

BCUK Background Briefing | Flame retardants

What are flame retardants and where are they used?

Flame retardants are chemicals used in consumer and industrial products to help prevent fires starting or to delay their spread. They were developed in response to the widespread use of synthetic materials which has increased the flammability of our built environment. Flame retardants within these materials are effective in reducing flammability (1). Often their use is required for compliance with fire safety regulations. Flame retardants may be added to materials post production (“additive” flame retardants) or chemically incorporated into them.

Worldwide, around 85% of all flame retardants are used in plastics; the rest are used mostly in textiles and rubber products (2). Products include

Electronics: e.g. circuit boards, computers, TVs

Furniture and furnishings: e.g. furniture foam, mattresses, wood, carpets

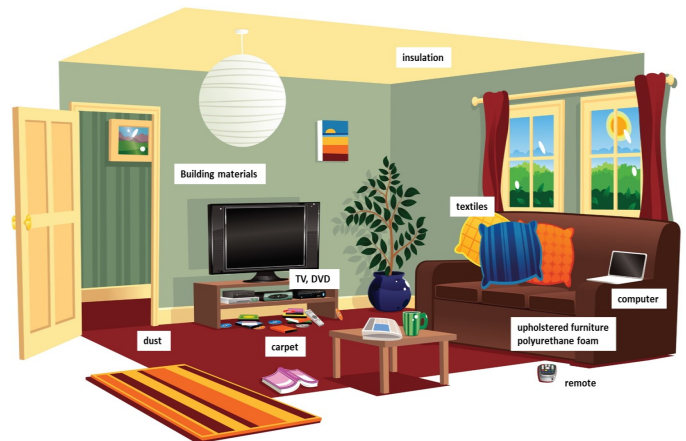
Clothing and fabrics: e.g. children’s clothing, sportswear, outdoor clothing

Building materials: e.g. cable coatings, insulation cladding

Transport: e.g. car seats, interiors, bumper bars

What types of chemicals are used as flame retardants?

There are many classes of flame retardants with different chemical structures and properties. The



Flame retardants can be found throughout the home.
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most commonly used worldwide (representing 34% of the global market) is aluminum hydroxide, an additive mineral flame retardant, generally regarded as safe (3).

However, some flame retardants do pose a risk to human health and the environment and these will be the focus of this background briefing. This group of flame retardants is collectively referred to as “organic” (meaning carbon-based) flame retardants and includes brominated flame retardants (BFRs), chlorinated flame retardants and organophosphorus flame retardants. Most organic flame retardants are additive.

Organic flame retardants

There are numerous organic flame retardants on the market. Chemicals and groups of chemicals and their abbreviations discussed in this brief are listed in Box 1; further details are in Appendix 1.

BCUK Background Briefing | Flame retardants

	Abbreviation and name of flame retardant	Description
<i>Legacy</i>	PBDEs polybrominated diphenyl ethers	Once most widely used BFR group, most banned in EU (8)
	HBCD hexabromocyclododecanes	BFR group once used widely, use is restricted in the EU
	PCBs polychlorinated biphenyls	Chlorinated phenols, banned globally in 2001
	PBBs polybrominated biphenyls	BFR group, banned in the EU and elsewhere
<i>In use</i>	TBBPA tetrabromobisphenol A	The most commonly used BFR, globally (9)
	BBMP 2,2-bis(bromomethyl)-1,3-propanediol	A novel BFR
	TPP triphenyl phosphate	Organophosphorus flame retardant
	TDCPP tris(1,3-dichloro-2-propyl) phosphate	Chlorinated organophosphorus flame retardant
	TCEP tris(2-chloroethyl) phosphate	Chlorinated organophosphorus flame retardant
	TBB 2-ethylhexyl-2,3,4,5-tetrabromobenzoate	Novel BFR
	TBPH bis(2-ethylhexyl) 3,4,5,6 -tetrabromophthalate	Novel BFR

Box 1: Organic flame retardants discussed in this brief. For details of uses and possible health effects, see Appendix 1

Organic flame retardants have been used in the UK and elsewhere since the 1970s (4). They account for around half of all flame retardants used worldwide (5). Until recently, BFRs were the most commonly used organic flame retardant. Now many are banned or restricted, due to safety concerns (6). These are known as “legacy” BFRs, as they are no longer used but are still present in the environment. Certain BFRs, including “novel BFRs” (newly introduced) are still in use. Due to environmental and health concerns, many legacy BFRs are being replaced by organophosphorus and chlorinated flame retardants (7).

