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

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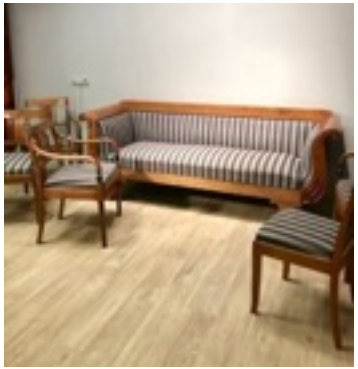
The Home Environment

- 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.

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

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

Chemical Applications in Building Materials and Common Household Items

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

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

Journal of Exposure Science & Environmental Epidemiology **30**, 247–252 (2020) | Cite this article

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)

- Insulation
- Drywall/Wallboard
- **Flooring**
- Furniture
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  - TVs
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Chemical Applications in Building Materials and Common Household Items

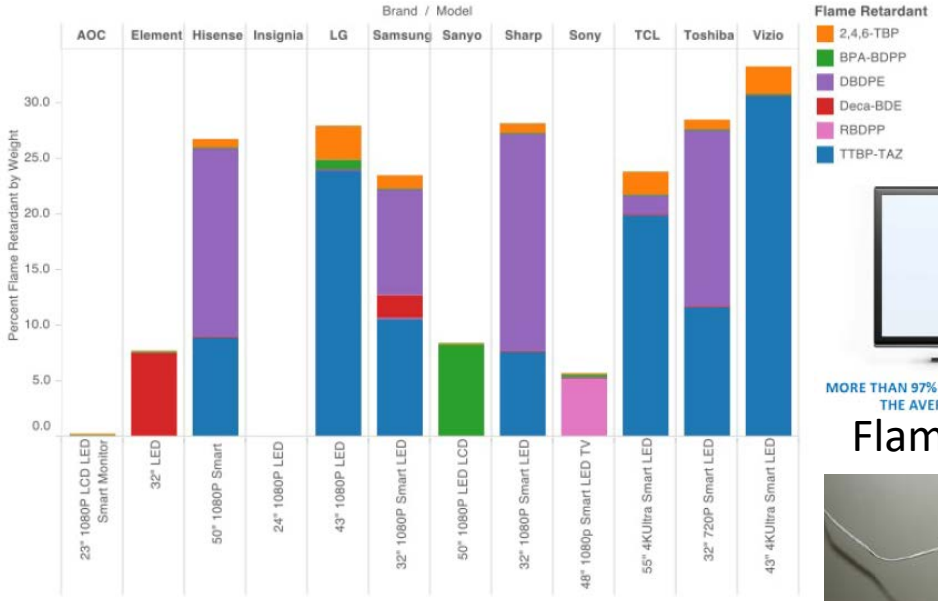
Dyes in synthetic (polyester) upholstery/ textiles?

Stain-repellant upholstery treatments (PFAS)?

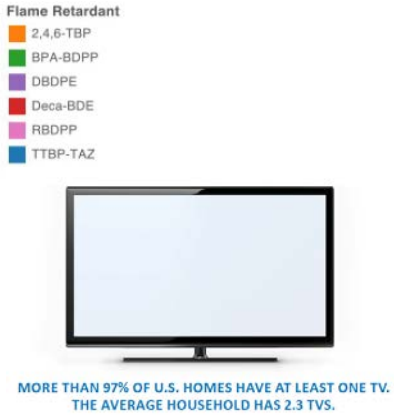
Flame retardant chemicals in the cushions and upholstery backcoating?

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

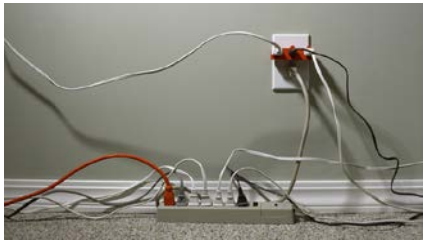
Chemical Applications in Building Materials and Common Household Items



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



Flame Retardants



Plasticizers

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

What is a Flame Retardant (FR)?

