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Content and migration of chemical additives from indoor consumer plastic products

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ABSTRACT

NILU has, on behalf of the Norwegian Environment Agency, performed chemical analyses of a selection of chemical additives in indoor consumer plastic products. The goal was to identify content and migration of the chemical additives in and from the products to particles and surfaces of the products at room temperature. The plastic products included; furniture wrap, wall papers, table cloths, shower curtains, floor tiles, mattresses, pillows, carpet underlays and a bathtub mat. Targeted chemicals were organophosphorous flame retardants (OPFRs), brominated flame retardants (BFRs) including tetrabromobisphenol A (TBBPA), chlorinated paraffins (CPs) and dechloranes. MCCPs and SCCPs were found in ‰ to % levels in PVC containing products. Four of the OPFRs were found in up to ‰ levels in adhesive foils to be put on furniture or floor/walls and mattresses. None of the targeted brominated compounds nor melamine were detected in the product samples.

NORWEGIAN TITLE

Innhold og migrasjon av kjemiske tilsetningsstoffer fra forbrukerprodukter i plast.

KEYWORDS

Organic chemicals | Indoor environment | Environmental chemistry

ABSTRACT (in Norwegian)

NILU har på oppdrag av Miljødirektoratet utført kjemisk analyse av et utvalg av kjemiske tilsetningsstoffer i forbrukerprodukter av plast. Formålet med studien var å identifisere innhold i og migrasjon av tilsetningsstoffene fra produktene til overflater i romtemperatur. Plastproduktene inkluderte dekorfolietapet, voksduker, dusjforheng, gulvfliser, madrasser, puter, teppeunderlag og en badekarsmatte. Kjemisk analyse ble utført for fosfororganiske flammehemmere (OPFRs), bromerte flammehemmere inklusive tetrabromobisfenol A (TBBPA), klorparafiner og dekloraner. MCCP og SCCP ble funnet i ‰ til % nivåer i plastprodukter i PVC. Fire av OPFRs ble målt i ‰-nivåer i dekorfolieprodukter og i flammebeskyttede madrasser. Ingen bromerte flammehemmere eller melamin ble detektert i prøvene.

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Contents

Summary

NILU has, on behalf of the Norwegian Environment Agency, performed chemical analyses of a selection of chemical additives in consumer plastic products used in indoor environment. The main goal was to identify the content and migration of the chemical additives in and from the products to air and surfaces of the products at room temperature.

The study was split in two parts. In part 1, the extractable content of the chemical additives in seven groups of plastic consumer products was analysed and quantified by cutting the products in smaller pieces and extracting in solvent. In part 2, the individual product with highest content were selected to study the migration of the chemical additives to the surfaces of the products. This part was conducted in closed metal containers containing the products with the release to surfaces studied by collecting wipe samples of the surfaces after two weeks in the closed container. Analyses were performed on gas or liquid chromatography coupled to mass spectrometry (GC-MS, LC/MS) using internal standards for identification and quantification of the content in all samples.

The results showed that MCCPs and SCCPs were present in ‰- to %-levels in PVC containing plastic products. For some of the products the CPs were also migrating to the surfaces of the products during storage in room temperature. Four of the targeted OPFRs were present at ‰-levels in adhesive foils to be put on furniture or floor/walls, and in a shower curtain.

Migration analysis of chemical additives from indoor consumer plastic products

1 Introduction

The main goal of the study was to identify the content and migration of chemical additives in and from plastic consumer products to surfaces of the products at room temperature. The products were selected based on the criteria of having large surface areas and from which emission/release of chemical additives may have potential for exposure to indoor environments.

In recent years, studies have shown that chemical additives are present in indoor matrices (e.g., house dust), but the sources for the additives are not yet well characterized. A better understanding of the content and release of chemical additives in and from plastic products is crucial for chemical regulation and reduced exposure for humans and the environment.

2 Samples

All the plastic consumer products that were included in the study (n=40) were selected and purchased by NILU in agreement with the Norwegian Environment Agency. The selection criteria were i) plastic consumer products commonly used in homes, ii) large surface areas, and iii) potential to effect human exposure in indoor residential environments. A complete list of all samples is given in Table 1.

Table 1: Plastic consumer products included in this study, grouped in product types and with information on samples selected for part 2.

Sample nr.	Product group	Specific product name (in Norwegian), Supplier	Part 1	Part 2
1	Furniture wrap/ Wall-paper	D-C-fix Blackwood dekorfolie, Megaflis	Yes	Yes*
2	Furniture wrap/ Wall-paper	D-C-Fix Designfolie selvklebende, Clas Ohlson	Yes	
3	Furniture wrap/ Wall-paper	D-C-fix Uni blau dekorfolie, Megaflis	Yes	Yes*
4	Furniture wrap/ Wall-paper	Gekkofix selfadhesive foil, Lindas Dekor	Yes	Yes
5	Furniture wrap/ Wall-paper	Premium kontaktplast sort trestruktur, PVCflis	Yes	Yes
6	Furniture wrap/ Wall-paper	Selvklebende PVC vanntett oljetett marmor tapet, CDON	Yes	Yes
7	Furniture wrap/ Wall-paper	DC-FIX Self-adhesive Wall tiles, Lindas Dekor	Yes	Yes
8	Furniture wrap/ Wall-paper	Veggflis Subway Marble, PVCflis.no	Yes	
9	Furniture wrap/ Wall-paper	D-C-Wall Ceramics Selvklebende Tapet, Clas Ohlson	Yes	Yes
10	Furniture wrap/ Wall-paper	Nyans tapet Art deco, Megaflis	Yes	
11	Furniture wrap/ Wall-paper	Selvklebende PVC vanntett oljetett grønn tapet, Light in the box	Yes	Yes

