



GREEN SCIENCE  
POLICY INSTITUTE

# Chemicals Applications of Concern – Highly Fluorinated Chemicals and the "Six Classes"

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Founder, Green Science Policy Institute

Research Associate in Chemistry, UC Berkeley

September, 2017

# HEALTHIER PRODUCTS, HEALTHIER PEOPLE

## THE SIX CLASSES APPROACH FOR REDUCING HARMFUL CHEMICALS



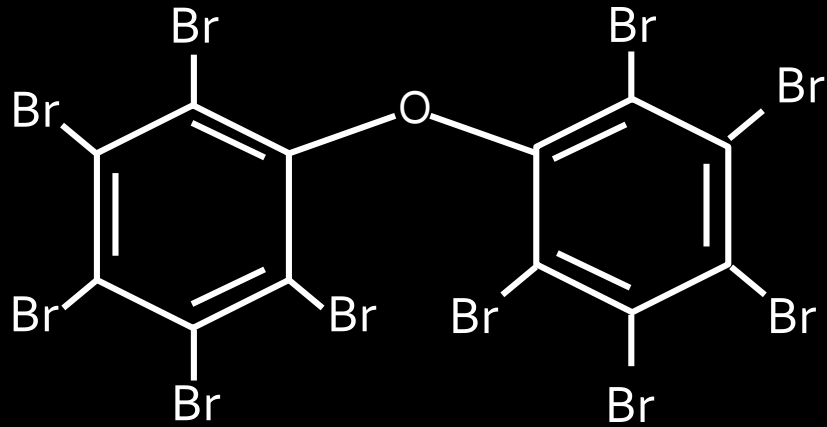


# U.S. Toxic Substances Control Act (1976)

- 62,000 previous chemicals “grandfathered”
- 23,000 new chemicals
  - 85% have no health data
  - 67% have no data at all



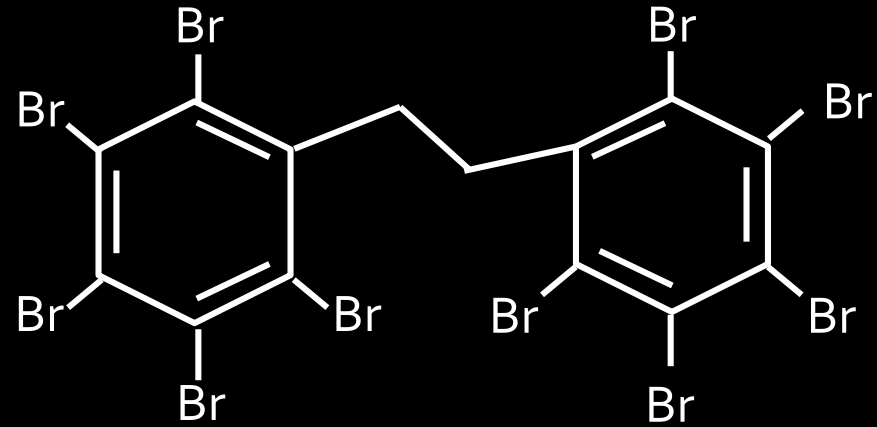
# Regrettable Substitution



Decabromodiphenyl  
ether

Concerns:

- Persistence
- Bioaccumulation
- Toxicity



Decabromodiphenyl  
ethane

Concerns:

- Persistence
- Bioaccumulation
- Toxicity

# Human Toxicological Trial?

“We are conducting a massive clinical toxicological trial, and our children and our children's children are the experimental subjects.”



-Herbert Needleman & Philip Landrigan



# GREEN SCIENCE POLICY INSTITUTE

**Environmental Science & Technology**  
Building Research & Information (2022) 48(6):738-755

**Building insulation: using codes**

**Novel and High Volume Use Flame Retardants in US Couches**  
Heather M. Thomas F.  
Nicholas S.  
Departments  
Support

**Fluorin**  
Laurel A. Margaret  
Silent Sp  
Californi  
Green  
Depart  
Enter  
Natio  
Unit  
Che  
Ox  
Di

**ENVIRONMENTAL LETTERS**  
Science & Technology

**Detection of Poly- and Perfluoroalkyl Substances (PFASs) in U.S. Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants**  
Xindi C. Hu,<sup>1,2</sup> David Q. Andrews,<sup>3</sup> Andrew B. Lindstrom,<sup>4</sup> Thomas A. Bruton,<sup>4</sup> Laurel A. Schaidt,<sup>4</sup> Philippe Grandjean,<sup>5</sup> Rainer Lohmann,<sup>6</sup> Courtney C. Carignan,<sup>7</sup> Arlene Blum,<sup>1,3</sup> Simona A. Balan,<sup>8</sup> Christopher P. Higgins,<sup>9</sup> and Elsie M. Sunderland<sup>1,2</sup>

<sup>1</sup>Harvard T. H. Chan School of Public Health, Boston, Massachusetts 02215, United States  
<sup>2</sup>Harvard John A. Paulson School of Engineering and Applied Sciences, Cambridge, Massachusetts 02138, United States  
<sup>3</sup>Environmental Working Group, Washington, D.C. 20009, United States  
<sup>4</sup>National Exposure Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, United States  
<sup>5</sup>University of California at Berkeley, Berkeley, California 94720, United States  
<sup>6</sup>Silent Spring Institute, Newton, Massachusetts 02460, United States  
<sup>7</sup>University of Rhode Island, Narragansett, Rhode Island 02882, United States  
<sup>8</sup>Green Science Policy Institute, Berkeley, California 94705, United States  
<sup>9</sup>California Department of Toxic Substances Control, 1001 I Street, Sacramento, California 95814, United States (Formerly at the Green Science Policy Institute, Berkeley, California 94705, United States)  
<sup>10</sup>Colorado School of Mines, 1500 Illinois Street, Golden, Colorado 80401, United States

**Supporting Information**

**ABSTRACT:** Drinking water contamination with poly- and perfluoroalkyl substances (PFASs) poses risks to the developmental, immune, metabolic, and endocrine health of consumers. We present a spatial analysis of 2013–2015 national drinking water PFAS concentrations from the U.S. Environmental Protection Agency's (U.S. EPA) third Unregulated Contaminant Monitoring Rule (UCMR3) program. The number of industrial sites that manufacture or use these compounds, the number of military fire training areas, and the number of wastewater treatment plants are all significant

**Hydrological units with detectable PFASs**

**Meaning the PFASs**

**Meaning the PFASs**



## Education



## Research

## Retreats

# Policy & Purchasing Change

# Six Classes Videos

An innovative approach to reducing toxics

1

Highly  
Fluorinated

2

Antimicrobials

3

Flame  
Retardants

4

Bisphenols  
+ Phthalates

5

Some  
Solvents

6

Certain Metals



**VIEW and SHARE: [www.SixClasses.org](http://www.SixClasses.org)**

Healthier products, healthier people in four minutes!

