Earth Sciences
UNIVERSITY OF TORONTO

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I, Miriam L. Diamond, 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. Personal Information. I am a Professor in the Department of Earth Sciences at the University of Toronto with cross appointments in the Department of Chemical Engineering and Applied Chemistry, Dalla Lana School of Public Health, School of the Environment, and Department of Physical and Environmental Sciences at the University of Toronto. I received a B.Sc. from the University of Toronto in 1976, a M.Sc. in Zoology from the University of Alberta in Edmonton Alberta in 1980, a M.Sc.Eng. in Mining Engineering from Queen's University in Kingston, Ontario, and a PhD. in Chemical Engineering and Applied Chemistry from University of Toronto in 1990. My research concerns the sources, emissions and fate of environmental chemicals and exposure of these chemicals to humans and ecosystems. I am a Fellow of the Royal Geographic Society. I have served on the Board of Directors and Executive Committee of the Society of Environmental Toxicology and Chemistry, and have been an Associate Editor of the journal *Environmental Science and Technology*, the leading journal in the field, since 2012. I have held the INNOLEC Science Guest Chair in Chemistry, Masarykova Univerzita, Czech Republic, been a visiting scholar in the Department of Applied Environmental Science at Stockholm University, and the Joseph R. Meyerhoff Visiting Professorship at the Weizmann Institute in Israel. In 2008 I was appointed by the Minister of Environment of the Province of Ontario to co-chair the Toxics Reduction Scientific Expert Panel that brought in Canada's first Toxic Reduction Act. I have served on numerous advisory panels for the U.S. Environmental Protection Agency and on a National Academies of Sciences expert panel, and I am a member of the Canadian Chemicals Management Plan Science Committee. I have attached my CV and list of publications.

2. Personal Expertise. A major focus of my research has been documenting emissions and fate of semi-volatile organic compounds or SVOCs (those with boiling points between 240° and $400^{\circ}C$ according to WHO 1997[1]) in the indoor and outdoor urban environments. In 2005 we published the first paper to show that household dust, and not diet, was a major exposure route of the flame retardant polybrominated diphenyl ethers (PBDEs). This marked a radical shift in understanding sources and pathways of these and other SVOCs that are used in consumer products.[2] We were also the first to quantitatively estimate the emissions and fate of PBDEs in an indoor environment using a mathematical model that we developed[3,4] and, in conjunction with Prof. Stuart Harrad of the University of Birmingham, we measured house dust levels of organohalogen flame retardants.[5,6,7] Additionally, we documented the release into the indoor environment of deca-BDE, although it had not been expected to migrate from the products to which it was added because of its very low vapour pressure.[8]

3. Working with colleagues, we have measured concentrations of PBDEs in indoor dust, and in indoor and outdoor air that originate from indoor products and building materials.[9,10,11,12] Our data show that PBDEs migrate from consumer products into the indoor air and dust, and from there make it into the outdoor environment. In this study, we measured the geographic pattern of PBDE outdoor air concentrations at locations across Toronto, Canada, and found that it coincides with the inventory of PBDE-containing products found indoors.[13,14,15] In other words, we determined that PBDEs were migrating from consumer products into the indoor air, and then into outdoor air. The only plausible explanation for this spatial pattern of PBDEs in outdoor air is that the PBDEs migrated out of consumer products, as industries using PBDEs do not have this geographic pattern in Toronto.

4. Other organohalogen flame retardants in addition to PBDEs migrate from consumer products into the indoor environment, including into house dust. We determined this by sampling and analyzing 12 additive organohalogen flame retardants plus PBDEs in the surface wipes of casings of electronic and electrical equipment and the dust of 35 homes in the Toronto area.[16] We found particularly elevated concentrations of penta-, octa- and decaBDE mixtures, tris(1,3-dichloro-2-propyl)phosphate (TDCPP), tetrabromobenzotriazole (TBB), bis(2-ethylhexyl) tetrabromophthalate (TBPH), decabromodiphenyl ethane (DPDPE) and octabromotrimethylphenylindane (OBIND) in both surface wipes and house dust samples.[17,18,19]

5. In points 3 and 4, I explained that specific organohalogen flame retardants migrate from consumer products to indoor and outdoor air based on evidence from measurements. We know that organohalogen flame retardants as a class (not just the specific chemicals we identified in house dust) tend to migrate out of consumer products because they are typically used in additive form (i.e. not chemically bonded to the materials containing them) and because of their physical-chemical properties.[20] The first critical physical-chemical property is that organohalogen flame retardants are semi-volatile organic compounds (SVOCs) and the second property is that these compounds are persistent indoors:

> i) Organohalogen flame retardants as a class are SVOCs[20]. According to the U.S. EPA,[21] a chemical can be classified as a SVOC if its boiling point (a physical-chemical property) is greater than that of water and may vapourize (change from liquid or solid phase to vapour phase as measured by a chemical's vapour pressure) at or above room temperatures. A SVOC can exist simultaneously in a solid phase (i.e., as a flame retardant in a polymer), AND in the vapour phase (i.e., in air). The significance of these flame retardants being SVOCs is that over time, some of the molecules of an organohalogen flame retardant added to a polymer will migrate into air. The migration is purely a function of the chemical being a SVOC and that it is added to, rather than reacted with or bound to, the polymer.
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> ii) Organohalogen flame retardants are persistent indoors. Their persistence is a desired property for a flame retardant, i.e., the molecule will not break down during the life time of the product to which it has been added. However, the implication of this persistence is that the chemical will not break down indoors after it has migrated from the product.

6. The phenomenon of human exposure to constituents in house dust has been well established in the asthma and allergy field.[22] As noted above, our exposure analysis demonstrated that house dust is also a major source of human exposure to penta- and octaBDEs.[23] This finding has been corroborated by other exposure studies, including studies of organohalogen flame retardants in addition to PBDEs.[24,25,26,27] However, the most recent research suggests that organohalogen concentrations in house dust may be a proxy for another exposure pathway, that of direct transfer from product-to-hand, followed by hand-to-mouth transfer.[28,29] In other words, the most recent research indicates that humans are exposed to organohalogen flame retardants by touching consumer products in which these chemicals are present in additive form and by touching house dust which also contains organohalogen flame retardants. The measurement of organohalogen flame retardants in house dust is thus an indicator of the levels of organohalogen flame retardants in the home that residents come into contact with, both when they touch consumer products containing these chemicals and when they touch or inhale the dust itself.

7. In summary, there is a sufficient body of knowledge to conclude that all organohalogen flame retardants – because they are SVOCs – will tend to migrate out of the consumer products in which they are present in

additive form, resulting in human exposure. Once released indoors, organohalogen flame retardants will accumulate in indoor dust, and they are persistent in the indoor environment. Humans are exposed to organohalogen flame retardants as a result of direct contact with consumer products and with indoor dust containing these compounds. The inevitability of this human exposure, combined with the evidence showing that these compounds have toxicity, leads to the conclusion that all organohalogen flame retardants present in consumer products in additive form pose significant risks to human health.

I therefore urge the CSPC to ban the use of additive organohalogen flame retardants in the four consumer product categories covered in this petition.

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