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Substituting Environmentally Relevant Flame Retardants: Assessment Fundamentals

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Abstract

In preventive fire safety measures, incorporating a flame retardant in combustible materials and plastics is a common procedure applied to reduce the risk of fires.

However, the discovery of toxicologically and ecotoxicologically problematic or hazardous flame retardants, as well as their decomposition products, in the various compartments of the biosphere (e.g. sediments, water, indoor air, biota) has in the past led to public debate and to regulations requiring the reduced use of such substances.

The German Federal Environmental Agency (Umweltbundesamt, UBA) has commissioned a research project on these issues, which was carried out as a cooperative project of Öko-Recherche GmbH (Frankfurt/M.) together with the Institute for Toxicology of the University of Kiel, and Institut für sozial-ökologische Forschung (ISOE) GmbH (Frankfurt/M., Institute for Social-Ecological Research).

The task of the now completed study was to develop evaluation criteria for the substitution of environmentally relevant flame retardants. For this purpose a selection of thirteen flame retardants (including synergistic antimony trioxide) was examined with regard to their environmentally relevant properties (essentially: toxicity, ecotoxicity, and suitability for closed-loop substance management), and corresponding substance profiles were elaborated. Furthermore, it was examined how these flame retardants are currently utilized in important areas of application, and on what conditions the utilization of flame retardants depends. This applications-oriented analysis also sought to ascertain what possibilities for action are available for replacing environmentally harmful with less problematic flame retardants.

The specific flame retardants examined included four brominated flame retardants, including polybrominated diphenyl ether, three organic phosphorus-based flame

retardants (halogenated and not halogenated), of which one substance is specifically used for textiles, and furthermore two inorganic phosphorus compounds, one nitrogen-based flame retardant, and sodium borate decahydrate (Borax). Aluminium trihydroxide was selected as the most important mineral-based flame retardant, and antimony trioxide as a halogen synergist.

The selected products are used in various sectors with different fire safety requirements. These sectors are:

- Insulation materials and one-component foams composed of polyurethane rigid foam (construction sector),
- structural and cladding elements made of unsaturated, fibre-glass reinforced polyester resins (rail vehicle sector),
- printed circuit boards (largely manufactured from epoxy resins),
- casings for computers, printers and similar IT components, as well as TV appliances in the electrical and electronic sector, and
- textiles for mattresses and upholstered furniture.

Proceeding from the toxicological and ecotoxicological substance characteristics identified in the study, the following summary evaluation results:

Summary evaluation of flame retardants	
I Phase-out is recommended	- Decabromodiphenyl ether - Tetrabromo bisphenol A, additive
II Reduction is expedient, substitution desirable	- Tetrabromo bisphenol A, reactive - Tris(chloropropyl)phosphate
III Problematic properties; reduction expedient	- Hexabromocyclodo-decane - Sodium borate decahydrate (Borax) - Antimony trioxide
IV No recommendation possible due to gaps in knowledge	- Bis(pentabromophenyl)ethane - Resorcinol-bis-diphenylphosphate - Pyrovatex CP neu - Melamin cyanurate
V Use is unproblematic	- Red phosphorus (encapsulated) - Ammonium polyphosphate - Aluminium trihydroxide

The applications-focused analysis of flame retardants shows that with regard to most of the examined products, a trend has started towards the substitution of halogenated flame retardants, or new formulations of flame retardant systems have been and are being developed that refrain from using halogenated flame retardants. Organic phosphorus flame retardants are gaining importance on the one hand, as are on the other hand design-based and materials-based fire safety approaches that are able to do without flame retardants. The evaluation views this trend as positive; however, the environmental relevance and especially the emissions behaviour of the organic phosphorus additives will demand greater attention in future. Overall, the various application areas show a substantial potential for substituting and reducing the use of environmentally relevant flame retardants.