BERKELEY LAB
ENVIRONMENTAL ENERGY
TECHNOLOGIES DIVISION

Sept. 11, 2014

I, Donald Lucas, am writing this statement in support of the Petition to the CPSC to regulate four categories of household products containing non-polymeric additive organohalogen flame retardants.

1. I am a scientist at the Lawrence Berkeley National Laboratory (LBNL) and a Professional Researcher in the School of Public Health at the University of California, Berkeley (UCB). I officially retired in 2011, but I continue to perform research in the areas of combustion byproducts at LBNL, UCB, and the Energy and Resources Group at UCB. Before retiring I was a Principal Investigator in the Combustion Group of the Environmental Energy Technologies Division (EETD), and was a Deputy Director for EETD and the Environment, Health, and Safety Division. I am on the Executive Committee for the International Congress on Toxic Combustion Byproducts and their Health Effects, and received their Adel Sarofim Award in 2013. I also serve as a consultant to the Green Science Policy Institute. I received a B.S. in Chemistry from the Illinois Institute of Technology in 1972 and a Ph.D. in Physical Chemistry from the University of California, Berkeley in 1977. I have attached a copy of my curriculum vitae and a list of my scientific publications.

2. Based on my expertise, it is my opinion that, in the case of fires, organohalogen flame retardants used in plastic, foam, fabrics, and other products in residences can lead to the formation of increased amounts of toxic combustion byproducts. It is also my opinion that, as currently used, organohalogen flame retardants do not provide fire safety benefits that justify their use (Talley, 1995; Mehta, 2012; Blais and Carpenter, 2013; Tao, 2005; BEARHFTI, 2002; Babrauskas, 1983; Schuman and Hartzell, 1987). Other experts I collaborate with have described the human and environmental health effects associated with organohalogen flame retardants and their combustion byproducts, so my statements below will be limited to the formation of products of combustion.

3. Organohalogen flame retardants are used in products and assemblies such as electronic enclosures, furniture foam, building insulation, and other items, but they do not make the products flameproof. If a large enough ignition source is involved, flaming combustion of fire-retarded items can occur; for smaller ignition sources, smoldering combustion may happen.

4. Most fire deaths and injuries result from inhalation of smoke containing narcotic/asphyxiant and/or irritant combustion byproducts such as toxic gases and particulates (Hall 2011; Stec and Hull, 2010). These combustion byproducts may be directly toxic or cause such irritation that they impair vision and breathing, ultimately resulting in incapacitation. In addition to the combustion products of immediate concern for survival in a fire, other harmful by-products including halogenated dioxins and furans (generally referred to as dioxins) can cause chronic health effects in those exposed to the fires, contaminate the air, soil, and water long-term, and spread from the

fire site when burned materials are removed.

5. Though in some sense every fire is different, a few factors most strongly influence toxic product yield. These factors include material composition, such as the presence or absence of organohalogen flame retardants (Stec and Hull, 2010). The incorporation of organohalogen flame retardants into the material composition can increase the generation of combustion byproducts of concern for both acute and chronic fire toxicity, for reasons described in detail below.

6. Fire effluents from the combustion of materials containing organohalogen flame retardants can be **more acutely toxic** for the following reasons:

i. Greater amounts of irritant gases, such as hydrogen chloride (HCl) or hydrogen bromide (HBr) combustion products, and particulate matter of varying size and toxicity can be produced (Stec and Hull, 2010). In fact, these irritant gases are the active fire retardant species, which act by preventing the complete oxidation of the fuel to carbon dioxide and water. HCl and HBr can cause incapacitation, reducing ability to escape a fire. If inhaled, these can also penetrate deep into the lung and injure tissue. If a fire occurs where large amounts of materials with added organohalogen flame retardants burn, significant amount of HCl or HBr will be produced, since HCl and HBr are the thermodynamically favored products for organohalogen flame retardants. For example, furniture foam with chlorinated flame retardants can produce 10 grams of HCl per kg of foam burned for every 1% by mass of chlorine it contains (the amount of halogenated fire retardants in foam varies, but it is commonly used at levels up to 5% (Allen et al., 2008). While the actual concentration depends on the room size and ventilation rate, it should be noted that the American Conference of Governmental Industrial Hygienists (ACGIH) ceiling limit for HCl is 2 ppm, and that in a small room (50 m^3) with little ventilation, 100 ppm of HCl can be produced by 1 kg of burning foam.

ii. Greater amounts of asphyxiant/narcotic gases that are combustion byproducts, such as carbon monoxide and hydrogen cyanide, can be produced, leading to loss of consciousness and ultimately death if people are exposed to high levels or for long amounts of time (Braun et al., 1987; Levin et al., 1985; Purser, 1990, Krasny et al., 2001).

iii. Greater amount of soot and smoke can be produced, which obscures visibility and impedes escape. The action of chlorine and bromine radicals from organohalogen flame retardants can prevent the complete oxidation of the hydrocarbons present in most fires, resulting in higher yields of partial combustion products, which are apparent as greater amounts of soot and smoke (Stec and Hull, 2010).

