

Appendix B: Organophosphate Flame Retardants

These brief fact sheets are meant to provide the reader with a brief summary of the most common flame retardants' use, environmental behavior, contamination, human exposure, toxicity, and regulation.

TDCPP

Tris (1,3-dichloro-2-propyl) phosphate
"TDCP", "Chlorinated Tris"
CAS Number: 13674-87-8

Registered Trade Names

- Fyrol FR-2; Antiblaze 195.

Use

- An additive flame retardant in flexible polyurethane foams in furniture and mattresses and plasticizer in rigid polyurethane foams, resins, plastics, textile, and rubber.ⁱ
- Production and use in furniture foam increased significantly after phase out of Penta-BDE.ⁱⁱ
- National production volume in 2012: 10- 50 million pounds.ⁱⁱⁱ
- Demand is expected to increase.^{iv}

Health Risk

- Considered a carcinogen by the State of California.^v
- Exposure to TDCPP house dust concentrations associated with altered hormone levels and decreased semen quality in men recruited through a U.S. infertility clinic.^{vi}
- Metabolizes to several other carcinogenic substances.^{vii}
- A 2006 assessment by the Consumer Product Safety Commission found it posed a threat to human health.^{viii}
- Animal studies suggest it is neurotoxic, an endocrine disruptor, and a reproductive toxicant.^{ix}
- Neurotoxic to brain cells and potentially more toxic than chlorpyrifos, a known developmental neurotoxicant.^x
- Structurally similar to TDBPP and TCEP.

Exposure

- Used for decades as a flame retardant and plasticizers in a wide variety of applications, resulting in widespread environmental contamination of the indoor and outdoor environment.
- Used in children's sleepwear in the 1970s; manufacturers voluntarily stopped treating sleepwear in 1977 due to concerns regarding its mutagenicity.^{xi}
- Detected in most treated wastewater samples and in surface water from discharge of municipal and industrial wastewater.^{xii}
- Does not break down in water and is not removed by conventional wastewater treatment methods.^{xiii}
- Detected in domestic wastewater, likely from washing articles with flame retardants. Released to waste water from TDCPP-treated polyester garments during washing (37% after 20 washings).^{xiv}
- Detected in rivers, the sea, and drinking water in Japan and Canada.^{xv}
- Detected in household and office dust, indoor air, and in streams, sewage and sludge. Found in human adipose tissue, seminal plasma and breast milk.^{xvi}
- Identified in baby products, including car seats, changing table pads, nap mats, crib mattress pads, infant sleepers, and other foam products for infants and young children.^{xvii}
- Detected in many U.S. couches.^{xviii}
- Concentrations may be higher in offices and vehicles than in homes.^{xix}
- Higher levels of TDCPP in documented in dust from electronics shops, furniture stores, a pharmacy, and office buildings, than in homes.^{xx}

Regulation

- 2011: Listed under California's Proposition 65.
- 2012: Center for Environmental Health initiated first-ever legal action against retailers and producers of TDCPP contaminated products for not labeling products containing TDCPP.^{xxi}

TCPP

Tris(1-chloro-2-propyl) phosphate
CAS Number: 13674-84-5

Registered Trade Names

- Hostaflam OP 820; Amgard TMCP; Fyrol PFC, Antiblaze 80

Use

- Global use increased in the 1960s as replacement for TCEP.^{xxii}
- Used in rigid and flexible polyurethane foam for upholstered furniture and automotive applications and in rigid PU insulation foams.^{xxiii}
- In Europe, over 98% is used as a flame retardant in the production of polyurethane for use in construction and furniture.^{xxiv}
- Used in polyurethane board in construction.^{xxv}
- National production volume in 2012: Over 50 million pounds.^{xxvi}

Health Risks

- Few data available on health risks.
- No data on effects on humans are available.
- No data on dermal, inhalation, or oral routes of exposure and no studies have been conducted on reproduction.
- Structurally similar to three tris flame retardants (TCEP, TDBPP, and TDCPP) identified as causing cancer by the State of California.

Exposure

- High concentrations detected inside automobiles, buses and subway cars.^{xxvii}
- Detected in most treated wastewater samples and in surface water from discharge of municipal and industrial wastewater.^{xxviii}
- Does not break down in water and is not removed by conventional wastewater treatment methods.^{xxix}
- Present in air samples from cars, offices, and furniture stores.^{xxx}
- Detected in airborne particles over the Asian seas as well as in the Polar Regions. Elevated concentrations were observed in proximity to the Asian.^{xxxi}
- Found in foam baby products, including nursing pillows, changing pads, booster seats, car seats, and bassinets.^{xxxii}

Regulation

- Not regulated

TCEP

Tris (2-chloroethyl) phosphate

“Tris”, “TRCP”

CAS Number: 115-96-8

Registered Trade Names

- Antiblaze 100; Celluflex CEF; Disflamoll TCA; Fyrol CEF; Niax 3CF, Tolgard TCEP; Genomoll P; Hostaflam UP810; Levagard EP

