

Flame Retardants in Building Materials and Consumer Products: Concerns for Exposure

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NICHOLAS SCHOOL
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The Home Environment



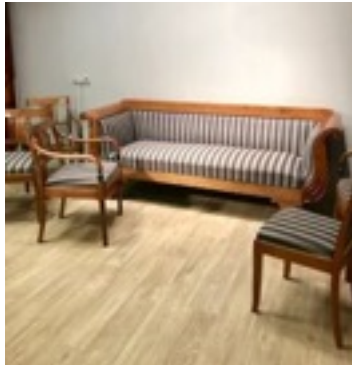
- People, and particularly small children, spend a majority of their time indoors
- Building materials and consumer products are manufactured to meet specific codes and safety ratings, and are treated with specific chemicals

Changes in Home Construction

Circa 1900s



www.houselogic.com



www.pamono.com

Today



www.oldhouseguy.com



www.dhifurniture.com

- Introduction of electricity & indoor plumbing
- Development of energy efficient homes
- In the US, home sizes are increasing as family size decreases

Chemical Applications in Building Materials and Common Household Items



(a) Spraying and shaving of foam



(b) Foam removal using a powered brush tool

Fig. 1. Representative images of spray foam insulation (SPF) activities.



- **Insulation**
- Drywall/Wallboard
- Flooring
- Furniture
- Electronics
 - TVs
 - Computers
 - Electrical cords

Urinary biomarkers for the flame retardant TCIPP were ~30X higher in workers applying spray foam compared to general population (Bello et al. 2018)

Chemical Applications in Building Materials and Common Household Items



- Insulation
- **Drywall/Wallboard**
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Strobilurin fungicides in house dust: is wallboard a source?

Ellen M. Cooper, Rosie Rushing, Kate Hoffman, Allison L. Phillips, Stephanie C. Hammel, Mark J. Zylka & Heather M. Stapleton 

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487 Accesses | 4 Citations | 15 Altmetric | [Metrics](#)

Chemical Applications in Building Materials and Common Household Items



Plasticizers in vinyl
(>20% by weight)

Vinyl flooring in homes associated with higher urinary phthalates levels
(Just et al. 2020; Hammel et al. 2020)



Stain-repellant treatments in carpeting

Per- and polyfluorinated alkyl substances (PFAS) are higher in dust from homes with carpets vs homes without carpets
(Schlummer et al. 2013; Hall et al. 2020)

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Chemical Applications in Building Materials and Common Household Items



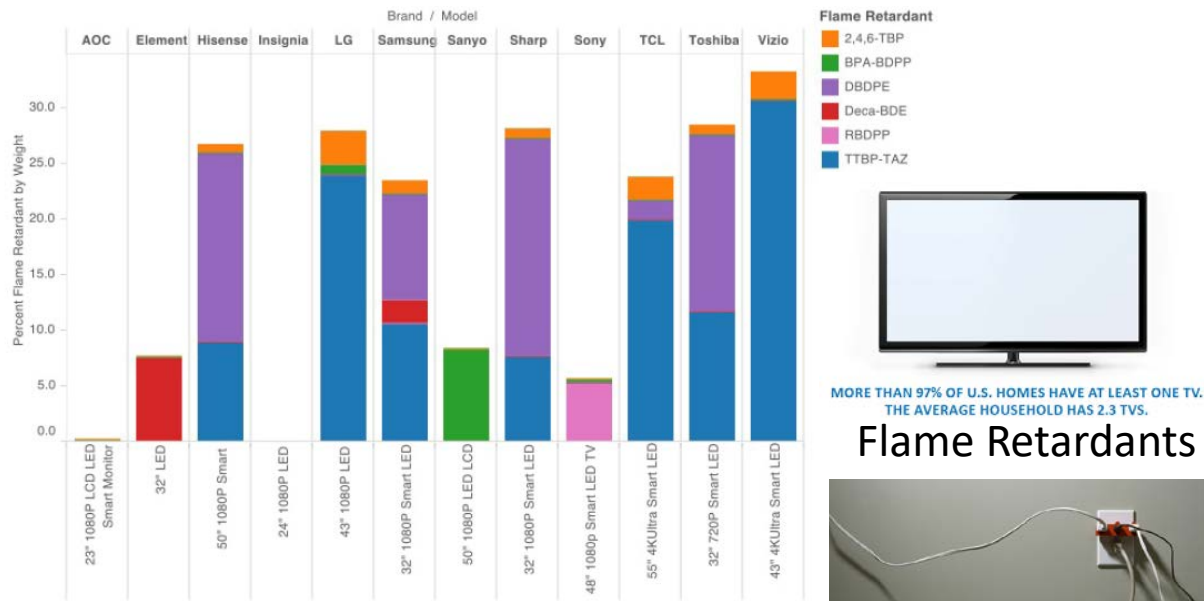
Dyes in synthetic (polyester) upholstery/textiles?

