Supporting Information

AUTHORS: SHE-JUN CHEN,[†] YUN-JUAN MA,^{†,‡} JING WANG,^{†,‡} DA CHEN,[§]
XIAO-JUN LUO,[†] BI-XIAN MAI[†]

ADDRESS: STATE KEY LABORATORY OF ORGANIC GEOCHEMISTRY,
GUANGZHOU INSTITUTE OF GEOCHEMISTRY, CHINESE
ACADEMY OF SCIENCES, GUANGZHOU 510640, CHINA,
GRADUATE SCHOOL, CHINESE ACADEMY OF SCIENCES,
BEIJING 100049, CHINA, AND DEPARTMENT OF
ENVIRONMENTAL AND AQUATIC ANIMAL HEALTH, VIRGINIA
INSTITUTE OF MARINE SCIENCE, THE COLLEGE OF WILLIAM
AND MARY, GLOUCESTER POINT, VIRGINIA 23062, US

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Concentration, Composition and Children's Exposure and
Risks Assessment**

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Methodology

Estimation of room air PBDE concentrations. The PBDEs in the room air can be described by

$$V \times \int_0^T C = (MR \times SA - V \times C \times q)dt \quad (1)$$

where V is the volume of the room (m^3), C is the PBDE concentration in the room air (pg/m^3) due to emission from the toy, MR is the PBDE migration rate from the toy to air ($\text{ng}/\text{m}^2\text{-h}$), SA is the total surface area of the toys (cm^2), q is the room ventilation, and t is the emission duration (h). When equilibrium is reached, the PBDE concentration in room air can be calculated simply by

$$C = MR \times SA/Vq \quad (2)$$

Here, it is assumed that the PBDEs will distribute uniformly in room air after being emitted from the toys; the particle deposition to the floor is not considered.

***In vivo* test for BFR migration into human saliva.** A rubber toy (teether) and a hard plastic toy that contained most of the PBDE congeners with concentrations near the 75th percentile values were used for the migration test. The tests for the rubber toy and the hard plastic toy were performed separately by five volunteers. Three $1.5 \text{ cm} \times 2 \text{ cm}$ pieces were cut from the respective toys and rinsed with distilled water. The pieces were stirred, moved, received pressure with the tongue, or lightly chewed in the mouth, as opposed to being heavily chewed or ground. The test was done for 30 min by one volunteer and for 15 min by the others. Saliva samples were collected from each volunteer in an Oak Ridge centrifuge tube (NALGENE, Rochester, NY) approximately

every 5 min. The saliva was then extracted three times with methylene dichloride in a Teflon funnel. Three saliva blanks (saliva collected prior to contacting the toy pieces) were treated in the same way. The extract was purified on a silica/alumina column, and the amount of BFR was determined by GC-ECNI-MS. The migration rates of PBDEs, DBDPE and BTBPE are listed in Table S3.

FIGURE S1. The congener profiles of penta, octa, and decaBDEs in each type of toys and commercial PBDE products. Data of commercial PBDE products are from Guardia et al.

(1).

FIGURE S2. Loading plots of the principal component analysis (PC2 versus PC3) for foam toys.

Table S1. Input parameters used for BFR exposure assessment from children's toys for different age groups in different exposure scenarios.

Age group	Common parameter	Inhalation					Mouthing		Dermal contact		Oral ingestion (hand-to-mouth)		
		IR ^c	t ^d	SA ^d	Q ^e	V ^d	t ^f	CA ^e	t ^d	CA ^g	TE ^h	SA ^h	EF ⁱ
	BW ^b (kg)	(m ³ /day)	(h/day)	(m ²)	(h ⁻¹)	(m ³)	(min/day)	(cm ²)	(hour/day)	(cm ²)		(cm ²)	(events/h)
3-12 months	8.10												
(3-18 months) ^a	8.67 ^a	4.5	20	0.5	0.6	210	17	10	2.0	98.6	0.05	20	30.7
1-3 years	11.8												
(1.5-3 years) ^a	11.6 ^a	6.8	18	2.0	0.6	210	2	10	2.0	129.7	0.05	20	25.8
3-5 years	17.6	8.3	16	2.0	0.6	210	NA ^j	NA	2.0	206.2	0.05	20	23.2
5-9 years	25.4	10.0	14	2.0	0.6	210	NA	NA	2.0	230.0	0.05	20	16.4
9-14 years	43.6	14.5	12	2.0	0.6	210	NA	NA	2.0	336.6	0.05	20	9.6

