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Review

BDE-209 in the Australian Environment: Desktop review

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ABSTRACT

The commercial polybrominated diphenyl ether (PBDE) flame retardant mixture c-decaBDE is now being considered for listing on the Stockholm Convention on Persistent Organic Pollutants. The aim of our study was to review the literature regarding the use and detection of BDE-209, a major component of c-decaBDE, in consumer products and provide a best estimate of goods that are likely to contain BDE-209 in Australia. This review is part of a larger study, which will include quantitative testing of items to assess for BDE-209. The findings of this desktop review will be used to determine which items should be prioritized for quantitative testing. We identified that electronics, particularly televisions, computers, small household appliances and power boards, were the items that were most likely to contain BDE-209 in Australia. Further testing of these items should include items of various ages. Several other items were identified as high priority for future testing, including transport vehicles, building materials and textiles in non-domestic settings. The findings from this study will aid in the development of appropriate policies, should listing of c-decaBDE on the Stockholm Convention and Australia's ratification of that listing proceed.

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1. Introduction

Since the 1970'1970′s flame retardants have been used in a diverse array of petroleum-based consumer products, including textiles, foam, electronics and electrical equipment [1]. Polybrominated diphenyl ethers (PBDEs) are synthetic bromine based flame retardants that have been amongst the most abundantly used flame retardants. Including isomers, there are 209 different possible types of brominated diphenyl ethers, called congeners. Historically, three commercial mixtures of PBDEs have been or still are used, known as c-octaBDE, c-pentaBDE and c-decaBDE. The BDE-209 congener is the major component of c-decaBDE, see Fig. 1 [2]. Global commercial production of BDE-209 is estimated to have begun in the 1960′s to early 1970′s [3]. By 2010, approximately 1.3 million tonnes of c-decaBDE had been produced worldwide [3].

The main application of c-decaBDE is in high impact polystyrene (HIPS) used in consumer goods, particularly electronic goods, although it also has applications in a wide range of additional commercial polymers, including acrylonitrile butadiene styrene (ABS), rubber, polyvinyl chloride, and polycarbonates [1]. Another major application of c-decaBDE is to treat textiles, including upholstery materials for the aviation and automotive industries (seat covers and carpets), as well as textiles used for domestic and commercial furnishings, including carpets, furniture upholstery and curtains [1,4]. Estimates of how much c-decaBDE has been used for each of these purposes vary greatly. For example, applications in electrical appliances and equipment are estimated at anywhere from ~13-80% of total usage; whilst applications to textiles and building and construction are estimated to account for 10–26% and 26% of total usage, respectively [5–7].

PBDEs are semi-volatile additive flame retardants. PBDEs are not physically bonded to polymers or textiles and may be released from their point source by off-gassing (volatilization), directly partitioning from their point source into other materials and via abrasion [8–11]. The widespread use of PBDEs in items commonly found in homes leads to contamination of the indoor environment, particularly of household dust [12,13]. Once in the environment, PBDEs can debrominate to form lower BDE congeners and can also form other products, such as bromophenols, furans and dioxins [14–19]. The relevance of debromination to human exposure may be most pronounced for BDE-209, the dominant congener in dust [20,21]. Infants and toddlers have the highest intake of BDE-209, which is likely due in large part to intake via dust, due to greater dust ingestion rates (55–200 mg/day) compared to adults (4–100 mg/day) [22].

As with other persistent chemicals capable of long-range transport that have been produced in large volumes, BDE-209 has been detected in environmental samples of soil, sediment, leachate, sewage, dust, mammals, birds and fish [13,20,23–34]. Biomonitoring studies have found BDE-209 in human blood serum [35,36], breast milk [37–40], cord blood [41], placenta [42,43] and infant faeces [44]. However, as with all PBDE congeners, there is limited data on human health effects associated with exposure to BDE-209. Studies suggest an association between BDE-209 and impaired cognitive development and delayed neurological development in early life [45,46]. As summarised and detailed in Costa and Giordiano [47], animal studies report BDE-209 may cause developmental neurotoxicity, affecting motor and cognitive domains, as seen for other PBDEs, including BDE-47 and BDE-99. Its acute and chronic toxicities are relatively low, with the liver and the thyroid as the primary targets, though there is some evidence of carcinogenicity [47]. Limited in vivo and in vitro studies have also evidenced effects of BDE-209 on thyroid hormone homeostasis and direct effects on nervous system cells [47].

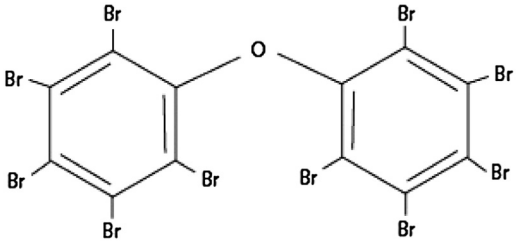

Fig. 1. Chemical Structure of BDE-209.

Concerns over the bioaccumulation potential, persistence, long-range transport and toxicity of the congeners found in c-octaBDE and c-pentaBDE resulted in their addition to the Annexes of Stockholm Convention in 2009. Now c-decaBDE is being considered for listing on the Stockholm Convention [48]. To inform decision making on how best to manage BDE-209 in the Australian context, in particular with regards to listing on the Stockholm Convention, we reviewed the extent of use of BDE-209 in Australian consumer products. This review forms the first part in a larger study that will include quantitative testing of BDE-209 in goods. We aim to provide a best estimate of which goods are likely to contain BDE-209 in Australia and also identify areas of uncertainty. This will enable prioritisation of testing in the subsequent component of this study.

2. Methods

To provide a best estimate of products likely to contain BDE-209 in Australia we undertook the following:

- A review of standards and codes pertaining to flammability in Australia, to identify products that may require treatment with flame retardants (we did not search for flammability standards pertaining to electronics and electrical appliances, as it has previously demonstrated that BDE-209 is likely to be found in these products [52])
- A review of grey-literature (industry, government and technical) reports regarding reported uses of BDE-209
- A review of scientific reports assessing products for their BDE-209 content, to identify any further items that may contain BDE-209, as well as to provide a best estimate for likely concentrations of BDE-209 in treated items

We initially sought to clarify some uses of BDE-209 by contacting major Australian manufacturers or organisations in the relevant areas of uncertainty. Attempts to obtain information through this approach proved extremely difficult and the information obtained (if available) was neither specific nor informative to the Australian context. We were therefore unable to pursue this aspect of the approach further.

Using the information obtained, we then provided an estimate of the likelihood of specific goods containing BDE-209 in Australia.

3. Results

Despite the dearth of primary scientific reports, we identified a variety of other sources of information regarding potential applications of BDE-209 in Australia. We identified several standards and one code, the Building Code of Australia (BCA), pertaining to flammability of items being manufactured, sold or used in construction within Australia (Fig. 2), which we believe may be important drivers of the use of flame retardants in these materials.

Several informative grey literature reports were identified. The most comprehensive industry report of BDE-209 applications is provided by the Bromine Science and Environmental Forum (Table 1) [51]The reference text "Flame Retarded Materials",