Written evidence submitted by the Cancer Prevention and Education Society

Why are toxic chemicals used?

1. *Why are toxic chemicals used in consumer products? What benefit do they offer? How are levels of toxicity measured?*

The argument used to justify the use of flame retardants (FRs) is that they delay time to ignition when a fire starts. However, a recent study by UCLAN (1) has shown that flame retardants increase fire toxicity, the principal cause of deaths in fires. This begs the question, why are flame retardants being used at all?

2. *What new technologies and materials are being developed to reduce the use of toxic chemicals? Are they widely available and affordable for producers?*

The high flammability and fire toxicity of PU and PIR foams used in furniture and in building insulation respectively are the main cause of the problem. If non-flammable alternatives to PIR foams were used in construction the need for FRs could be avoided. Likewise, with PU foam used in furniture. Alternatively, if PU foam is covered with a non-flammable cover made of Cottonsafe (wool/cotton yarn) then excellent fire resistant and fire toxicity properties can be achieved (1). Yes, they are affordable. What price is a human life?

Health risks

3. *Which toxic chemicals pose a significant risk to human health? How pervasive is the risk? Who is most at risk? How do producers make consumers aware of health risks identified in their products?*

Flame retardants (FRs)have a long history of well documented toxicity. Fire retardants made of PBDEs have largely been phased out. However, they are still present in old furniture, etc. The PBDEs have now been replaced by different brominated flame retardants (BFRs) and organophosphate flame retardants (OPFRs), some of which are halogenated. Some of the replacement BFRs have structures remarkably similar to the PBDEs, e.g. decabromodiphenylethane. Many of the OPFRs have increasing evidence of toxicity.

The UK has some of the highest levels of FRs in the world of both legacy and emerging flame retardants (Brommer 2015). British toddlers and adults are exposed to a level of FRs an order of magnitude higher than Norwegians (Kademolou et al 2017). They are in air, dust and on surfaces including windows, floors and carpets. They are found in homes and offices and the wider environment including wildlife and lakes. They are in maternal milk and are present in infants, toddlers, children, adults and house pets. They partition between air and dust depending on their molecular weight and volatility. Effects of FRs are documented in a large and ever-increasing scientific literature of *in vitro, in vivo* and human observational studies. Effects reported in the literature include cancer, neurotoxicity, developmental, behavioural, endocrine, metabolic, reproductive, developmental and allergy. Another major concern is that they may increase fire toxicity, the principal cause of death in fires, begging the question of why they are being used at all.

Some organophosphate FRs (OPFRs) are persistent, bioaccumulative and toxic. Their use is therefore a major concern. Most OPFRs have low vapour pressure and partition to indoor dust, making it a significant source of exposure. In addition, inhalation and dermal uptake from surfaces can contribute to the total OPFR exposure. Children are especially vulnerable to EDCs. 19 epidemiological studies report associations of pre-natal and childhood concentrations of PBDEs with impaired behaviour. PBDEs have been detected in human serum, adipose and liver tissue, placenta, cord serum and breast milk. PBDEs persist for decades because of their long half-lives. The bioaccumulation of PBDEs in humans is of substantial concern, particularly for the developing nervous system. Neurodevelopment begins early in the embryonic period with neurulation and extends through puberty and early adulthood with synaptogenesis and myelination. Experimental studies, in both in vitro and in animal models, have extensively documented PBDE neurotoxicity and long-lasting behavioural alterations with prenatal and postnatal exposures. Prenatal exposure to PBDEs in humans occurs via transplacental transfer from mother to foetus during gestational development and through breastmilk during infancy. Ingestion of household dust from frequent hand-to-mouth behaviours and crawling on household surfaces additionally contribute to infants and children having the highest body burden of PBDEs on a lipid basis. Evidence from animal models indicates that both OPFRs and novel BFRs induce neurobehavioural toxicity. (Vuong et al 2018)

OPFRs are a class of endocrine disrupting chemicals (EDCs) with ubiquitous exposures that have been measured in 90-100% of adult urine samples. These chemicals are not chemically bonded to foam and migrate into the air and dust of indoor environments. Animal studies indicate that exposure to OPFRs can disrupt endocrine function through altered thyroid action, steroidogenesis, or oestrogen metabolism, and can also impair embryo development. Reductions in sperm motility and increased serum total T3 levels were associated with increasing OPFR exposures. Concentrations of some urinary metabolites were negatively associated with proportions of successful fertilization, implantation, clinical pregnancy, and live birth (Carignan et al 2017).

Placental accumulation of FRs is dose dependent and in some cases sex specific (Baldwin et al 2017).