^a Age group and corresponding body weight for only mouthing scenario.

^b Body weight (BW) reported by Zhang et al. (2).

^c Inhalation rate reported by U.S. EPA (3).

^d Exposure time (t), total toy surface area (SA), Room volume (V), based on a rough survey in Guangzhou conducted by the authors.

^e Ventilation rate (q) and Contact area (CA) reported by Bremmer et al. (4).

^f Mouthing time (t) reported by Juberg et al. (5).

^g Contact area (CA) estimated from U.S. EPA's Exposure Factors Handbook (6).

^h Transfer efficiency (TE) reported by Washburn et al. (7).

ⁱ Frequency of contact (EF) reported by Xue et al. (8).

^j Not available.

Table S2. Descriptive statistics for the BFR concentrations (ng/g) and detection frequency (DF, %) in different type of the toys.

	Hard plastic toy				Foam toy				Rubber/soft plastic toy				Stuffed toy			
	Range	Mean	Median	DF	Range	Mean	Median	DF	Range	Mean	Median	DF	Range	Mean	Median	DF
Penta	ND ^a -5372.4	293.4	90.9	76.7	ND-109	34.4	23.2	94.4	ND-603	46.6	ND	6.67	1.09-1.98	1.53	1.53	100
Hexa	ND-117386	5763	188	80.0	ND-205	30.0	11.1	94.4	ND-2352	157	ND	6.67	0.32-2.53	0.93	0.53	100
Hepta	ND-301926	15909	162	73.3	ND-451	48.8	17.1	94.4	ND-7063	471	ND	6.67	0.53-14.9	3.08	0.75	100
Octa	ND-209396	11283	796	90.0	19.9-2022	392	198	100	ND-5575	424	ND	20.0	7.09-27.7	12.4	10.0	100
Nona	ND-584779	27900	2558	93.3	48.0-10397	1281	505	100	ND-8778	696	ND	20.0	14.4-158	44.3	19.9	100
Deca	ND-4231832	201988	34308	93.3	17.3-61453	3974	219	100	ND-33269	3554	ND	26.7	89.0-1088	284	117	100
PBDEs	162-5344154	263135	52998	100	236-72403	5761	958	100	ND-57639	5349	ND	26.7	112-1293	347	150	100
DBDPE	ND-117006	9168	1379	80.0	ND-5686	1323	719	88.9	ND-7547	1144	ND	40.0	ND-260	118	103	50.0
BTBPE	ND-236515	13429	309	66.7	ND	ND	ND	0.00	ND-3694	295.	ND	13.3	ND	ND	ND	0.00
PBB	ND-76720	3074	27.9	63.3	ND	ND	ND	0.00	ND-1076	71.7	ND	16.7	ND	ND	ND	0.00

^a Nondetectable

Table S3. The BFR migration rates from hard plastic toy into saliva in in vivo tests (pg/cm²-min).

