CLEAN WATER ACTION
CONNECTICUT

Written Testimony of Susan Eastwood
Coalition for a Safe and Healthy Connecticut and Clean Water Action
Before the Connecticut General Assembly Committee on Children
February 24, 2015
In Support of HB 6806, AN ACT CONCERNING
TOXIC FIRE RETARDANTS IN CHILDREN'S PRODUCTS

Senator Bartolomeo, Representative Urban and honorable members of the Children's Committee,

Thank you for the opportunity to speak today in strong support of **HB 6806.**

My name is Susan Eastwood and I am a resident of Ashford and a parent of two grown children. I am the Director of Communications and Outreach for Clean Water Action CT and the Coalition for a Safe and Healthy Connecticut, a group of over 50 non-profits working to phase out toxic chemicals from everyday products.

Clean Water Action and the Coalition for a Safe and Healthy Connecticut **strongly support HB 6806,** An **Act Concerning Toxic Fire Retardants in Children's Products**. This bill would ban any product containing flame retardant chemicals marketed for the use of children three years of age or younger. I commend the leadership of this Committee in their efforts to protect our most vulnerable from chemicals of high concern in items they are in contact with for many hours each day.

There are a number of chemicals of concern used as flame retardants in children's products, including pentabromodiphenyl ether (pentaBDE, a mixture of PBDEs), several variations of "chlorinated Tris" flame retardants and Firemaster 550 (FM 550). Scientific studies linking one or more of these chemicals to serious disease are mounting up and pointing to serious health impacts from exposure at an early age including hormone disruption, toxicity to the developing nervous system, reproductive toxicity, and cancer.

- Higher levels of PentaBDE are associated with adverse health effects in people, including decreased IQ, fine motor coordination, and ability to focus attention in children, and hormonal changes in both men and women.

- Chlorinated tris (TDCPP) has been shown to change genetic material and cause cancer in animals. TDCPP was voluntarily removed from children's pajamas in the 1970's when it was found to be a probable human carcinogen. It has now shown up in many other products

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including nursing pillows, changing mattresses, and bassinettes. (Hidden Hazards report – see attachment)

- TCEP is linked to nervous system impairment including seizures, brain lesions, memory loss and learning problems.

- TDCCP has been associated with cancer of the liver, kidney, brain and testis. It also has been shown to have negative health impacts to the liver, kidney, bone marrow and testis.

- Firemaster 550 (FM 550) damages genetic material and is associated with obesity and anxiety in animals.

The Coalition for a Safe and Healthy CT participated in a national study which tested common items from the nursery for chlorinated tris. Of 20 items tested, 18 contained at least one form of tris, including the two items purchased in Connecticut[1]. The report "Hidden Hazards in the Nursery", released on January 19, 2012, is attached to my testimony.

Another study showed the presence of these toxic flame retardants in nap mats! Of the 24 nap mats tested, 22 contained flame retardants and nine of those contained chlorinated Tris. The nap mat submitted from Connecticut tested the highest for levels of TCPP![2]

High levels of flame retardants are added to polyurethane foam found in children's products and home furnishings. In the Hidden Hazards study the concentration of flame retardant was on average 3.9% of the entire weight of the foam! These chemicals off-gas and get into the air and house dust. Dust is known to be a major source of exposure to many flame retardants and young children have been found to have the highest levels. More than 96% of dust samples collected in the Boston area contained TDCP. TCEP has also been widely detected in our surface water, indoor air, and dust. And, in our children! Biomonitoring studies on children have shown extremely high levels of flame retardants[3].

Parents are advised to vacuum their homes frequently with a HEPA filter and wash their children's hands often, in an attempt to minimize exposure. Is this a reasonable way to protect our children from exposure to carcinogens?

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[1] Erika Schreder, "Hidden Hazards in the Nursery", Washington Toxics Coalition/Safer States, January 2012. http://watoxics.org/files/hidden-hazards-in-the-nursery

[2] Caroline Cox, "Naptime Nightmares? Toxic Flame Retardants in Child Care Nap Mats", Center for Environmental Health, February 2013. http://www.ceh.org/storage/documents/Flame_Retardants/nap_mat_report_2_19_2013.pdf

[3] Tests reveal high chemical levels in kids' bodies - CNN - Planet in Peril http://www.youtube.com/watch?v=pBXvJWWlgss

Certainly, the goal of fire prevention is a good one but it can be accomplished more effectively in other ways. Proven ways of reducing fire-related deaths include fire-safe cigarettes, sprinklers, smoke detectors and enforcement of building codes. Other flame retarding materials may be used in place of foam; wool is a natural flame retardant and is already used in baby products marketed as safer. There are other chemical flame retardants that are safer alternatives as well.

In fact, recent flammability tests have shown there is virtually no significant fire safety benefit to the use of these chemicals.[4] Since it is the foam and not the outer coating of fabric that is treated with these chemicals, the fabric in these products will ignite anyway. Once the fabric ignites, the large flames are not retarded by the presence of these toxic chemicals. Further, the chemicals released from the foam increase the toxicity of the smoke.

In conclusion, we feel that this bill is an important step to protect our children from toxic flame retardants in children's products.

We urge your support of **HB 6806**.

Thank you.

Sincerely,

Susan C Eastwood

Susan Eastwood
Clean Water Action
Coalition for a Safe and Healthy Connecticut

[4] Shaw, S; Blum, A; Weber, R; Kurunthachalam, K; Rich, D; Lucas, D; Koshland, C; Dobraca, D; Hanson, S; Birnbaum; "Halogenated Flame Retardants: Do the Fire Safety Benefits Justify the Risks?" Reviews on Environmental Health Vol. 25, No. 4; (2010).

Naptime Nightmares?
Toxic Flame Retardants in Child Care Nap Mats

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February, 2013

Contributors to this report include Alaska Community Action on Toxics, Clean and Healthy New York, Clean Water Action – Connecticut, Clean Water Action – Massachusetts, Vermont Public Interest Research Group, and Washington Toxics Coalition

This report was written by Caroline Cox, research director at the Center for Environmental Health.

Summary

Nap time should be a healthy, peaceful and restful time for children in child care. Yet, this report shows that children sleep on foam nap mats containing toxic flame retardant chemicals during what should be dream-filled napping.

This toxic exposure occurs because chemical flame retardants are frequently added to foam. At first glance, this concept can seem to make some sense - foam burns easily. However, the concept does not translate to reality. In fact, government studies have shown that flame retardants in foam-containing products do not improve fire safety as they are typically used.

In addition, many chemical flame retardants are toxic. Some have been linked to serious health problems like cancer, obesity, and allergies. There is little publicly available information about the safety of others.

Flame retardants used in everyday products, including nap mats, are typically secrets – the chemicals used to treat foam are not identified on product labels or elsewhere.

We found that 22 out of the 24 foam-containing nap mats we tested had been treated with at least one chemical flame retardant. Nineteen of our 24 nap mats had been treated with two or more flame retardant chemicals. Nine of the mats contain chlorinated Tris, a cancer-causing chemical that was removed from children's pajamas more than 30 years ago because it caused genetic damage.

Flame retardant chemicals in nap mats escape into the air wherever they are used or stored. Children (and their teachers) breathe in these chemicals while they nap and while they play or work in rooms where nap mats are kept.

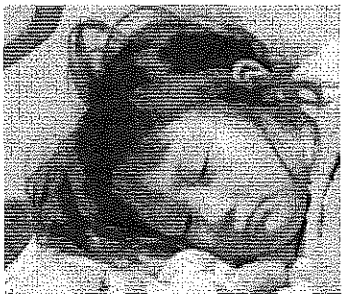
Children should not be exposed to unnecessary toxic chemicals anytime, but especially while they nap. We recommend that parents and child care providers choose nap mats that are not made with foam. We also encourage parents, teachers, and others to demand that regulatory agencies and elected officials protect all of us from exposure to toxic chemicals.