Some FRs induce adipogenesis in human primary adipocytes (Tung et al 2017)

FRs act as developmental neurotoxicants via direct effects on neural cell differentiation (Slotkin et al 2017)

OPFRs affected mitochondrial activity, cell survival and superoxide production; they have a greater effect on Leydig cells than the BFRs they have replaced (Schang et al 2016)

Recent animal studies suggest that exposure to TDCIPP and components present in FM550 (contains triphenyl phosphate) can lead to reproductive and developmental effects including reduced fecundity, problems with heart development, reductions in bone development and even cancer. *Therefore, the use of current FRs in residential furniture may still lead to increased risks for adverse health outcomes* (Cooper et al 2016)

With the phasing-out of the polybrominated diphenyl ether (PBDE) flame retardants due to concerns regarding their potential developmental toxicity, the use of replacement compounds such as organophosphate flame retardants (OPFRs) has increased. In a study of the nematode C. elegans, triphenyl phosphate (TPHP) inhibited larval development at levels comparable to 3 PBDEs. In addition, 9 of the 11 chemicals that inhibited C. elegans larval development also caused significant mitochondrial toxicity. These results suggest that some of the replacement OPFRs may have levels of toxicity comparable to PBDEs (Behl et al 2016).

Significant associations were found between the prevalence of atopic dermatitis and the presence of TCIPP and TDCPP in floor dust, whereas TBP was significantly related to the prevalence of asthma and allergic rhinitis (Wei et al 2015)

Results from a study support the conclusion that the alternative flame-retardant mixture FM550 may be obesogenic because it contains peroxisome proliferator-activated receptor γ(PPARγ) ligand(s). The likely mediator of the adipogenic effect of FM550 is Triphenyl phosphate (TPHP), as TPP binds PPARγ, activates PPARγ-mediated transcription and induced adipogenesis. That FM550 and TPHP are adipogenic has implications for both development of obesity and loss of bone health in humans. Interestingly, the trisubstituted OPFRs have a structural similarity to organotins, a class of compounds for which the tri-substitution is known to be important for obesogenic activity. Thus, TPHP is likely to be a significant contributor to the obesogenic activity of FM550 (Pillai 2014)

Some halogenated OPFRs adversely affect development of early life zebrafish (Dishaw et al 2014)

Several OPFRs (TDCPP, TPhP, TCP, etc) have shown *in vitro* endocrine disruption potential via human nuclear receptors, ER alpha, ER beta, AR, GR and PXR. The effects of these OPFRs were dependent on their side chain structures, and TPhP and TCP, in particular, had pleiotropic effects against nuclear receptors (Kojima et al 2013).

TPHP is labelled as a compound with dangerous effects for the environment by ECHA (Waaijers et al 2013).

In a study of the flame-retardant mixture Firemaster 550, rats were given oral dosages that approximate human exposures. The authors concluded that the results implicated FM550 as an EDC and an obesogen at *environmentally relevant levels*. In the rat dams, the chemical EH-TBB significantly accumulated in all three tissues with the highest concentrations measured in adipose tissues (Patisaul et al 2012).

The Cl-containing OPFRs are proven to be carcinogenic, and other severe negative human health effects were found for Cl-containing OPFRs as well as for TCP *which makes these OPFRs unsuitable as alternatives for BFRs*. TPhP, DCP and TCEP would also not be suitable alternatives for BFRs, because they are considered to be toxic to (aquatic) organisms and/or (potential) carcinogenic (van der Veen & de Boer 2012)

OPFRs may affect neurodevelopment *with similar or greater potency compared to known and suspected neurotoxicants such as the OP pesticide chlorpyrifos*. The results of experiments in PC12 cells results demonstrate that different OPFRs show divergent effects on neurodifferentiation, suggesting multiple mechanisms of toxicity (Dishaw et al 2011)

Flame retardants (FRs) are used in furniture, carpets, building insulation, electronic goods, fabrics, mattresses, vehicles and other items. Exposure occurs when additive FRs come out of the goods into air, dust and onto surfaces

The efficacy of FRs in upholstered furniture has been questioned and studies reporting toxicity continue to emerge including reproductive and developmental toxicity, altered metabolism, neurotoxicity, thyroid effects, reproductive effects and cancer. Student dormitories tended to have a higher level of some FRs compared to common rooms probably due to a higher density of furniture and electronic goods. (Dodson et al 2017).

Some flame retardants have been banned/phased out e.g. the PBDEs but are sometimes replaced with molecules with similar structures e.g. decabromodipheyl ethane. Many of the replacement FRs are organophosphates, both halogenated and non-halogenated.