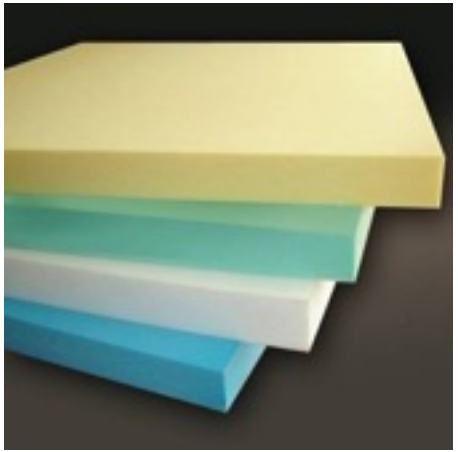
Definition:

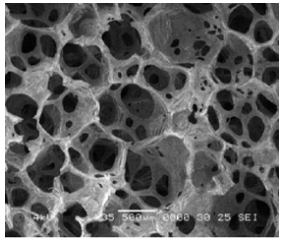
"A substance added or a treatment applied to a material in order to suppress, significantly reduce or delay the combustion of the material" *EHC:192, WHO 1997*

- 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)





Timeline

Research on PBDEs Increases Concerns

1990s

1975 — **CA TB-117 Enacted**

2002 — **EU Ban on Penta & Octa**

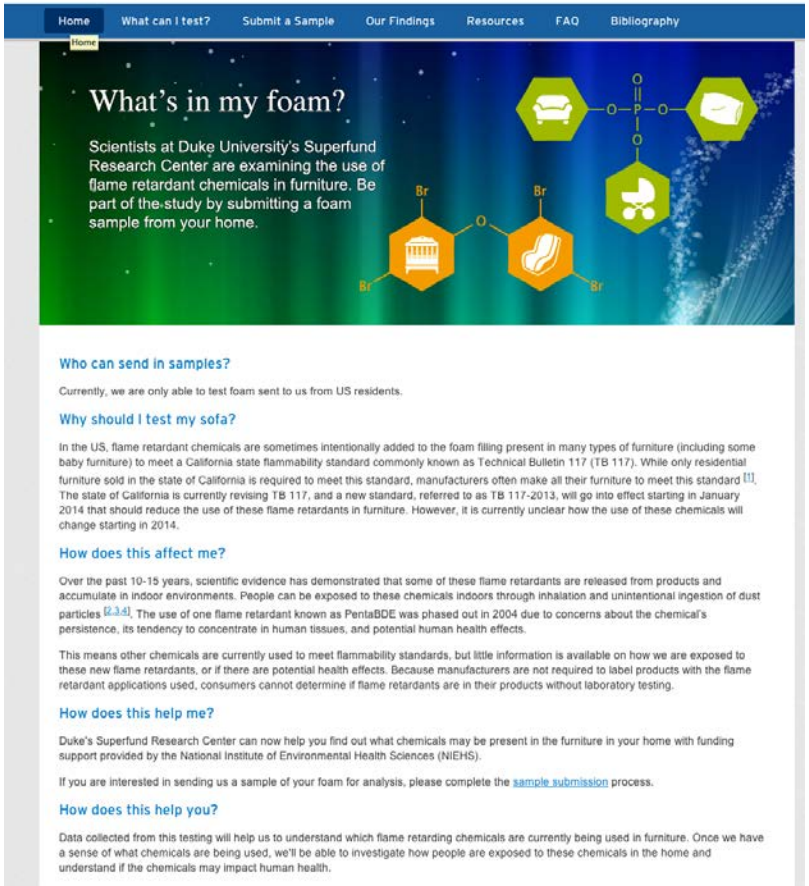
2004 — **US Voluntary Phase Out of Penta & Octa**

