FLAME RETARDANTS, HEALTH, AND ENVIRONMENT: HOW PEER-REVIEWED SCIENCE CAN IMPACT REGULATORY DECISION-MAKING

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Abstract:

Historically, regulatory decisions regarding flammability standards have been made without consideration of the health and environmental impacts of chemicals most likely to be used to meet the standards. Major uses of flame retardant chemicals in North America are in 1) electronics 2) building materials and insulation 3) polyurethane foam in furniture, transportation and juvenile products and 4) wire and cable applications. Scientific studies have shown persistence and toxicity of some flame retardant chemicals and bioaccumulation in humans, animals, and the environment. As consumers and decision makers learn of these findings as well as, in some cases, the lack of a documented fire safety rationale for some uses of flame retardants, they can choose alternative methods to maintain fire safety without potential toxicity. Bringing current peer-reviewed science documenting health and environmental impacts of toxic or untested chemicals to the attention of the public and decision-makers can contribute to regulations that reduce their use. As an example, this paper discusses a unique California flammability standard and the chemicals that have been used to meet it. Examples are presented of alternative strategies that can reduce fire hazard without toxicity and how peer-reviewed science can contribute to regulatory decisions that protect health and environment.

Introduction

Technical Bulletin 117 (TB117), a unique California flammability standard, requires the polyurethane foam in upholstered furniture and juvenile products to withstand exposure to a small open flame for twelve seconds[1]. According to the furniture industry, all furniture sold in California and about 25% of furniture sold in the U.S. outside California and in Canada meets TB117. From its implementation in the early 1980s until 2004, TB117 was primarily met with penta-brominated diphenyl ether (pentaBDE), the most studied of the flame-retardants. PentaBDE and the other PBDEs are structurally similar to known human toxicants PBBs, PCBs, dioxins and furans (Figure 1). In addition to having similar mechanisms of toxicity in animal studies[2], PBDEs similarly persist and bioaccumulate in humans and animals[3]. In 1999 and 2001, 98%[4] and 95%[5], respectively, of the usage of pentaBDE, was in North America, in large part to meet TB117. PentaBDE was banned in California in 2003 due to its persistence and toxicity; eight other states and the European Union (EU) followed suit. In 2004, Chemtura, (previously Great Lakes Chemical), the sole U.S. manufacturer, voluntarily ceased production and in 2009 pentaBDE was listed as a persistent organic pollutant under the Stockholm Convention. However PBDEs continue to be global pollutants, moving from reservoirs in consumer products in homes into the biota.

The main replacement for pentaBDE in furniture and juvenile product foam was Firemaster 550, also produced by Chemtura, a mixture of four flame retardant chemicals whose composition was a trade secret. In 2004, the EPA Design for the Environment predicted reproductive, neurological, & developmental toxicity and persistent degradation products from Firemaster 550[6]. In 2005, Chemtura agreed to conduct reproductive and developmental toxicity and migration studies by January 2009. Data provided by Chemtura in November 2008 is currently being evaluated by the EPA. Firemaster 550 components include: (1) triphenyl phosphate (highly eco-toxic) (2) Triaryl phosphate isopropylated (probable reproductive toxin) (3) Bis (2-ethylhexyl) tetrabromophthalate (4) 2-ethylhexyl-2,3,4,5-tetrabromobenzoate[7]. Components of Firemaster 550 are found in dust[7] and sewage sludge[8]. Firemaster 600, as described on the Chemtura website with a composition that is a trade secret, is beginning to replace Firemaster 550.

Today, tris (1,3-dichloro-2-propyl) phosphate, also called chlorinated tris, TDCP is another widely used flame retardant for polyurethane foam. It is produced by ICL under the trade name Fyrol and by Albermarle under the trade name Antiblaze. The U.S. Consumer Product Safety Commission (CPSC) estimates the lifetime cancer risk from tris-treated furniture foam is up to 300 cancer cases/million[9]. Their chronic hazard guidelines define a substance as hazardous if lifetime cancer risk exceeds one in a million.

