

## Sources of Exposure

## Toxicokinetics and Normal Human Levels

## Biomarkers/Environmental Levels

# ToxGuide™

for

# Phosphate Ester Flame Retardants

CAS# 126-71-6; 126-73-8; 78-51-3;  
115-86-6; 13674-84-5; 13674-87-8;  
115-96-8; 1330-78-5

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U.S. Department of Health and  
Human Services  
Public Health Service  
Agency for Toxic Substances  
and Disease Registry  
[www.atsdr.cdc.gov](http://www.atsdr.cdc.gov)

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### General Populations

- The general population is primarily exposed to phosphate ester flame retardants through ingestion of contaminated food. Most foods contain trace amounts of phosphate esters due to their extensive use in plastics.
- Drinking water may become contaminated due to leaching from plastics or industrial waste water discharge.
- Exposure may also occur through inhalation of contaminated air. Hydraulic fluid is the main source of phosphate esters in outdoor air, while fumes from plastics, adhesives, foams or electronics may contaminate indoor air.
- Dermal exposure may occur through contact with contaminated soil.

### Occupational Populations

- Workers in industries that manufacture phosphate esters or products containing phosphate esters are at greater risk of exposure than the general population.
- Exposure may also occur during the transport, processing or disposal/recycling of flame retardants.

### Toxicokinetics

- In animal studies, TDCP, TCEP, TnBP, and TCP were well absorbed following oral exposure.
- Significant amounts of TDCP and TnBP were absorbed through rat skin, but TnBP was poorly absorbed through pig skin.
- The available data suggested that phosphate esters are widely distributed throughout the body.
- TDCP, TCEP, and TnBP undergo extensive metabolism and the metabolites are rapidly excreted, principally in the urine.

### Normal Human Levels

- No data available.

### Biomarkers

- There are no biomarkers that can be used to quantify exposure to phosphate ester flame retardants.
- Detection of a specific phosphate ester in adipose tissue may be an indication exposure.

### Environmental Levels

#### *Air*

- No data were available for air levels in the United States.

#### *Sediment and Soil*

- No data were available for sediment/soil levels in the United States.

#### *Water*

- Concentration in rivers, lakes and groundwater are commonly around 0.5 µg/L.
- In surface water, the average concentrations of TCEP, TDCP, and TPP were 0.1, 0.1, and 0.04 µg/L, respectively.

### Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. Toxicological Profile for Phosphate Ester Flame Retardants. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Services.

## Chemical and Physical Information

## Routes of Exposure

## Relevance to Public Health (Health Effects)

### Phosphate Ester Flame Retardants are Trisubstituted Phosphate Esters

- Phosphate ester flame retardants are human-made chemicals that are typically liquids at room temperature, however some are solids. They are composed of groups of chemicals with similar properties but different structures.
- Phosphate esters are added to consumer and industrial products in order to reduce flammability. They are used in plasticizers, hydraulic fluids, solvents, extraction agents, antifoam agents, and coatings for electronic devices.
- The phosphate esters evaluated here are tris(2-chloroethyl) phosphate (TCEP), tributyl phosphate (TnBP), tris(2-butoxyethyl) phosphate (TBEP), tris(1,3-dichloro-2-propyl) phosphate (TDCP), triphenyl phosphate (TPP), tris(2-chloroisopropyl) phosphate (TCPP), triisobutyl phosphate (TiBP), and tricresyl phosphate (TCP).

- Inhalation – Major route of exposure for the general and occupational populations.
- Oral – Predominant route of exposure for the general population through ingestion of contaminated food or water.
- Dermal – Minor route of exposure for the general population. Major route of occupational exposure.

### Phosphate Ester Flame Retardants in the Environment

- Phosphate flame esters are released into the environment as a result of industrial sources and disposal of consumer products.
- Due to their prevalence and persistence, phosphate esters are considered to be emerging pollutants.
- Phosphate esters can change chemical composition in the environment.
- Particulate-phase phosphate esters are subject to wet and dry deposition, while semi-volatile phosphate esters have the potential to hydrolyze to diesters, monoesters and phosphoric acid.
- Most phosphate esters are poorly soluble in water and adsorb strongly to soils.
- Phosphate esters biodegrade in aquatic and terrestrial environments.

Health effects are determined by the dose (how much), the duration (how long), and the route of exposure.

### Minimal Risk Levels (MRLs)

#### Inhalation

- No inhalation MRLs were derived for phosphate ester flame retardants.

#### Oral

- No oral MRLs were derived for TPP, TiBP, or TCPP.

The following MRLs were derived for acute-duration oral exposure ( $\leq 14$  days):

- 1.1 mg/kg/day for TnBP
- 4.8 mg/kg/day for TBEP

The following MRLs were derived for intermediate-duration oral exposure (15–354 days):

- 0.6 mg/kg/day for TCEP
- 0.08 mg/kg/day for TnBP
- 0.09 mg/kg/day for TBEP
- 0.05 mg/kg/day for TDCP
- 0.04 mg/kg/day for TCP

The following MRLs were derived for chronic-duration oral exposure ( $\geq 365$  days):

- 0.2 mg/kg/day for TCEP
- 0.08 mg/kg/day for TnBP
- 0.02 mg/kg/day for TDCP
- 0.02 mg/kg/day for TCP

### Health Effects

- Limited data are available regarding health effects in humans. Long-term occupational exposure to TDCP and TPP did not produce adverse health effects. Allergic reactions have been associated with consumer products containing TPP.
- In long term oral rat studies, TCEP caused brain lesions and decreased fertility; TnBP induced lesions in the urinary bladder; TBEP caused liver lesions; TDCP caused lesions in the kidney and liver; TCP induced adrenal and ovarian lesions; and TPP, TiBP and TCPP produced no significant adverse effects.
- TCEP, TnBP, and TDCP all produced tumors following long-term oral administration.
- DHHS and EPA have not classified the carcinogenic potential of the phosphate ester flame retardants. IARC has determined that TCEP is not classifiable as to its carcinogenicity in humans.

### Children's Health

- In animal studies, continuous exposure to TCEP caused reduced viability of offspring and continuous exposure to TnBP resulted in reduced pup body weight.