description	Mass of Sample (mg)	Dilution Factor	DOTP Conc. (µg/ml)	DINCH Conc. (µg/ml)	ATBC Conc. (µg/ml)	TXIB Conc. (µg/ml)	Phthalate Conc. (µg/ml)
43	Fish	50.64	75		124.0		65.30	
44	Weapon	49.40	75	59.39	71.46		125.8	
	Feet/Hands	48.41	75		126.19			
	Head	48.27	75		54.36		122.1	
45	Truck	48.76	75			173.9	55.29	
46	Truck	47.85	75			164.8	70.81	
47	Toy Razor	52.78	75		147.77			
48	Animals	51.2	75			293.0	49.10	
51	Pink Shoes	49.0	75	152.8		77.19		
	Doll Limbs	50.2	75	61.32		71.91		
53	Glove	50.3	22.5	55.02				
54	Monster	49.5	75				42.20	
55	Blocks	53.06	75	Unknown Plasticizer				
56	Boat	48.32	75	133.1				
57	Pig	50.89	75	222.0				
58	Food	55.1	75			244.6		205.1
58.2	(replicate)	48.9	75			216.9		159.2
58	Ball	52.85	75			91.88	43.24	
59	Ducks	51.57	75			217.5		
62	Photo book	54.04	75	183.4				

Table 3. Quantitative Analysis of Plasticizers. Mass % results.

Sample #	Part Description	% DOTP	% DINCH	% ATBC	% TXIB	% Phthalate	Total % Plasticizer
2	Baby Doll Limb	57.92					57.92
	Baby Doll Face	36.94					36.94
3	Baby Doll		25.27				25.27
5	Bowling Ball			13.16			13.16
15	Blue Inside Liner	24.36					24.36
18	Fake Teeth	35.07					35.07
21	Action Figure	10.12	11.64	6.21			27.96
23	Doll Head		22.22	15.28			37.50
	Limbs		14.37	7.88			22.24
24	Doll		14.40	7.59	11.19		33.17
26	Face		15.39	7.57			22.96
29	Face		15.10	9.30			24.41
32.1	Ball					43.30	43.30
32.2	(replicate)					39.26	39.26
32.3	(replicate)					43.19	43.19
37	Oven Bake Clay			16.56			16.56
42	Superhero Figure	10.95		6.75			17.70
42	Streetlight	8.59		7.42			16.01
43	Octopus		18.47	4.80			23.27
43	Fish		18.37		2.90		21.27
44	Weapon	9.02	10.85		5.73		25.60
	Feet/Hands		19.55				19.55
	Head		2.53		18.97		21.50
45	Truck			26.76	2.55		29.31
46	Truck			25.83	3.33		29.16

Sample #	Part Description	% DOTP	% DINCH	% ATBC	% TXIB	% Phthalate	Total % Plasticizer
47	Toy Razor		21.00				21.00
48	Animals			42.92	2.16		45.07
51	Pink Shoes	23.39		11.82			35.20
	Doll Limbs	9.16		10.74			19.91
53	Glove	2.46					2.46
54	Monster				6.39		6.39
55	Blocks						Unknown
56	Boat	20.65					20.65
57	Pig	32.71					32.71
58	Food			33.29		6.44	39.73
58.2	(replicate)			33.27		5.63	38.90
58	Ball			13.04	6.14		19.17
59	Ducks			31.63			31.63
62	Photo book	25.46					25.46

Table 4. Head-over-heels migration testing results; concentration of plasticizer in extracted volume. Three replicate tests each. Surface areas listed in italics indicate the surface was highly irregular.