Stain-repellant upholstery treatments (PFAS)?

Flame retardant chemicals in the cushions and upholstery backcoating?

- Insulation
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Chemical Applications in Building Materials and Common Household Items



Source: TV Reality: Toxic Flame Retardants in TVs
Report by Toxic Free Future, 2017

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- Furniture
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Plasticizers

What is a Flame Retardant (FR)?

Definition:

“A substance added or a treatment applied to a material in order to suppress, significantly reduce or delay the combustion of the material” *EHC:192, WHO 1997*

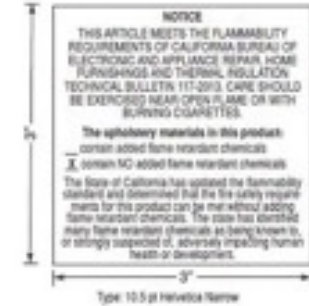
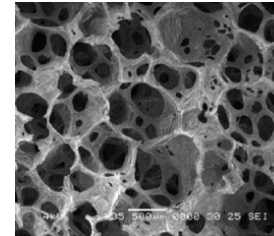
- Every year there are over a million fires reported
- Direct losses account for billions of dollars in damages
- Due to these concerns, a number of flammability standards and regulations have been introduced over the past few decades to try and reduce damages and harm inflicted by fire.



Furniture & Electronics

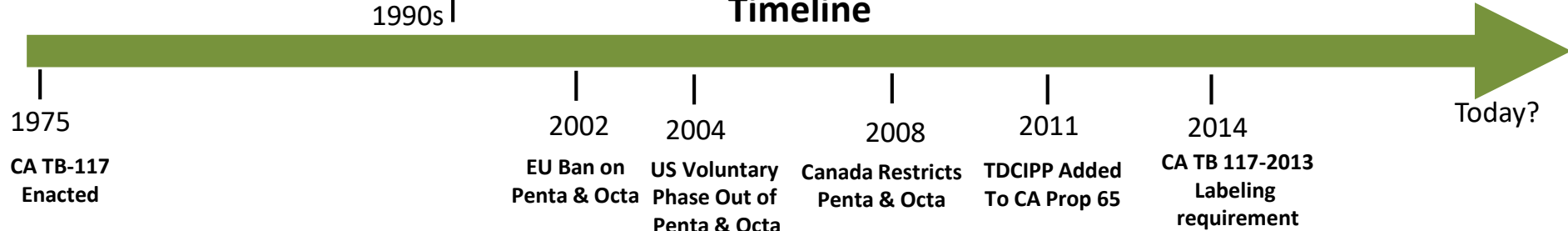
Flame Retardant Use in Polyurethane Foam (PUF)

NOTICE
THIS ARTICLE MEETS
THE FLAMMABILITY
REQUIREMENTS OF
CALIFORNIA BUREAU
OF HOME FURNISHINGS
TECHNICAL BULLETIN
117. CARE SHOULD BE
EXERCISED NEAR OPEN
FLAME OR WITH
BURNING CIGARETTES.



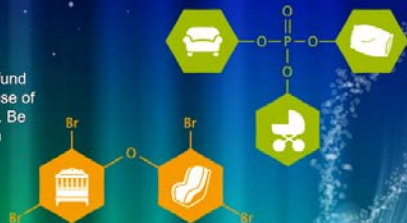
Research on PBDEs
Increases Concerns
1990s

Timeline



What's in my foam?

Scientists at Duke University's Superfund Research Center are examining the use of flame retardant chemicals in furniture. Be part of the study by submitting a foam sample from your home.



Who can send in samples?

Currently, we are only able to test foam sent to us from US residents.

Why should I test my sofa?