7. In addition to increasing the amount of acutely toxic gases and particles produced, the presence of organohalogen flame retardants in products during fires can increase the amounts of persistent organic pollutants produced by combustion processes, thus **increasing the chronic toxicity of fires**.

8. In particular, incomplete combustion of products containing organohalogen flame retardants leads to the formation of halogenated dioxins and furans, substances that are considered amongst

the most toxic chemicals known (Ebert and Bahadir, 2003; Babrauskas et al., 1988; Weber and Kuch, 2003).

9. Based on my research and knowledge of fire toxicity, I support regulations that prevent the use of organohalogen flame retardants in the four categories of consumer products covered in this petition.

Donald Lucas, Ph.D.
Lawrence Berkeley National Laboratory
Berkeley, CA 94720
510-316-6764
D_lucas@lbl.gov

References

J. G. Allen, M. D. McClean, H. M. Stapleton, and T. F. Webster, "Linking PBDEs in house dust to consumer products using X-ray fluorescence.," *Environ. Sci. Technol.*, vol. 42, no. 11, pp. 4222–8, Jun. 2008.

V. Babrauskas, "Upholstered Furniture Heat Release Rates: Measurements and Estimation," *J. Fire Sci.*, vol. 1, no. 1, pp. 9–32, Jan. 1983.

V. Babrauskas, R. Harris, R. G. Gann, B. C. Levin, B. T. Lee, R. D. Peacock, M. Paabo, W. Twilley, M. F. Yoklavich, and H. M. Clark, "Fire Hazard Comparison of Fire-Retarded and Non-Fire-Retarded Products," *NBS Spec. Ed. 749. Natl. Bur. Stand., Gaithersbg. MD*, 1988.

BEARHFTI. Technical Bulletin 117 Draft 2/2002: Requirements, Test Procedure and Apparatus for Testing the Flame and Smolder Resistance of Upholstered Furniture. Sacramento, CA: California Bureau of Electronic and Appliance Repair Home Furnishings and Themal Insulation. February.

M. Blais and K. Carpenter, "Flexible Polyurethane Foams: A Comparative Measurement of Toxic Vapors and Other Toxic Emissions in Controlled Combustion Environments of Foams With and Without Fire Retardants," *Fire Technol.*, 2013.

E. Braun, B. C. Levin, M. Paabo, J. Gurman, T. Holt, and J. Steel, *Fire Toxicity Scaling: NBSIR 87-3510. Gaithersburg, MD: U.S Department of Commerce, National Bureau of Standards*. 1987.

J. Ebert and M. Bahadir, "Formation of PBDD/F from flame-retarded plastic materials under thermal stress.," *Environ. Int.*, vol. 29, no. 6, pp. 711–6, Sep. 2003.

J. Hall, Fatal Effects of Fire. (2011). at <http://www.nfpa.org/~/media/Files/Research/NFPA%20reports/Overall%20Fire%20 Statistics/osfataleffects.pdf>

J. Krasny, W. J. Parker, and V. Babrauskas, *Fire Behavior of Upholstered Furniture and Mattresses*. Norwich NY: Noyes Publications / William Andrew Publishing, LLC, 2001.

B. C. Levin, M. Paabo, M. Lou Fultz, and C. S. Bailey, "Generation of hydrogen cyanide from flexible polyurethane foam decomposed under different combustion conditions," *Fire Mater.*, vol. 9, no. 3, pp. 125–134, Sep. 1985.

S. Mehta, "Upholstered Furniture Full Scale Chair Tests – Open Flame Ignition Results and Analysis. U.S. Consumer Product Safety Commission. [Memorandum]," 2012.

D. A. Purser, "The Development of Toxic Hazard in Fires from Polyurethane Foams and the Effects of Fire Retardants.' in *Flame Retardants '90*, London: Elsevier Applied Science Publishers, 1990, pp. 206–221.

J. G. Schuhmann and G. E. Hartzell, "Flaming Combustion Characteristics of Upholstered Furniture," *J. Fire Sci.*, vol. 7, pp. 368–402, 1989.

A. Stec and R. Hull, *Fire Toxicity*. Woodland Publishing in Materials, 2010.

R. Weber and B. Kuch, "Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated – chlorinated dibenzodioxins and dibenzofurans," vol. 29, pp. 699–710, 2003.