What We Did

Organizations from across the country – Center for Environmental Health (California and New York), Alaska Community Action on Toxics, Clean Water Action Connecticut, Clean Water Action Massachusetts, Clean and Healthy New York, Vermont Public Interest Research Group, and Washington Toxics Coalition – contributed nap mats to this project. We purchased 21 nap mats containing polyurethane foam from major retailers and child care supply companies in October and November 2012. Most of the purchases were made online. In addition we obtained three nap mats from child care centers.

We sent foam samples from each of the 24 nap mats to Dr. Heather Stapleton (Nicholas School of the Environment, Duke University) for independent analysis. The samples were identified only by a code, so that the lab did not know which products were being tested. Her lab analyzed the foam from each nap mat for flame retardants using mass spectrometry. Details of the analytical methods Dr. Stapleton used are described in Environmental Science and Technology 45: 5323–5331, available online at http://pubs.acs.org/doi/pdf/10.1021/es2007462.

What We Found



Our tests identified 10 flame retardant chemicals in our nap mats. Four of these are commonly used as a mixture often called Firemaster 550. Three of them are commonly used as a mixture we call the "Tert-butyl mixture."

All but two of the 24 nap mats were made from foam treated with flame retardants, and all but five of the 24 mats contained at least two flame retardant chemicals or mixtures.

The most common flame retardant was triphenyl phosphate (TPP), in 18 nap mats. We found chlorinated Tris (TDCPP) in nine mats. Eight mats contained a mixture equivalent to Firemaster 550, and eight contained the "Tert-butyl mixture."

For complete results about each of the nap mats we tested, see "Detailed Results" at the end of this report.

Flame Retardants
Not Effective in Nap Mats

Flame retardants are chemicals added to polyurethane foam to make it less likely that the foam will burn if it's in contact with the flame from a match or a candle. However, in nap mats (and most other uses of foam) the foam is covered by fabric and would not be directly in contact with flames until the fabric has burned away. That kind of a fire is so big that the retardants are ineffective.

Government studies and fire experts have found that flame retardants are ineffective as they are used in furniture and products like nap mats.

Here's what the Consumer Product Safety Commission (CPSC) wrote in 2012 after conducting a series of experiments with upholstered furniture:

"...the fire-retardant foams did not offer a practically significantly greater level of open-flame safety than did the untreated foams."

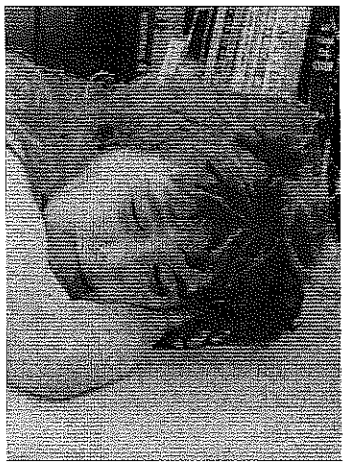
Here's what fire safety scientist Vytenis Babrauskas wrote in 1983 after a series of experiments with furniture:

"Furniture using polyurethane foams with retardants added to meet California state requirements did not show any reduction in the rate of heat release compared to ordinary polyurethane foams."

Smoke detectors add to our fire safety – deaths from home fires are half as common now as they were before smoke detectors were common. Foam treated with flame retardants, in most situations, does not.

Flame Retardants

Not Good for Children (or for the Adults Who Care for Them)



The flame retardants used in nap mats are a diverse group of chemicals that cause a wide array of health problems. Cancer, obesity, reduced fertility, hormone disruption, and allergies are just a few of the problems that have been linked to exposure to these flame retardants. And this list is likely to be incomplete. None of the chemicals used as flame retardants have been comprehensively tested and there are large gaps in our knowledge about the toxicity of these chemicals.

Particularly concerning is the ability of these chemicals to disrupt the normal functions of our hormones. Hormones are chemical messengers that work together in a system that "regulates all biological processes in the body from conception through adulthood and into old age." Hormones are potent in tiny amounts, and research over the last several decades has shown, similarly, that "low-dose effects are remarkably common" in studies of hormone-disrupting chemicals.

We found ten flame retardant chemicals in our nap mats. Four of these chemicals are used in the mixture commonly sold as Firemaster 550; three others are used in a mixture we call the "Tert-butyl mixture." (See the next page for the names of the chemicals used in those two mixtures.) Details about health hazards associated with the flame retardants we found include the following:

- TCPP (tris (1-chloroisopropyl) phosphate) caused genetic damage in studies of human cells. In tests with laboratory animals, TCPP changed the length of the menstrual cycle.

- TDCPP (chlorinated Tris; tris- (1,3-dichloroisopropyl) phosphate) is identified as a cancer-causing chemical by the state of California and the National Research Council. In laboratory animals it is toxic to developing embryos and also causes genetic damage in studies of human cells. It also disrupted the development of cells that are part of the nervous system. In men attending infertility clinics, exposure to TDCPP was linked with

changes in hormone levels.

- **TPP** (triphenyl phosphate) damaged the nervous system in studies of laboratory animals. It also has caused skin allergies. In men at infertility clinics, TPP exposure is linked with lower sperm production.

- **Firemaster 550** (and other retardants made with the same four chemicals: isopropyl phenyl diphenyl phosphate, di (isopropyl phenyl) phenyl phosphate, tetrabromobenzoate, and tetrabromodiethylhexyl phthalate) caused obesity and disrupted normal hormone function in tests with laboratory animals.

- **Tert-butyl mixture** (4-(tert-butyl)phenyl diphenyl phosphate (2), bis(4-(tert-butyl)phenyl) phenyl phosphate (3), and tris(4- (tert-butyl)phenyl phosphate) has very little toxicological information. At least one of the chemicals in the mixture affects the liver.

Flame Retardant Regulations

Many nap mats - 18 of the 24 mats we tested - are sold with tags indicating that they comply with TB117 (the California Bureau of Electronic and Appliance Repair, Home Furnishings, and Thermal Insulation Technical Bulletin 117) and its associated regulations. However, according to state regulators, nap mats are not actually subject to the requirements of TB117.

For the past four decades, TB117 has resulted in the addition of unnecessary chemical flame retardants to a variety of foam-containing products. Earlier this month, the state of California released a proposed update for TB117 (TB-117 2013) that would create real fire safety benefits without the use of harmful flame retardant chemicals.

For information about the new update of TB117, see http://www.bhfti.ca.gov/about/laws/propregs.shtml.

Nine of the nap mats we tested contain chlorinated Tris (TDCPP). In California, products that can expose consumers to chlorinated Tris, which is known to the state to cause cancer, must be labeled as such. None of the mats were labeled in this way.

Last fall, the Center for Environmental Health tested nap mat foam for TDCPP at Paradigm Environmental Services (Rochester NY) and initiated legal action against suppliers of nap mats for their failure to comply with state consumer protection law. CEH filed lawsuits alleging violation of California consumer protection law against 8 nap mat suppliers on February 15, 2013.

Exposure to Flame Retardants in Nap Mats

Flame retardant chemicals in nap mats escape into the air wherever they are used or stored. Children breathe this air while they nap, and also if they play in areas where the nap mats are stored.

Some of the evaporated flame retardants will settle on children's skin, and be absorbed through their skin.

In addition, some of the evaporated flame retardants settle on dust particles. Children ingest this dust when it gets on their fingers and they put their fingers in their mouths.

Teachers in child care centers are exposed to flame retardants in similar ways.

A recent study sponsored by the California Air Resources Board found TDCPP and Firemaster 550 chemicals in dust samples from every child care facility studied (40). Concentrations of TDCPP were higher in facilities that used foam nap mats than in facilities that did not.