Sample #	**Part Description**	**Plasticizer Quantitation (Mass %)**	**Approx. Surface Area (cm^2)**	**Extracted DOTP Conc. (µg/ml)**	**Extracted DINCH Conc. (µg/ml)**	**Extracted ATBC Conc. (µg/ml)**	**Extracted TXIB Conc. (µg/ml)**	**Extracted Phthalate Conc. (µg/ml)**
2	Baby Doll Limb	58% DOTP	12.6	6.56				
			11.8	13.0				
			12.2	11.8				
	Baby Doll Face	37% DOTP	12.2	0.953				
			11.4	0.936				
			11.8	1.79				
3	Baby Doll	25% DINCH	12.0		0.976			
			12.0		0.812			
			12.0		2.44			
5	Bowling Ball	14% ATBC	10.6			3.26		
			10.6			4.10		
			10.6			4.52		
15	Blue Inside Liner	24% DOTP	9.90	2.50				
			9.90	2.27				
			9.90	1.69				
18	Fake Teeth	35% DOTP	12.2	2.65				
			12.2	2.68				
			12.2	2.87				
21	Action Figure	10% DOTP, 12% DINCH, 6 % ATBC	*17.0*	0.847	Not Found	1.58		
			13.8	1.14	Not Found	3.34		
			16.6	1.46	2.28	3.27		

Sample #	Part Description	Plasticizer Quantitation (Mass %)	Approx. Surface Area (cm^2)	Extracted DOTP Conc. (µg/ml)	Extracted DINCH Conc. (µg/ml)	Extracted ATBC Conc. (µg/ml)	Extracted TXIB Conc. (µg/ml)	Extracted Phthalate Conc. (µg/ml)
23	Doll Head	22% DINCH, 15% ATBC	11.4		9.67	7.06		
			11.8		5.92	6.81		
			11.6		4.28	7.30		
	Arm	14% DINCH, 8% ATBC	*9.43*		0.636	2.14		
			9.43		1.14	2.63		
			10.6		0.588	1.48		
24	Doll	14% DINCH, 8% ATBC, 12% TXIB	11.8		9.12	2.87	9.56	
			11.8		10.5	4.31	9.88	
			11.8		11.7	3.38	10.8	
26	Face	15% DINCH, 8% ATBC	11.4		1.51	2.30		
			11.4		2.32	3.05		
			11.4		1.55	2.55		
29	Face	15% DINCH, 9% ATBC	13.7		1.36	3.79		
			13.7		1.39	3.73		
			12.6		1.41	4.11		
32	Ball	42% DINP	12.8					8.01
			12.8					7.26
			12.8					7.16
37	Oven Bake Clay	16% ATBC	13.8			Over Range		
			13.8			Over Range		
			13.8			Over Range		
42	Superhero Figure	11% DOTP, 7% ATBC	*10.3*	0.510		1.76		
			10.3	3.26		2.44		
			10.7	0.646		1.58		

Sample #	Part Description	Plasticizer Quantitation (Mass %)	Approx. Surface Area (cm^2)	Extracted DOTP Conc. (µg/ml)	Extracted DINCH Conc. (µg/ml)	Extracted ATBC Conc. (µg/ml)	Extracted TXIB Conc. (µg/ml)	Extracted Phthalate Conc. (µg/ml)
42	Streetlight	8% DOTP, 7% ATBC	*5.11*	0.150		0.796		
			5.73	0.112		0.507		
			6.68	0.105		0.639		
43	Octopus	18% DINCH, 5% ATBC	12.2		3.61	1.08		
			12.2		4.12	1.25		
			12.2		4.44	0.928		
43	Fish	18% DINCH, 3% TXIB	11.4		6.11		6.17	
			11.4		8.89		6.70	
			11.4		12.0		6.94	
44	Feet/Hands	20% DINCH	11.9		1.36			
			8.17		3.18			
			9.85		4.55			
	Head	3% DINCH, 19% TXIB	7.54				8.86	
			11.4				14.8	
			11.4				18.2	
45	Truck	27% ATBC, 3% TXIB	11.8			8.81	1.33	
			12.2			10.6	1.41	
			12.2			8.84	1.35	
46	Truck	26% ATBC, 3% TXIB	12.2			6.05	1.17	
			12.2			9.27	1.48	
			12.2			7.54	1.33	
47	Toy Razor	21% DINCH	11.0		5.24			
			11.0		8.16			
			11.0		6.58			