In the US, flame retardant chemicals are sometimes intentionally added to the foam filling present in many types of furniture (including some baby furniture) to meet a California state flammability standard commonly known as Technical Bulletin 117 (TB 117). While only residential furniture sold in the state of California is required to meet this standard, manufacturers often make all their furniture to meet this standard [1]. The state of California is currently revising TB 117, and a new standard, referred to as TB 117-2013, will go into effect starting in January 2014 that should reduce the use of these flame retardants in furniture. However, it is currently unclear how the use of these chemicals will change starting in 2014.

How does this affect me?

Over the past 10-15 years, scientific evidence has demonstrated that some of these flame retardants are released from products and accumulate in indoor environments. People can be exposed to these chemicals indoors through inhalation and unintentional ingestion of dust particles [2-3,4]. The use of one flame retardant known as PentaBDE was phased out in 2004 due to concerns about the chemical's persistence, its tendency to concentrate in human tissues, and potential human health effects.

This means other chemicals are currently used to meet flammability standards, but little information is available on how we are exposed to these new flame retardants, or if there are potential health effects. Because manufacturers are not required to label products with the flame retardant applications used, consumers cannot determine if flame retardants are in their products without laboratory testing.

How does this help me?

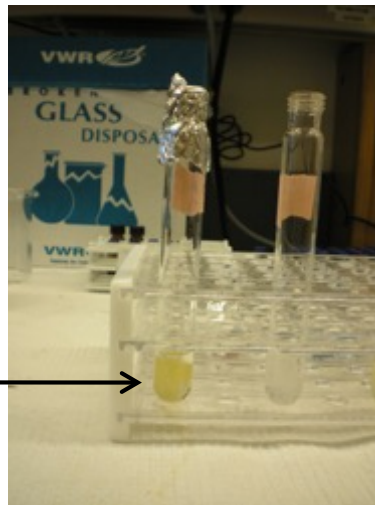
Duke's Superfund Research Center can now help you find out what chemicals may be present in the furniture in your home with funding support provided by the National Institute of Environmental Health Sciences (NIEHS).

If you are interested in sending us a sample of your foam for analysis, please complete the [sample submission](#) process.

How does this help you?

Data collected from this testing will help us to understand which flame retarding chemicals are currently being used in furniture. Once we have a sense of what chemicals are being used, we'll be able to investigate how people are exposed to these chemicals in the home and understand if the chemicals may impact human health.