Detailed Results

Description	Brand	Store	State	TCPP	TDCPP	TPP	Fire-master 500 or equivalent product	Tert-butyl mixture
Yellow Rainbow Rest Mat	No brand	Lakeshorelearning.com	CA		X	X		X
Red/Green Pillow Folding Rest Mat	The Children's Factory	Lakeshorelearning.com	CA			X	X	
Blue/Red Indestructible Folding Mat	The Children's Factory	Lakeshorelearning.com	CA		X	X		X
Blue/Green Hygenic Folding Mat	The Children's Factory	Lakeshorelearning.com	CA			X	2 of 4 chemicals in mixture	X
Blue Kindermat Deluxe	Peerless Plastics	Schoolspecialty.com	CA		X	X		X
Blue Nap Mat	Colgate		NY			X	X	
Rest Assured Nap Mat by Anthony Williams	Marlo Plastics Products	Toys R Us	VT			X	X	
Blue/Teal Heat Sealed 4-Fold Nap Mat	The Children's Factory	Lakeshorelearning.com	WA		X	X	2 of 4 chemicals in mixture	X
3-Section Blue Mat	Mahar Manufacturing	Busykids.com	CA			X	2 of 4 chemicals in mixture	X
Green Rest Assured Nap Mat by Anthony Williams	Marlo Plastics Products	Northshorecare.com	CA			X	X	
Microban Nap Mat	Safety 1st	Amazon.com	CA	X	X			

Description	Brand	Store	State	TCPP	TDCPP	TPP	Fire-master 500 or equivalent product	Tert-butyl mixture
Red/Blue 3-Section Infection Control Mat	The Children's Factory	Busykids.com	CA			X	2 of 4 chemicals in mixture	X
Yellow Rest Mat	Wesco	Kaplanco.com	CA			X	X	
Green Deluxe Flat Rest Mat	Grantco MFG	USMarkerboard.com	CA			X	X	
Red/Blue Economy Flat Rest Mat	Grantco MFG	USMarkerboard.com	CA			X	X	
Red/Blue 3-Section Infection Control Mat	The Children's Factory	Kaplanco.com	CA			X	X	
Microban Nap Mat	Safety 1st		AK	X	X			
KinderMat	Peerless Plastics		AK			X	3 of 4 chemicals in mixture	
Daydreamer Blue/Green Nap Mat	Peerless Plastics	Barclay School Supplies	NY		X	X		X
2" Germ-free Rest Mat	Angeles		CT	X				
Children's Blue Rest Mat	Peerless Plastics	Target	MA		X			
Children's Blue Rest Mat	Peerless Plastics	Target.com	CA		X			
Blue Rest Mat	Wesco	Sears.com	CA					
Deluxe Memory Foam Nap Mat	Aquatopia	Babies R Us	WA					

What You Can Do

Parents:

- Purchase nap mats made without polyurethane foam. Options that are not usually treated with flame retardants are polyester fiberfill, cotton, and wool.
- Ask nap mat suppliers about their use of flame retardant chemicals, and purchase products from companies that pledge they no longer use any of these chemicals. CEH is pursuing legally binding agreements to eliminate flame retardants with several leading nap mat suppliers.
- Ask your child care provider to purchase mats made without polyurethane foam or to purchase mats from companies who have agreed not to use flame retardants.
- Wash your hands and your children's hands often, especially before eating.

Child Care Providers:

- Purchase nap mats made without polyurethane foam. Options that are not usually treated with flame retardants are polyester fiberfill, cotton, and wool.
- Ask nap mat suppliers about their use of flame retardant chemicals, and purchase products from companies that pledge they no longer use any of these chemicals. CEH is pursuing legally binding agreements to eliminate flame retardants with several leading nap mat suppliers.
- Ask your child care supply store to sell mats made without polyurethane foam or to sell mats from companies that have agreed not to use flame retardants.
- Children and teachers should wash their hands often.
- Vacuum or wet mop nap areas often. Use a HEPA vacuum cleaner if available.
- Open windows as much as possible.

Everyone:

- Support state efforts to provide toxic-free fire safety (See details on the next page.) Take action to support flame retardant free furniture and baby products: http://bit.ly/YkZkT4.
- Support efforts to fix our nation's outdated and ineffective chemical policy regulations.

Pending State Actions

California:

- Technical Bulletin 117-2013 (TB 117-2013)
  Draft standard would revise California's outdated and ineffective flammability standard for furniture and baby products which has become a de facto national requirement. The draft standard would provide greater fire safety without the use of toxic flame retardants throughout the United States and Canada. Take action at http://bit.ly/YkZkT4. Contact Judy Levin at the Center for Environmental Health for more information: judy@ceh.org

- California: AB 127
  Does not ban flame retardants in building insulation, but notes their toxicity, and states the legislature's intention of reducing their use in plastic foam building insulation. For more information, go to http://www.changecalifornia.org/ or contact Kathryn Alcántar at the Center for Environmental Health: Kathryn@ceh.org

Connecticut: HB 6332
Bans sale of any product containing Chlorinated Tris flame retardants (TDCPP (also called TDCP), TCEP or TCPP) marketed for the use of children three years of age or younger. For more information, go to http://www.safehealthyct.org/ or contact Anne Hulick at Clean Water Action-CT: ahulick@cleanwater.org

Maine: Introduced, no bill number yet
Directs the Department of Environmental Protection to add the flame retardant Chlorinated Tris (TDCPP) to the list of chemicals of concern, and the list of chemicals of high concern. For more information, go to http://www.preventharm.org or contact Steve Taylor at Environmental Health Strategy Center: stevetaylor@preventharm.org

Maryland: HB 99
Prohibits the sale of specified child care products (toys, car seats, nursing pillows, strollers) that contain Chlorinated Tris (TCEP). For more information, go to http://www.marylandpirg.org/issues/mdp/healthy-kids-healthy-

maryland or contact Jenny Levin at Maryland PIRG: jlevin@marylandpirg.org

Massachusetts:

- SD 1618
  Bans the sale of children's products and residential upholstered furniture containing Chlorinated Tris (TDCPP, TCEP, TCPP), and any product containing PBDEs (DecaBDE, OctaBDE, and PentaBDE) and provides that replacement chemicals not be chemicals of high concern. For more information contact: Elizabeth Saunders at Clean Water Action-MA: esaunders@cleanwater.org
- An Act for Healthy Families and Businesses (no bill number yet)
  Sponsors: Rep. Kaufman and Sen. Donnelly
  Creates a comprehensive yet flexible program to support businesses to transition away from using and selling products containing toxic chemicals that harm the health of children or adults and replacing them with safer alternatives. For more information: http://www.healthytomorrow.org/2013/01/healthy-families-and-businesses.html or contact: Elizabeth Saunders at Clean Water Action-MA: esaunders@cleanwater.org

New York SO3703/AO4741
Expands the Tris-free children's and baby act by expanding the definition of "Tris" to include TDCPP in children's products. For more information contact Kathy Curtis at Clean and Healthy New York clean.kathy@gmail.com.

Vermont: S 81/H 241
Bans the sale of certain consumer products containing PBDEs (octaBDE, pentaBDE, and decaBDE), and bans the sale of residential furniture or children's products containing Tris (TDCPP, TCEP, and TCPP). For more information, go to http://www.vpirg.org/ or contact Lauren Hierl at Vermont PIRG: lhierl@vpirg.org

Washington: HB 1294/SB 5181
Bans the use of Chlorinated Tris (TDCPP, TCEP), and any other chemical that has been identified as a high priority chemical of high concern for children, in children's products and residential upholstered furniture. For more information go to http://watoxics.org/chemicals-of-concern or contact Ivy Sager-

Rosenthal at Washington Toxics Coalition:
isagerrosenthal@watoxics.org

The following legislatures do not have pending flame retardant legislation yet, but intend to do so in the 2013 session.

Alaska:
Contact: Alaska Community Action on Toxics
Pamela Miller at: pamela@akaction.org

Illinois:
Contact: Illinois PIRG
Hailey Gold at: hwitt@illinoispirg.org

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WASHINGTON TOXICS COALITION

safer states

Hidden Hazards in the Nursery

Hidden Hazards in the Nursery

Sponsors

Washington Toxics Coalition
www.watoxics.org
Washington Toxics Coalition protects public health and the environment by eliminating toxic pollution. WTC promotes alternatives, advocates policies, empowers communities, and educates people to create a healthy environment.