Median concentrations of TCIPP in dust in all UK microenvironments exceeded those reported elsewhere in the world. Moreover, concentrations of TCIPP and TDCIPP in 2 UK car dust samples were – at 370 μg g^{-1} and 740 μg g^{-1} respectively – amongst the highest reported globally in indoor dust to date. Consistent with this, concentrations of TDCIPP in dust from UK cars exceed significantly those detected in the other microenvironments studied. Concentrations of EHDPP were shown for the first time to be significantly higher in classroom dust than in samples from other microenvironments (Brommer & Harrad 2015)

Concentrations of 'emerging' flame retardants (EFRs) are reported to be increasing in the UK indoor environment – some are capable of endocrine disruption and DNA damage. They are found in human milk with exposure from diet, air and dust (Tao et al 2017).

Restrictions on PBDEs have increased demand for new FRs in the UK, with the result that human exposure to PBDEs in UK homes and offices has decreased while exposure to new FRs has risen. Relatively volatile EFRs (e.g., tetrabromoethylcyclohexane−DBE−DBCH) were more frequently detected in indoor air (detection frequencies >60%), while less volatile FRs (e.g. tetrabromobisphenolA−bis(2,3-dibromopropylether (TBBPA−BDBPE) and decabromodiphenyl ethane (DBDPE)) were predominant in dust (Tao et al 2016).

Dermal contact with flame-retarded consumer products contributes substantially to human body burdens of PBDEs and HBCDs. However, the reported higher PBDE body burdens in toddlers than adults are likely associated with other exposure pathways such as increased hand-to-mouth behaviour and indoor dust ingestion (Abdallah & Harrad 2018)

In a study of OPFRs in the indoor environment TCPP was found to be the most abundant in air in Canada. This chemical has a registered usage in the EU of 10,000-100,000 tonnes per annum. FRs also partition to window surfaces and dust. OPFRs tend to accumulate more in air than dust or window film compared to PBDEs and BFRs (Vykoukalova et al 2017)

A Norwegian study found that inhalation seems to be the major exposure pathway for ΣTCPP and tris(2-chloroethyl) phosphate (TCEP), while participants had higher exposure to TBOEP and triphenyl phosphate (TPHP) via dust ingestion (Xu at al 2016).

Upholstered furniture, electronics and building insulation contain large amounts of FRs. TBBP-A and HBCDs in the milk of first-time mothers from the Boston, MA area was found at concentrations within the range of those measured in several other countries. Results suggest that body burdens of these BFRs are related to lifestyle factors, potentially including diet and domestic electronics (Carignan et al 2012)

Hexabromocyclododecane (HBCD) is a high-production-volume chemical used as flame retardant in polystyrene insulation and textiles. Because it is not chemically bound to the polymer, HBCD can migrate into the environment, contaminating indoor dust and foodstuff. Serum concentrations of HBCDs were correlated with the exposure via dust, but not via dietary ingestion (Roosens et al 2009)

Toddlers and children may be particularly exposed to FRs because they spend a lot of time on the ground and put their hands and objects into their mouths (Vuong et al 2018). Dermal absorption of FRs from furniture surfaces is also a problem especially in hot weather when people are likely to be wearing less clothes and have direct skin to surface contact (Abdallah&

One of the principal conflicts comes from the trade-off between energy efficiency and indoor air quality. FRs are used in insulation material, furniture, electronics, etc. However, a recent 2018 study is important to note: Organophosphate FR (OPFRS) levels in the environmental certified low-energy preschools were lower than those in the reference preschool and the non-certified low-energy preschool, probably attributed to the usage of environmentally friendly and low-emitting building materials, interior decorations, and consumer products. *Therefore, stricter requirements for building materials and indoor furnishings could help reduce OPFR in preschools* (Persson et al 2018)

Exposure to OPFRs varies seasonally with higher levels of exposure in summer (Hoffman et al 2017)

The presence of certain types of goods e.g. electronic, soft furniture, etc. affects the levels of FRs detected in rooms. For example, student dormitory rooms tended to have higher levels of some FRs compared to common rooms, likely to be a result of the density of furniture and electronics (Dodson et al 2017)

UK dust in homes, schools, offices and automobiles is the highest in the world so the risk is all pervasive. Infants, toddlers and children are most at risk because of breast-feeding, crawling and mouthing of their hands and objects; also they are much more vulnerable to the effects of chemicals because they are still developing.

Producers give no advice to the general public when buying products containing flame retardants. Products may carry a label saying that the item meets the fire regulations but do not say how. Retailers may not know if their products contain FRs and which ones in particular. The public level of knowledge about risks of FRs is mostly non-existent.

