

Indoor emissions and fate of flame retardants

A modelling approach

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Abstract

A significant number of consumer goods and building materials act as emission sources of flame retardants (FRs) in the indoor environment. As a result, FRs have become ubiquitous indoors raising concerns about human exposure and possible health implications. Once released indoors, FRs can escape to the outdoors where they can persist, be transported over long distances and present a threat to the environment. Despite the increasing number of studies reporting the occurrence of FRs in the indoor environment, the understanding of i) how and to what extent these chemicals are released from indoor sources, and ii) their subsequent fate indoors remains limited. The overarching objective of this thesis was to improve this understanding by assessing the indoor emissions and fate of FRs using a combination of multimedia modelling strategies and experimental/empirical approaches. **Paper I** identifies a number of knowledge gaps and limitations regarding indoor emissions and fate of FRs and the available modelling approaches. These include a limited understanding of the key emission mechanisms for low volatility FRs, uncertainties regarding indoor air/surface partitioning, poor characterization of dust and film dynamics and a significant lack of knowledge regarding indoor reaction/degradation processes. In **Paper II** we highlighted the serious scarcity in physicochemical property data for the alternative FRs and demonstrated the applicability of a simple QSPR technique for selecting reliable property estimates for chemical assessments. A modelling fate assessment indicated a strong partitioning to indoor surfaces and dust for most of the alternative FRs. Indications for POP (persistent organic pollutant)-like persistence and LRT (long-range transport) and bioaccumulative potential in the outdoor environment were also identified for many alternative FRs. Using an inverse modelling approach in **Paper III** we estimated 2 to 3 orders of magnitude higher emissions of organophosphate FRs (0.52 and $0.32 \text{ ng}\cdot\text{h}^{-1}$) than brominated FRs ($0.083 \mu\text{g}\cdot\text{h}^{-1}$ and $0.41 \mu\text{g}\cdot\text{h}^{-1}$) in Norwegian households. An emission-to-dust signal was also identified for organophosphate FRs suggesting that direct migration to dust may be a key fate process indoors. No evidence of a direct source-to-dust transfer mechanism was seen in **Paper IV** where the chemical transfer between a product treated with an organophosphate FR and dust in direct contact was experimentally investigated. It was concluded though that direct contact between an FR source and dust can result in contamination hotspots indoors.

Keywords: *flame retardants, BFRs, OPFRs, indoor environment, emissions, fate, modelling.*

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