Safer States
www.saferstates.org
Safer States is a network of diverse environmental health coalitions and organizations around that country that share a bold and urgent vision. We believe families, communities, and the environment should be protected from the devastating impacts of our society's heavy use of chemicals.

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Editorial Review

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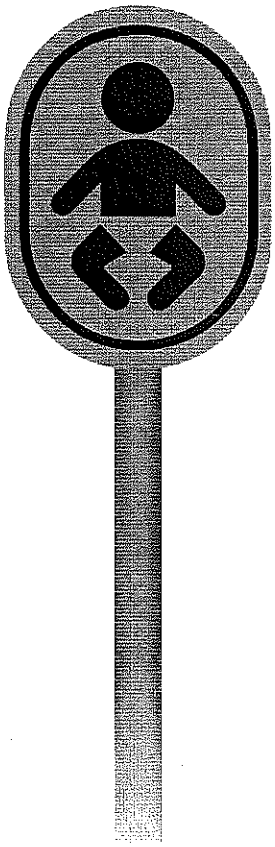


Hidden Hazards in the Nursery

Executive Summary

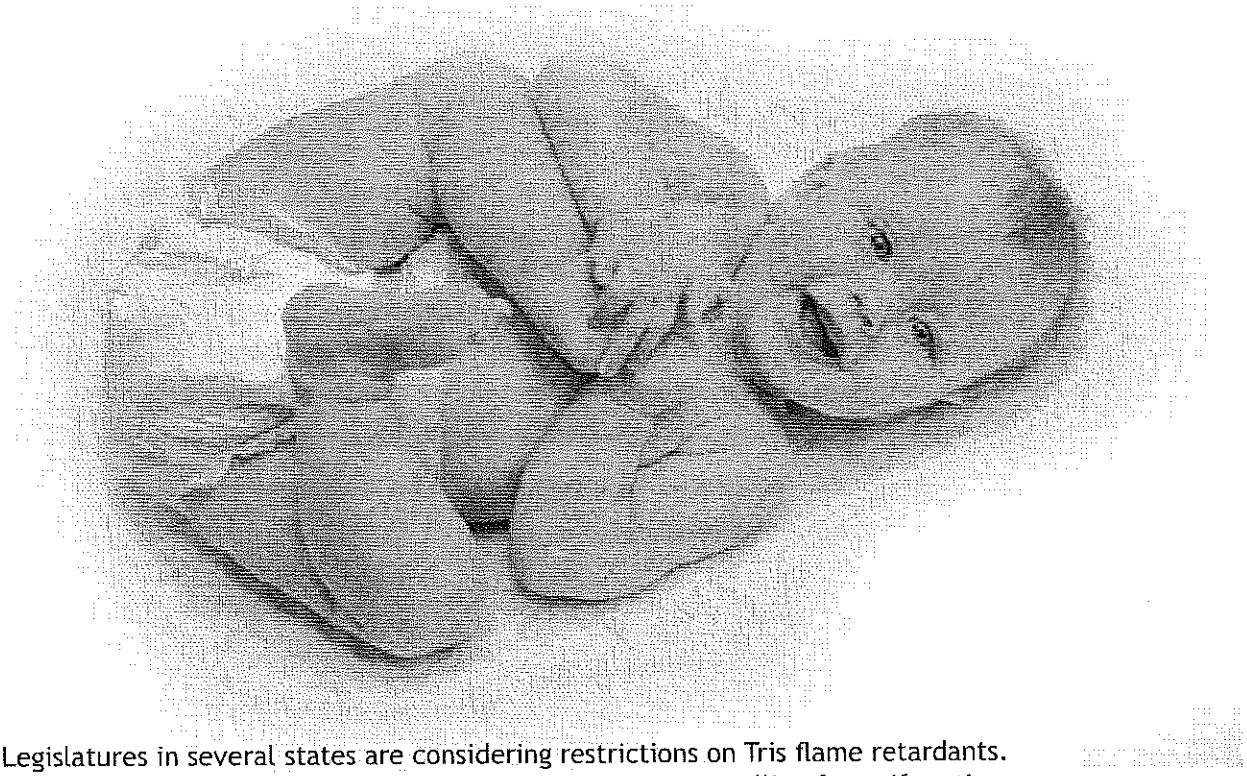
Parents expect the products they buy for their babies to be safe. But new testing of 20 baby and children's products, including bassinet pads, nursing pillows, changing pads, and car seats, has found toxic flame retardants in 85% of the items.

Washington Toxics Coalition and Safer States tested newly purchased baby and children's items from major retailers including Babies R Us, Sears, Walmart, and Target. Products were purchased in Connecticut, Maryland, Massachusetts, Michigan, New York, and Washington State. All of the products tested contained polyurethane foam, which is commonly treated with flame retardants in many types of products.

Analysis of the foam found toxic flame retardants present in 17 of the 20 items tested. Sixteen of the items with flame retardants contained "Tris" flame retardants. The most frequently detected Tris flame retardant was a chemical known as chlorinated Tris, or TDCPP. Chlorinated Tris became well known for its removal from children's pajamas in the 1970s after laboratory studies found it could cause mutations, making it potentially cancer-causing. It has received increased attention as it has come into widespread use to replace the phased out PBDEs as flame retardants in foam, and the State of California listed chlorinated Tris as a carcinogen in October of 2011. Another Tris flame retardant, TCEP, has also been designated a carcinogen.

Flame retardants were present at high concentrations. The 17 products that tested positive for the additives contained an average level of 3.9% flame retardants by weight in the foam. Because these flame retardants are not chemically bound to the foam, they can escape from it and contaminate home environments.

Children are likely to have both more exposure to flame retardants and greater vulnerability to their effects. Children spend more time on or near the floor, and have more hand-to-mouth contact than adults, increasing their exposure to chemicals found in household dust. Because they are still developing, children are also more susceptible to the harmful effects of toxic chemicals.



Legislatures in several states are considering restrictions on Tris flame retardants. Environmental health organizations across the country are calling for swift action to stop the use of chlorinated Tris in baby and children's products, as well as policy changes to stop companies from replacing one toxic chemical with another.

Washington State Legislatures should ban toxic Tris flame retardants in consumer products, particularly the carcinogens TCEP and TDCPP. States were the first to take action on PBDE flame retardants, and can take swift action to address this new threat. New York banned TCEP in early 2011, and a number of state legislatures will consider bans on Tris flame retardants in 2012.

Washington State should require companies to make safer products and switch to the safest chemicals and manufacturing methods. For too long, many companies have gone from one toxic chemical to another, never making health and safety a priority. To get off the toxic treadmill, companies need to find safer materials, processes, and chemicals to replace toxic chemicals in products. States should adopt policies requiring companies that use toxic chemicals to conduct thorough assessments and identify safer materials, processes, and chemicals.

Introduction

Flame retardant chemicals have a long history of toxic troubles. In 1973, Michigan farm families had high levels of flame retardant exposure when the flame retardants PBBs were accidentally mixed into cattle feed, contaminating the food supply in that state. PCBs, used as coolants in electrical installations around the world, were banned in the United States in 1979 when they were discovered to cause cancer.

So perhaps we shouldn't have been so surprised in 2003 to learn that PBDEs, which had become one of the most commonly used flame retardants in the United States, were contaminating U.S. women's breastmilk at levels far greater than in other countries[1]. Like PCBs, the PBDE flame retardants were able to build up in people and wildlife and concentrate in breastmilk. By the late 1990s and early 2000s, scientists were discovering frighteningly fast increases in PBDE levels in wildlife such as harbor seals and orcas[2-4]. And researchers were discovering in laboratory studies that a single dose of PBDEs at a critical point in development could have lifelong impacts on learning and memory[5].

By dominating the market for both polyurethane foam and certain plastics, PBDEs had made their way into major products in our homes: our televisions, couches, and other foam-containing items such as nursing pillows. They were escaping from these products and building up in house dust, exposing adults and children right in their homes.