In addition to driving the use of toxic and untested flame retardant chemicals in the U.S., TB117 has led to the production of these chemicals in foam and furniture manufacturing plants across the south of China. The production capacity of flame retardants in China has gone from about 50 kilotons in 1993 to about 350 in 2006[10,11,12]. In 1999, China produced about 2.5 kilotons of the brominated flame-retardants annually; by 2006, about 80 kilotons were being produced[11,13]. The market share for the more toxic halogenated flame retardant chemicals is estimated to be about 20% in the EU and U.S. and about 55% in China[14].

While halogenated flame-retardants have attracted much attention from the scientific and environmental communities, key toxicity data on most flame-retardants is lacking. To meet government and industry standards, these chemicals are commonly used at levels up to 10% by weight of foam and 30% of the weight of the plastic of electronic housings

Halogenated flame-retardants are often semi-volatile and not covalently bound to the polyurethane foam or plastic to which they are added. Over time the chemicals can disassociate from the foam or plastic and migrate into dust, and then into humans and pets. They then move into the outdoor environment, wild animals, and the food supply. Many of the flame-retardants used in consumer products are found in house dust, dryer lint,[8] and believed to form thin films on walls and windows[15]. Toddlers and young children have much higher levels of pentaBDE than their mothers[16]. Californians have higher levels in their house dust and body fluids than residents of other states[17].

PBDEs and replacements also pose serious recycling and end of life problems**.** When electronics treated with flame retardant chemicals are exported to China, they are often burned, which can result in the production of brominated and chlorinated dioxins and furans[18]. Some brominated dioxins are ten times more toxic than chlorinated dioxins[18].

The contribution of flame retardant chemicals to reducing fire deaths has not been well documented in the peer-reviewed literature. California's TB116, a cover fabric flammability standard for furniture, is voluntary. TB117's effectiveness may be limited because after the fabric is burning, the foam can also ignite. The U.S. National Fire Protection Association (NFPA) data does not show a greater reduction in the rate of fire deaths in California than in other states that do not have furniture flammability standards (Figure 2). A 2008 National Fire Protection Association (NFPA) analysis focused on home fires that began with upholstered furniture is not detailed nor complete enough to show whether adding fire retardant chemicals to furniture foam in California since 1980 has made a measurable difference in fire deaths in that state.

Results and Discussion

In the following cases, the use of toxic or untested flame-retardants in consumer products has been reduced or eliminated after peer-reviewed scientific information was brought into regulatory decision-making:

(1) During the middle of the 1970s, the flame-retardant chemicals brominated tris [tris (2,3-dibromopropyl) phosphate] and chlorinated tris were used at levels of up to 10% of the weight of children's sleepwear fabric, and not covalently bonded to fabric. Brominated tris was found to be quickly absorbed in children's bodies, with 2,3-Dibromopropanol, a mutagenic and carcinogenic metabolite, found in a child's urine after wearing tris-treated sleepwear for only one night[19]. After studies documented their mutagenicity[20,21], both forms of tris were removed from use in children's sleepwear. Brominated tris and chlorinated tris are carcinogenic in animal studies and are also probable human carcinogens[22,6].

(2) Three international standards requiring that plastic enclosures around consumer electronics products resist external ignition from a small open flame, such as a candle flame, were proposed to the International Electrotechnical Commission (IEC) in 2002 and passed a series of votes in 30 countries through 2008. Household electronics products are well protected against potential ignition from internal heat sources by existing electronic flammability standards. The candle flame ignition requirement would have, if approved, resulted in the addition of hundreds of millions of pounds of flame retardant chemicals to consumer electronics each year[23]. In reviews of the U.S. fire statistics, NFPA found a negligible fire hazard from candle flame ignition of consumer electronics[24,25]. Some of the chemicals likely to have been used to meet the standard are known to be toxic and persistent; the rest lack adequate health and environmental data. These chemicals would have made the recycling and reuse of plastic from consumer electronics more difficult and expensive. A white paper[23] summarizing the peer-reviewed science

documenting the adverse health and environmental impacts of the chemicals most likely to be used to meet the standard contributed to the defeat of five electronic housing flammability standards in 2008[26].