How are we exposed to flame retardants?

Flame retardants that have been added to products such as sofas, textiles and mattresses may be released into the environment during

normal use, as well as during production, disposal, recycling, and when products are exposed to fire (10). Because of strict UK fire regulations, many materials and products sold in this country contain especially high proportions of additive organic flame retardants (11).

What is the problem with organic flame retardants?

Many flame retardants are bioaccumulative (accumulate inside cells) and toxic to wildlife and humans. Some are carcinogenic (cause cancer) (13, 14) and act as endocrine disrupting chemicals (15, 16). Several flame retardants have been classified as persistent organic pollutants by the UN (17, 18) and so can last for a very long time in the environment.

Flame retardants are found all over the world and

BCUK Background Briefing | Flame retardants

have been detected in air, dust, soil, water, food, and wildlife. They are regularly identified in human body fluids such as blood, urine, breast milk and placental tissue (19, 20). They can concentrate in fatty tissue resulting in high concentrations in oily fish and meat (21). In general, levels are higher in children than adults. This is probably due to intake from breastfeeding and greater exposure to dust (22).

Flame retardants that are endocrine disrupting chemicals (EDCs) interfere with our hormone system and may increase the risk of various health problems, including breast cancer. Flame retardants affect various hormones including thyroid hormones (23), and sex hormones, such as oestrogen (24).

Oestrogen encourages a high rate of cell division, which increases the risk of mutations, including those that lead to breast cancer. Some EDCs can trigger similar actions to those triggered by oestrogen, and so may increase breast cancer risk. For more on the health effects of EDCs see our [background briefing](#) on endocrine disrupting chemicals.

Due to long-term persistence in the environment, some legacy flame retardants are likely to remain a public health risk for some time. For example PCBs, which were banned for most uses in the UK in 1981 and completely in 2000, are detected routinely at high levels in humans, wildlife, soil, food and water in the UK and elsewhere (25).

PCBs are toxic, carcinogenic, bioaccumulative and EDCs (26). Another example are PBDEs, whose manufacture was banned or phased out in Europe and the US between 2002 and 2013 (27). In general, this has led to reduced levels detected in dust, soil and wildlife (28, 29), although PBDEs are still widespread in the global environment and remain elevated in certain wildlife (particularly species at the top of the food chain such as polar bears). Many PBDEs are toxic, bioaccumulative and EDCs (30).

Less is known about currently used flame retardants, although recent studies suggest their UK concentrations are increasing (31, 32) and indications are that they may be as harmful as those they have replaced (see below). This highlights the need to establish safety and efficacy first, before new compounds are introduced into the environment.

Flame retardants are usually chemically stable.



PBDE flame retardants are widespread in the environment and have been found in body fluids & tissues of wild-life, including polar bears.

BCUK Background Briefing | Flame retardants

However, in the environment they are eventually broken down by exposure to light or by microorganisms, to form break-down products. Also, when flame retardants are exposed to accidental fire (33) or incineration at the end of product life (34, 35) they may be converted to other compounds. Both of these pathways can produce chemicals with increased toxicity and a greater ability to bioaccumulate.

Organic flame retardant levels in the UK & USA are especially high

In general, the USA and the UK have the highest recorded levels of flame retardants in human body fluids (36). The highest concentrations of legacy PBDEs in mothers' milk have been detected in American women, and the second highest levels in those from the UK (37). Elevated levels of PBDEs have also been found in human blood serum in Californian children at 5 times the US average, and 10-100 times the European and Mexican average. In US populations, urinary metabolites (break-down products) of the novel organophosphorus flame retardant, TDCPP, have increased dramatically since 2002 (38).