Is it necessary?

Is it worth it?

Is there a safer alternative?



Classes 1 to 3

# Periodic table of elements

hydrogen 1 H 1.0079																		Halogens					helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122																	boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305																	aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80						
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29						
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 ★	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]					
francium 87 Fr [223]	radium 88 Ra [226]	89-102 ★ ★	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnium 110 Uun [271]	ununium 111 Uuu [272]	unubium 112 Uub [277]	ununquadium 114 Uuq [289]										

\* Lanthanide series

lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	praseodymium 59 <b>Pr</b> 140.91	neodymium 60 <b>Nd</b> 144.24	promethium 61 <b>Pm</b> [145]	samarium 62 <b>Sm</b> 150.36	europium 63 <b>Eu</b> 151.96	gadolinium 64 <b>Gd</b> 157.25	terbium 65 <b>Tb</b> 158.93	dysprosium 66 <b>Dy</b> 162.50	holmium 67 <b>Ho</b> 164.93	erbium 68 <b>Er</b> 167.26	thulium 69 <b>Tm</b> 168.93	ytterbium 70 <b>Yb</b> 173.04
actinium 89 <b>Ac</b> [227]	thorium 90 <b>Th</b> 232.04	protactinium 91 <b>Pa</b> 231.04	uranium 92 <b>U</b> 238.03	neptunium 93 <b>Np</b> [237]	plutonium 94 <b>Pu</b> [244]	americium 95 <b>Am</b> [243]	curium 96 <b>Cm</b> [247]	berkelium 97 <b>Bk</b> [247]	californium 98 <b>Cf</b> [251]	einsteinium 99 <b>Es</b> [252]	fermium 100 <b>Fm</b> [257]	mendelevium 101 <b>Md</b> [258]	nobelium 102 <b>No</b> [259]

\*\* Actinide series

# Cellular defense systems do not recognize organohalogens



Cellular bouncers  
(ABC transporters)

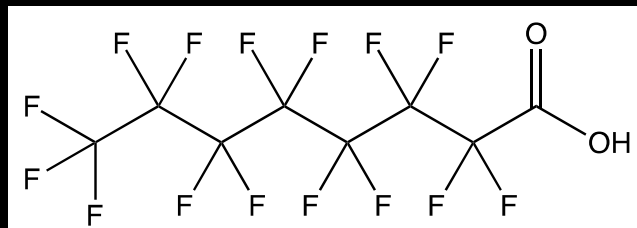


Cellular detoxification

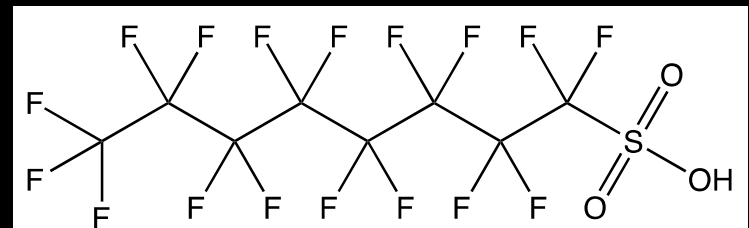
# Class 1: Highly Fluorinated Chemicals (PFASs) (per- and polyfluoroalkyl substances)

- All are highly persistent
- Long-chains are bioaccumulative
- PFOA and PFOS
  - Cancer (kidney and testicular)
  - liver disease
  - immune system effects
  - thyroid disease
  - developmental effects

PFOA

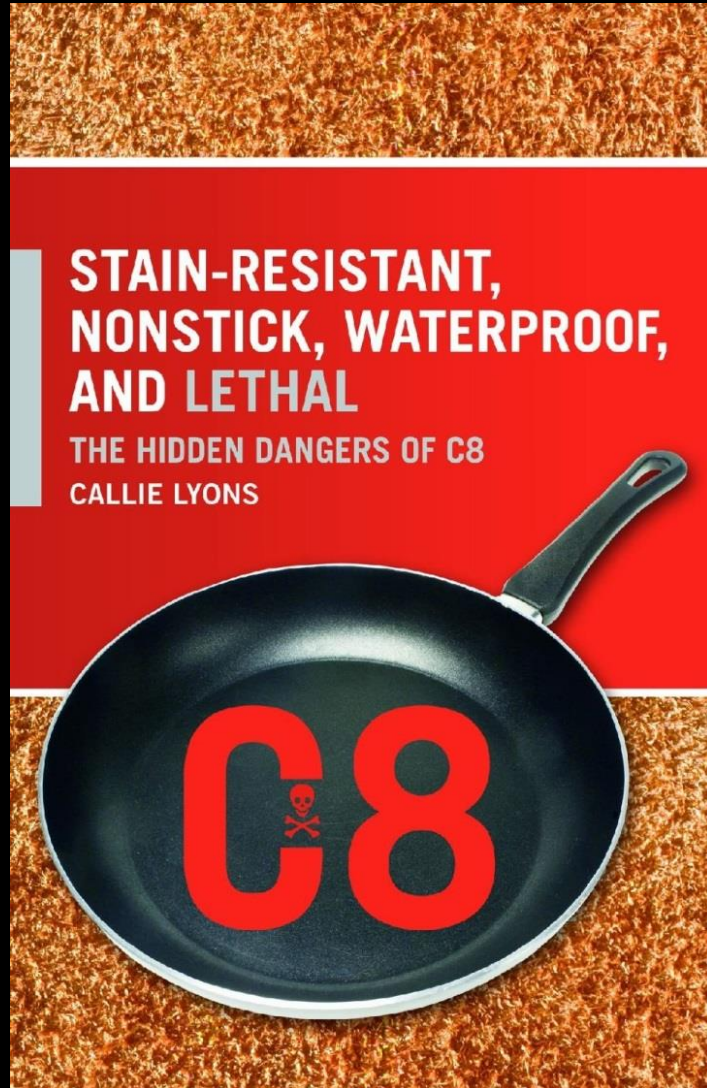


PFOS





Published 2007



2017

Watershed

Tracy K. Smith

US Poet Laureate

200 cows      more than 600 hilly  
acres  
property would have been even  
larger  
had J not sold 66 acres to DuPont  
for  
waste from its  
Washington Works factory  
where J was employed  
did not want to  
sell  
but needed money      poor  
health  
mysterious ailments

# May 2015 The Madrid Statement on Highly Fluorinated Chemicals



“We call on the international community to cooperate in limiting the production and use of PFASs and in developing safer non-fluorinated alternatives.”