Foam



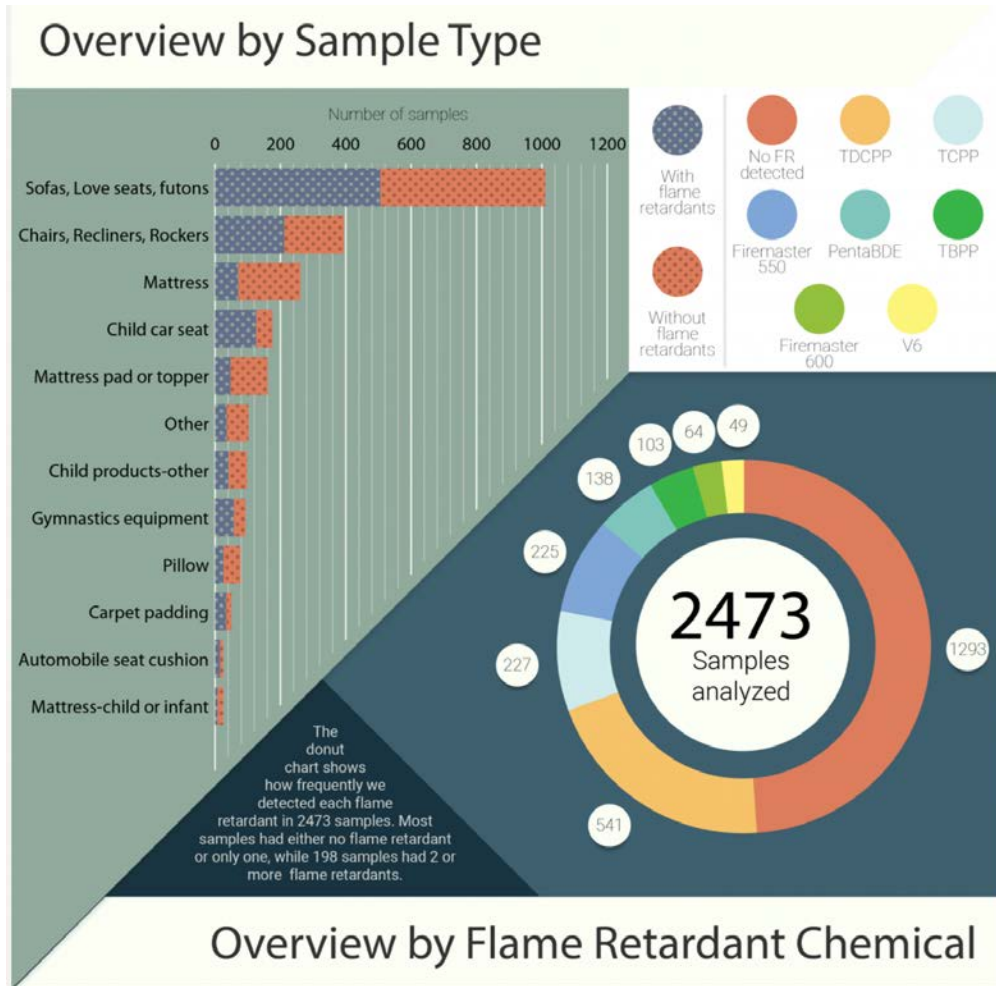
Analysis of the Foam Samples



Gas Chromatography Mass Spectrometry
(comparison with authentic standards)

What Have We Found?

- FR use is declining in residential furniture since 2014 (flammability standard was changed)
- Shift over time in the types of FRs used
- These data help in prioritizing human biomonitoring and health studies

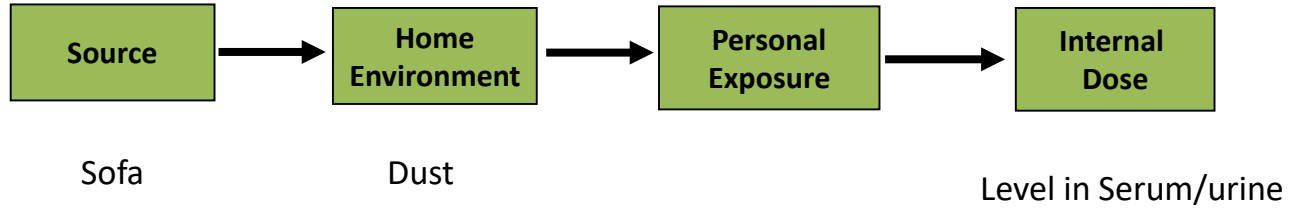


$$\text{Risk} = \text{Exposure} * \text{Hazard}$$

Question:

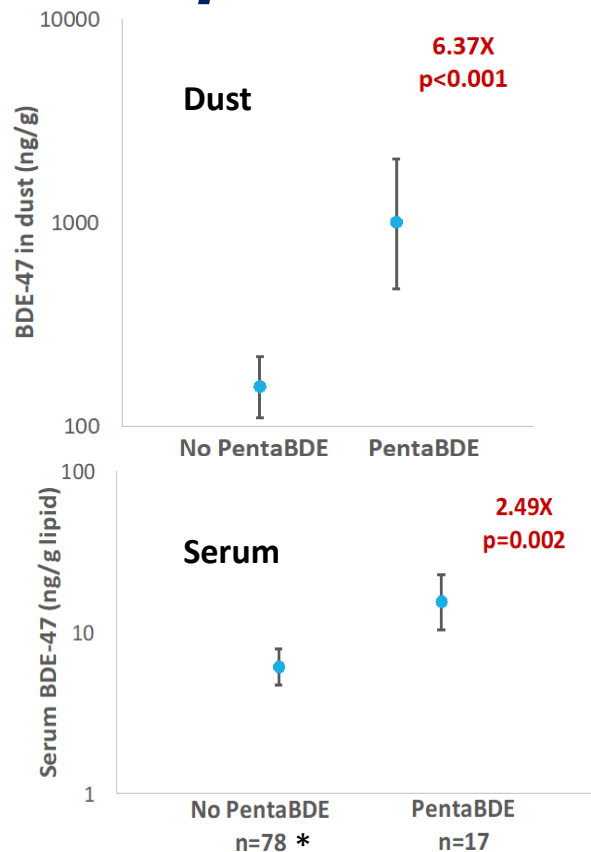
What products contribute most to our overall exposure to flame retardants?