12	Furniture wrap/ Wall-paper	Vanntett PVC tapet, Brunt tremønster CDON	Yes	
13	Table cloth	Home Superduk, Europris	Yes	
14	Table cloth	Home Voksduk, Europris	Yes	Yes
15	Table cloth	Voksduk, blomstrete hvit	Yes	
16	Table cloth	Voksduk rosa, Princess	Yes	
17	Table cloth	Voksduk blomstrete blå, Skapemer.no	Yes	
18	Table cloth	Voksduk blomstrete hvit, Skapemer.no	Yes	
19	Table cloth	Voksduk hvit, Sparkjøp	Yes	
20	Shower curtain	Brix Dusjforheng Sealskin, Bad.no/CDON	Yes	
21	Shower curtain	Dusjforheng PVC, CDON	Yes	Yes
22	Shower curtain	Home Dusjforheng, Europris	Yes	
23	Shower curtain	Ridder dusjforheng, Megaflis	Yes	
24	Floor	D-C-Floor Selvklebende gulvfliser, Clas Ohlson	Yes	Yes
25	Floor	Floor tiles plastikk, Europris	Yes	
26	Floor	Grey wood Gulvfliser, Lindas Dekor	Yes	Yes
27	Floor	Laminatgulv, Biltema	Yes	
28	Mattress	Pluss Comfort Madrass Recitel, Medicare trekk, Soveromsbutikken	Yes	
29	Mattress	Pluss Comfort Madrass Recitel, Pyroprotex trekk, Soveromsbutikken	Yes	
30	Mattress	Dreamzone Basic F5 Foam mattres Baby, Jysk	Yes	
31	Mattress	Dreamzone Plus T15 Madrassbeskytter, Jysk	Yes	
32	Mattress	Offshore Protection cover, Wonderland FR Supply	Yes	Yes**
33	Mattress	Offshore Top mattress, Wonderland FR Supply	Yes	Yes**
34	Pillow	Evje Kids Wellpur Pute, Jysk	Yes	
35	Pillow	Høie Nordic flammehemmende pute, Soveromsbutikken	Yes	

36	Pillow	Høie North Flammehemmende pute, FR Supply	Yes	
37	Pillow	Høie Trevira 85 Flammehemmende pute, Soveromsbutikken	Yes	
38	Carpet underlay	Anti-Slip Mat, Clas Ohlson	Yes	
39	Carpet underlay	Home Teppeunderlag PVC, Europris	Yes	Yes
40	Bathtub mat	Badekarmatte, Clas Ohlson	Yes	

**Bulked together to one sample in Part 2.*
***Bulked together to one sample in Part 2.*

3 Methods

3.1 Part 1 Measurements of extractable content of chemical additives in plastic products

In the first part of the study, the extractable content of the targeted chemical additives in the individual products was measured. This was done by cutting representative parts of each product in small pieces and extracting the pieces in acetone:hexane (1:1) using ultrasonication. The extract was sent for instrumental analyses without any clean-up steps. Solvent was exchanged for the specific analyses.

3.2 Part 2 Measurements of migration of chemical additives to dust particles

In the second part of the study, the release of chemical additives to the surface and particles on the surface of the individual products was measured. Fifteen of the 40 samples were selected based on the results from part 1 (Table 1). Two of the furniture wraps and two of the mattrasses were bulked together to one sample each as the pattern and concentration in part 1 were similar.

The study was performed inside metal (plastic free) containers. The metal containers were pre-cleaned in soap followed by hexane and acetone before any products were places inside them. The individual products were placed separately in a metal container. Four samples were done at a time. To control any contamination from the container or from leakage of indoor air, also one empty container was included for each sample batch. The containers were sealed and left in room temperature at the laboratory of NILU for two weeks. After two weeks the containers were opened and wipe samples were taken of the product surfaces and the inside walls of the containers. The wipe samples were collected using glass fiber filters (142 mm) soaked in solvent (iso-propanol). The glass fiber filters were pre-cleaned at 450˚C before sampling. The wipes from one container were packed together in aluminum foil, placed in two sealed plastic bags and stored cold until sample preparation. The wipes were extracted in hexane:acetone (1:1) using ultra sonication. The extracts were filtered before instrumental analysis.

Figure 1. Part 2 – Sample containers for measurements of release of chemical additives from plastic consumer products to surfaces.

4 Chemical analysis

The extracts from part 1 and 2 were analyzed for organophosphorous flame retardants (OPFRs, n=21), polybrominated flame retardants (PBDEs, n=25), novel brominated flame retardants (nBFRs, n=14), TBBPA (2,2',6,6'-tetrabromo-4,4'-isopropylidenediphenol), short-/medium-/long-chain chlorinated paraffins (SCCPs/MCCPs/LCCPs) and dechloranes (n=10). The full list of targeted compounds is given in Annex A.

Shortly, the instrumental analyses for PBDEs and nBFRs were performed on gas chromatography (GC) coupled to a high resolution mass spectrometer (HRMS) operated in electron impact ionization (EI) mode. OPFRs and melamine were analyzed on an ultra-high-pressure liquid chromatograph (UPLC) coupled to a triple quadrupole MS operated in positive mode using electrospray ionization (ESI). TBBPA was analyzed on a Vanquish UPLC coupled to an Q Exactive Plus HRMS operated in negative mode using ESI. SCCPs/MCCPs and dechloranes were analyzed on an Agilent GC coupled to HR-qTOF in electron capture negative ion (ECNI) mode. LCCPs were analyzed using an Agilent 1290 UPLC, 6546 qTOF (HRMS) in negative ESI mode.