2008 — **Canada Restricts Penta & Octa**

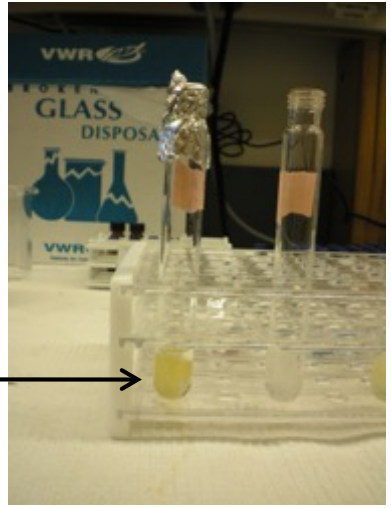
2011 — **TDCIPP Added To CA Prop 65**

2014 — **CA TB 117-2013 Labeling requirement**

Today?



Foam



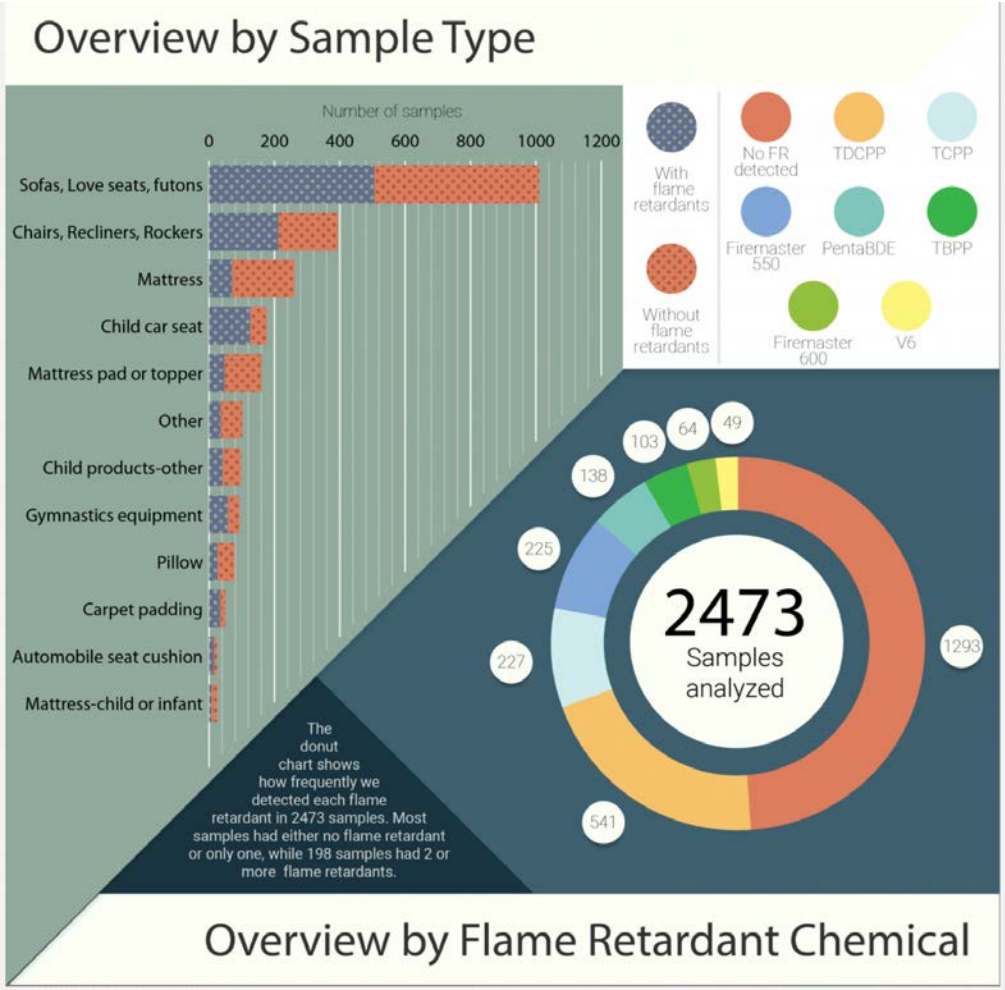
Analysis of the Foam Samples

Gas Chromatography Mass Spectrometry
(comparison with authentic standards)