Sample #	Part Description	Plasticizer Quantitation (Mass %)	Approx. Surface Area (cm^2)	Extracted DOTP Conc. (µg/ml)	Extracted DINCH Conc. (µg/ml)	Extracted ATBC Conc. (µg/ml)	Extracted TXIB Conc. (µg/ml)	Extracted Phthalate Conc. (µg/ml)
48	Animals	43% ATBC, 2% TXIB	11.4			17.1	1.27	
			11.4			15.7	1.99	
			11.4			17.4	1.54	
51	Pink Shoes	23% DOTP, 12% ATBC	*8.80*	2.07		7.93		
			8.80	2.45		7.42		
	Doll Head		11.4	1.93	2.53			
			10.6	3.16	4.29			
			11.4	2.22	3.00			
53	Glove	2% DOTP	11.4	0.178				
			11.4	0.170				
			11.4	0.245				
54	Monster	6% TXIB,	11.4				3.27	
			11.4				3.01	
			11.4				4.06	
56	Boat	21% DOTP	10.6	0.909				
			10.6	2.56				
			10.9	1.37				
57	Pig	33% DOTP	11.0	2.95				
			11.0	4.09				
			11.0	4.41				
58	Food	33% ATBC, 6% DEHP	11.4			20.9		
			11.4			18.6		
			11.4			17.9		

Sample #	Part Description	Plasticizer Quantitation (Mass %)	Approx. Surface Area (cm^2)	Extracted DOTP Conc. (µg/ml)	Extracted DINCH Conc. (µg/ml)	Extracted ATBC Conc. (µg/ml)	Extracted TXIB Conc. (µg/ml)	Extracted Phthalate Conc. (µg/ml)
58	Ball	13% ATBC, 6% TXIB	11.4			1.51	1.25	
			11.4			1.81	1.40	
			11.4			1.46	1.04	
59	Ducks	32% ATBC	11.4			17.8		
			11.4			19.7		
			11.4			20.0		
62	Photo book	25% DOTP	10.2	1.52				
			10.2	2.26				
			10.2	1.19				

Table 5. Head-over-heels migration results; plasticizer migration data per 10 cm^2. All migration values are **µg/min/10 cm^2**.

Sample #	Part Description	DOTP Migration	DINCH Migration	ATBC Migration	TXIB Migration	Phthalate Migration	Average Migration
2	Baby Doll Limb	2.18					
		4.58					3.59
		4.02					
	Baby Doll Face	0.65					
		0.69					0.87
		1.27					
3	Baby Doll		0.68				
			0.56				0.98
			1.69				
5	Bowling Ball			2.58			
				3.24			3.13
				3.57			
15	Blue Inside Liner	2.11					
		1.91					1.82
		1.43					
18	Fake Teeth	1.81					
		1.83					1.87
		1.96					
21	Action Figure	0.42	< 0.41	0.78			
			< 0.41	2.01			0.6 (DOTP) 0.38 (DINCH) 1.48 (ATBC)
			1.14	1.64			

Sample #	Part Description	DOTP Migration (µg/min/10 cm^2)	DINCH Migration (µg/min/10 cm^2)	ATBC Migration (µg/min/10 cm^2)	TXIB Migration (µg/min/10 cm^2)	Phthalate Migration (µg/min/10 cm^2)	Average Migration (µg/min/10 cm^2)
23	Doll Head		7.08	5.16			4.78 (DINCH) 5.08 (ATBC)
			4.18	4.42			
			3.04	5.26			
	Arm		0.56	1.90			0.68 (DINCH) 1.79 (ATBC)
			1.01	2.33			
			0.46	1.16			
24	Doll		6.41	2.02	6.74		7.34 (DINCH) 2.48 (ATBC) 7.12 (TXIB)
			7.40	3.04	6.98		
			8.22	2.38	7.64		
26	Face		1.11	1.68			1.31 (DINCH) 1.93 (ATBC)
			1.70	2.23			
			1.14	1.86			
29	Face		0.82	2.30			0.87 (DINCH) 2.43 (ATBC)
			0.84	2.26			
			0.94	2.73			
32	Ball					5.21	4.86
						4.72	
						4.65	
37	Oven Bake Clay			> 15.0			> 15
				> 15.0			
				> 15.0			
42	Superhero Figure	0.41		1.42			