(3) The U.S. Consumer Product Safety Commission, or CPSC, is moving forward with a staff draft federal furniture standard that addresses fire safety without the use of flame-retardant chemicals in polyurethane foam[27]. Peer-reviewed science documenting the potential for adverse health and environmental impacts and an economic analysis quantifying the large potential human health cost of the chemicals most likely to be used to meet a small open flame standard for foam, contributed to a decision for a smolder-only standard for fabric. A previous CPSC flammability standard, similar to TB117, which would have led to the increased use of fire-retardant chemicals in furniture foam, had been under consideration, but was removed from the current staff draft due in part to health and environmental concerns[28].

(4) The U.S. Senate Commerce Committee decided to eliminate Section 25 of the Senate CPSC Reform Act of 2008, which would have required open flame standards for foam in furniture, a de facto requirement for the use flame retardant chemicals. This decision was made after presentations of the peer-reviewed science documenting the adverse human health and environmental impacts of the chemicals most likely to be used.

(5) Illinois, Pennsylvania, New Jersey, and New York all considered enacting open flame requirements for furniture and juvenile products modeled on California's TB117 in 2007. After being informed of the scientific research documenting the toxicity of flame retardant chemicals and lack of proven benefits of TB117, these states decided not to move forward with the proposed standards.

(6) A review of the extensive scientific literature showing the neurotoxicity of the parent compound BDE-209 and the likely breakdown of BDE-209 to lower more toxic forms in the environment[29] contributed to the regulation of the use of decaBDE in the European Union[30], as well as the states of Washington[31], Maine[32], and Vermont[33].

Conclusions

Peer-reviewed science can help assess the fire hazards and costs to human health and the environment of flame-retardant chemicals, thus showing the importance of finding non-toxic methods of fire prevention. For example, reducing sources of ignition can prevent fires without adding chemicals to consumer products. A 60% decrease in fire deaths in the United States since 1980 parallels the decrease in per capita cigarette consumption,[3435] increased enforcement of improved building, fire, and electrical codes; and the increased use of smoke detectors and sprinklers. An estimated 65% of reported home fire deaths in 2000-2004 resulted from fires in homes without working smoke alarms[36].

Recent state laws mandating fire-safe cigarettes[37] and a voluntary industry standard for fire-safe candles promise further reductions in fire death and injury. Fire-safe candles are wider for stability and have shorter wicks on top that do not extend all the way to the bottom of the candle. Fire-safe cigarettes have "speed bumps" of thicker paper that stop the flow of oxygen and smoldering of the cigarette. If left unattended or if the smoker falls asleep, the cigarette will extinguish itself when it reaches a speed bump, rather than smoldering and starting a fire. The European Union and 44 U.S. states have passed legislation requiring fire-safe cigarettes.

Nonetheless, a number of current and pending standards, regulations, and legislation would lead to the use of flame retardant chemicals without consideration of potential adverse health or environmental impacts, and in some cases, without a demonstrated fire safety benefit:

(1) Plastic pallets with 3.5 pounds of decaBDE laminated on the outside are being promoted as having greater fire safety than wooden pallets, although wooden pallets have not been shown to pose a fire hazard. When dragged across a cement warehouse floor, plastic pallets coated with decaBDE are likely to leave decaBDE in dust, exposing forklift drivers and food stored on the pallets to decaBDE dust.

(2) Polyurethane and polystyrene building insulation materials are usually treated with halogenated flame-retardants. For example, hexabromocyclododecane (HBCD), currently used in all polystyrene building insulation, is persistent, bioaccumulative, and toxic and also included on the first EU list of sixteen "Substances of Very High Concern." HBCD is now found in household dust, breast milk, sewage sludge and in wildlife in increasing levels. Building

materials that have no potential fire hazard, such as insulation between building foundations and the soil, are treated with HBCD.

(3) Although juvenile products have not been shown to pose a fire hazard, California Technical Bulletin 117 de facto requires foam in products such as high chairs, nursing pillows, and changing pads to be treated with flame-retardants.

(4) California Technical Bulletin 604, if implemented, would lead to flame retardant chemicals or materials lacking health information in bed coverings such as comforters, mattress pads, and pillows. Since of the implementation of a stringent fire safety standard for mattresses and regulations for fire safe cigarettes, there is a lack of current data demonstrating the fire safety benefit for a bedcovering fire standard.