Once information about the hazards of PBDEs became widely known, state legislatures took action. Washington, California, and Maine were the first to act, banning the flame retardants. Eventually, the chemical manufacturers came to an agreement with the U.S. Environmental Protection Agency (EPA) to stop producing all forms of PBDEs.

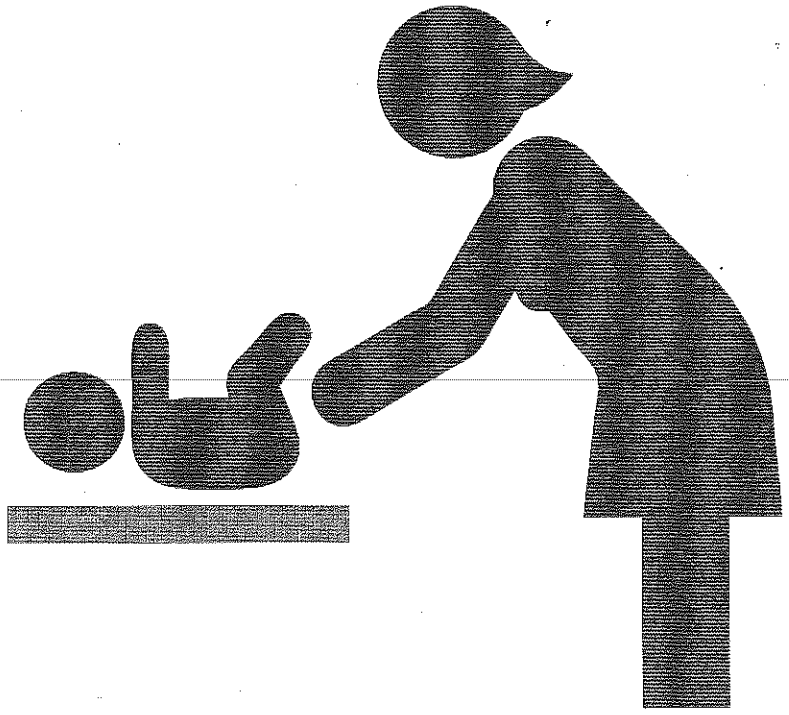
But instead of ending the legacy of toxic flame retardants, chemical companies and product manufacturers ignored what policymakers and consumers really wanted—safer products. Most companies failed to fully evaluate the replacement options for health and safety. Instead, they reached for the easiest substitutes, flame retardants that have their own toxic troubles.

Companies are not required to report what flame retardant they're using or label their products accordingly, so consumers have no way of knowing what chemicals their couch, changing pad, or nursing pillow contains. Scientists have attempted to fill in the information gap with testing, and the most recent information indicates that for baby products like changing pads and car seats, companies have chosen a chemical with a long history of problems: chlorinated Tris (TDCPP), used in children's pajamas in the 1970s and quickly removed when it was found to be mutagenic, making it potentially cancer-causing[6].

For most of the products we tested, no standard actually requires that they contain flame retardants. We only see flame retardants in many types of children's products because of an outdated flammability standard set by the state of California, known as TB117. These types of products are not required to contain flame retardants when they are sold in other states. Even in California, strollers, infant carriers, and nursing

pillows are exempt from flammability requirements. Car seats, however, are required to meet a national flammability standard under motor vehicle safety standards.

This study provides up-to-date information on what chemicals are being used in an array of baby products containing polyurethane foam. Washington Toxics Coalition and Safer States tested foam from changing pads, bassinet pads, nursing pillows, a walker, and a sleep positioner. We purchased 20 new products in Connecticut, Maryland, Massachusetts, Michigan, New York, and Washington State in September 2011. Pieces of the foam were removed from each item, labeled with a sample ID code, and shipped to Duke University for chemical analysis. Detailed information on the methods can be found in Appendix 2.

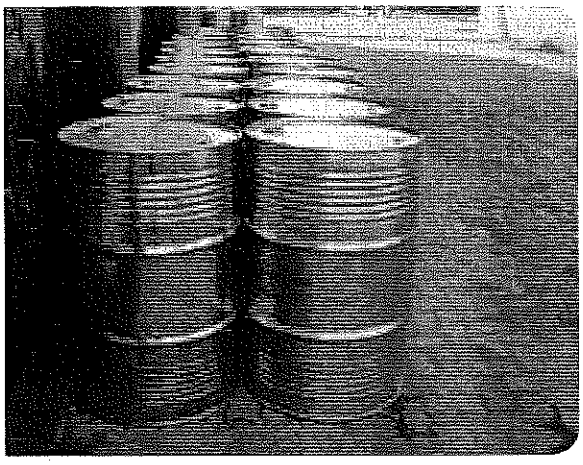


Toxic Cast of Characters

Chlorinated Tris, or TDCPP

TDCPP, or Tris (1,3-dichloro-2-propyl) phosphate, had its 15 minutes of fame in the late 1970s, when it was used in children's pajamas, then removed when it was discovered to be mutagenic[7]. The chemical faded out of the spotlight until the 2000s, when a replacement was needed for the persistent toxic flame retardant penta-BDE. TDCPP is now one of the leading chemicals used to treat polyurethane foam for flame resistance, and by 2006 between 10 and 50 million pounds were produced or imported into the United States on a yearly basis[8].

Sadly, the switch to TDCPP appears to have been more "out of the frying pan, into the fire" than a move from a toxic to safer chemical. TDCPP has not been thoroughly tested for health and safety, but the tests that have been conducted indicate that it is carcinogenic, may disrupt hormone levels, and may even be toxic to the nervous system.



BARRELS OF TDCPP

Cancer: TDCPP was designated as a carcinogen by the State of California under Proposition 65 in October 2011 based on laboratory studies finding increases in kidney, liver, and testicular tumors as well as evidence of mutagenicity[9, 10]. Previously, a Consumer Product Safety Commission (CPSC) assessment designated the chemical as a probable carcinogen and estimated the number of excess cancers due to exposure at 300 cancers per million adults[11]. Since most regulations are designed to limit excess cancers to one per million, this assessment put TDCPP's cancer hazard at 300 times the level considered acceptable.

Mutagenicity: A number of studies have tested whether TDCPP can cause mutations, heritable changes in DNA that can lead to cancer and other problems. TDCPP caused several kinds of mutations in some but not all cell lines[7, 10].

Hormone disruption: A study published in 2010 found that men with greater exposure to TDCPP had lower levels of thyroid hormone and higher levels of prolactin, a hormone involved in a number of functions[12]. The study evaluated exposure by determining the level of the flame retardant in house dust, and hormones were measured in blood serum.

Nervous system harm: Researchers have begun to look at whether TDCPP, like other similar chemicals, can harm the nervous system. A 2011 study tested the chemical's effects on the development of brain cells and compared its effects to those of chlorpyrifos, a pesticide known to be toxic to the nervous system[13]. By some measures, TDCPP was even more toxic to the cells than chlorpyrifos, with effects on cell development, number, and DNA synthesis.

As a result of its widespread use, TDCPP has been detected in house dust, indoor air, breast milk, semen, urine, surface water, fish, food, and drinking water [10, 13-16]. A 2009 Boston study of 50 homes found it in house dust at levels that were comparable to those of PBDEs, an indication of the significance of its use in the home environment[17].

TCEP

Tris (2-chloroethyl) phosphate, or TCEP, is another "Tris" flame retardant found in polyurethane foam as well as in other products. TCEP has been used for several decades, with production in 2006 reported as between 500,000 and one million pounds. It has also been reported to be used as a plasticizer and in industrial processes[18].

TCEP has been widely detected in surface water, with the United States Geological Survey finding it in 58% of 139 streams sampled nationally[19]. Tests of indoor air have found the chemical in homes, offices, libraries, hospitals, and computer classrooms [20, 21].

Laboratory studies have indicated that TCEP causes cancer, harms the nervous system, and impairs fertility. Because of these concerns, the European Union has designated it as a Substance of Very High Concern, and it has been listed by the state of California as a carcinogen under Proposition 65.