4. *How does the Government measure the health risks of toxic chemicals? What actions does the Government take to limit consumers' exposure to toxic chemicals? Should maximum residue limits (MRLs) be applied to toxic chemicals in consumer products? Are current trading standards sufficient to monitor toxic chemicals in consumer products (e.g. children's toys) and food?*

The standard reply is that chemicals are covered by REACH. However, REACH is glacially slow and retrospective with FRs taking years/decades to be evaluated. In the meanwhile, there is population-wide exposure to these chemicals.

COT has recently produced a 'scoping paper' on OP flame retardants which can be downloaded from their website.

Eliminating FRs used in furniture, electronics and insulation will, necessarily, reduce exposure to these potentially harmful substances. The main driver for change will be to use less flammable and less fire toxic materials in building products and domestic goods which will reduce the need for FRs. Modern materials such as polyurethane and PIR are highly flammable.

We need to aim for the elimination of the need for FRs by consideration of the following recommendations (adapted from Shaw et al 2010)**:**

(1) Flammability regulations can cause greater adverse environmental and health impacts than fire safety benefits.

(2) The current options for end-of-life disposal of products treated with flame retardants are problematic.

(3) Life-cycle analyses evaluating benefits and risks should consider the health and environmental effects of the chemicals, as well as their fire safety impacts.

(4) Most fire deaths and most fire injuries result from inhaling carbon monoxide and HCN[i], irritant gases, and soot. The incorporation of flame retardants can increase the yield of these toxic by-products during combustion.

(5) Fire-safe cigarettes, fire-safe candles, child-resistant lighters, sprinklers, and smoke detectors can prevent fires without the potential adverse effects of flame-retardant chemicals.

(6) Alternatives to flame retardant chemicals include using less flammable materials[ii], design changes, and safer chemicals.

Not requiring the use of FRs in furniture is the case in the domestic market in continental Europe. FRs are currently used to meet UK fire regulations without sufficient consideration of whether they increase fire toxicity (the main cause of fire deaths) and their chronic effects on people, animals and the wider environment. *FRs should not be put on the market without first establishing they are effective and safe at all stages of the life cycle (production, in normal use, during fires and at end of life).* **This is not currently the case**.

The safe disposal and recycling of products containing flame retardant is also highly problematic with imported goods into the EU containing higher levels of FRs than allowed in virgin goods.[iii]

Please ask us for a separate list of more than 180 scientific references documenting sources of exposure, environmental presence, and *in vitro, in vivo* and human health effects.

Environmental concerns

5. *What is the environmental risk from toxic chemicals? As part of its commitment in the 25 Year Environment Plan, what measures is the Government taking to reduce harmful chemicals in the environment? Will these measures be effective?*

These questions should be answered by Defra and environmental organisations. FRs are found in the wider environment.

6. *How are flame retardant treated products currently disposed of and what problems have been identified with these methods of disposal? What is international best practice for disposal?*

Furniture is taken to the dump creating problems for future generations. Electronic goods are sent to other countries for re-cycling creating problems for them and us when they come back to us in re-cycled goods (see end-note iii). Best practice is not to produce these chemicals at all to prevent them being kept in the circular economy or polluting water and air.

7. *Is current legislation on producer responsibility and management of waste sufficient for recyclers to identify toxic chemicals in products? Should materials treated with flame retardants be available for use as recycled material in consumer products?*

No. It is impossible to know whether a product contains FRs and which ones in particular. Flame retardant treated materials should not be recycled (see point 6 above).

UK policy

8. *Are the Furniture and Furnishings (Fire Safety) Regulations 1988 (as amended in 1989, 1993 and 2010) fit for purpose? If not, which aspects should be updated?*

Mr Terry Edge and others should advise on this question

9. *Does the Government's plan to target £9bn in savings through regulation by 2022 pose risks for chemical regulation?*

It could do so if resources are reduced for chemical regulation

10. *What risks or opportunities does Britain exiting the EU pose to regulation and import of these chemical substances or products containing these substances? What is the likely status of the UK's continued participation in the RAPEX system in the event of Britain leaving the EU?*

ChemTrust to advise

11. *How should substances of very high concern (SVHC) be regulated after the UK leaves the EU? How should the Government manage risk from newly identified toxic chemicals after the UK has left the EU?*

By either adhering to REACH or setting even higher standards.

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[i] . McKenna ST, Birtles R, Dickens K, Walker RG, Spearpoint MJ, Stec AA, Hull TR. Flame retardants in UK furniture increase smoke toxicity more than they reduce fire growth rate. Chemosphere. 2018 Apr;196:429-439

[ii] This is a key point: PU and PIR foams are highly flammable (Stec and Hull 2011) and form toxic gases when burnt, principally HCN

[iii] https://www.env-health.org/european-study-exposing-toxic-e-waste-chemicals-in-childrens-products-spurs-calls-for-policy-to-end-recycling-exemptions-for-hazardous-waste-2/