From Source to Internal Dose



Do Sofas Contribute to FR Exposure?

- PentaBDE is a commercial FR mixture commonly applied to furniture foam until 2005 (banned from use due to concerns about persistence and toxicity)
- If PentaBDE was positively identified in the sofa, levels in indoor dust were 6.4X higher than homes without PentaBDE in their sofa
- If PentaBDE was present in the sofa, blood levels of PBDEs were ~2.5X higher in people with PentaBDE in their sofa compared to people without PentaBDE in their sofa
- ONE item in the home was a significant predictor of exposure



Hammel et al. 2017

* Some participants did not provide blood samples

Do TVs Contribute to FR Exposure?

Dust Measurement of Two Organophosphorus Flame Retardants, Resorcinol Bis(diphenylphosphate) (RBDPP) and Bisphenol A Bis(diphenylphosphate) (BPA-BDPP), Used as Alternatives for BDE-209

Sicco H. Brandsma,^{*,†} Ulla Sellström,[‡] Cynthia A. de Wit,[‡] Jacob de Boer,[†] and Pim E. G. Leonards[‡]

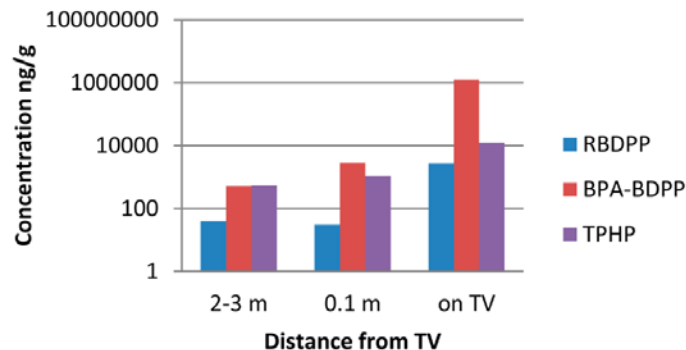


Figure 3. RBDPP, BPA-BDPP, and TPHP concentrations (ng/g) in house dust samples from The Netherlands collected at different distances from a TV set (logarithmic scale).

- Non-halogenated organophosphate based flame retardants measured in dust collected near TVs
- Concentrations increased with proximity to TV
- Different than flame retardants in US TVs- does this suggest regional differences in FR use?

Emissions of Chemicals from TVs During a Fire

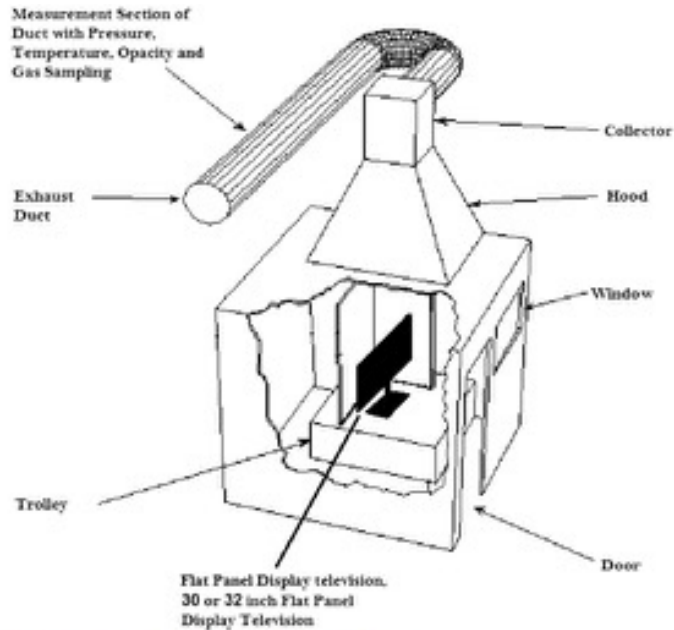


Figure 1. SBI test apparatus schematic.

- Researchers set flat panel TVs (n=6 in triplicate) on fire and measured emissions in the exhaust duct
- Identified a number of chemicals emitted that were independent of flame retardant treatment:
 - Acrolein (up to 3,340 ppb)
 - Benzene (up to 41,900 ppb)
 - Dichloromethane (up to 826 ppb)
 - Styrene (up to 6,810 ppb)
 - Toluene (up to 4,920 ppb)
 - Brominated furans/dioxins** (higher emissions in TVs containing brominated flame retardants).