Signed by 230 scientists from 40 countries

2015: Environmental Health Perspectives

# 2015-16

The Opinion Pages | OP-ED COLUMNIST

The New York Times

## Chemicals in Your Popcorn?

JUNE 4, 2015



Nicholas Kristof

What do a pizza box, a polar bear and you have in common?

All carry a kind of industrial toxicant called poly- and perfluoroalkyl substances, or PFASs, that do two things: They make life convenient, and they also appear to increase the risk of cancer.

## These Chemicals in Pizza Boxes and Carpeting Last Forever

More than 200 scientists around the world document the threats of perfluorinated compounds and call for more government control.

By **Lindsey Konkel**, National Geographic  
PUBLISHED MAY 01, 2015



 NATIONAL GEOGRAPHIC

The Intercept

## THE TEFLON TOXIN

DuPont and the Chemistry of Deception



Sharon Lerner

Aug. 11 2015, 3:35 p.m.



133

Home

The New York Times Magazine

## The Lawyer Who Became DuPont's Worst Nightmare

Rob Bilott was a corporate defense attorney for eight years. Then he took on an environmental suit that would upend his entire career — and expose a brazen, decades-long history of chemical pollution.

By NATHANIEL RICH JAN. 6, 2016



# Law: Claims in the Ohio Valley

*(The Teflon Toxin Goes to Court, Sharon Lerner, The Intercept)*

September 2015: 3,500 personal injury and 37 wrongful death claims in Ohio Valley against DuPont went to trial

October 2015: \$1.6 million for kidney cancer.

July 2016: \$5 million for testicular cancer.

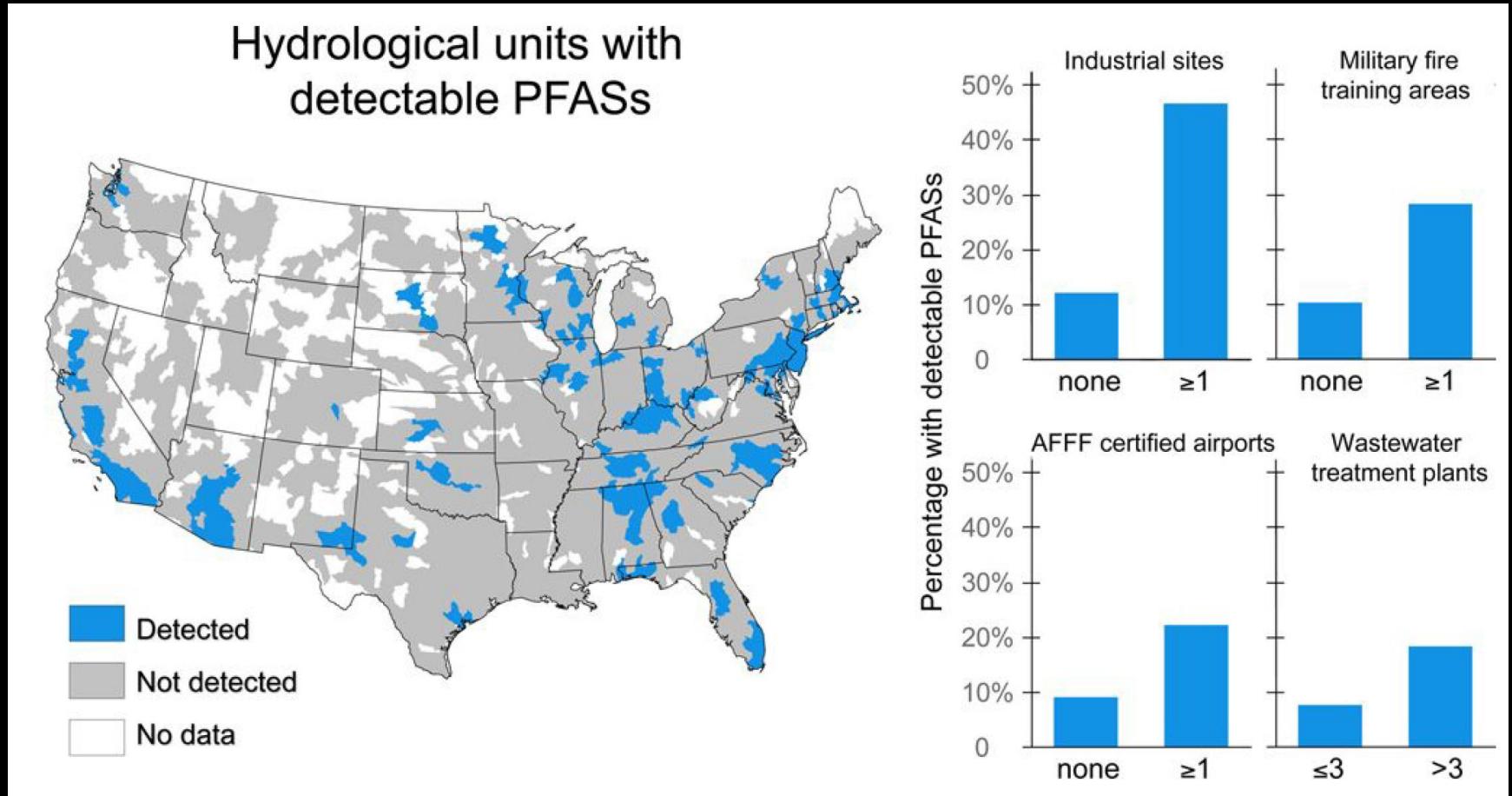
January 2017: \$10.5 million for malice

February 2017: \$671 million to settle claims in Ohio Valley

“If the chemical were really dangerous, DuPont attorneys contended, government agencies would have regulated it. “