5 Results

5.1 Part 1

In total, seventeen of the targeted chemical additives were detected in at least one product. Nine of these were detected at high concentrations and in more than one product group: SCCPs, MCCPs, TCPP, TPhP, EHDP, TEHP, 2-IPPDPP, TBOEP, and TIPPP (Figure 2 and Figure 3). The targeted chemical additives detected at highest concentrations in the products in Part 1 are listed in Table 2-Table 3 (name, CAS-number, EC-number, analytical limit of detection (LOD), quantified concentrations).

The highest concentrations were measured for MCCPs and SCCPs that were found in % levels (36-99 mg/g) in three samples and in ‰ levels (0.1-8 mg/g) in four samples. Also EHDP, TCPP, and TPhP were found at ‰ levels in some products. The compounds detected in the highest number of samples were TEHP, TPHP, and EHDP (Table 2). On the other hand, none of the targeted brominated flame retardants, dechloranes, or LCCPs were detected in any of the samples in Part 1 and TBBPA was only detected in two of the samples

In addition to the targeted compounds included in this study, also bisphenols and other phenols were observed in five of the product groups (i.e. sample 5, 11, 21, 31, 38). Further identification and quantification of these were not a part of this study.

Table 2: Summary of results in part 1 of the study. Presented are the five OPFRs detected at highest concentrations in the individual product samples (ng/g) and in the largest number of the studied products.

	Triphenyl phosphate (TPP/TPHP)	**2-ethylhexyl diphenyl phosphate (EHDP)**	**Tris(2-chloroisopropyl)-phosphate (TCPP)**	**Tris(2-ethylhexyl)-phosphate (TEHP)**	**2-isopropyl phenyl diphenyl phosphate (2-IPPDPP)**
CAS	115-86-6	1241-94-7	13674-84-5	78-42-2	64532-94-1 28108-99-8
EC-number	204-112-2	214-987-2	237-158-7	201-116-6	248-848-2
LOD (ng/g)	120	334	67	10	5
Detection (nr samples per total)	18/40	10/40	5/40	19/40	7/40
	Concentrations (ng/g)				
Furniture wrap/Wall-paper Sample 1 – D-C Fix Blackwood Adhesive film	2 329	<LOD	<LOD	292	<LOD
Furniture wrap/Wall-paper Sample 3 – D-C Fix Uni blau Adhesive film	4 737	<LOD	<LOD	2 491	<LOD
Furniture wrap/Wall-paper Sample 4 – Gekkofix selfadhesive foil	44 376	<LOD	<LOD	<LOD	<LOD

Furniture wrap/Wall-paper Sample 5 – Premium Adhesive film*	38 087	<LOD	**232 358**	27 432	6 138
Furniture wrap/Wall-paper Sample 6 - Selfadhesive PVC waterproof wall paper	14 735	44 894	<LOD	47 653	<LOD
Furniture wrap/Wall-paper Sample 7 – DC-Fix Self-adhesive wall tiles*	18 178	**272 086**	<LOD	445	1 070
Furniture wrap/Wall-paper Sample 9 – D-C Wall ceramics Selfadhesive wall paper	<LOD	8 743	<LOD	89	38
Furniture wrap/Wall-paper Sample 11 - Selfadhesive PVC waterproof wall paper	37 453	**110 838**	<LOD	45 168	<LOD
Furniture wrap/Wall-paper Sample 12 - Waterproof PVC wall paper	31 802	**84 560**	<LOD	19 044	<LOD
Table cloth Sample 14 – Home Wax cloth	18 627	35 815	<LOD	1 719	<LOD
Table cloth Sample 18 - Wax cloth t	436	*48*	<LOD	3 753	<LOD
Table cloth Sample 19 - Wax cloth	2 135	*36*	< LOD	29	2 400
Shower curtain Sample 21 - Shower curtain PVC	3 277	13 067	866	17 496	<LOD
Floor Sample24 – D-C-Floor Selfadhesive floor tiles*	7 932	92 705	<LOD	2 756	380
Floor Sample 26 – Grey wood Floor tiles*	7 402	**187 388**	<LOD	530	159
Mattress Sample 28 – Pluss comfort mattress, Medicare	40 421	<LOD	<LOD	<LOD	<LOD
Mattress Sample 32 – Offshore Protection cover	**246 218**	<LOD	<LOD	<LOD	<LOD

Mattress Sample 33 – Offshore Top Mattress	**179 399**	<LOD	<LOD	<LOD	<LOD
Carpet underlay Sample 39 - Home Carpet underlay PVC	<LOD	<LOD	<LOD	33	<LOD

*Highest number of detected OPFRs.

Table 3: Summary of results in part 1 of the study. Presented are the chlorinated paraffins (SCCPs, MCCPs and LCCPs) in µg/g and TBBPA in ng/g.