Use

- Used in foam in baby products and furniture; PVC vinyl, home electronics (including televisions and computers); adhesives; upholstery in cars, trains and planes; carpet backings, rubber, plastics, paints and varnishes.
- In Europe, mainly used in the building industry (e.g., roofing insulation), the furniture and the textile industry (e.g., back-coatings for carpets and upholstery).
- Use has declined since the 1980s, when TCEP began to be replaced by TDCPP and TCPP.^{xxxiii}
- Impurity in the commercial flame retardant V6 (14% by weight).^{xxxiv}
- Annual U.S. production/import volume was 1-10 million pounds for the reporting years from 1986 through 2002.^{xxxv}
- National Production volume for 2012 is withheld from USEPA’s Chemical Access Tool database due to confidential business information claims.^{xxxvi}

Health Risks

- Considered a carcinogen by the State of California.^{xxxvii}
- TCEP has been found to increase cancer risk and has been linked to reproductive effects and neurotoxicity in animals. There is also evidence that it can cause tumors in the kidney and liver in animals and can damage the learning center of the brain in animals.^{xxxviii}
- Structurally similar to TDBPP and TDCPP.

Exposure

- Detected in 14 of 101 polyurethane foam baby products, including nursing pillows, portable cribs and baby carriers.^{xxxix}

- Measured in indoor air samples and in dust in homes, offices, schools, and cars. Correlated with the commercial flame retardant V6 in dust samples from polyurethane foam found in baby products, furniture and cars.^{xl}
- Does not break down in water and is not removed by conventional wastewater treatment methods.^{xli}
- Detected in most treated wastewater samples and in surface water from discharge of municipal and industrial wastewater.^{xlii}
- Detected in drinking water and groundwater.^{xliii} Widely detected in surface water in the U.S. USGS detected it in 59% of 139 U.S. streams.^{xliv}
- Detected in airborne particles over the Asian seas as well as in the Polar Regions.^{xlv}
- Recently detected for the first time on the Antarctica ice sheet, providing evidence of its ability to travel long distances.^{xlvi}
- Human exposure may occur from drinking contaminated water, eating contaminated food, or breathing contaminated dust. Young children may be exposed to TCEP by mouthing plastic products or touching plastic products and putting their hands in their mouths.^{xlvii}

Regulation

- 1982: USEPA issued a decision not to require testing of TCEP because, "...available data indicate that production and use result in little risk of occupational or consumer exposure and there is no known release to the environment...EPA finds no basis for believing that the compound may present an unreasonable risk to human health or the environment."^{xlviii}
- 1992: TCEP added to California's list of carcinogens.^{xlix}
- 2010: EU listed TCEP as Substance of Very High Concern due to concerns about reproductive toxicity and the potential to impair fertility.^l
- 2011: New York State banned certain children's products containing TCEP (ban began December 1, 2013); violators subject to civil penalties.^{li}
- 2012: TCEP Added to Europe's REACH candidate list.
- 2013: USEPA announced decision to conduct full risk assessment.^{lii}

TCP

Tricresyl phosphate

CAS Number: 1330-78-5

Registered Trade Names

- Kronitex TCP; Phosflex179A; Disflamoll TKP; Lindol; Celluflex 179C

Use

- Commercial TCP is a mixture of 28 components.
- Applied as a backcoating to upholstery fabrics when used as a flame retardant in upholstered furniture and on nylon, polyester, olefin, cotton, non-cotton cellulose, PVC and fabric blends. Used in leather Cloth (PVC), upholstery, book binding, seat covers, footwear, raincoats, handbags, PVC and rubber cables, hoses, flexible pipe, coal mining, conveyor belts.^{liii liv}
- National production volume in 2012: 1-10 million pounds.^{lv}

Health Risks

- TCP is a neurotoxin and has chronic organ and reproductive and developmental toxicity in animals.^{lvi}
- For humans, ingestion may result in delayed neurotoxicity, but data is limited.^{lvii}

Exposure

- The tri-ortho-isomer of TCP (TOCP) is neurotoxic to humans and has been associated with 60,000 cases of worldwide poisoning.^{lviii}

Regulation

- 2011: Nominated for in-depth toxicological evaluation by NTP.

TBEP

Tris(2-butoxyethyl) phosphate
CAS Number: 78-51-3

Registered Trade Names

- Kronitex KP-140; KP 140; Phosflex T-bep

Use

- Primarily used as a flame retardant in polyurethane rubber. Also used in floor polishes and as a plasticizer in rubber and plastics.
- National production volume in 2012: 1-10 million pounds.^{lix}

Health Risks

- Animal studies shown that the liver is the target organ for TBEP toxicity. Neurotoxic effects in rats are inconsistent. Inhibited brain and plasma cholinesterases in hens. The long-term toxicity and carcinogenicity of TBEP has not been studied.^{lx}

Exposure

- General population is exposed mostly via food (from use of TBEP as a plasticizer in packaging plastics) and drinking-water (contaminated by leaching from synthetic rubbers used in plumbing washers).^{lxi}
- The most abundant organophosphate in indoor dust in a Swedish study, possibly due to its use in floor polish and waxes.^{lxii}

Regulation

- Not regulated

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