Cancer: The National Institutes of Health conducted a two-year study of mice and rats exposed to TCEP in their food, and found increases in kidney tumors in rats[22]. Other studies have found increased rates of kidney tumors, leukemia, and thyroid cancer[23].

Nervous system harm: In laboratory studies, animals exposed to TCEP developed convulsions and striking damage to the brain including lesions and loss of neurons [23, 24]. The animals also had lasting damage to learning and memory.

Reproductive toxicity: TCEP appears to have the ability to broadly affect fertility. Mice exposed to the chemical had reduced sperm count, damaged sperm, and fewer pups per litter[25]. When researchers attempted to mate unexposed females with exposed males, the pairs did not exhibit normal mating behavior and only one female bore a litter.

TCPP

TCPP, or Tris (1-chloro-2-propyl) phosphate, is structurally similar to TCEP and TDCPP and apparently came into greater use in the 1960s as a replacement for TCEP[16]. It is produced in very large quantities, reported at between 10 and 50 million pounds in 2006, and used in both rigid and flexible polyurethane foams.

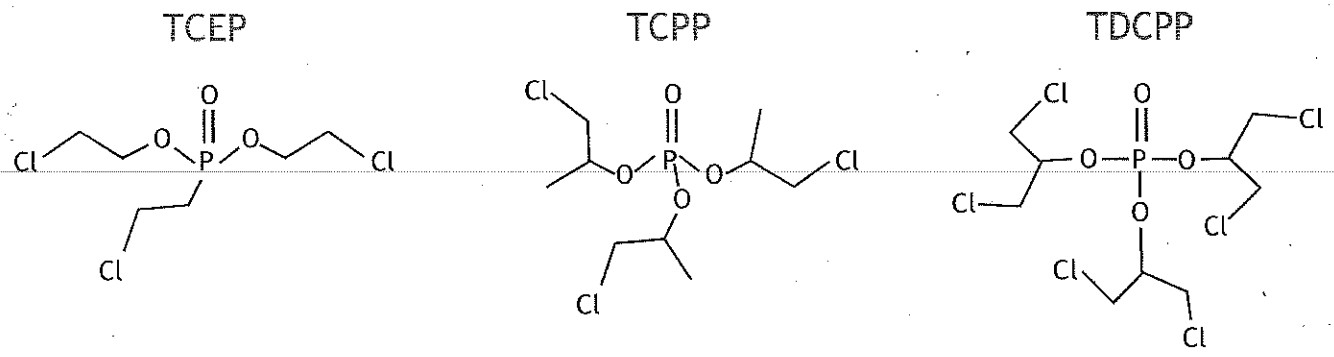
TCPP has been found in discharges from homes and industries[16]. It is known to leach out of foam into air, and has been found in air samples in cars, offices, and furniture stores[16, 26, 27]. Very little information is available on TCPP's toxicity. Basic laboratory testing shows that it has low to moderate acute toxicity and moderate to high aquatic toxicity. Full testing on reproductive and immune effects has not been conducted, but one study found that hens ceased egg production after treatment with TCPP[16]. The structural similarity of TCPP to the other Tris flame retardants raises suspicions that it will have similar toxicity.

Firemaster 550

Firemaster 550 is a mixture of four different compounds, introduced by Great Lakes Chemical Corporation in 2001 and used as a replacement for penta-BDE in foam. Firemaster 550 contains triphenyl phosphate (TPP), bis (2-ethylhexyl) tetrabromophthalate (TBPH), 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB), as well as a suite of triaryl phosphate isomers.

TBB and TBPH have been detected in house dust, and TBB has been found in biosolids at levels comparable to those of one of the PBDE forms, deca-BDE. Little is known about their toxic effects. TBPH is very similar, however, to the hormone-disrupting phthalate DEHP; it is essentially a brominated form of the chemical. Animals metabolize DEHP to the form MEHP, which in turn is similar to the Firemaster 550 component TBB[28].

A 2010 study tested whether Firemaster 550 could cause DNA damage in fathead minnows. Researchers found the fish can accumulate TBPH and TBB to some extent, and that exposed fish had damage to DNA[28]. The primary health and safety concern for TPP, the other component of Firemaster 550, is its toxicity to aquatic organisms[29].



THE SIMILAR CHEMICAL STRUCTURES OF TCEP, TCPP, AND TDCPP

Toxic Flame Retardants in Children's Products

Since companies don't disclose what flame retardants they are using in their products, scientists have been working since the phaseout of PBDEs to uncover their replacements. Since 2009, studies testing polyurethane foam in furniture and children's products have primarily identified the Tris flame retardants as well as the components of Firemaster 550.

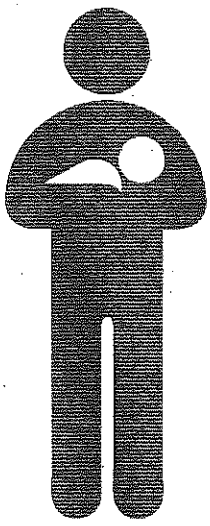
Earlier this year, a study of 101 baby products found chlorinated Tris in 36% of the products, TCEP in 14%, and Firemaster 550 in 17%. That study collected items currently in use, so it provided information on flame retardants in products already in homes, some in use since as early as 2002[6].

For this study, we purchased brand-new items to obtain up-to-date information on flame retardants in children's products currently for sale. We selected foam-containing baby and children's items from major retailers including Babies R Us, Target, Walmart, and Sears, in six states. We sent samples of the foam from each of these products to Dr. Heather Stapleton's research laboratory at Duke University for testing.

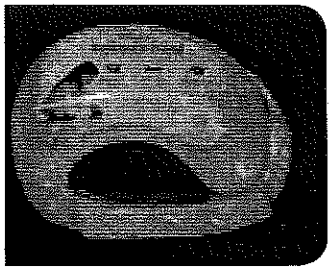
Our tests indicate that chlorinated Tris is far and away the most prevalent flame retardant in children's products. TDCPP was present in 16 of the 20 products, an 80% detection rate. Products containing the chemical included a nursing pillow, a co-sleeper, changing pads, bassinet pads, car seats, booster seats, and an activity walker. Altogether, TDCPP made up 63% of the total flame retardants detected in the 20 products tested.

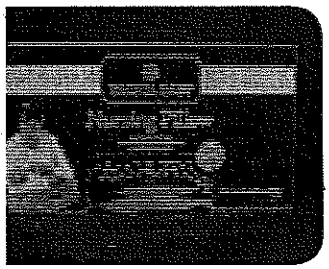
Flame retardants were present in the products at high levels. TDCPP was detected in the foam portion of the product at an average level of 2.6% by weight, and concentrations ranged up to 5%. Total flame retardant concentrations ranged from 1.5% to 5.5%, with an average of 3.9%.

TDCPP was nearly always paired with TCPP, although the latter was often present in smaller concentrations. In some cases, TCPP was present at higher concentrations than TDCPP. Only one product included TCEP, paired with several other flame retardants including one known as V6, which contains TCEP as an impurity. Firemaster 550 was present in only one product, an infant recliner made with dense foam. An as yet unidentified chlorinated organophosphate flame retardant (U-OPFR) was also detected in six products, and was observed in the previous study of baby products[6].



WE SELECTED FOAM-CONTAINING BABY AND CHILDREN'S ITEMS FROM MAJOR RETAILERS INCLUDING BABIES R US, TARGET, WALMART, AND SEARS, IN SIX STATES...FLAME RETARDANTS WERE PRESENT IN THE PRODUCTS AT HIGH LEVELS.