# Watersheds with point sources have higher detection frequencies for PFASs

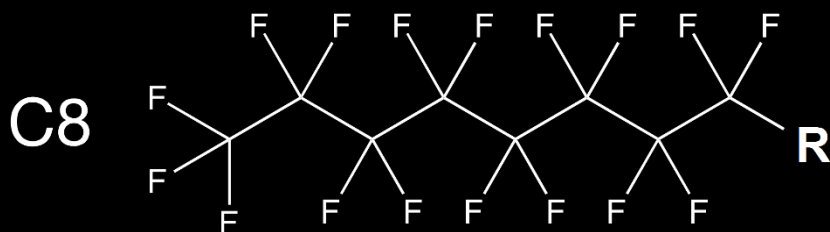


# AFFF foam in training exercises

- Drinking water of six million Americans contaminated with PFAS
- AFFF firefighting are a major contributor
- Air Force said:
  - “will not use AFFF foam in training”
  - “will replace all C8 foam with C6”



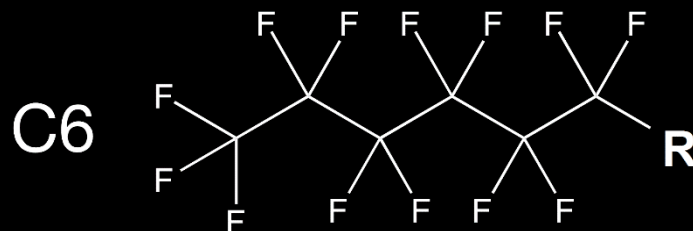
# Regrettable Substitution



## C8 Fluoro-compounds

### Concerns:

- Extreme persistence
- Bioaccumulation
- Toxicity



## C6 Fluoro-compounds

### Concerns:

- Extreme persistence
- Bioaccumulation in plants
- Suspected toxicity
- More mobile
- Remediation more difficult
- Many more different C6s
- Chemical structures unknown
- Harder to measure and monitor
- Less regulated

# Fluorinated Alternatives?



## Fluorinated Alternatives: Myths versus Facts



Long-chain highly fluorinated chemicals — including PFOA, PFOS and other C8 compounds — were used for decades to give water-repellant, stain-resistant, and non-stick properties to furnishings, carpets, outdoor gear and other products. Exposure to PFOA has been linked to kidney and testicular cancer, elevated cholesterol, decreased fertility, thyroid problems and changes in hormone functioning in adults as well as adverse developmental effects and decreased immune response in children<sup>1</sup>.

Due to such harmful effects, the long-chain chemicals were recently phased out and replaced by numerous similar compounds, including short-chain molecules called C6 and C4<sup>2</sup>. Industry says these alternatives are safe, sustainable, and well-tested<sup>3</sup>. A look at the facts shows those claims don't stick.

### THE BOTTOM LINE

Highly fluorinated chemicals pose a potential risk to human health and the environment, and they should only be used with safeguards when their function is essential.



**MYTH:** "PFOA-free" means safe.

**FACT:** Products advertised as "PFOA-free" often contain replacement chemicals made with the same **problematic chemical building blocks** as PFOA.

Since PFOA has been phased out, numerous related chemicals that are equally persistent and may pose similar health risks have replaced it<sup>4</sup>. To prevent such "regrettable substitutions", the entire class of highly fluorinated chemicals should be avoided.

**MYTH:** Short-chain fluorinated alternatives like the 6 and 4 carbon-based compounds have been thoroughly tested and are safe.

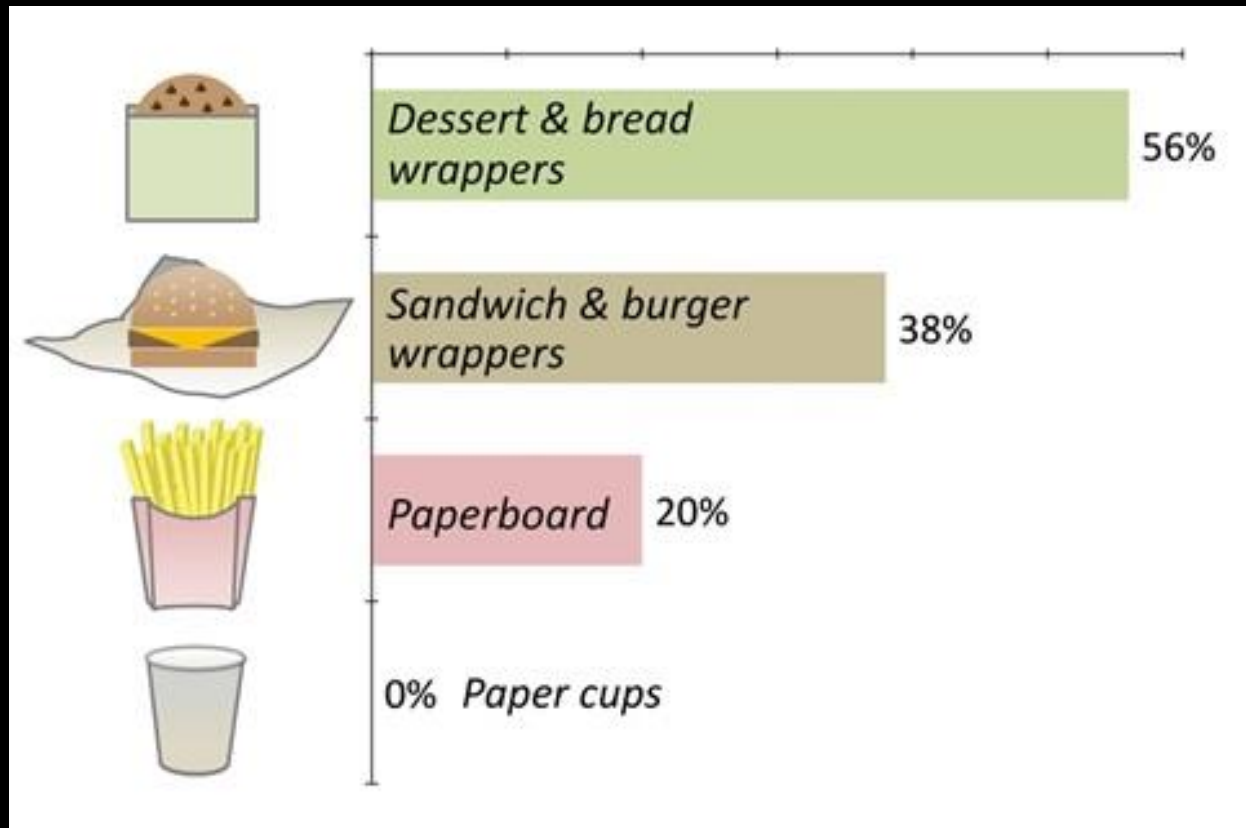
**FACT:** Recent studies suggest these alternatives may cause similar health problems as the long chain compounds.