	SCCPs	**MCCPs**	**LCCPs**	**2,2',6,6'-tetrabromo-4,4'-isopropylidene-diphenol (TBBPA)**
CAS	85535-84-8	85535-85-9	63449-39-8	79-94-7
EC-number	287-476-5	287-477-0	264-150-0	201-236-9
LOD (µg/g For CPs, ng/g for TBBPA)	1.4	8.7	2.0	0.005
Detection (nr samples per total)	5/40	7/40	0/40	2/40
	Concentrations (µg/g)			**Concentrations (ng/g)**
Furniture wrap Sample 5 Premium adhesive film	**572**	**3 175**	<LOD	0.74*
Furniture wrap Sample 6 Selfadhesive PVC waterproof wall paper	<LOD	**7 733**	<LOD	<LOD
Furniture wrap Sample 7 DC-FIX Self-adhesive Wall tiles	**102**	**771**	<LOD	<LOD
Wall paper Sample 11 Selfadhesive PVC waterproof wall paper	**3 664**	**3 788**	<LOD	<LOD*
Furniture wrap Sample 12 Waterproof PVC wall paper	**1 048**	**36 849**	<LOD	0.74*
Shower curtain Sample 21 Shower curtain PVC	**36 444**	**68 422**	<LOD	<LOD*
Floor Sample 27 Laminate floor	<LOD	<LOD	<LOD	0.02
Carpet underlay Sample 39 Home carpet underlay PVC	<LOD	**98 511**	<LOD	<LOD

*Analysis showed presence of Bisphenol A; 4,4'-Bisphenol S; 2,2'-Bisphenol F; 4-tert-pentylphenol; nonylphenol.

The products with the highest number of detected compounds were also those with the highest concentrations of targeted chemical additives (sample 5, 6, 7, 11, 12, 21, 24, 26). Seven of these are all the same product type (adhesive foils to be put on furniture or floor/walls). One was the shower curtain in PVC. Two samples had very high concentrations, but only from one compound (i.e., TPhP). These were mattresses used for offshore facilities (Sample 32 and 33).

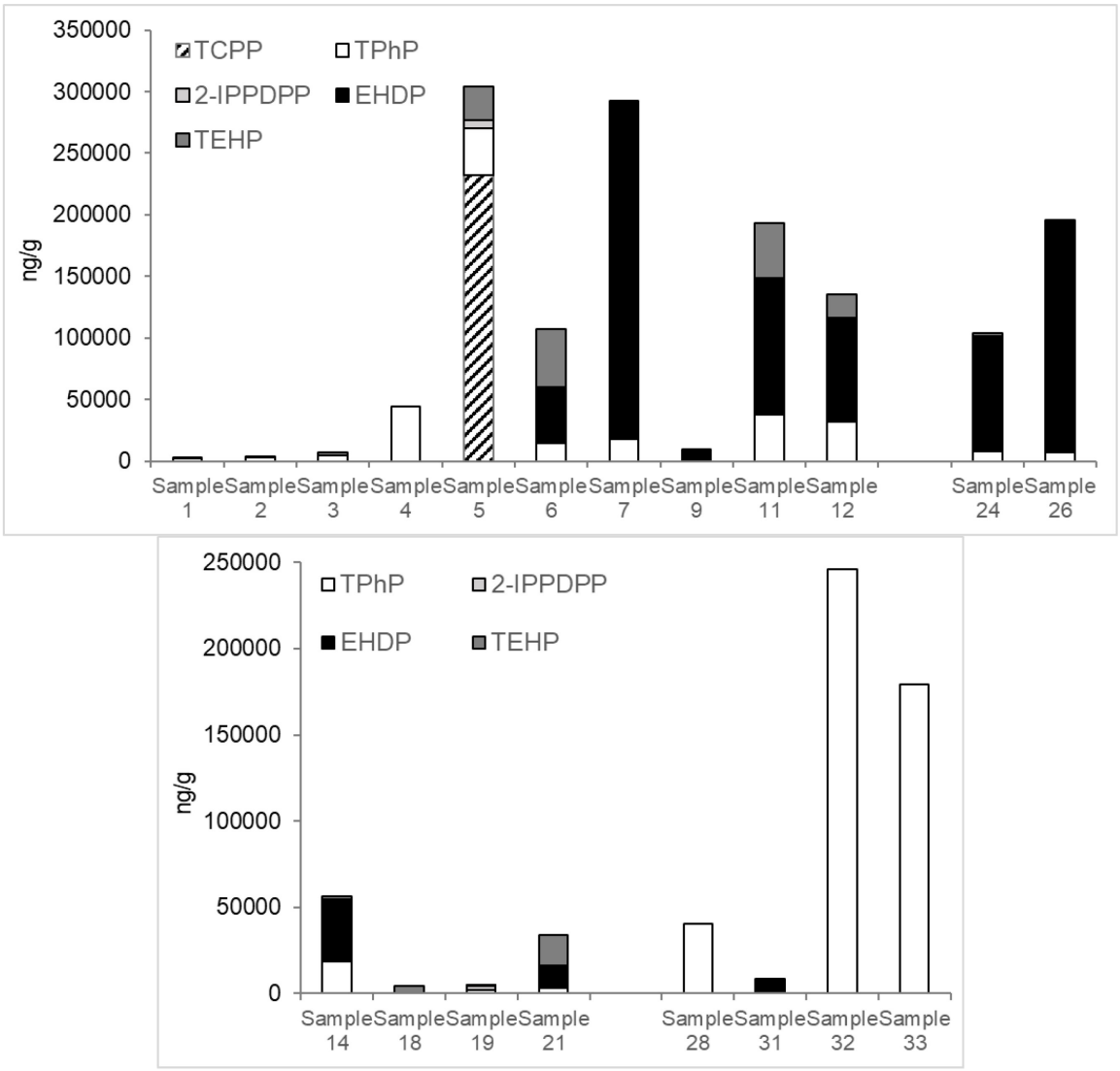

Figure 2. Profiles and concentrations (ng/g) of OPFRs in furniture wrap/wall-paper/floor (above) and table cloth, shower curtain, underlay, and mattrasses (below).