The USA and the UK also have high levels of flame retardants in dust (39). The highest ever recorded levels of TDCPP were identified recently in Californian dust (40). Similarly, PBDE levels in indoor dust are generally highest in the USA, although levels of one PBDE and HBCD were highest in UK indoor dust (41). Another recent

study (42) which compared levels of flame retardants in UK and Norwegian dust, found levels of most were higher in UK dust, including PBDEs which were 20-30 times higher and several organophosphorus flame retardants which were 11 times higher.

There is a strong correlation between exposure to flame retardants and furniture regulatory standards: California has the highest exposure in the world and until recently had the most stringent furniture flammability standards (43). In response to health and safety concerns about flame retardants, regulations were amended in 2013 (44) and flame retardants are no longer required in Californian-made furniture. Currently, the UK (and Ireland) have some of the most stringent furniture fire regulations in the world, resulting in increased exposure of infants, children and adults to flame retardants (45).

Organic flame retardants & breast cancer

Legacy flame retardants and breast cancer

Studies in humans have shown that legacy flame retardants increase breast cancer risk (e.g. 46). Polychlorinated biphenyls (PCBs) are associated with increased breast cancer risk (47) as well as increased mortality following breast cancer diagnosis (48). One study found a significant increase in the risk of breast cancer in individuals with higher plasma or fat levels of certain PCB metabolites (break-down products) (49).

BCUK Background Briefing | Flame retardants

A study of US women exposed to high levels of the banned BFRs, PBBs, through accidental contamination of food 30 years ago, found higher exposure was associated with an increased breast cancer risk; although the results were not statistically significant (i.e. an association could not be demonstrated by statistical analysis) due to the small sample size (50). The International Agency for Research on Cancer (IARC) has classified PBBs as “probably carcinogenic” (51).

In vitro studies have shown that PBDEs (BFRs, also now banned) increase breast cell proliferation and prevent programmed cell death in normal breast cells (52) and breast cancer cell (53) which suggest exposure to these may increase breast cancer risk. One PBDE was found to counteract the anti-cancer effects of tamoxifen. Another legacy BFR, HBCD, was shown to be oestrogenic (54), so may also increase the risk of breast cancer.

Flame retardants in current use and breast cancer

There is limited information on the health effects in humans of currently used BFRs and other organic flame retardants, with most of it coming from animal or *in vitro* studies. Although humans and animals are not directly equivalent in all aspects of biology, some effects seen in animals may suggest that similar effects occur in humans. Many currently used flame retardants have been shown to be EDCs that affect oestrogens (55) or androgens (male hormones) (56) and some, including the BFRs, BBMP and TDCPP, increase

incidence of mammary tumours in rodents (57). These studies suggest a link to breast cancer, although research in humans has not yet been undertaken which might demonstrate whether or not these flame retardants are linked to increased breast cancer risk.

In vitro studies show that TBBPA can inhibit a key oestrogen-metabolising enzyme and cause an increase in levels of circulating oestrogen (58), potentially causing endocrine disruption which may lead to increased breast cancer risk.

Flame retardants in combination with other EDCs may also result in enhanced oestrogenic effects and so be especially harmful. One *in vitro* study found mixtures containing several chlorinated flame retardants increased breast cancer cell multiplication, due to additive effects of the mixture (59).

Links to other health problems

Legacy BFRs including PBDEs and HBCD may be associated with thyroid disorders (60). Exposure to low concentrations of PBDEs during childhood may lead to hypothyroidism (61). PBDE exposure has also been linked to autistic behaviour in children (62) and prenatal exposure has been linked to neuro-developmental disorders including learning and behavioural problems (63, 64). HBCD is now classified as a suspected human reproductive toxicant (65), meaning it can damage an unborn child.