[www.greensciencepolicy.org/  
highly-fluorinated-chemicals/](http://www.greensciencepolicy.org/highly-fluorinated-chemicals/)



# Fluorine in U.S. fast food packaging paper

(percent positive; 400 products sampled)



Adopted from Schaider L. 2016 *Fluorinated compounds in U.S. fast food packaging*.

Should these products be considered compostable?

# Policy: New York

APRIL 28, 2017 | Albany, NY

## Governor Cuomo Announces State Agencies Save \$19.6 Million with Green Practices

ENVIRONMENT

- New York state's new purchasing requirements for single use food containers and packaging:
  - "...products purchased ...on State contracts **shall not contain perfluorinated chemicals (PFCs)**..."



## Purchasing: Phasing out the class of PFASs

- The idea of tackling PFASs was sparked at a conference in which IKEA discussed its goal to phase out the use of fluorinated chemicals
- Kaiser Permanente is phasing out all PFASs and flame retardants from its furnishings
- “If IKEA can do it, Kaiser Permanente can do it”

# Purchasing: A large retailer celebrates!

“In another couple weeks, we will stop offering C6 chemistry fabric protection.

If a customer asks for it, we will explain that the manufacturer does not recommend treating the product with any type of fabric protection.

So tonight, I will open a nice bottle of Merlot, and share a toast with my wife over the fact that we have made a few more products safer for a few more people in this world.”



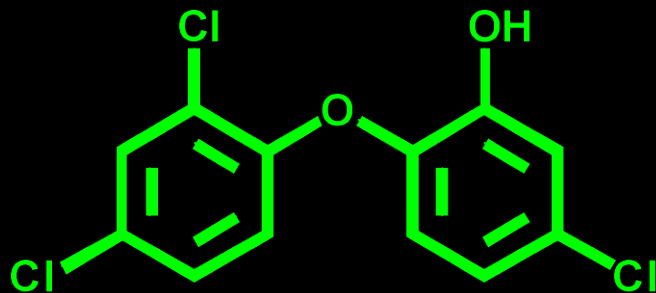


# Policy: Proposed State Legislation

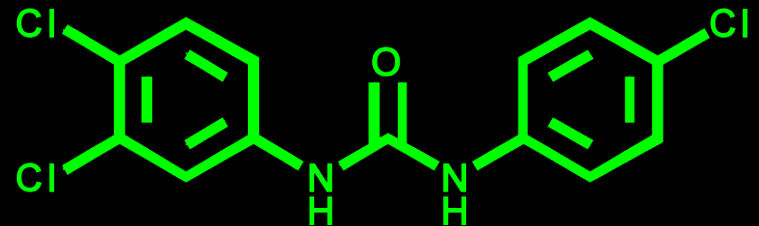
- **California** Assembly Bill 958 (Ting)
  - Pending bill mandates that the state study PFAS in food packaging and sets a timeline for issuing regs.
- **Vermont, Washington**
  - 2017 bills would have prohibited different PFASs in food contact materials
- **Washington** State Children's Safe Products Act
  - 2016 Proposal to add entire class of PFASs to list of chemicals of high concern for children

# Class 2: Antimicrobials

Triclosan

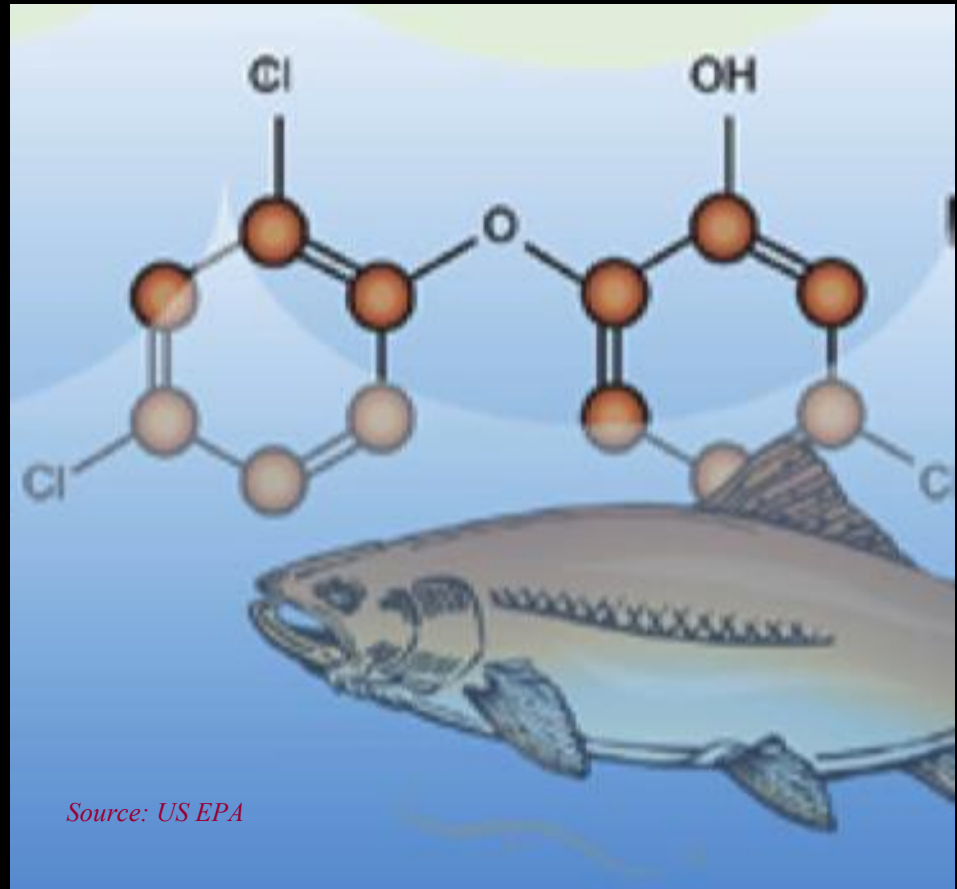


Triclocarban





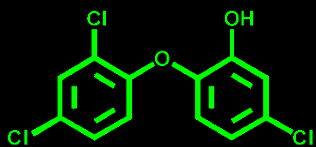
**5 – 10 Seconds**  
(ineffective)