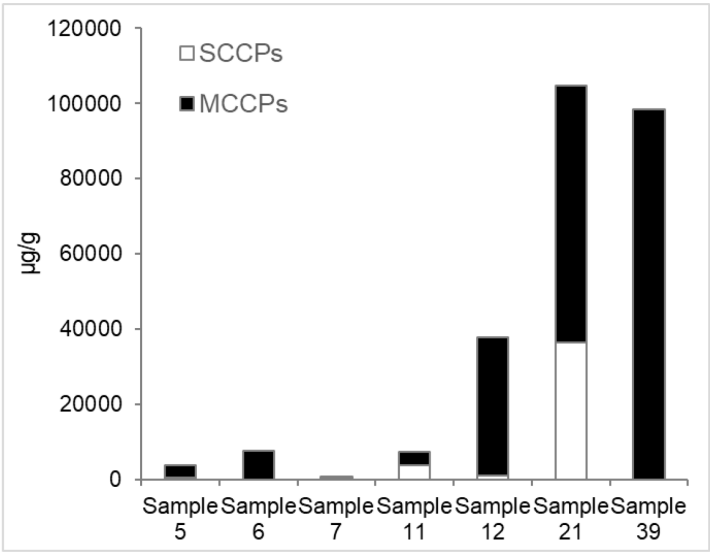

Figure 3 Profiles and concentrations (µg/g) of SCCPs and MCCPs in furniture wrap/wall-paper, shower curtain, and underlay.

5.2 Part 2

In total, 18 of the targeted chemical additives were detected in at least one of the selected products included in part 2. Six of these additives were detected at high concentrations and in more than two product group: SCCPs, MCCPs, TPhP, EHDP, TCPP, and TEHP (Table 4-5, Figure 4-5).

Table 4: Summary of results in part 2 of the study. Presented are the four chlorinated compounds detected in wipe samples (ng/sample).

	SCCPs	MCCPs	Syn-DP	Anti-DP
CAS	85535-84-8	85535-85-9	135821-03-3	135821-74-8
EC-number	287-476-5	287-477-0		
LOD (ng/sample)	10	100	0.03	0.03
	Concentrations (ng/sample)			
Furniture wrap/Wall-paper Sample 1+3 D-C Fix Adhesive film Blackwood/Uni blau	94	238	0.7	1.9
Furniture wrap/Wall-paper Sample 4 Gekkofix selfadhesive foil	125	441	0.6	1.7
Furniture wrap/Wall-paper Sample 5 Premium Adhesive film	760	2 048	<LOD	<LOD
Furniture wrap/Wall-paper Sample 6 Self-adhesive PVC waterproof wall-paper	84	613	2.0	4.8
Furniture wrap/Wall-paper Sample 7 D-C Fix Self-adhesive wall tiles	859	5 186	<LOD	<LOD
Furniture wrap/Wall-paper Sample 9 D-C Wall Ceramics Selfadhesive wall-paper	116	609	0.2	0.5
Furniture wrap/Wall-paper Sample 11 Selfadhesive PVC waterproof wall-paper	860	1 221	1.0	3.3
Table cloth Sample 14 Home Wax cloth	109	1 550	2.7	8.8
Shower curtain Sample 21 Shower curtain PVC	5878	20 467	0.5	1.0
Floor Sample 24 D-C-Floor Self-adhesive floor tiles*	32	228	0.5	1.5
Floor Sample 26 Grey wood Floor tiles*	171	1 082	<LOD	<LOD
Mattress Sample 32+33 Offshore Top Mattress/Protection cover	169	587	<LOD	<LOD
Carpet Underlay Sample 39 Home Carpet underlay PVC	128	6299	0.23	0.43