Sample #	Part Description	DOTP Migration (µg/min/10 cm^2)	DINCH Migration (µg/min/10 cm^2)	ATBC Migration (µg/min/10 cm^2)	TXIB Migration (µg/min/10 cm^2)	Phthalate Migration (µg/min/10 cm^2)	Average Migration (µg/min/10 cm^2)
42	Superhero Figure	2.64		1.97			1.18 (DOTP) 1.54 (ATBC)
				1.23			
	Streetlight	0.24		1.30			<0.41 (DOTP) 0.94 (ATBC)
				0.74			
				0.80			
43	Octopus		2.47	0.74			2.78 (DINCH) 0.75 (ATBC)
			2.82	0.86			
			3.04	0.64			
	Fish		4.48		4.52		6.58 (DINCH) 4.83 (TXIB)
			6.50		4.90		
			8.74		5.08		
44	Face/Hands		0.95				2.68
			3.24				
	0.16		3.85				
	Head				9.78		11.3
					10.82		
					13.32		
45	Truck			6.24	0.94		6.52 (ATBC) 0.94 (TXIB)
				5.26	0.96		
				6.04	0.93		
46	Truck				0.80		5.23 (ATBC) 0.91 (TXIB)
					1.01		

Sample #	Part Description	DOTP Migration (µg/min/10 cm^2)	DINCH Migration (µg/min/10 cm^2)	ATBC Migration (µg/min/10 cm^2)	TXIB Migration (µg/min/10 cm^2)	Phthalate Migration (µg/min/10 cm^2)	Average Migration (µg/min/10 cm^2)
46	Truck			5.16	0.91		
47	Toy Razor		3.96				5.04
			6.18				
			4.98				
48	Animals			12.32	0.93		12.22 (ATBC) 1.17 (TXIB)
				11.46	1.46		
				12.70	1.12		
51	Pink Shoes	1.96		3.75			2.14 (DOTP) 7.26 (ATBC)
				3.51			
	Doll Head	1.41	1.85				1.85 (DOTP) 2.48 (DINCH)
			3.38				
		1.63	2.20				
53	Glove	0.13					<0.18
		0.12					
		0.18					
54	Monster				2.39		2.52
					2.20		
	2.32				2.97		
56	Boat	0.72					1.26
	2.50	2.02					
		1.05					

Sample #	Part Description	DOTP Migration (µg/min/10 cm^2)	DINCH Migration (µg/min/10 cm^2)	ATBC Migration (µg/min/10 cm^2)	TXIB Migration (µg/min/10 cm^2)	Phthalate Migration (µg/min/10 cm^2)	Average Migration (µg/min/10 cm^2)
57	Pig	1.12					2.9
		1.55					
		1.67					
58	Food			15.28			13.98 (ATBC) <0.18 (DEHP)
				13.58			
				13.10			
	Ball			1.10	0.91		1.17 (ATBC) 0.9 (TXIB)
				1.33	1.02		
				1.07	0.76		
59	Ducks			13.04			14.04
				14.40			
				14.66			
62	Photo book	1.24					1.35
		1.84					
		0.97					

Table 6. Wipe test results. Each "wipe" consisted of 10 swipes over a 100 cm^2 surface. Total of 3 wipes per sample.

Sample #	Part Description	% Plasticizer	Calculated Conc. of Plasticizer in Wipe Extract Solution (µg/ml)	µg/Wipe	Total µg per 3 Wipes
5-1	Bowling Ball	14% ATBC	20	290	490
5-2			9.4	140	
5-3			3.8	56	
32-1	Ball	42% DINP	700	10500	32000
32-2			1000	15000	
32-3			410	6200	
37-1	Oven Bake Clay	16% ATBC	>>120	>>1800	>5400
37-2			>>120	>>1800	
37-3			>>120	>>1800	
46-1	Truck	26% ATBC	69	1040	2350
46-2			47	710	
46-3			39	590	
57-1	Pig	33% DOTP	95	1430	2300
57-2			38	570	
57-3			33	490	
62-1	Photo book	25% DOTP	65	980	1700
62-2			24	360	
62-3			21	320	