http://foam.pratt.duke.edu

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



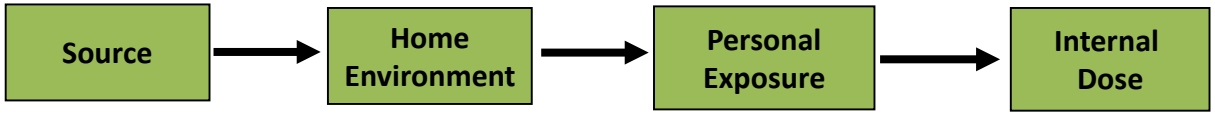
http://foam.pratt.duke.edu

Risk = Exposure * Hazard

Question:

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

From Source to Internal Dose



Sofa

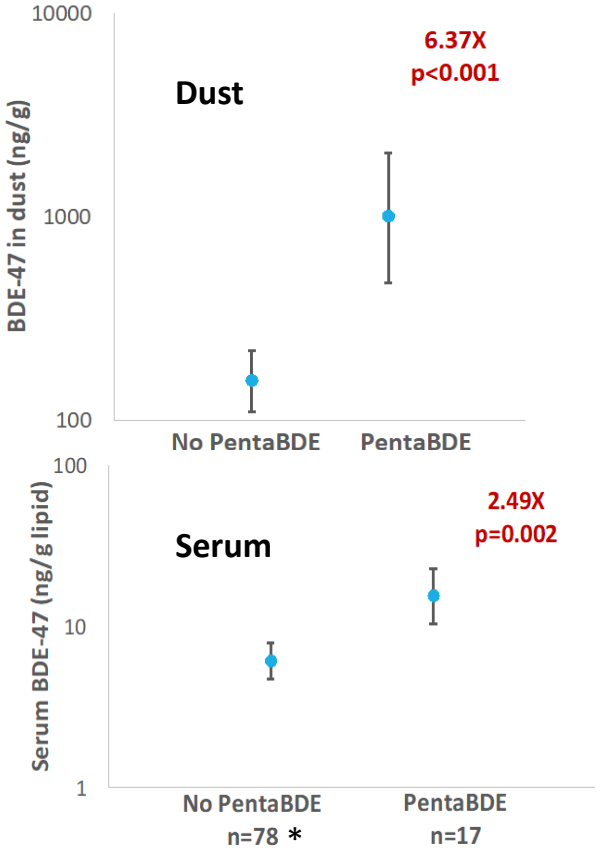
Dust

Level in Serum/urine

Serum

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 identify 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?

ENVIRONMENTAL Science & Technology

Article

pubs.acs.org/est

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[†]

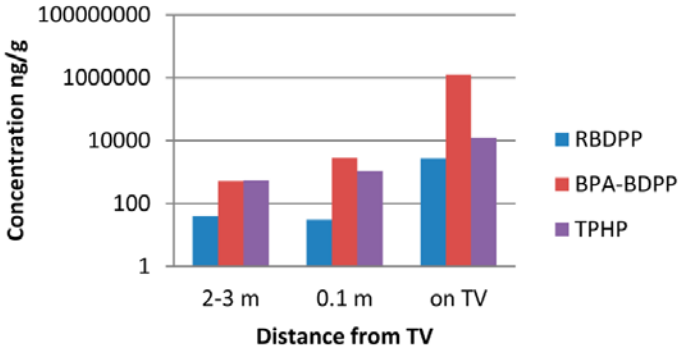


Figure 3. RBDPP, BPA-BDPP, and TPHP concentrations (ng/g) in house dust samples from The Netherlands collected at different distances from a TV set (logarithmic scale).

- 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?