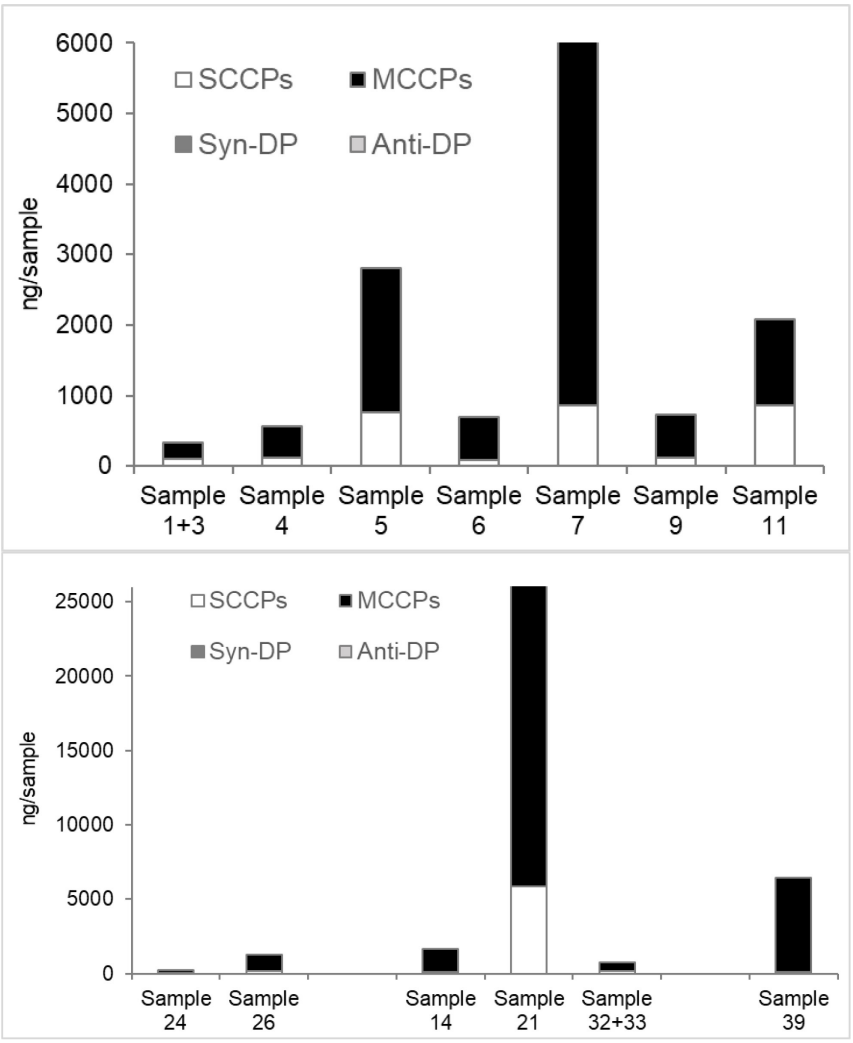

Figure 4. Profiles and concentrations (ng/sample) of chlorinated compounds released to the surfaces in furniture wrap/wall-paper (above) and floor, table cloth, shower curtain, and mattresses (below).

Table 5: Summary of results in part 2 of the study. Presented are the four OPFRs detected in highest concentrations wipe samples (ng/sample).

	Triphenyl phosphate (TPP/TPHP)	**2-ethylhexyl diphenyl phosphate (EHDP)**	**Tris(2-chloroisopropyl)-phosphate (TCPP)**	**Tris(2-ethylhexyl)-phosphate (TEHP)**
CAS	115-86-6	1241-94-7	13674-84-5	78-42-2
EC-number	204-112-2	214-987-2	237-158-7	201-116-6
LOD (ng/sample)	23	62	92	54
	Concentrations (ng/sample)			
Furniture wrap/Wall-paper Sample 1+3 DC-Fix Adhesive foil Blackwood/Uni blau	82	<LOD	<LOD	<LOD
Furniture wrap/Wall-paper Sample 4 Gekkofix selfadhesive foil	809	<LOD	<LOD	<LOD
Furniture wrap/Wall-paper Sample 5 Premium Adhesive film	278	825	**4 170**	360
Furniture wrap/Wall-paper Sample 6 Self-adhesive PVC waterproof wall-paper	472	40	<LOD	<LOD
Furniture wrap/Wall-paper Sample 7 DC-Fix Self-adhesive wall tiles	137	**364**	<LOD	844
Furniture wrap/Wall-paper Sample 9 D-C Wall Ceramics Self-adhesive wall-paper	202	<LOD	<LOD	<LOD
Furniture wrap/Wall-paper Sample 11 Self-adhesive PVC waterproof wall-paper	124	**418**	<LOD	<LOD
Table cloth Sample 14 Home Wax cloth	935	1107	**193**	<LOD
Shower curtain Sample 21 Shower curtain PVC	107	516	<LOD	85
Floor Sample 24 D-C-Floor Self-adhesive floor tiles*	147	317	<LOD	<LOD
Floor Sample 26 Grey wood Floor tiles*	67	**807**	<LOD	<LOD
Mattress Sample 32+33 Offshore Top Mattress/Protection cover	**12 176**	<LOD	<LOD	114
Carpet Underlay Sample 39 Home Carpet underlay PVC	<LOD	<LOD	<LOD	<LOD