Volunteer	BDE28	BDE47	BDE66	BDE100	BDE99	BDE153	BDE154	BDE138	BDE183
1	2.24	3.95	2.24	2.54	3.88	5.88	27.7	3.43	19.2
2	ND ^a	0.300	ND	ND	ND	1.172	4.67	ND	30.3
3	ND	ND	ND	ND	ND	ND	1.57	ND	15.7
4	ND	2.34	ND	ND	1.58	1.48	4.40	ND	22.6
5	ND	ND	ND	ND	ND	0.71	2.37	ND	20.4
95th value	2.24	3.95	2.24	2.54	3.88	5.88	27.7	3.43	30.3
50th value	ND	0.30	ND	ND	ND	1.17	4.40	ND	20.4

^a Nondetectable

(Continued)

BDE197	BDE203	BDE196	BDE208	BDE207	BDE206	BDE209	DBDBE	BTBPE
11.8	9.11	8.96	17.4	37.1	39.1	2960	769	21.2
18.8	19.3	18.3	36.9	63.4	44.0	347	ND	14.1
23.1	23.2	23.7	49.0	81.3	78.0	255	ND	ND
16.2	18.3	18.1	30.9	48.5	41.4	79.2	ND	8.67
ND	0.73	0.74	ND	ND	ND	ND	ND	41.9
23.1	23.2	23.7	49.0	81.3	78.0	2960	769	41.9
16.2	18.3	18.1	30.9	48.5	41.4	255	ND	14.1

Table S4. The hazard quotients of children's exposure to PBDEs via toys.

Age group	BDE47	BDE99	BDE153	BDE209
3-12 months ^a	0.0009	0.0008	0.0006	0.0083
1-3 years ^a	0.0001	8.1E-05	5.5E-05	0.0007
3-12 months	0.0002	3.0E-05	0.0001	0.0007
1-3 years	6.0E-05	1.4E-05	1.4E-05	6.3E-05
3-5 years	3.3E-05	8.6E-06	2.5E-06	2.2E-08
5-9 years	1.0E-05	2.7E-06	7.9E-07	6.8E-09
9-14 years	6.8E-06	1.7E-06	5.1E-07	4.4E-09

^a Calculating with the estimated 95th exposure doses via mouthing toys.

Table S5. Congener-specific concentrations of BFRs in each type of toys (ng/g).

NO.	BDE28	BDE47	BDE66	BDE100	BDE99	BDE138	BDE153	BDE154	BDE183	BDE196	BDE197	BDE203	BDE206	BDE207	BDE208	BDE209	DBDPE	BTBPE	PBB
Plastic toys																			
P1	ND ^a	78.0	ND	11.0	60.1	86.5	1323	164	9010	3129	3791	1839	3340	8347	592	128830	6192	ND	ND
P2	1.2	9.7	2.6	1.5	13.4	4.2	8.3	2.9	31.6	65.4	41.7	69.5	326	557	241	1617	867	39.1	ND
P3	ND	ND	ND	ND	15.9	115	117	25.0	1007	426	570	623	3425	2856	982	63861	17906	886.3	473.3
P4	8.5	43.3	9.0	2.4	28.2	ND	16.8	4.2	33.1	48.2	25.4	164	269	267	159	56.3	5141	51.5	327.8
P5	15.5	19.6	8.5	9.8	36.0	174	2486	123	27079	3632	6169	4874	8278	6360	1637	54270	16503	4981.0	1564
P6	ND	ND	ND	ND	ND	ND	ND	ND	ND	368	573	211	2913	2947	793	114919	21242	150.6	ND
P7	4.5	62.4	6.8	19.2	94.2	84.7	1253	145	10672	2728	3372	1451	6152	7315	1116	153251	7272	ND	11.1
P8	ND	ND	ND	ND	ND	ND	ND	ND	ND	1261	1944	2094	12424	6135	1876	104370	7427	5524.0	1341
P9	7.8	7.4	4.5	4.6	11.5	28.0	16.7	7.0	96.3	45.7	61.5	61.1	265	234	82.5	7184	970	318.0	36.4
P10	ND	121	11.3	ND	ND	602	ND	ND	ND	174	297	138	321	553	132	3664	1788	715.9	19.4
P11	18.2	ND	11.2	14.4	65.1	7711	1943	137	12843	2971	4029	6728	11065	6258	1684	154082	18212	11853	3497
P12	17.5	55.5	10.1	18.0	78.8	1842	3110	361	20977	3396	5109	2999	4636	5251	1249	46989	11697	14836	1362
P13	9.9	44.8	ND	10.2	55.0	3017	1660	171	10650	1190	2165	2752	5577	3159	970	51803	5930	6577	523
P14	20.5	108	50.2	24.2	178	49.0	327	47.8	1534	386	491	618	3619	2499	563	49107	14020	1150	305
P15	ND	ND	ND	ND	ND	ND	ND	ND	ND	36.2	26.5	31.5	130	103	49.1	3829	ND	ND	ND
P16	ND	ND	ND	ND	ND	9.9	ND	ND	3.2	13.8	5.6	14.6	28.1	24.6	19.3	88.7	471.62	2.42	ND
P17	0.8	ND	ND	ND	ND	113.9	4.0	ND	21.0	13.0	11.1	12.3	46.6	29.3	11.3	292	521.31	24.86	13.6
P18	ND	ND	ND	ND	ND	ND	ND	ND	ND	61.7	86.8	41.3	143	232	80.6	1362	ND	ND	ND
P19	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.2	4.3	8.9	22.2	22.5	14.2	80.8	ND	ND	ND
P20	ND	224	ND	ND	ND	4250	79.83	9.09	ND	ND	ND	ND	ND	ND	ND	ND	598.81	2437.83	ND
P21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	63.5	55.8	39.7	206	587.11	ND	ND
P22	ND	4652	456	ND	264	117386	ND	ND	227.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