**Lifetime exposure in  
aquatic organisms**  
(toxic)

# Do we need them?

- Beneficial in certain medical applications
- No proven benefit over soap & water
- Ineffective in flooring and general-use plastic



FDA Draft  
Monograph  
on lack of efficacy  
and safety

First  
detection  
in fish

FDA removes  
assorted  
antimicrobials from  
drug category

Patented

1964

1974

1984

1994

## A History of Triclosan in the U.S.

2002

Top ten water  
contaminant

2007

Endocrine  
disruptor;  
Detectable in  
97% of breast  
milk samples

2016

FDA determines 19  
antimicrobials not  
safe or effective in  
consumer soaps

2013

> 2,000  
antimicrobial  
products.

2010

NGOs petitions  
FDA to prohibit  
triclosan in soaps.  
NGO sues FDA.



# The Florence Statement on Triclosan and Triclocarban



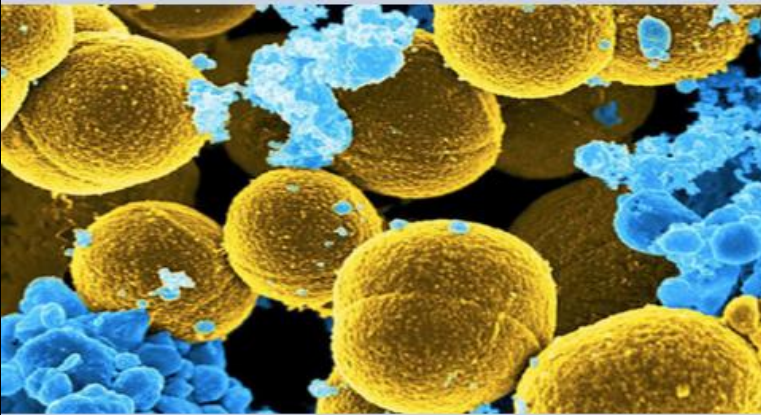
Documents the scientific consensus about:

- potential for harm
- recommendations to prevent further harm

Signed by 205 international scientists

# Recent Reports

## **Antimicrobials in Hospital Furnishings: Do They Help Reduce Healthcare-Associated Infections?**

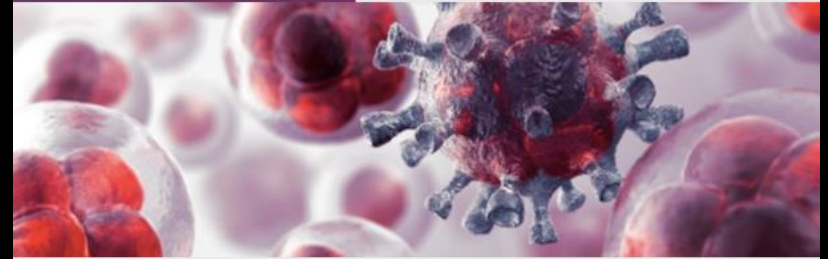


Ted Schettler MD, MPH

March 2016



A PERKINS+WILL WHITE PAPER /



## **Healthy Environments: Understanding Antimicrobial Ingredients in Building Materials**

MARCH 2017

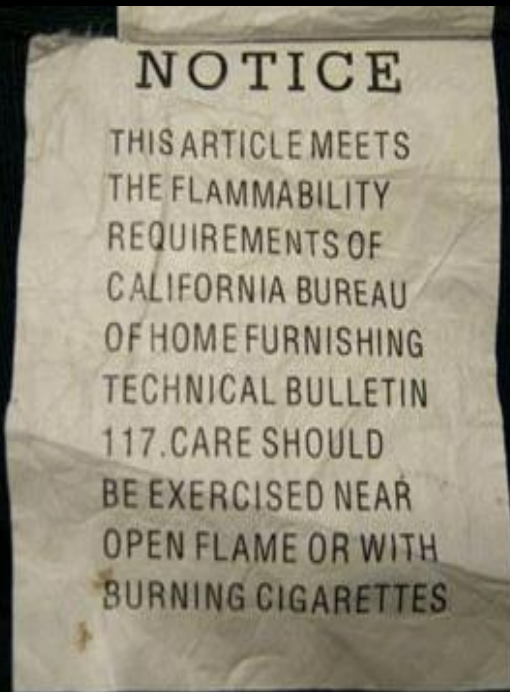
Healthy Building Network  
Perkins+Will

# Class 3 Flame retardants

## 1970s Flammability Standards

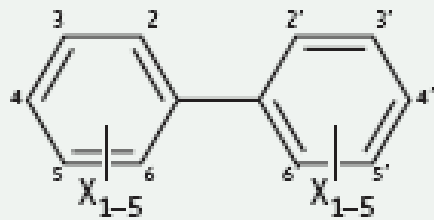
- Children's sleepwear
- Furniture and baby product foam
- Foam building insulation

# Technical Bulletin 117

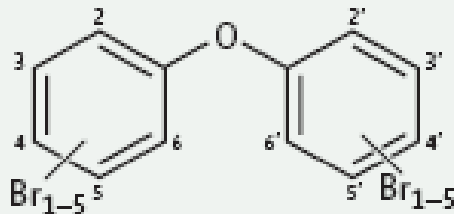


- Required furniture foam to withstand a small open flame for 12 seconds
- No significant fire safety benefit (fires start in exterior fabric not filling)

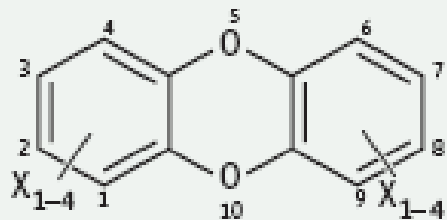
# PentaBDE Flame Retardant



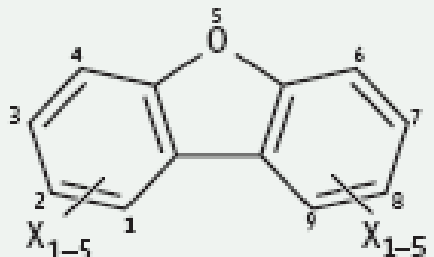
PCBs (X = Cl) and PBBs (X = Br)



PBDEs



Dioxins (X = Cl or Br)



Furans (X = Cl or Br)

Used from 1975 to 2004  
to meet TB117.