Source: Brandsma et al., 2013

Emissions of Chemicals from TVs During a Fire

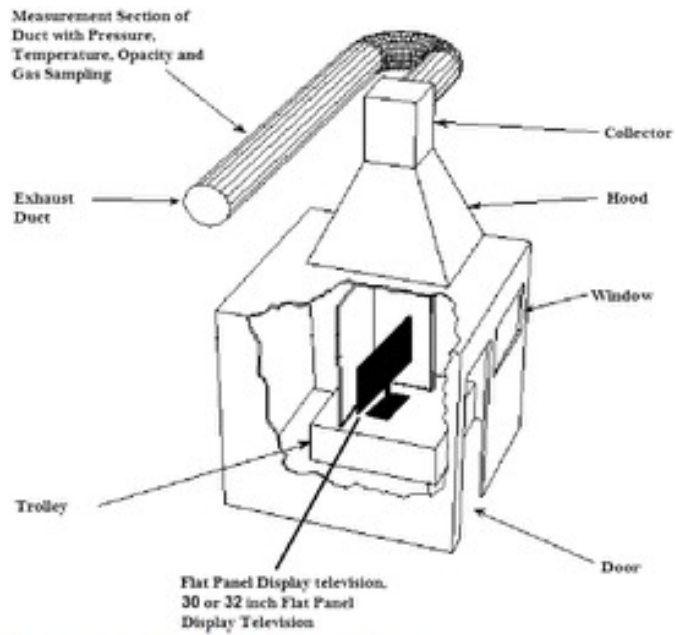


Figure 1. SBI test apparatus schematic.

Blais et al. 2014

- 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).

Firefighters Exposures

Table 2
Air concentrations of flame retardants (μg/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
TDCPP	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

Fent et al. 2020

- 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)

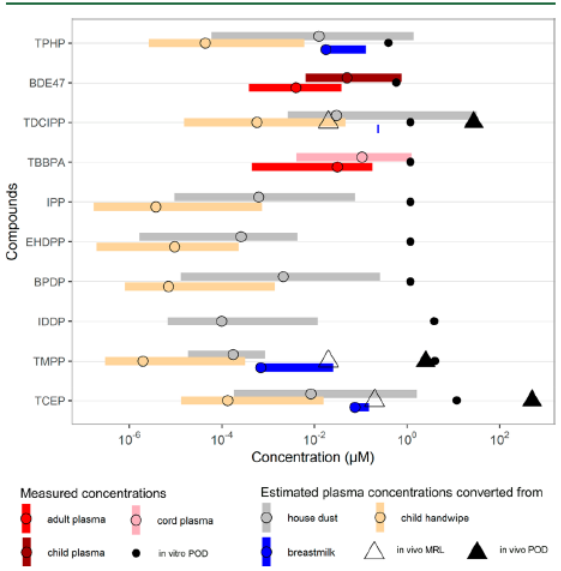


Figure 3. Flame retardant plasma concentrations measured or estimated from ingestion using data from house dust, breast milk, and/or handwipe samples (colored bars and circles) are compared to the most potent *in vitro* concentration per chemical (black dots) and *in vivo* point of departure (POD; triangles). 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.

Acknowledgements

Duke University

- Dr. Kate Hoffman
- Dr. Lee Ferguson

My Lab Group

- Shaza Gaballah
- Samantha Hall
- Dr. Stephanie Hammel
- Dr. Nicholas Herkert
- Emina Hodzic
- Taylor Hoxie
- Dr. Christopher Kassotis
- Dr. Erin Kollitz
- Jessica Levasseur
- Amelia Lorenzo
- Kirsten Overdahl
- Dr. Allison Phillips
- Dr. Matt Ruis
- Rachel Smith
- Sharon Zhang

- Sam Cohen
- Catherine Kastleman
- Bryan Luukinen

NIH National Institute of Environmental Health Sciences
Your Environment. Your Health.

R01 ES016099
P42 ES010356

EPA United States Environmental Protection Agency

Duke Cancer Institute

Michael & Annie Falk Foundation

Thanks to our **participants** for providing samples for all of these studies!!

Questions?