BCUK Background Briefing | Flame retardants

Studies have shown that certain currently used replacement BFRs are *carcinogenic in animals. For example TBBPA can cause cancers of the uterus in female rats and liver cancer in male mice (66), and BBMP causes cancer in several sites in rodents, and is anticipated to be a human carcinogen (67). In rodents, TDCPP induces tumours in liver, kidney and testes and TCEP induces kidney tumours (68).

TCEP and the organophosphorus flame retardant TPP cause endocrine disruption in mice, which affects male reproductive development (69). *In vitro* studies suggest currently used BFRs, TBB and TBPH, are possible reproductive toxicants (70) and may reduce effectiveness of pharmaceutical drugs and cause endocrine disruption of thyroid and androgen hormones (71, 72).

Furniture & furnishings regulation

In an effort to reduce deaths and injuries associated with house fires, in 1988 the UK government introduced stringent fire regulations known as the Furniture and Furnishings (Fire) (Safety) Regulations 1988, which set levels of fire resistance for new and second-hand domestic upholstered furniture, furnishings and other products containing upholstery supplied in the UK (73). These regulations do not require products to use flame retardant chemicals, but in practice, they are often needed for products to

be legally compliant (74).

There is growing debate as to whether organic flame retardants reduce the risk of fire deaths or injuries (75). A 2009 report commissioned by the UK Department for Business, Innovations and Skills concluded that current fire safety regulations saved 54 lives and result in 780 fewer non-fatal casualties each year (76). In contrast, a 2015 report by ANSES (French Agency for Food, Environmental and Occupational Health and Safety) (77) into the fire safety of upholstered furniture concluded the role of flame retardants in preventing fires and fire deaths and injuries was not possible to measure. Rather than recommending the use of flame retardants in upholstered furniture, they recommend more general fire safety measures such as smoke alarms and information campaigns.

Some research has suggested that the presence of flame retardants increases the toxicity of fumes and gases released in house fires, thereby reducing the capacity to escape a fire (78).



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*Although Breast Cancer UK cites research that involves animal experiments we do not fund any research which involves the use of animals

BCUK Background Briefing | Flame retardants

Conclusion

Legacy flame retardants are known to be harmful to human health and the environment and the limited data on organic flame retardants in current use suggests they could be equally problematic. There is growing concern amongst scientists worldwide that brominated and chlorinated flame retardants are harmful to human health and the environment and should no longer be used (79). Fire safety is essential in the modern world due to the widespread use of synthetic materials with high flammability. Alternative measures to promote fire safety without risking human health should be a priority, including the increased use of smoke detectors, improved product design which achieves an inherent high fire safety level, and the use of less toxic flame retardants.

Glossary

bioaccumulative: builds up inside cells
carcinogenic: can cause cancer
endocrine disrupting chemical (EDC): chemical that disrupts normal functioning of the hormone system
in vitro: performed or taking place in a test tube, culture dish, or elsewhere outside a living organism
metabolite: break-down product produced by cellular metabolism
oestrogenic: mimics the effects of natural oestrogen; may increase breast cancer risk
reproductive toxicant: substance that causes adverse effects on the reproductive system, including adverse effects on developing foetus
additive flame retardant: added after product or material is manufactured; readily released into the environment
legacy flame retardant: no longer used but still present in the environment
novel flame retardant: recently introduced to the market
organic flame retardant: carbon-based flame retardant

We welcome your feedback, if you have any comments or suggestions about this leaflet please contact us at info@breastcanceruk.org.uk or on 0845 680 1322



What is Breast Cancer calling for?

- Changes to the UK's furniture fire safety regulations that remove the need for the use of organic flame retardants and create genuine impetus for designing out both flammability and toxicity.
- A requirement for a visible display label, to provide consumers with point-of-purchase information on the presence and type of flame retardants contained in the product, similar to the EU energy label. This is also important for recycling and safe disposal of products.
- The UK Government to commit to maintaining or strengthening EU restrictions on the use of hazardous flame retardant chemicals once the UK has left the EU.
- The eventual phase out of hazardous flame retardants in all consumer and industrial products and their replacement with safer alternatives.