98% of use in US and  
Canada in 2003



# Human Health

Higher pentaBDE

associated with

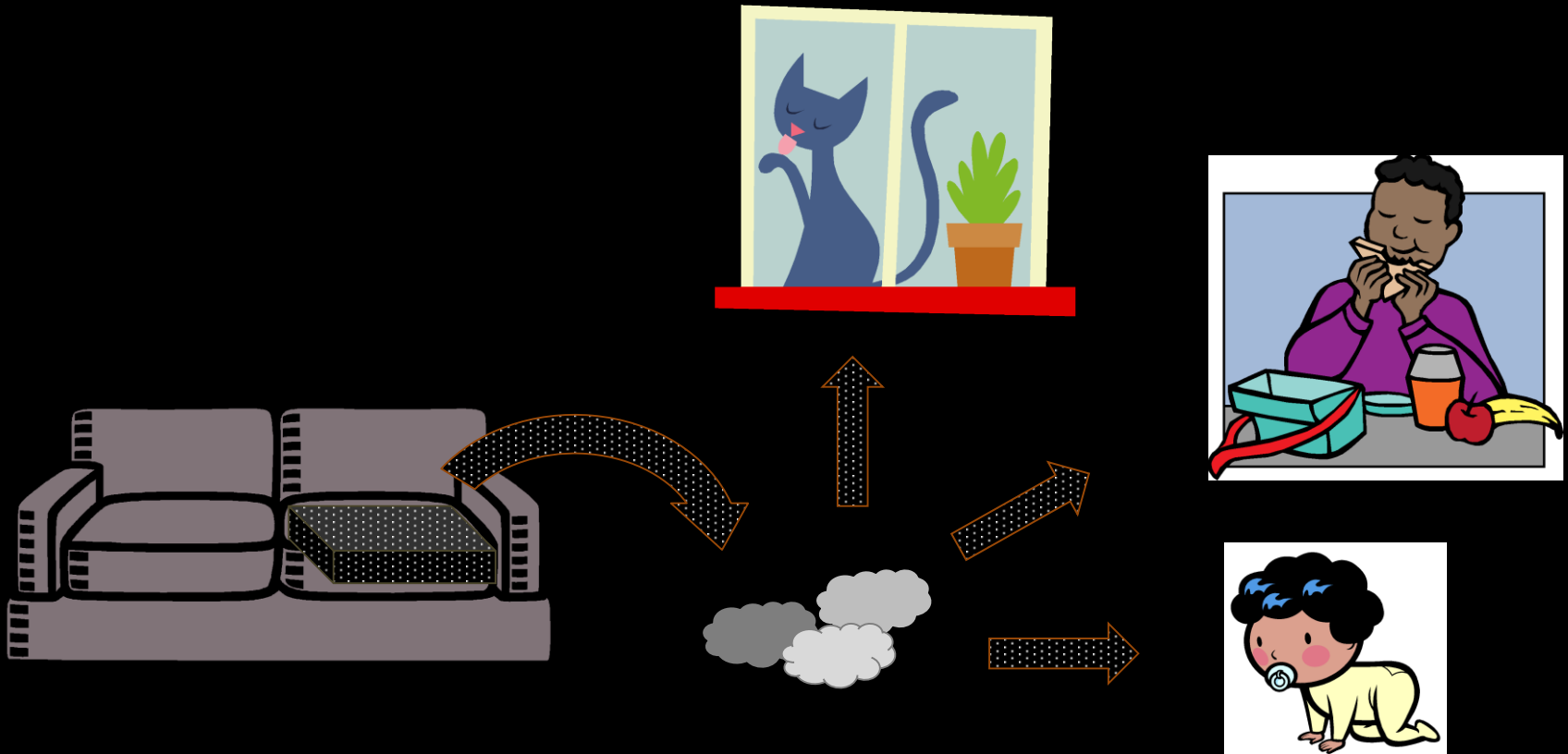
lower birth weight  
impaired attention  
poorer coordination  
lowered IQ



longer time to get pregnant  
altered thyroid hormones

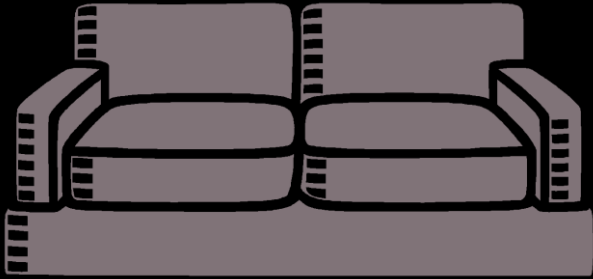


# From Products to People



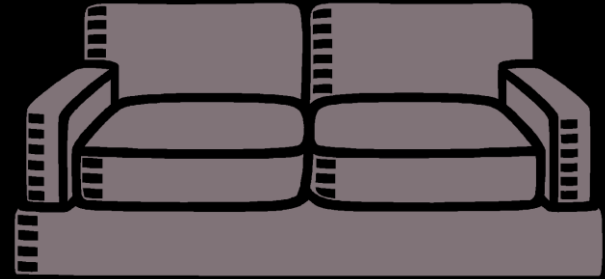
# TB117 Fire Safety Benefit?

TB117 foam



~

Non - TB117 foam



“No significant, consistent difference...”

