

Flame Retardant Chemicals Commonly Found in Furniture

General Information

This document provides an overview of 9 flame retardants (FRs) commonly used in residential furniture that are the focus of Duke University's furniture foam testing project. For each chemical, we've included what we currently know about the health risks from exposure to those FRs and links to additional resources. Most of these chemicals do not have high acute toxicity, meaning exposure for adults to these chemicals does not result in immediate health risks. However, long-term (also called chronic) exposure and/or low dose exposure during critical periods in a child's life may lead to health problems that develop over time. In many cases, the adverse effects of exposure to these FRs are not yet fully understood.

Flame retardant chemicals in consumer products are often organic (carbon-based) chemicals that contain either an organophosphate chemical structure, or bromine or chlorine atoms. *Organophosphate* chemical structures are common in pesticides and have a section that contains a specific kind of chemical group with oxygen atoms clustered around a phosphate atom. Bromine and chlorine are both part of the halogen chemical group, and chemicals with these atoms are often called *halogenated*. Some FR chemicals include both *halogenated* and *organophosphate* chemical structures, and some commercial FR products include mixtures of multiple FR chemicals.

Some types of FR chemicals are persistent, bioaccumulative, and potentially or definitely toxic. *Persistent* chemicals do not degrade, or break down, quickly. *Toxic* compounds produce harmful health effects. *Bioaccumulative* compounds are typically stored in the body in fat deposits, accumulating over long periods of time. Persistent and bioaccumulative chemicals, if toxic, can have long-lasting impacts on human health and the environment. This is because these chemicals are stored in and remain in living tissue and do not degrade over a long period of time. Some other FRs are toxic but degrade quickly and do not bioaccumulate, yet can still have substantial and lasting health impacts.

Halogenated FR compounds have structures that are similar to thyroid hormones. Some of these compounds may cause health problems by acting like thyroid hormones and interfering with the normal activity of those hormones. Thyroid hormones are involved in important functions such as breathing and heart function, digestion and metabolism, activity of other hormones, and muscle and brain development.

We know less about the health effects of organophosphate FR compounds than halogenated, but we do know they are structurally similar to organophosphate

pesticides. Organophosphate pesticides can cause nerve damage and cognitive problems in adults and may harm brain development in children. Some researchers are concerned that organophosphate FRs may have similar health impacts. Some organophosphate FR chemicals may change brain and heart development, responses to sex hormones, and reproduction. Organophosphate compounds are usually not persistent and do not bioaccumulate.

Some FR chemicals are *reactive* - that is, they are chemically bound to the base material (foam). These compounds are less likely to escape into the environment than the more common *additive* FR chemicals, which are physically mixed with the base material and may volatilize or leach out from consumer products where they're included.

Penta BDE

PentaBDE is a commercial FR mixture containing brominated chemicals called PBDEs (polybrominated diphenyl ethers). PentaBDE has been used for decades in residential furniture, but due to concerns over its persistence, ability to accumulate in humans, and its potential toxicity, the US began a phase-out of pentaBDE in 2005.

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- ✓ Halogenated
 - ✓ Persistent
 - ✓ Bioaccumulative
 - ✓ Likely thyroid hormone disruptor
 - ✓ Likely toxic for brain development
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For more information on PBDEs, including pentaBDE, read the [ToxFAQs summary](#) created by the US Agency for Toxic Substances and Disease Registry.

TDCPP

TDCPP, or tris (1,3-dichloro-2-propyl) phosphate, is an organophosphate FR that is being used to replace PentaBDE. TDCPP, which is used as an additive FR in resins, polymers, latexes, and foams, is most widely used in the US (annual estimations are 4,500- 22,700 metric tons).¹ There is evidence that TDCPP is a probable carcinogen and a developmental neurotoxicant², as well as an endocrine disruptor in fish.

-
- ✓ Halogenated
 - ✓ Organophosphate
 - ✓ Persistent
 - ✓ Bioaccumulative
 - ✓ Likely endocrine disruptor
 - ✓ Likely toxic for brain development
 - ✓ Probably carcinogenic
-

For more information on TDCPP, read:

- [this Environmental Health Perspectives article, “Exposure to TCDD Appears Widespread,”](#)
- [this technical report published by California’s EPA in 2011](#), and
- EPA’s [2005 assessment](#) and [2015 update](#) of alternatives to FRs used in polyurethane foams report

TCPP

TCPP is very similar in structure to TDCPP (see above) - it’s used as an additive FR in resins, polymers, latexes, and foams, and is most widely used in the US (annual estimations are 4,500-22,700 metric tons).³ As a relatively new FR additive, little is known about possible health effects. However, TCPP may cause cancer and accumulates in the liver and kidneys.⁴

¹ Meeker JD, et al. Urinary metabolites of organophosphate flame retardants: Temporal variability and correlations with house dust concentrations. *Environ Health Perspect* 121:580-585. (2013); <http://dx.doi.org/10.1289/ehp.1205907>

² Dishaw LV, et al. Is the PentaBDE replacement, tris (1,3-dichloropropyl) phosphate (TDCPP), a developmental neurotoxicant? Studies in PC12 cells. *Toxicol Appl Pharmacol* 256(3):281–289. (2011); <http://dx.doi.org/10.1016/j.taap.2011.01.005>

³ See first footnote

⁴ Van der Veen, I. & de Boer, J. Phosphorus flame retardants: Properties, production, environmental occurrence, toxicity and analysis. *Chemosphere* 88, 1119–1153 (2012).

