

Substitution of decaBDE containing flame-retardant used for treatment of textile fabrics

This case study aims to illustrate a chemical substitution process. It is based on publicly available information on company's experience as well as on substance hazards, alternative to the hazardous substance and regulatory information. The case study is neither complete nor comprehensive in illustrating all substitution options of a substance but rather exemplary.

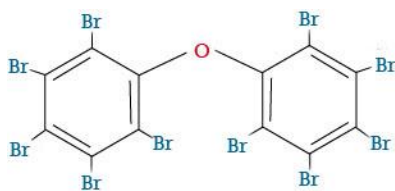
1. Case description

A Workshop at a Theatre (WAT) decided to find a better solution for the processing of fabrics used on stage. They would like to achieve a sufficient quality and fire resistance and to avoid using decaBDE (decabromodiphenyl ether) since this substance is one of the candidates for stronger legislative norms e.g. it may become permitted only for exceptional uses.

They participated in a voluntary phase out programme, where an expert, provided by the programme, shared an enormous amount of literature listing various alternatives. In his research the expert found a case study from a company with similar profile product. Flame retardant properties of this product are provided by citric acid. Successful experience by another small workshop encouraged WAT to try this product.

1.1 Hazards of brominated flame-retardants

Brominated flame-retardants (a group of chemicals including decaBDE) are regarded as a threat to the environment and humans due to their high persistence, bioaccumulation in terrestrial food chains and potentially endocrine disruptive properties. Apart from the main exposure pathway for the general public through food chain, human exposure to this substance can occur during its synthesis, production of mixtures, treatment of fabrics, and use of fabrics.



- decaBDE: Decabromodiphenyl ether
- CAS nr. 1163-19-5
- EC nr. 214-604-9
- Very persistent, very bioaccumulative substance (conclusion by EU Risk assessment)
- No harmonised classification, but indications of toxicity and mutagenic effects from notifications in the CLI
- Substance on EU authorisation list due to vPvB properties (2012)
- Proposed for EU wide restriction (2015)
- Listed by OSPAR convention
- Proposal to add decaBDE to the Stockholm Convention for Persistent Organic Pollutants (2013)
- Included in RoHS directive (2008)
- Potential endocrine disruptor (developmental toxicity, weak thyroid hormone disruptor) but tests performed did not followed standardised test guidelines [1]

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1.2 Regulatory status of decaBDE

Since the European Commission in charge of risk assessment concluded that decaBDE is a vPvB (very persistent, very bioaccumulative) substance, the legislative proposal for the EU-wide restriction on the use of decaBDE is currently on the table. The proposal would restrict the use and marketing of decaBDE as a constituent in mixtures and articles, at a concentration equal to or greater than 0.1% by weight exempting the use for aircraft; motor vehicles; agricultural and forestry vehicles, electrical and electronic equipment (compliant with RoHS requirements).

Environmental Protection Agency (EPA) of U.S.A, considering the potential restrictions in European Union and other reasons also, has established a voluntary EPA-Industry programme to phase out all uses of decaBDE except for transportation and military purposes by 2012.

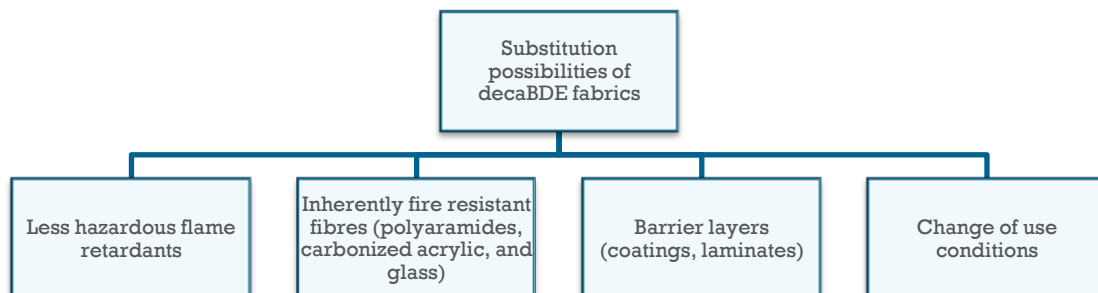
DecaBDE is used in Europe in a range of 10 000-100 000 tonnes a year. It is widely used as an additive flame retardant in many different industry sectors. Major uses are for plastics and textiles, but also other uses are reported (adhesives, sealants, coatings, inks).

2. Substitution process

2.1 Identification of possible alternatives

The decaBDE is used for treatment of certain textile fabrics in order to achieve high fire resistance (transportation, public spaces, high risk occupancy areas, military etc) in a range 7,5-20% of fabric weight. Problems of finding suitable alternatives are linked to a high functionality of the decaBDE. Since flame-retardants have to be stable (decaBDE is very persistent and does not degrade in the environment), it is hard to find a substance that is both safe and sufficiently stable.