# San Antonio Statement on Brominated and Chlorinated Flame Retardants

- Signed by over 200 scientist's from 30 countries
- Documents health and environmental harm and lack of proven fire safety benefit



Pulitzer Prize

Finalist

Goldsmith Prize

Investigative Reporting

Environmental

Journalists Society

Environmental Reporting

Gerald Loeb Award

Business and Financial Journalism

National Press Club

Consumer Award

# Chicago Tribune



QUESTIONS? CALL 1-800-TRIBUNE

SUNDAY, MAY 6, 2012

BREAKING NEWS AT CHICAGOTRIBUNE.COM

TRIBUNE WATCHDOG

## Playing with fire

A deceptive campaign by industry brought toxic flame retardants into our homes and into our bodies. And the chemicals don't even work as promised.

By PATRICIA CALLAHAN AND SAM ROE  
Tribune reporters

**D**r. David Heimbach knows how to tell a story. Before California lawmakers last year, the noted burn surgeon drew gasps from the crowd as he described a 7-week-old baby girl who was burned in a fire started by a candle while she lay on a pillow that lacked flame retardant chemicals.

"Now this is a tiny little person, no bigger than my Italian greyhound at home," said Heimbach, gesturing to approximate the baby's size. "Half of her body was severely burned. She ultimately died after about three weeks of pain and misery in the hospital."

Heimbach's passionate testimony about the baby's death made the long-term health concerns about flame retardants voiced by doctors, environmentalists and even firefighters sound abstract and petty.

But there was a problem with his testimony: It wasn't true. Records show there was no dangerous pillow or candle fire. The baby he described didn't exist.

Neither did the 9-week-old patient who Heimbach told California legislators died in a candle fire in 2009. Nor did the 6-week-old patient who he told Alaska lawmakers was fatally burned in her crib in 2010.

Heimbach is not just a prominent burn doctor. He is a star witness for the manufacturers of flame retardants.

His testimony, the Tribune found, is part of a decades-long campaign of deception that has loaded the furniture and electronics in American homes with pounds of toxic chemicals linked to cancer, neurological deficits, developmental problems and impaired fertility.

The tactics started with Big Tobacco, which wanted to shift focus away from cigarettes as the cause of fire deaths, and continued as chemical companies worked to preserve a lucrative market for their products, according to a Tribune review of thousands of government, scientific and internal industry

stoked the public's fear of fire and helped organize and steer an association of top fire officials that spent more than a decade campaigning for their cause.

Today, scientists know that some flame retardants escape from household products and settle in dust. That's why toddlers, who play on the floor and put things in their mouths, generally have far higher levels of these chemicals in their bodies than their parents.

Blood levels of certain widely used flame retardants doubled in adults every two to five years between 1970 and 2004. More recent studies show levels haven't declined in the U.S. even though some of the chemicals have been pulled from the market. A typical American baby is born with the highest recorded concentrations of flame retardants among infants in the world.

People might be willing to accept the health risks if the







Office of Governor

**Edmund G. Brown Jr.**



June 18, 2012

## Governor Brown Directs State Agencies to Revise Flammability Standards

‘We must find better ways to meet fire safety standards by reducing and eliminating - wherever possible - dangerous chemicals.’

# California Flammability Standard TB117-2013

**Mandatory January 1, 2015**

**Flame retardants not needed,  
but can still be used**

**Product Labels Required**

## NOTICE

THIS ARTICLE MEETS THE FLAMMABILITY REQUIREMENTS OF CALIFORNIA BUREAU OF ELECTRONIC AND APPLIANCE REPAIR, HOME FURNISHINGS AND THERMAL INSULATION TECHNICAL BULLETIN 117-2013. CARE SHOULD BE EXERCISED NEAR OPEN FLAME OR WITH BURNING CIGARETTES.

The upholstery materials in this product:

       contain added flame retardant chemicals  
  X   contain NO added flame retardant chemicals

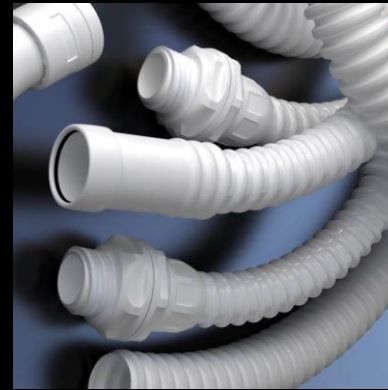
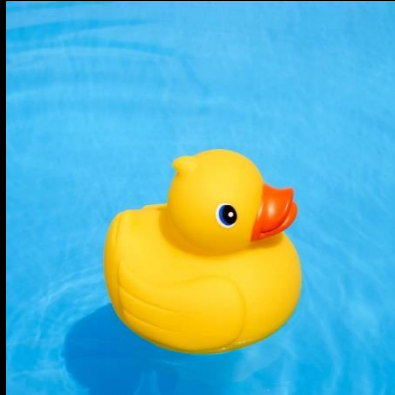
The State of California has updated the flammability standard and determined the fire safety requirements for this product can be met without adding flame retardant chemicals. The State has identified many flame retardant chemicals as being known to, or strongly suspected of, adversely impacting human health or development.

# Bisphenols



**FUNCTIONS:** hardening agents, strengtheners, stabilizers

# Phthalates



**FUNCTIONS:** plasticizers, lubricants, solvents, fragrances

# Class 5: Some Solvents



**FUNCTIONS:** dissolving and dispersing other substances



# Class 6: Certain Metals

Mercury



Arsenic



Cadmium



Lead



FUNCTIONS: conductors, malleable, resistant to corrosion



# Six Classes Videos

An innovative approach to reducing toxics

1

Highly  
Fluorinated

2

Antimicrobials

3

Flame  
Retardants

4

Bisphenols  
+ Phthalates

5

Some  
Solvents


6

Certain Metals



**VIEW and SHARE: [www.SixClasses.org](http://www.SixClasses.org)**

Healthier products, healthier people in four minutes!

A high-altitude mountain peak with a climber. The sun is bright in the upper left corner, creating a lens flare. The mountain is covered in snow and ice, with a climber visible on a ridge. The sky is a deep blue.

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[www.greensciencepolicy.org](http://www.greensciencepolicy.org)

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A scenic mountain landscape. In the foreground, a dirt path leads through a field of green grass and red wildflowers. In the background, a large, snow-capped mountain peak rises above a layer of white clouds. The sky is clear and blue.

**By reducing use of Six Classes**

**We can have a healthier world.**

**For more information**  
**Google: Green Science Policy**  
**[www.greensciencepolicy.org](http://www.greensciencepolicy.org)**