P23	3.3	8.8	2.0	1.1	5.4	ND	1.7	ND	2.8	14.7	8.1	11.2	87.5	91.0	41.3	738	587.12	2.99	ND
P24	20.8	77.7	16.5	26.4	119	109	2289	250	17935	3338.2	5841	3865	7948	6713	1540	66739	14156	32896	2432
P25	ND	5.6	5.4	ND	8.3	1.6	54.7	15.8	286	165.9	199	107	605	738	303.1	3408	ND	5306	150
P26	7.2	7.0	ND	ND	6.4	ND	13.2	4.7	67.1	100.2	64.5	179	1327	844	365.5	26434	ND	ND	96
P27	14.5	43.0	11.1	7.6	40.4	ND	65.1	14.8	418	219.7	212	550	1020	1168	391	42182	5953	299	6.79
P28	ND	84.5	ND	30.2	143	1155	ND	525	30691	5400	11073	3439	9443	26645	3589	196796	25311	ND	352.8
P29	7.5	123	9.3	27.7	156	ND	3382	381	31749	4653	12667	3524	19514	34909	6387	551636	52984	117006	2993
P30	9.7	162	83.8	47.7	280	ND	14264	1357	301926	47657	128743	32996	172094	373759	38926	4231832	236515	ND	76720
Foam																			
F1	6.8	16.1	15.2	13.0	36.3	60.4	107	37.5	451	822	405	795	1448	1533	930	964	3711.38	ND	ND
F2	2.2	6.1	1.1	1.3	3.3	ND	3.0	1.7	9.7	72.6	26.4	80.3	751	560	271	5867	ND	ND	ND
F3	7.9	5.3	4.3	4.1	6.2	ND	6.8	5.4	18.5	199	90.7	204	4989	3635	1773	61453	5311.99	ND	ND
F4	1.4	3.9	0.5	0.8	2.9	ND	ND	ND	1.2	9.0	5.1	5.8	21.7	17.0	9.4	290	502.20	ND	ND
F5	2.0	3.6	1.4	0.6	2.8	3.8	9.2	2.6	30.4	61.8	24.0	66.1	104	84.3	49.1	98.9	545.14	ND	ND
F6	2.2	10.5	1.3	1.8	9.6	4.3	18.2	6.8	89.3	392	111	365	401	338	250	202	1084.52	ND	ND
F7	3.8	27.4	7.4	4.3	46.7	8.7	89.8	20.2	12.6	13.5	7.1	15.6	24.3	21.9	15.2	474	ND	ND	ND
F8	2.2	5.3	1.2	0.8	3.8	1.5	5.7	2.7	15.7	41.2	15.2	42.7	28.8	23.8	27.5	17.3	486.59	ND	ND
F9	7.0	14.7	4.3	0.9	6.5	ND	5.8	1.8	19.2	88.7	26.6	101	174	163	77.9	216	885.15	ND	ND
F10	4.8	34.1	4.1	6.5	37.7	6.5	48.9	10.0	80.4	235	108	219	255	492	499	150	5685.82	ND	ND
F11	ND	ND	ND	ND	ND	ND	ND	ND	ND	110	43.5	99.2	217	210	125	203	692.48	ND	ND
F12	2.2	8.8	1.7	1.7	7.9	ND	2.1	1.4	5.3	27.2	10.5	29.0	57.0	37.6	21.1	91.2	516.41	ND	ND
F13	2.1	7.5	1.3	1.1	4.6	ND	2.4	1.2	8.7	71.3	22.1	84.6	192	182	92.8	221	695.78	ND	ND
F14	11.3	42.0	7.9	1.5	12.2	1.3	11.3	4.1	27.4	168	50.5	171	263	161	118	218	812.78	ND	ND
F15	1.6	7.7	1.1	1.5	7.0	ND	4.2	2.0	11.1	69.0	26.1	80.0	162	118	85.1	220	768.06	ND	ND
F16	3.0	8.5	1.6	1.4	8.1	4.0	12.1	4.2	54.1	315	83.6	296	394	253	162	223	742.88	ND	ND
F17	2.0	11.2	1.5	1.6	8.3	2.7	7.7	2.1	33.7	228	65.8	229	527	323	169	514	803.68	ND	ND