There are several possibilities for substitution of flame retarded fabrics containing decaBDE used for fabrics, but due to specific conditions of the theatre workshops, the only possible option is substitution with less hazardous flame retardant. Workshop hesitates to use the inherently resistant fabrics since they might not visually correspond to the needed outfit.



Researchers, charged by European Commission and Environmental Protection Agency of U.S.A, identified various alternative flame retardants for textile fabrics.

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But the best alternative shortlisted by EU risk assessment process (ethane-1,2-bis(pentabromophenyl)), is also a potential threat for environment due to its persistency.

Table 1. Hazard profile of the shortlisted alternatives to decaBDE, modified table from Background document to RAC and SEAC opinions on deca BDE

Alternative substance	CAS No	Hazard profile	Technical feasibility	Economic feasibility
Magnesium hydroxide (MDH)	1309-42-8	Persistent, since metal	Wide range, but inefficient	Lower price, higher concentration
3 Tris(1,3-dichloro-2-propyl) phosphate (TDCPP)	13674-87-8	Carcinogen (cat.2), potential neurotoxin, negative effects on female fertility, persistent, toxic	Textiles, limited range	Lower price, similar concentration
Aluminium trihydroxide (ATH)	21645-51-2; 8064-00-4	Insufficient information	Wide range, but inefficient	Lower price, higher concentration
Ethylene bis(tetrabromophthalimide) (EBTBP)	32588-76-4	Very persistent, bioaccumulative, debromination products, insufficient information	Drop-in	Higher price, same concentration
2,2'-oxybis[5,5-dimethyl-1,3,2-dioxaphosphorinane] 2,2'-disulphide	4090-51-1	Insufficient information	Viscose fibres only	Significantly higher price, similar or lower concentration, requires more expensive raw materials
Red phosphorous	7723-14-0	Persistent by default, potential hepatotoxicity, aquatic acute toxicity cat. 3, but potentially also chronic aquatic toxicity	Certain polymers, cotton-rich textiles	Lower price, lower concentration
Ethane-1,2-bis(pentabromophenyl)	84852-53-9	Subject to evaluation under REACH based on PBT/vPvB concern.	Drop-in	Higher price, same concentration
1,3,5-triazine-2,4,6-triamine (melamine)	108-78-1	No significant concerns	Only very specific uses reported	Economically feasible, but not full information yet

Melamine, a sufficiently safe alternative upon current knowledge, has been used in other studies, but for very specific fibres. As none of the alternatives promise an absence of long-term hazards combined with good technical performance, the

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expert suggested the company to use findings reported by a case study in a similar industry sector. Danish National School for Theatre and Contemporary Art made a similar study of three products.

Table 2. Products studied by Danish National School for Theatre and Contemporary Art

Alternative product	Ingredients	Hazard profile	Health and environmental assessment	Comments
Burnblock	citric acid, sodium benzoate	Not classified	The Danish Technological Institute: mild hazards due to citric acid, which is also naturally occurring, irritant substances with no long term effects. Biodegradable in aquatic environment.	Weak odour during use the product is bearing the flame retardant properties for ca. 5 cycles of chemical or industrial washing
Flamecheck	ammonium bromide (< 10 %) and a non specified anionic surfactant (< 10%)	Not classified (MSDS)	none	strong smell of ammonia even when it dries out
Protiflam A	aminated inorganic acids and surface active substances	Not classified (MSDS)	none	
Flamol K	not known	Neither product, nor ingredients are classified as hazardous	none	Weak odour during use

2.2 Selected alternative and justification

Several years passed since publication of a case study by Danish National School for Theatre and Contemporary Art, and the information about all products but Burnblock was no longer available. After checking the information on the website and clarifying some questions directly asking the producer, the company WAT decided to try this product.

To make this decision, following criteria were important for WAT company:

- Hazards: no known long lasting hazards
- Information reliability: hazard assessment by independent institution: Danish Technological Institute
- Price: the preliminary estimates show, that Burnblock, depending of type of fibre, could be in the same range of price of even cheaper
- Technical feasibility: used by similar branch, the product promises a sufficient fire resistance (tested by independent laboratory)

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- Durability: the product is bearing flame retardant properties for ca. 5 cycles of chemical or industrial washing.

After clarification of the price the company will decide whether Burnblock is a good alternative for flame retardant.

2.3 Implementation

Not done yet.

2.4 Costs and savings

Literature data give estimation, that suitable alternatives are > 2 times more expensive. The costs of decaBDE are estimated as 4 €/kg. The discussion with producer leads to conclusion that product could be same range of price or even cheaper.

3. Evaluation

Conclusion on the substitution: not done yet.

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