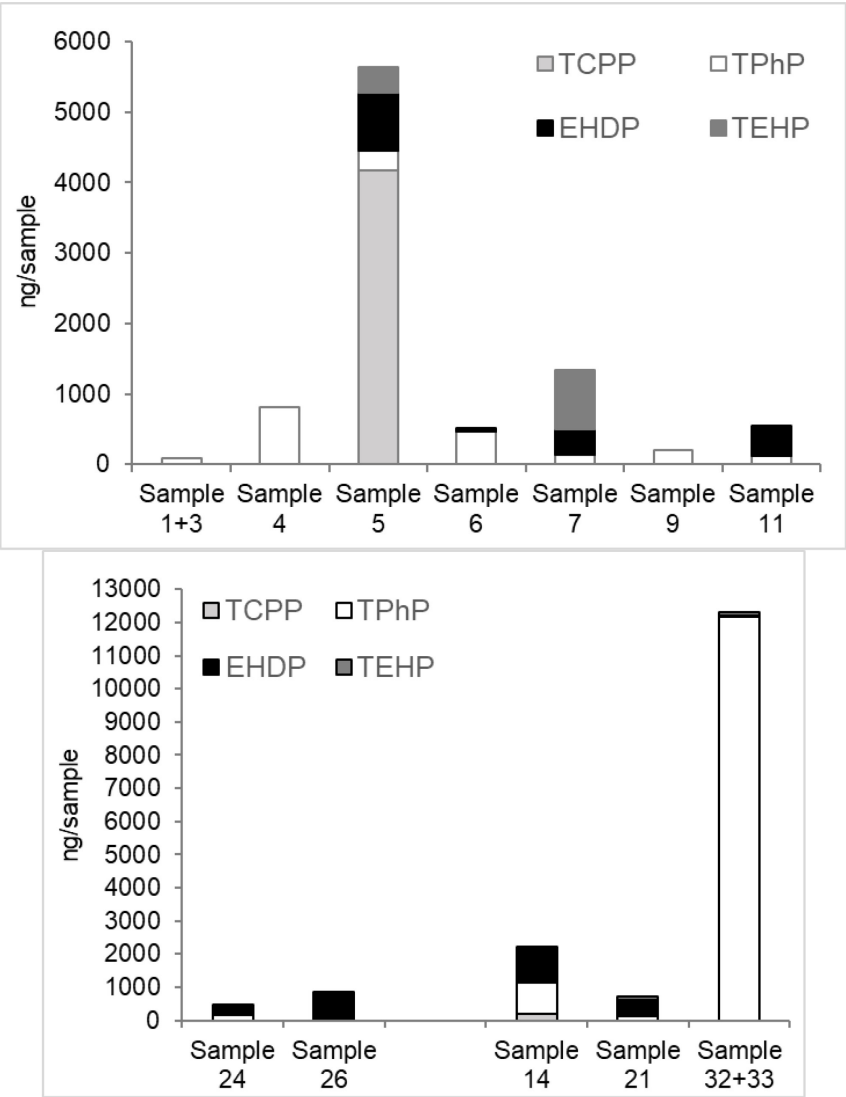

Figure 5. Profiles and concentrations (ng/sample) of OPFRs released to the surfaces in furniture wrap/wall-paper (above) and floor, table cloth, shower curtain, and mattrasses (below).

6 Conclusion

Products with high concentrations of SCCPs, MCCPs, and OPFRs were identified in this study. Products with PVC were found to be sources for both CPs and OPFRs. In addition, adhesive foils to be put on furniture/floor/walls were also identified as sources for these chemicals, both those containing PVC and those who do not inform about PVC content. The targeted products in this study did not contain any brominated flame retardants and TBBPA. This suggests that other product types are the sources for these chemicals.

In detail, high concentrations of SCCPs, MCCPs, and some OPFRs were found as extractable content and in surface wipe samples of the plastic consumer products. The highest extractable concentrations were detected for MCCPs and SCCPs in products made of PVC: A shower curtain (Sample 21), waterproof wall-paper (Sample 12, 11, 6), and a carpet underlay (Sample 39). The detected concentrations here were on % level. High concentrations of SCCPs and MCCPs were also found in the surface wipe samples from these product (Sample 6, 11, 21, and 39). CPs were also detected in the other surface wipe samples from products selected for in Part 2. This included also products that did

not have detectable levels in the extractable content (Part 1). The reason for this may be the higher LOD in Part 1 than in Part 2.

High extractable concentrations were also detected for EHDP, TCPP, TPhP, and TEHP. The highest concentrations as well as the highest number of detected compounds were found for seven adhesive foils to be put on furniture or floor/walls, and a shower curtain in PVC. Very high concentrations of TPhP were measured in mattrasses used for offshore facilities (Sample 32 and 33).

None of the targeted brominated flame retardants nor melamine were detected in any of the samples. This may suggest that they originate from other products than those targeted in this study and thereby other products than the CPs and OPFRs originate from.

The results of the surface wipes samples shows that the chemical additives also migrate to the surface itself or to particles on the surface of the products and particles settled on the walls of a sampling container. There was no direct connection between the highest extractable content and the highest amount in the surface wipe samples. The reason for this is not known.

As chemicals in products and materials are emitted and released to indoor air and dust they will contribute to the chemical exposure for humans, and act as a direct source of contamination to outdoor ambient air, and the wider outdoor environment. Studies on chemicals in indoor settled dust and air therefore provide an early warning for what chemicals that are released from products and materials and can support prioritization of hazardous chemicals. In order to understand where regulatory actions are needed, the sources for the prioritized chemicals need to be further identified. The results from this study show that analysis on chemical content in products and materials and analysis of migration of chemicals from products and materials could support regulators with such information. A combination of indoor screening studies and product analyses on a broader scale may identify more chemicals of concern and their sources. This will be valuable information for regulators.

Annex A

Targeted chemicals in the study.

Full name	Alternative name	Abbreviation	CAS no	EC no	LOD (ng/g)
Novel brominated flame retardants - nBFRs					
Allyl 2,4,6-tribromophenyl ether	2-(allyloxy)-1,3,5-tribromobenzene	ATE (TBP-AE)	3278-89-5	221-913-2	0.03
α-Tetrabromoethyl-cyclohexane	1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane	α-TBECH (DBE-DBCH)	3322-93-8 1232836-48-4	222-036-8	0.19
ß-Tetrabromoethyl-cyclohexane		ß-TBECH (DBE-DBCH)	3322-93-8 1232836-49-5		0.13
γ/δ-Tetrabromoethyl-cyclohexane		γ/δ-TBECH (DBE-DBCH)			0.09
2-Bromoallyl-2,4,6-tribromophenyl ether		BATE (TBP-BAE)	99717-56-3		0.04
Pentabromotoluene	2,3,4,5,6-pentabromotoluene	PBT	87-83-2	201-774-4	0.07
Pentabromoethylbenzene	2,3,4,5,6-pentabromo-ethylbenzene	PBEB	85-22-3	201-593-0	0.03
1,2,3,4,5-pentabromo-benzene		PBBZ	608-90-2		0.28
Hexabromobenzene	1,2,3,4,5,6-hexabromobenzene	HBB	87-82-1	201-773-9	0.12
2,3-dibromopropyl-2,4,6-tribromophenyl ether	1,3,5-tribromo-2-(2,3-dibromopropoxy)benzene	DPTE (TBP-DBPE)	35109-60-5	252-372-0	0.03
2-ethylhexyl-2,3,4,5-tetrabromobenzoate		EHTBB	183658-27-7	814-310-6	0.03
1,2-bis(2,4,6-tribromophenoxy)ethane	FireMaster 680	BTBPE	37853-59-1	253-692-3	0.06
Bis(2-ethylhexyl)-tetrabromophthalate		TBPH (BEH-TBP)	26040-51-7	247-426-5	0.24
Decabromodiphenylethane	1,1'-(ethane-1,2-diyl)bis-[pentabromobenzene]	DBDPE	84852-53-9	284-366-9	2.58
2,2',6,6'-tetrabromo-4,4'-isopropylidenediphenol		TBBPA	79-94-7	201-236-9	0.005
Polybrominated diphenylethers - PBDEs					
2,2',4-TriBDE		BDE-17	147217-75-2	874-730-0	0.15
2,4,4'-TriBDE		BDE-28	41318-75-6	868-402-6	0.15
2,2',4,4'-TetBDE		BDE-47	5436-43-1	690-137-8	0.15
2,2',4,5'-TetBDE		BDE-49	243982-82-3		0.15
2,3',4,4'-TetBDE		BDE-66	189084-61-5	621-543-5	0.15
2,3',4',6-TetBDE		BDE-71	189084-62-6	620-888-9	0.15
3,3',4,4'-TetBDE		BDE-77	93703-48-1	621-837-3	0.15
2,2',3,4,4'-PenBDE		BDE-85	182346-21-0	621-547-7	0.15