F18	1.8	3.5	1.0	0.7	2.8	ND	3.1	1.4	10.8	50.8	17.8	55.5	109	72.7	47.0	118	571.71	ND	ND
Rubber/soft plastic																			
R1	ND	ND	ND	ND	ND	ND	ND	ND	ND	34.76	19.50	31.98	122	89.37	52.79	495	7547	3694	1076
R2	ND	ND	ND	ND	ND	ND	ND	ND	ND	172	287	234	557	681	158	19466	ND	ND	ND
R3	33.0	72.0	81.6	60.3	306	745	1331	277	7063	1354	2466	1755	4279	3609	890	33269	5237	713	0.00
R4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1589	ND	ND
R11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	61.28	ND	ND	ND
R12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	341.47	ND	ND
R14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	529.03	ND	ND
R15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	262.62	ND	ND
Stuffed																			
S1	0.10	0.20	0.08	0.14	0.19	0.05	0.16	0.16	0.53	3.23	1.81	2.05	6.34	5.14	2.93	89.0	ND	ND	ND
S2	0.15	0.27	ND	0.19	0.27	ND	0.28	0.23	0.76	4.29	2.50	2.67	7.41	5.87	3.73	109	ND	ND	ND
S3	0.16	0.46	0.10	0.21	0.50	0.07	2.18	0.30	14.9	9.13	7.31	11.3	64.4	73.7	19.8	1088	ND	ND	ND
S4	0.27	0.45	0.13	0.24	0.40	0.09	0.27	0.26	1.03	4.82	2.81	2.93	9.12	8.48	4.57	125	ND	ND	ND
S5	0.16	0.29	0.09	0.00	0.24	0.06	0.19	0.19	0.58	3.85	2.49	2.30	7.70	6.25	3.67	109	ND	ND	ND
S6	0.27	0.48	0.12	0.22	0.36	0.11	0.25	0.24	0.74	4.79	2.79	3.05	13.6	14.8	8.55	187	ND	ND	ND

^a Nondetectable

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