Blais et al. 2014

Firefighters Exposures

Table 2

Air concentrations of flame retardants ($\mu\text{g}/\text{m}^3$) during active fire and overhaul periods.

Analyte	Fire Period (N = 12) ^d			
	Median ^c	Range	N of samples detected	LOD/2 Range
PBDEs^a				
BDE-47	3.47	0.07–13.9	8	0.07–0.15
BDE-99	4.94	0.03–13.8	10	0.03–0.08
BDE-153	–	–	–	–
BDE-154	0.09	0.03–12.7	1	0.03–0.24
BDE-206	0.08	0.03–4.50	1	0.03–0.24
BDE-209	15.6	0.03–67.7	9	0.03–0.13
NPBFRs				
TBBPA	0.24	0.03–18.5	5	0.03–0.24
TBB	7.71	0.08–25.2	11	0.08
TBPH	0.86	0.03–3.65	9	0.03–0.24
DBDPE	0.08	0.03–2.18	2	0.03–0.24
OPFRs^b				
TCPP	0.12	0.05–4.04	1	0.05–0.36
TDCCP	0.13	0.05–113	2	0.05–0.36
TPP	408	0.02–2110	11	0.02
TCP	0.04	0.01–897	4	0.01–0.05

- Several studies have been found elevated exposure to flame retardants, dioxins, PFAS and PAHs in firefighters (Shaw et al. 2013; Park et al. 2015; Rotander et al. 2015; Trowbridget et al. 2020)
- Flame retardant concentrations in indoor air significantly increase during a fire event (~2 orders of magnitude)

Flame Retardant Health Concerns

- Toxicity data suggest that many of the “New” Organophosphate flame retardants are just as toxic as the PBDEs they are replacing (Behl et al. 2016; Alzualde et al. 2018; Blum et al. 2019)
- Epidemiological studies
 - DBDPE associated with thyroid hormone levels (Chen et al. 2019; Zhao et al. 2021)
 - TDCIPP associated with thyroid disease and thyroid cancer case status (Poutasse et al. 2019; Kassotis et al. 2020)

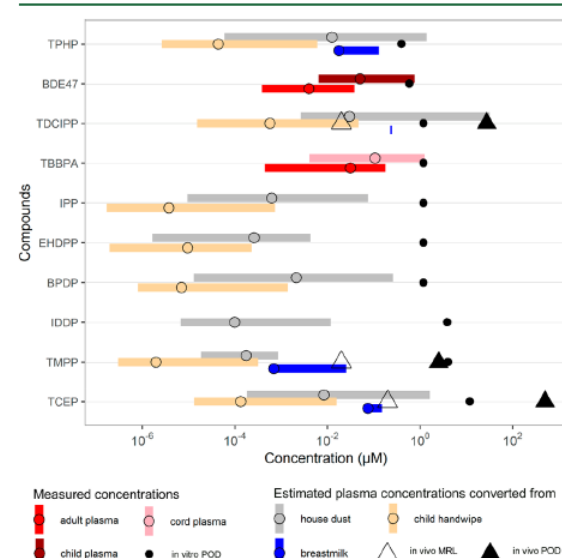


Figure 3. Flame retardant plasma concentrations measured or estimated from ingestion using data from house dust, breast milk, and/or handwipe samples (colored bars and circles) are compared to the most potent *in vitro* concentration per chemical (black dots) and *in vivo* point of departure (POD; triangles). The filled triangles represent rat plasma concentrations based on *in vivo* POD values (when available), and the empty triangles represent the minimum risk levels (MRLs). The colored bars represent the range of concentrations, and the circles represent the mean, median, or maximum median (see the [Supporting Information](#) for further details about these calculations).

Summary

- Changes in construction and manufacturing have increased the load of potentially harmful chemicals in our homes. This includes flame retardants, plasticizers, synthetic dyes, stain-repellant chemicals, pesticides and more.
- These chemical treatments have been linked with exposure in the general population (e.g. flame retardants, phthalates and some pesticides) and are considered toxic and/or carcinogenic
- More research is needed to understand emission of these chemicals, and their transformation products, from these building materials and consumer products, particularly during fire events.



Duke University

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Your Environment. Your Health.

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Questions?