Firemaster® 550

Firemaster® 550 (FM 550) is a mixture of brominated and organo-phosphorous FRs. It was advertised as a replacement for pentaBDE following its phase-out. Other than some limited testing carried out by the manufacturer, little information on the health effects of Firemaster 550 is available. However, a recent study conducted by researchers at Duke University and NC State found that some of the components in FM 550 bioaccumulate and act as an endocrine disruptor. Exposure to FM 550 may also contribute to obesity, metabolic disruption, and increase the onset of puberty.

For more information, read [this press release from NC State University](#) on the 2013 study of Firemaster 550 by Patisaul et al. (2013), with coauthor Dr. Heather Stapleton. You can read the full study [online at PubMed](#).

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- ✓ Halogenated
 - ✓ Organophosphate
 - ✓ Likely thyroid hormone disruptor
 - ✓ Likely obesogenic
 - ? Persistent
 - ? Bioaccumulative
-

Firemaster® 600

Firemaster® 600 (FM 600) is a mixture of brominated and organophosphorus FRs. It is advertised as a replacement for pentaBDE. Other than some limited testing carried out by the manufacturer, little information on the health effects of Firemaster 600 is available.

-
- ✓ Halogenated
 - ✓ Organophosphate
 - ? Persistent
 - ? Bioaccumulative
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V6

V6 is a chlorinated organophosphate FR mixture. One particular FR which occurs in V6 as an impurity is tris(2-chloroethyl) phosphate or TCEP. TCEP, which is grouped with other phosphate ester FRs such as triphenyl phosphate (TPP) and TDCPP, is considered a carcinogen.

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- ✓ Halogenated
 - ✓ Organophosphate
 - ✓ Persistent
 - ? Possibly toxic for reproduction
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TBPP

TBPP, or Tris-isobutylated triphenyl phosphate, is a mixture of organophosphate FRs that do not contain halogens (e.g. bromine or chlorine). About 40% of the TBPP mixture is a chemical called triphenyl phosphate (TPP), and TBPP is found in commercial flame retardant mixtures.⁵ Limited data exist on the health impacts of this mixture, but scientific studies have shown that TPP can have high acute aquatic toxicity. EPA conducted a risk characterization for TBPP in 2008, but that document is no longer available online.

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- ? Endocrine disruptor
 - ? Toxic for heart development
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ITP Mix

ITP, or isopropyl triphenyl phosphate, is an organophosphate FR chemical that is also used in hydraulic fluids and as a plasticizer. The name, ITP Mix, means that there are variations in the chemical shape of the ITP compounds that can affect how they react. Research at Duke University has

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- ✓ Organophosphate
 - ✓ Persistent
 - ✓ Carcinogenic
 - ? Possibly toxic for reproduction
-

found ITP compounds in the FR mixture FM550⁶ and other flame retardant mixtures.⁵ Research in human cells has found that organophosphate FRs are carcinogenic and can damage immune, neurological, and developmental systems.⁷

MPP Mix

MPP, or methyl phenyl phosphate, is a mixture of organophosphate FRs that do not contain halogens (e.g. bromine or chlorine). Triphenyl phosphate (TPP) is also a primary component in MPP (see TBPP info above for more information on TPP). Little information is available on the toxicity and levels of exposure to chemicals found in this mixture.

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- ✓ Organophosphate
 - ✓ Persistent
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⁵ Stapleton, H. M., Allen, J. G., Kelly, S. M., Konstantinov, A., Klosterhaus, S., Watkins, D., ... & Webster, T. F. (2008). Alternate and new brominated flame retardants detected in US house dust. *Environmental science & technology*, 42(18), 6910-6916.

⁶ Phillips, A. L., Hammel, S. C., Konstantinov, A., & Stapleton, H. M. (2017). Characterization of Individual Isopropylated and tert-Butylated Triarylphosphate (ITP and TBPP) Isomers in Several Commercial Flame Retardant Mixtures and House Dust Standard Reference Material SRM 2585. *Environmental science & technology*, 51(22), 13443-13449.

⁷ Dishaw, L. V., Powers, C. M., Ryde, I. T., Roberts, S. C., Seidler, F. J., Slotkin, T. A., & Stapleton, H. M. (2011). Is the PentaBDE replacement, tris (1, 3-dichloro-2-propyl) phosphate (TDCPP), a developmental neurotoxicant? *Studies in PC12 cells. Toxicology and applied pharmacology*, 256(3), 281-289.