Full name	Alternative name	Abbreviation	CAS no	EC no	LOD (ng/g)
2,2',4,4',5-PenBDE		BDE-99	60348-60-9	690-282-7	0.15
2,2',4,4',6-PenBDE		BDE-100	189084-64-8	690-350-6	0.15
2,3',4,4',6-PenBDE		BDE-119	189084-66-0	620-889-4	0.15
3,3',4,4',5-PenBDE		BDE-126	366791-32-4		0.15
2,2',3,4,4',5'-HexBDE		BDE-138	182677-30-1	621-550-3	0.15
2,2',4,4',5,5'-HexBDE		BDE-153	68631-49-2	690-275-9	0.15
2,2',4,4',5,6'-HexBDE		BDE-154	207122-15-4		0.15
2,3,3',4,4',5-HexBDE		BDE-156	405237-85-6		0.15
2,2',3,4,4',5',6-HepBDE		BDE-183	207122-16-5		0.15
2,2',3,4,4',6,6'-HepBDE		BDE-184	117948-63-7		0.15
2,3,3',4,4',5',6-HepBDE		BDE-191	446255-30-7		0.15
2,2',3,3',4,4',5,6'-OctBDE		BDE-196	446255-39-6		0.15
2,2',3,3',4,4',6,6'-OctBDE		BDE-197	117964-21-3		0.15
2,2',3,3',5,5',6,6'-OctBDE		BDE-202	67797-09-5		0.15
2,2',3,3',4,4',5,5',6-NonBDE		BDE-206	63936-56-1 63387-28-0	264-565-7	0.15
2,2',3,3',4,4',5,6,6'-NonBDE		BDE-207	437701-79-6		0.10
DecaBDE		BDE-209	1163-19-5	214-604-9	1.0
Organophosphorous flame retardants – OPFRs					
Triethyl phosphate		TEP	78-40-0	201-114-5	7
Tri(2-chloroethyl)phosphate		TCEP	115-96-8	204-118-5	6
Tris(2-chloroisopropyl)phosphate		TCPP (TCIPP)	13674-84-5	237-158-7	67
Triisobutyl phosphate		TiBP (TnBP)	126-71-6	204-798-3	13
Butyl diphenyl phosphate		BdPhP	2752-95-6	220-398-1	10
Triphenyl phosphate		TPP (TPhP)	115-86-6	204-112-2	120
Dibutyl phenyl phosphate		DBPhP	2528-36-1	219-772-7	10
Tris(1,3-dichloro-2-propyl)-phosphate		TDCPP (TDCIPP)	13674-87-8	237-159-2	15
Tris(2-butoxyethyl) phosphate		TBEP (TBOEP)	78-51-3	201-122-9	5
Tricresyl phosphate	Tris(methylphenyl) phosphate	TCP	1330-78-5	215-548-8	5
2-ethylhexyldiphenyl phosphate		EHDP (EHDPP)	1241-94-7	214-987-2	334
Tris(4-isopropylphenyl) phosphate		TIPPP	2502-15-0 68937-41-7	219-703-0 273-066-3	12
Tris(2-ethylhexyl)phosphate		TEHP	78-42-2	201-116-6	10
2-isopropylphenyl diphenyl phosphate		2-IPPDPP	64532-94-1 28108-99-8	248-848-2	5

Full name	Alternative name	Abbreviation	CAS no	EC no	LOD (ng/g)
4-isopropylphenyl diphenyl phosphate	Diphenyl p-isopropylphenyl phosphate	4-IPPDPP	55864-04-5		30
Bis(4-isopropylphenyl) phenyl phosphate		B4IPPPP	55864-07-8		30
Melamine			108-78-1	203-615-4	
Dechloranes					
Syn-Dechlorane plus	Syn-dodecachloropenta-cyclooctadecadiene	syn-DP	135821-03-3		90
Anti-Dechlorane plus	Anti-dodecachloropenta-cyclooctadecadiene	anti-DP	135821-74-8		110
Dechlorane 601		Dec-601	13560-90-2		60
Dechlorane 602		Dec-602	31107-44-5	250-472-9	50
Dechlorane 603		Dec-603	13560-92-4		50
Dechlorane 604		Dec-604	34571-16-9	252-097-6	760
Dibromo-aldrin		Dba	20389-65-5	660-975-9	340
Chlorinated paraffins					
Short-chain chlorinated paraffins		SCCPs	85535-84-8	287-476-5	1400
Medium-chain chlorinated paraffins		MCCPs	85535-85-9	287-477-0	8700
Long-chain chlorinated paraffins		LCCPs	63449-39-8	264-150-0	2000

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