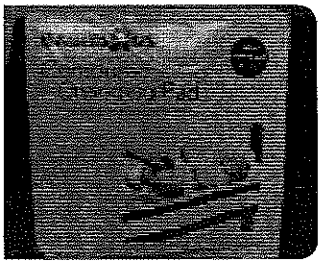


Table 1: Flame Retardants in Children's Products

Product	State Purchased	Flame Retardants*
My Brest Friend Deluxe Nursing Pillow	WA	TDCPP, TCPP
Balboa Baby Nursing Pillow	WA	none detected
Mini classic Co-sleeper by Arm's Reach	WA	V6, TCPP, TCEP, TDCPP, U-OPFR
Munchkin Contour Changing Pad	WA	TDCPP, TCPP
Summer Changing Pad	WA	TDCPP, TCPP, U-OPFR
Babies R Us Contoured Changing Pad	WA	TCPP, TDCPP, U-OPFR
Summer Bassinet Pad	WA	TDCPP, TCPP, U-OPFR
Graco Turbobooster Elite Booster Seat (for auto use)	WA	TDCPP, TCPP
Comfort Deluxe Booster Seat (for auto use)	WA	TDCPP, TCPP
Safety 1st Sounds 'n Lights Activity Walker	WA	TDCPP, TCPP
First Years Co-sleeper	MD	none detected
Dex Changing Pad	MD	TDCPP, TCPP
Nap Nanny Infant Recliner	MA	Firemaster 550
Cosco Scenera Convertible Car Seat	MA	TCPP, TDCPP, U-OPFR
Eddie Bauer Pop-up Booster Seat (non-auto use)	NY	none detected
Nod-a-way Bassinet	CT	TDCPP, TCPP
Babies R Us Bassinet Pad	CT	TCPP, TDCPP, U-OPFR
Graco Snugride Infant Car Seat	MI	TDCPP
Chicco Key Fit Infant Car Seat	MI	TDCPP, TCPP
Britax Roundabout 50 Convertible Car Seat	NY	TDCPP

** Flame retardant detected at highest concentration listed first.*

From Foam to People

In researching the now phased-out PBDE flame retardants, scientists learned that for some pollutants, ingestion of house dust can be the main source of exposure. Like PBDEs, the Tris flame retardants are additive, meaning they are not chemically bound to the materials they are used in, and are therefore likely to escape from those materials. Tris flame retardants are not yet as well studied as PBDEs, but studies so far indicate that they are building up in house dust as well as in indoor air.

Studies in Sweden conducted in the early 2000s found TDCPP and TCEP in dust collected from homes, a day care center, a hospital, offices, and other public locations. Concentrations ranged up to 94 ppm, with the highest level of TCEP found in a library and the highest TDCPP concentrations in an office. Researchers also tested air for the flame retardants, finding both compounds and concluding that both air and dust

are significant sources of exposure for children and adults. Because of their greater contact with the floor and higher hand-to-mouth contact, children were predicted to have much higher exposures than adults[30].

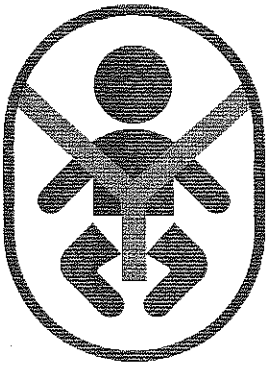
In the U.S., samples of dust from homes in the Boston area contained surprisingly high levels of TDCPP, with 96% of the samples containing the chemical. The mean level was 1,890 parts per billion (ppb), comparable to the levels of PBDEs found in the homes. Some homes had extremely high concentrations, however, leading researchers to conclude that approximately 5% of American homes could have very high levels of the compounds[17].

In a typical U.S. home, Tris flame retardants are most likely to be found in foam-containing items, including upholstered furniture and baby products. The products tested in this study are likely to contribute to contamination of indoor air and house dust with TDCPP and TCEP and thus contribute to human exposures. Infants may have particularly high exposures to the flame retardants from baby products because of their close proximity. Use in car seats is also likely to lead to air and dust exposures inside automobiles.

Table 2: Summary Chart of Flame Retardants Found in Children's Products

Flame Retardant	Number of Products	Types of Products
TDCPP (Chlorinated Tris)	16	Nursing Pillow, Co-sleeper, Changing Pads, Bassinet Pads, Car Seats, Booster Seats, Activity Walker
TCPP	14	Nursing Pillow, Co-sleeper, Changing Pads, Bassinet Pads, Booster Seats, Car Seats, Activity Walker
U-OPFR (unidentified chlorinated organophosphate flame retardant)	6	Co-sleeper, Changing Pads, Bassinet Pads, Car Seat
TCEP	1	Co-sleeper
V6	1	Co-sleeper
Firemaster 550 (TPP, TBB, TBPH)	1	Infant Recliner

Safer Choices



ORBIT BABY, A MANUFACTURER OF STROLLERS, BASSINETS, AND CAR SEATS, REPORTS THAT IT MEETS FLAMMABILITY STANDARDS WITHOUT THE USE OF BROMINATED OR CHLORINATED CHEMICALS.

Flame retardants are used in children's products such as changing pads primarily to meet a flammability standard set by the state of California. This standard applies to furniture and juvenile products only within California, but is widely adhered to by companies with national distribution for their products. Nursing pillows and baby carriers were recently specifically exempted from this standard, known as Technical Bulletin 117. For car seats, a flammability standard under the Federal Motor Vehicle Safety Standards applies.

While many companies use chemical flame retardants to meet these standards, others use alternative materials that do not involve chemical additives. For instance, manufacturers can replace plastic components with non-flammable materials such as metal, glass, or ceramics; polyester fill, such as that typically used in pillows, can replace foam for some uses, meeting standards without added flame retardants[31]. Even with polyurethane foam, barriers can be used and commonly are for mattresses.

When Washington State evaluated alternatives to deca-BDE for upholstered furniture, it concluded that inherently fire-resistant cover materials could be used, such as those made from synthetic fibers, as well as barrier materials[29].

Because of the widespread concern about toxicity of flame retardants containing bromine or chlorine, which describes most of the commonly used flame retardants on the market today, efforts are underway to generate additional safer alternatives. Options under development include a polymer based on a byproduct of cashew nut processing, a silicon-based polymer, nanoclay, and others[32-34]. Alumina trihydrate is also considered a safer, effective option[35].

Orbit Baby, a manufacturer of strollers, bassinets, and car seats, reports that it meets flammability standards without the use of brominated or chlorinated chemicals. Instead, its blend of cotton and wool meets the California standard for juvenile products as well as federal motor vehicle standards for car seats.

Getting Off the Toxic Treadmill

Thirty-five years after passage of what was supposed to be a landmark federal toxics law, most chemical companies and product manufacturers have never made health and safety a priority in their chemical choices. The law doesn't require them to. The Toxic Substances Control Act, passed by Congress in 1976, grandfathered in tens of thousands of chemicals, allowing their use without requiring them to undergo testing or be safe for people and wildlife. New chemicals today must undergo only a perfunctory approval lacking the kind of rigorous testing most Americans would expect.

Our testing of flame retardants in baby products shows that when companies abandoned PBDEs, neurotoxic flame retardants that were building up in people and wildlife, they failed to replace them with a safer option. Instead, most companies reached for a chemical previously removed from children's sleepwear because of safety concerns.

To get us off this toxic treadmill, we need laws that require testing of all chemicals for health and safety and end the use of chemicals that cause cancer, infertility, nervous system harm, and other serious health problems. The Safe Chemicals Act of 2011, introduced in Congress by Senator Frank Lautenberg, would move in this direction. At the state level, a number of states have taken action to ban toxic chemicals including bisphenol A (BPA) and toxic flame retardants. Some are also developing programs to move companies toward safer chemicals, materials, and processes in their products.

Recommendations

The Washington State Legislature should ban toxic Tris flame retardants in consumer products, particularly the carcinogens TCEP and TDCPP.

States were the first to take action on PBDEs, and can take swift action to address this new threat. New York banned TCEP in early 2011, and a number of states will consider bans on Tris flame retardants in 2012. States can't wait for Congress—they need to protect their residents from this immediate threat. At the same time, action at the state level will prompt Congress to act. States are proven laboratories for chemicals policy, showing what actions will succeed in protecting health and providing a model for federal action. State action also motivates industry to seek a federal solution, to avoid a patchwork of regulation across the country.

Washington State should require companies to replace toxic chemicals with safer solutions.