BCUK Background Briefing | Flame retardants

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BCUK Background Briefing | Flame retardants

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This information has been written for members of the public to help them understand more about how and why certain chemicals may be linked to a potentially increased risk of breast cancer.

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This work in no way claims to be a comprehensive treatment of the subject of all chemicals associated with breast cancers. This article is for information only and should not be used for the diagnosis or treatment of medical conditions. Breast Cancer UK is a breast cancer prevention charity and is unable to offer specific advice about the diagnosis or treatment of breast cancer. If you are worried about any symptoms please consult your doctor.

If you would like to receive the information in this leaflet in a different format please contact Breast Cancer UK on 0845680 1322 or email info@breastcanceruk.org.uk

BCUK Background Briefing | Flame retardants

Appendix 1: Flame Retardants discussed in this background briefing

Abbreviation and name	Class	Regulatory status and examples of use (past or current)	EDC, carcinogen or toxic
PBDEs polybrominated diphenyl ethers	Brominated	Several are banned in EU & California several listed as POPs under Stockholm convention; previously used in electronic devices, upholstery, furniture	EDCs affect hypothalamus, pituitary, thyroid, oestrogen and androgens Reproductive toxicity, neurotoxicity, DNA damage and immune effects (1)
HBCD hexabromocyclododecanes	Brominated	Authorisation required in EU, exemptions for use in polystyrene; to be phased out globally by 2020; previously used in insulation boards, textiles, polystyrene	EDCs affects thyroid, oestrogen (oestrogen mimic) (2) Category 2 reproductive toxicity (3);
PCBs polychlorinated biphenyls	Chlorinated	Banned in EU and globally, 2001; previously used in electrical fluids, copy paper	EDCs affect thyroid Toxic; Carcinogenic to humans, likely associated with breast cancer (4) (5)
PBBs polybrominated biphenyls	Brominated	Banned in EU; previously used in electrical appliances, foams; textiles	Probable human carcinogen (6); some evidence increases breast cancer in women (7)
TBBPA tetrabromobisphenol A	Brominated	In use; electrical equipment (e.g. printed circuit boards) additive in polystyrene, resins, adhesives, some textiles and paper	EDC affects thyroid; oestrogen metabolism Probably carcinogenic (8)
BBMP 2,2-bis(bromomethyl)-1,3-propanediol	Brominated	In use; resins, plastics, polyurethane foams	Causes mammary tumours in rats; anticipated human carcinogen (9)
TPP triphenyl phosphate	Organo-phosphorus	In use; synthetic (polyester) resins	EDC, affects testosterone levels (10)
TDCPP tris(1,3-dichloroisopropyl) phosphate	Organo-phosphorus (chlorinated)	In use; polyurethane foams for furniture	EDC affects thyroid, oestrogen androgen (11) metabolite causes mammary tumours in rats (12) classified as a carcinogen under California proposition 65 (13)
TCEP tris(2-chloroethyl) phosphate	Organo-phosphorus (chlorinated)	In use; polyurethane foam for furniture Some restrictions of use (14)	EDC, affects testosterone levels (15) classified as a carcinogen under California proposition 65 (16)
TBB 2-ethylhexyl-2,3,4,5-tetrabromobenzoate	Brominated (novel BFR)	In use; polyurethane foam for furniture, carpet backing, bedding, insulation, packaging, neoprene, PVC, coated fabrics	EDC affects thyroid, androgens, glucocorticoid (17) possible reproductive toxicant (18)
TBPH bis(2-ethylhexyl) 3,4,5,6-tetrabromophthalate	Brominated (novel BFR)	In use; polyurethane foam for furniture, carpet backing, bedding, insulation, packaging, neoprene, PVC, coated fabrics	EDC affects thyroid, androgen, glucocorticoid hormones (19) potentially carcinogenic (based on structural similarity to other carcinogens) possible reproductive toxicant (20)

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