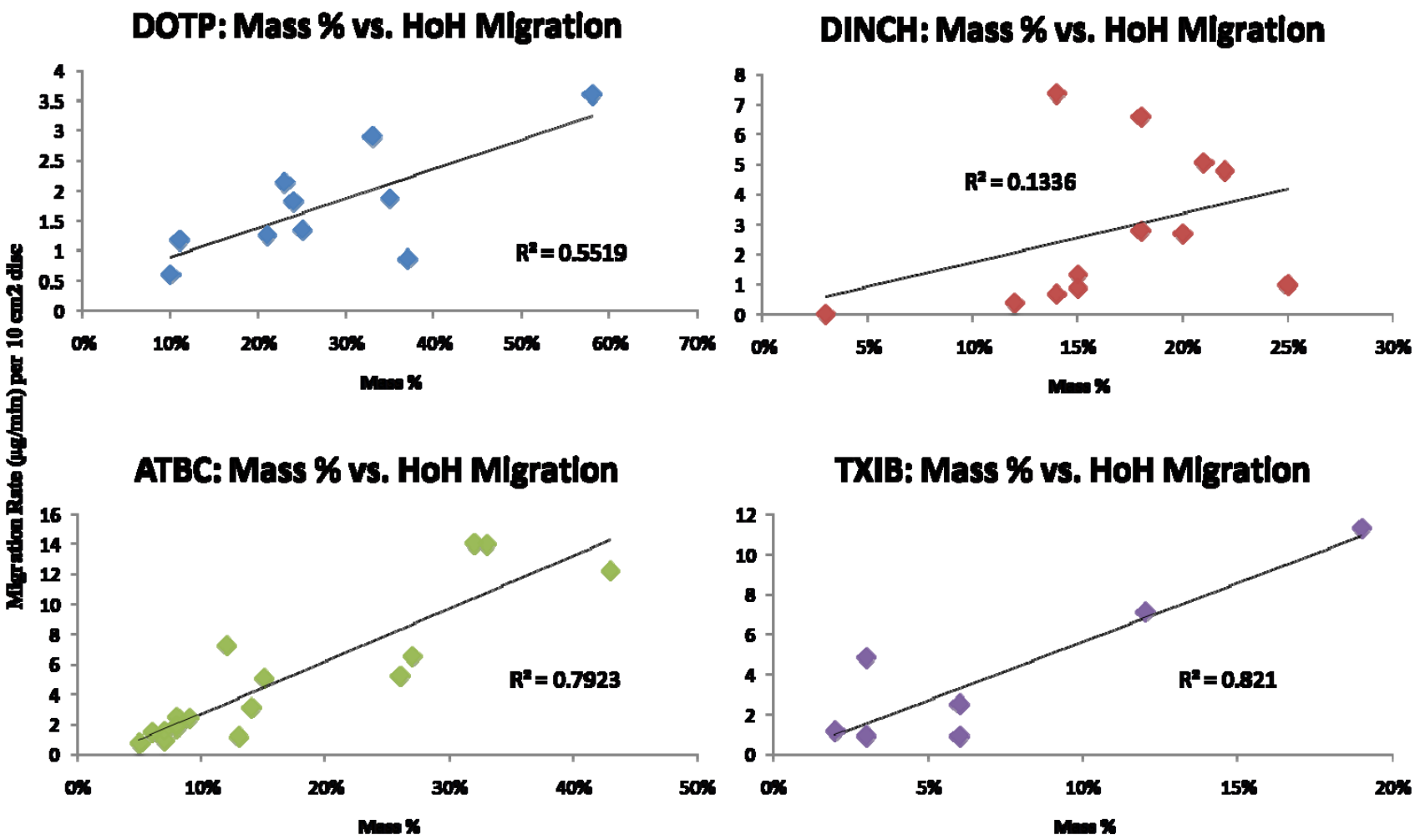

Figure 1. Mass % by weight vs. migration rate per 10 cm^2 surface area for the four most abundant plasticizers.