The Draft Environmental Screening Assessment of Tetrabromobisphenol A in Canada

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Introduction

The *Canadian Environmental Protection Act, 1999* (CEPA 1999) requires that the Minister of the Environment and the Minister of Health conduct screening assessments of substances that meet the categorization criteria set out in the Act and Regulations to determine, in an expeditious manner, whether substances present or may present a risk to the environment or to human health. Based on the results of a screening assessment, the Ministers can propose taking no further action with respect to the substance, adding the substance to the Priority Substances List (PSL) for further assessment, or recommending that the substance be added to the List of Toxic Substances in Schedule 1 and, where applicable, the implementation of virtual elimination.

Materials and Methods

A screening assessment involves an analysis of a substance using readily available information to determine whether the substance is "toxic" or capable of becoming "toxic" as defined in CEPA 1999. This environmental screening assessment examines various supporting information and develops conclusions based on a weight of evidence approach as required under Section 76.1 of CEPA 1999. The screening assessment does not present an exhaustive review of all available data; rather, it presents the most critical studies and lines of evidence supporting the conclusions. One line of evidence includes consideration of risk quotients to identify potential for ecological effects. However, other concerns that affect current or potential risk, such as persistence, bioaccumulation, chemical transformation and trends in environmental concentrations, are also examined in this assessment.

Results and Discussion

The brominated flame retardant tetrabromobisphenol A (TBBPA; CAS RN 79-94-7) and two derivative compounds, ethoxylated TBBPA (CAS RN 4162-45-2) and TBBPA allyl ether (CAS RN 25327-89-3), are on the Domestic Substances List (DSL) and were identified in a Pilot Project list of 123 substances selected as candidates for screening assessments based on chemical attributes which suggest they may be environmentally persistent and inherently toxic to non-human organisms.

TBBPA is used primarily as a reactive flame retardant in flame-retarded epoxy and polycarbonate resins.[1] Flame-retarded epoxy resins containing TBBPA are used in the manufacture of electronic circuit boards. TBBPA flame-retarded polycarbonate resins are used in communications and electronics equipment, appliances, transportation devices, sports and recreation equipment, lighting fixtures and signs.[1,2] When used reactively, TBBPA is chemically integrated into the matrix of the polymer being treated, losing its chemical identity. Although most of the TBBPA involved in the reaction is chemically bonded to the polymer, there is evidence that a small fraction is available for leaching from the finished product.[3] Approximately 10% of TBBPA is used as an additive flame retardant, primarily in acrylonitrile-butadiene-styrene (ABS) resins and phenolic resins used in the manufacture of such products as automotive parts, pipes and fittings, refrigerators and other appliances, business machines and telephones.[1] Additive flame retardants are physically combined with the material being treated, rather than chemically bonded as with reactive flame retardants, and therefore are considered more readily available for potential losses through leaching from the polymer matrix.

The available information suggests that the two derivative compounds are restricted to specialty or niche applications. Ethoxylated TBBPA is an additive flame retardant used in engineering polymers, epoxy resins, thermoset and thermoplastic polyesters, polyurethane, laminates for electronic circuit boards, and adhesives and coatings.[4] The substance may also be used reactively in unsaturated polyesters.[5] TBBPA allyl ether is a reactive flame retardant used in polyester foams and expanded polystyrene.[1,2]

TBBPA is the largest selling brominated flame retardant, with world market demand about 120,000 tonnes in 2001.[6] Global production of TBBPA has risen markedly in recent years, increasing nearly 300% over the nine-year period from 1991 to 2000 and 35% in one year from 1999 to 2000.[7] Little information is available on the production of TBBPA derivative compounds, however the combined total worldwide use of the five recognized derivatives is estimated to be about 25% that of TBBPA.[1]

Few measured data are available on the two TBBPA derivative compounds; however predictions based on modelled data suggest that they will demonstrate properties and toxicities similar to the parent compound. TBBPA is characterized by having low to moderate water solubility (e.g. 0.063 to 4.16 mg/L)[8,9] that is responsive to both temperature and pH, low vapour pressure (e.g., < 1.19×10^{-5} Pa at 20°C)[10] and a moderately high octanol/water partition coefficient (e.g., log Kow 4.5-5.3; 5.903).[11,12] As a phenolic compound, TBBPA is weakly acidic and can exist in undissociated (neutral) and dissociated (ionized) forms. The predominating species present in an aquatic system is related to the pH of the system, with the undissociated form prevalent at lower pH. The observed variability in water solubility is accounted for by the presence and proportion of the two forms, as ionized TBBPA is expected to have higher solubility than the neutral form. There are similar implications for the log Kow, which might be expected to vary as the water solubility alters with changing pH.[4] This in turn has implications for the bioavailability and uptake of TBBPA by organisms.

TBBPA may be released to the environment during manufacturing and polymer processing operations, throughout the service life of articles containing it, and at the end of article service life during disposal operations. When released into the environment, TBBPA is expected to distribute predominantly into the sediment and soil compartments, binding to the organic fraction of particulate matter. Laboratory and field studies indicate that TBBPA degrades only slowly in the environment, and complete mineralization of the substance has not yet been demonstrated. Based on standard ready biodegradation testing, TBBPA is considered not readily biodegradable.[13]

TBBPA has demonstrated toxicity to aquatic organisms, with adverse effects on survival, reproduction and development observed at exposure concentrations within the range of its water solubility in species of fish[14], aquatic invertebrates[15] and algae.[16] Lowest toxicity values for aquatic species include a 96-h LOEC of 0.018 mg/L obtained for mean shell deposition in the Eastern oyster, *Crassostrea virginica*,[17] and 72-h EC50 values of 0.09 to 0.89 mg/L for reduced cell growth in the marine alga, *Skeletonema costatum.*[18] Exposure to soil organisms inhibited growth in some terrestrial seedling plants[19] and reproduction in the earthworm species, *Eisenia fetida*.[20] In mammals, sublethal exposures to TBBPA have been associated with reduced levels of thyroid hormones and altered brain morphometry[21], and *in vitro* studies indicate that the substance may be immunosuppressive[22].

TBBPA has been measured in all environmental media, with highest concentrations associated with urbanized and industrial regions. The substance has also been detected in a variety of aquatic and terrestrial species at concentrations up to 376 µg/kg fw.[23] High tissue levels may indicate the presence of very high local concentrations available for uptake by organisms in the area. Alternatively, bioaccumulation of TBBPA may be occurring with the subsequent potential for food chain transfer and secondary poisoning of predator species. Accumulation and bioconcentration of TBBPA have been demonstrated in several species of fish and aquatic invertebrates, with a highest reported bioconcentration factor of 3200 reported for the freshwater midge, *Chironomus tentans*.[24]

TBBPA has been shown to degrade under anaerobic conditions to form bisphenol A, a potentially persistent substance that is associated with adverse endocrine effects in aquatic and terrestrial organisms. This degradation pathway has been documented in freshwater sediments and anoxic marine sediments[25,26], but it may also occur in other anaerobic systems.

As with other assessments conducted under CEPA 1999, the draft screening assessment and proposed conclusions with regard to CEPA “toxic” will be published in the *Canada Gazette*, Part I and posted on the CEPA Registry Web site at: http://www.ec.gc.ca/CEPARegistry/subs_list/assessments.cfm for a 60-day public comment period. After consideration of the public comments, the final report with conclusions will be published in the *Canada Gazette*.

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