The addition of flame retardant chemicals to foam and plastic usually slows combustion by seconds and can only meet a moderate flammability standard. The severe new U.S. flammability standard for mattresses has been met by a barrier technology rather than the addition of chemicals. In mattresses, flame retardant polymeric fabrics are wrapped around the foam to serve as a barrier to ignition. The CPSC estimates that this standard will prevent 78% of deaths from fires that originate in mattresses[38]. Possibly a related technology could be used to protect the foam inside furniture from ignition. Other design alternatives, such as making electronics of metal, glass, or ceramics instead of plastics, can reduce flammability without chemicals[39]. In homes, reducing sources of ignition, alternative strategies, and technologies can lead to increased fire safety without the potential health and environmental hazard from toxic or unknown chemicals.

In some cases flame-retardant chemicals appear to provide a benefit. For example, a few seconds delay of ignition following an airplane crash is predicted to save lives[40]. In such cases, health and environmental information about the flame-retardants should be required before use. Movement to safer alternative chemicals and technologies should be encouraged.

Flame-retardant chemicals in our homes should not pose a potentially greater hazard to our health and environment than the risk of the fires they are supposed to prevent. Equivalent or greater fire safety can be achieved with new technologies and materials, product design, and green chemistry. Decision makers should use peer-reviewed science to evaluate fire safety benefits as well as health and environmental risks prior to promulgating new requirements leading to the use of flame-retardant chemicals.

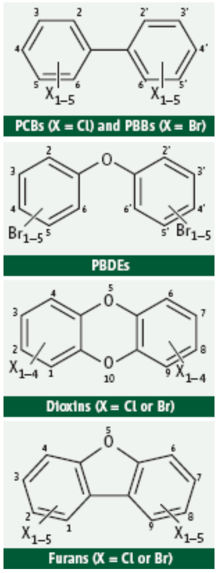


Figure 1. PBDEs are structurally similar to known human toxicants PBB, PCBs, dioxins and furans.

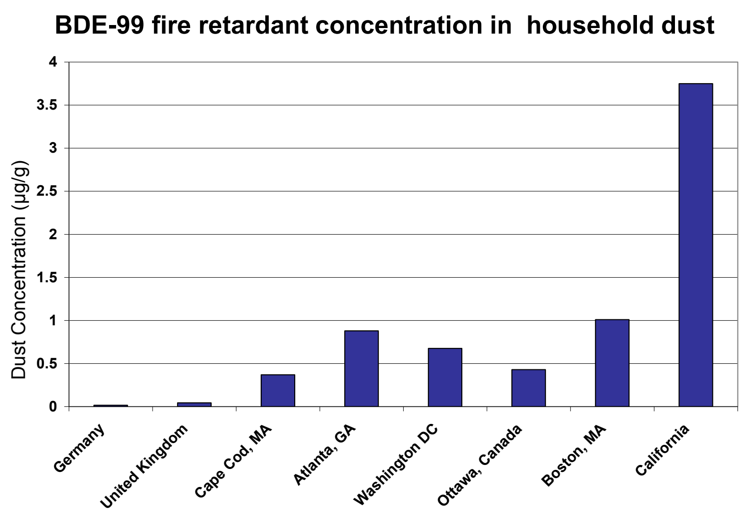
5 Year Averages of Fire Deaths

1980-1984 Compared to 1995-1999

National Fire Protection Association Report, June 2006

California	down 32%
Texas	33%
New York	40%
Florida	31%
Pennsylvania	30%
Illinois	39%
Ohio	39%
Michigan	30%

Figure 2. California's decline in fire death rate from 1980-1984 to 1995-1999 was consistent with those of the other seven largest states in the U.S., which do not have fire safety regulations for furniture.



Source: **Elevated House Dust and Serum Concentrations of PBDEs in California: Unintended Consequences of Furniture Flammability Standards?** Zota, Ami R.,et al, Environ. Sci. Technol., 2008, 10.1021/es801792z

Figure 3. Median concentration of BDE-99 in household dust in different locations.

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