To get off the toxic treadmill, companies need to find safer materials, processes, and chemicals to replace toxic chemicals in products. Without legal requirements, however, only the most health- and safety-conscious companies will take this kind of action. To level the playing field and avoid costly and unproductive substitutions, states should pass legislation requiring companies that use toxic chemicals to conduct thorough assessments and identify safer materials, processes, and chemicals. Eleven states are already working together, as part of the Interstate Chemicals Clearinghouse, to create a common understanding of how companies should assess chemical hazards and identify safer options.

Appendices

Appendix 1:

Complete Results

Table 3: Detailed Results

Product	TCEP (mg/g)	TCPP (mg/g)	TDCPP (mg/g)	"V6" (mg/g)	U-OPFR (mg/g)	Firemaster 550 TPP (mg/g)	Firemaster 550 TBB (mg/g)	Firemaster 550 TBPH (mg/g)	Total Flame Retardants (mg/g)
My Brest Friend Deluxe Nursing Pillow	< 0.04	2.04	30.50	ND	ND	<0.02	<0.02	<0.01	**32.54**
Balboa Baby Nursing Pillow	< 0.04	<0.01	<0.08	ND	ND	<0.02	<0.02	<0.01	**ND**
Mini classic Co-sleeper by Arm's Reach	2.99	17.95	0.64	24.97	X	<0.02	<0.02	<0.01	**46.55**
Munchkin Contour Changing Pad	< 0.04	4.46	40.12	ND	ND	<0.02	<0.02	<0.01	**44.60**
Summer Changing Pad	< 0.04	17.68	25.27	ND	X	<0.02	<0.02	<0.01	**42.95**
Babies R Us Contoured Changing Pad	< 0.04	37.65	17.20	ND	X	<0.02	<0.02	<0.01	**54.85**
Summer Bassinet Pad	< 0.04	19.84	22.30	ND	X	<0.02	<0.02	<0.01	**42.14**
Graco Turbobooster Elite Booster Seat (for auto use)	< 0.04	0.31	34.98	ND	ND	<0.02	<0.02	<0.01	**35.29**
Comfort Deluxe Booster Seat (for auto use)	< 0.04	16.83	24.10	ND	ND	<0.02	<0.02	<0.01	**40.93**
Safety 1st Sounds 'n Lights Activity Walker	< 0.04	1.86	24.78	ND	ND	<0.02	<0.02	<0.01	**26.64**
First Years Co-sleeper	< 0.04	<0.01	<0.08	ND	ND	<0.02	<0.02	<0.01	**ND**
Dex Changing Pad	< 0.04	0.76	23.55	ND	ND	<0.02	<0.02	<0.01	**24.31**
Nap Nanny Infant Recliner	< 0.04	<0.01	<0.08	ND	ND	15.85	20.20	9.75	**45.80**
Cosco Scenera Convertible Car Seat	< 0.04	15.34	0.05	ND	X	<0.02	<0.02	<0.01	**15.39**
Eddie Bauer Pop-up Booster Seat	< 0.04	<0.01	<0.08	ND	ND	<0.02	<0.02	<0.01	**ND**
Nod-a-way Bassinet	< 0.04	9.85	33.04	ND	ND	<0.02	<0.02	<0.01	**42.89**
Babies R Us Bassinet Pad	< 0.04	25.80	16.22	ND	X	<0.02	<0.02	<0.01	**42.02**
Graco Snugride Infant Car Seat	< 0.04	<0.01	50.63	ND	ND	<0.02	<0.02	<0.01	**50.63**
Chicco Key Fit Infant Car Seat	< 0.04	0.43	34.72	ND	ND	<0.02	<0.02	<0.01	**35.15**
Britax Roundabout 50 Convertible Car Seat	< 0.04	<0.01	46.48	ND	ND	<0.02	<0.02	<0.01	**46.48**

Notes:

X: indicates that U-OPFR detected by LC/MSMS, but no standard was available for measurement or confirmation purposes

ND: not detected

Appendix 2:

Detailed Methods

Children's products containing polyurethane foam were purchased in Connecticut, Maryland, Massachusetts, Michigan, New York, and Washington State from major retailers. In most cases, products outside of car seats bore the TB 117 label. An approximately one-inch cube of foam was cut from each product, packaged in aluminum foil and a ziploc bag, labeled with the sample ID, and sent to Duke University for analysis.

Analytical methods are as follows, courtesy of Heather Stapleton, Duke University.

Materials:

Internal standards were purchased from Chiron (Trondheim, Norway) and Wellington Laboratories (Guelph, Ontario). 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB) and bis (2-ethylhexyl)-2,3,4,5-tetrabromophthalate (TBPH) were purchased from Wellington Laboratories. Tris (2-chloroethyl) phosphate (TCEP), tris (1-chloro-2-propyl) phosphate (TCPP) and tris (1,3-dichloroisopropyl) phosphate (TDCPP) were purchased from Sigma-Aldrich (St. Louis, MI), Pfaltz & Bauer (Waterbury, CT), and ChemService (West Chester, PA), respectively. Deuterated standards for TCEP and TDCPP were synthesized by Dr. Vladimir Belov (Goettingen, Germany). Deuterated TPP was purchased from Sigma Aldrich (St. Louis, MI). A commercial mixture of V6 was purchased from a flame retardant manufacturer in China (Hongming Auxiliaries CO., LTD, Jiande, Zhejiang Province, China). All solvents used throughout this study were HPLC grade.

Sample Analysis by Mass Spectrometry:

All foam samples were first screened for flame retardant additives. Briefly, small pieces of foam (approximately 0.05 grams) were sonicated with 1 mL of dichloromethane (DCM) in a test tube for 15 minutes. The DCM extract was syringe-filtered to remove particles and then transferred to an autosampler vial for analysis by gas chromatography mass spectrometry (GC/MS). All extracts were analyzed in full scan mode using both electron ionization (GC/EI-MS) and negative chemical ionization (GC/ECNI-MS). Pressurized temperature vaporization injection was employed in the GC. GC/MS method details can be found in [36]. All significant peaks observed in the total ion chromatograms were compared to a mass spectral database (NIST, 2005) and to authentic standards when available.

If a previously identified flame retardant chemical was detected during the initial screening, a second analysis of the foam sample, using a separate piece of the foam, was conducted for quantitation of detected flame retardants. Methods for extracting and measuring flame retardants in foam are reported in earlier publications[6, 17]. Briefly, approximately 100mg samples of foam were extracted with dichloromethane using accelerated solvent extraction. Extracts were reduced in volume to approximately 2-3 mLs and weighed. Aliquots (100-500 µL) were transferred to 100 mL volumetric flasks and diluted with dichloromethane. A final 1 mL aliquot was then transferred to a GC autosampler vial and the appropriate internal standards (dTCEP, dTDCPP, dTPP or F-BDE 69) were added. The brominated components of the Firemaster 550 mixture, TBB and TBPH, were quantified by GC/ECNI-MS by monitoring molecular fragments m/z 357/471 and 463/515, respectively. TCEP, TCPP, TDCPP, and TPP were quantified by GC/EI-MS by monitoring m/z 249/251, 277/201, 381/383, and 325/326, respectively. V6 was measured using liquid chromatography tandem mass spectrometry (LC/MS-MS) using multiple reaction monitoring (MRM) by integrating responses for the transition from m/z 582.7 to 234.8 and using dTCEP as an internal standard. A five point calibration curve was established for all analytes with concentrations ranging from 20 ng/mL to 2 µg/mL.

Appendix 3:

Glossary

Acronym	Full Chemical Name
DEHP	bis (2-ethylhexyl) phthalate
MEHP	mono (2-ethylhexyl) phthalate
PBB	polybrominated biphenyl
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
TBB	2-ethylhexyl-2,3,4,5-tetrabromobenzoate
TBPH	bis (2-ethylhexyl) tetrabromophthalate
TCEP	Tris (2-chloroethyl) phosphate
TCPP	Tris (1-chloro-2-propyl) phosphate
TDCPP	Tris (1,3-dichloro-2-propyl) phosphate
TPP	triphenyl phosphate

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