Phosphorus

7723-14-0

Hazard Summary

White phosphorus is used in the manufacture of munitions, pyrotechnics, explosives, smoke bombs, in artificial fertilizers, and rodenticides. White phosphorus is extremely toxic to humans, while other forms of phosphorus are much less toxic. Acute (short-term) oral exposure to high levels of white phosphorus in humans is characterized by three stages: the first stage consists of gastrointestinal effects; the second stage is symptom-free and lasts about two days; the third stage consists of a rapid decline in condition with gastrointestinal effects, plus severe effects on the kidneys, liver, cardiovascular system, and central nervous system (CNS). Inhalation exposure has resulted in respiratory tract irritation and coughing in humans. Chronic (long-term) exposure to white phosphorus in humans results in necrosis of the jaw, termed "phossy jaw." EPA has classified white phosphorus as a Group D, not classifiable as to human carcinogenicity.

Please Note: The main sources of information for this fact sheet are EPA's Integrated Risk Information System (IRIS) (5), which contains information on oral chronic toxicity and the RfD, and the Agency for Toxic Substances and Disease Registry's (ATSDR's) Toxicological Profile for White Phosphorus. (4)

Uses

- Most phosphorus is used in the production of phosphoric acid and phosphates, which are used in the fertilizers industry. (4)
- White phosphorus is used in the manufacture of munitions, pyrotechnics, explosives, smoke bombs, in artificial fertilizers, rodenticides, phosphor bronze alloy, semiconductors, electroluminescent coating, and chemicals. (1,4)

Sources and Potential Exposure

- Occupational exposure to white phosphorus may occur for workers in the munitions and other industries. (1)
- Exposure may also occur during the military use of white phosphorus-containing munitions. (4)

Assessing Personal Exposure

- No information is available on the assessment of personal exposure to white phosphorus.

Health Hazard Information

Acute Effects:

- Acute oral exposure to high levels of white phosphorus in humans is characterized by three stages: the first stage consists of gastrointestinal effects; the second stage is symptom-free and lasts about 2 days; the third stage consists of a rapid decline in condition with severe gastrointestinal (vomiting, abdominal cramps and pain), kidney, liver, cardiovascular, and CNS effects. (1,2,4)
- Acute inhalation exposure has resulted in respiratory tract irritation and coughing in humans. (4)

- Respiratory, liver, and kidney effects have been reported in animals acutely exposed to white phosphorus smoke via inhalation. (4)
- Dermal exposure to white phosphorus in humans may result in severe burns, which are necrotic, yellowish, fluorescent under ultraviolet light, and have a garlic-like odor. (1)
- Acute animal tests in rats and mice have shown white phosphorus to have extreme acute toxicity from oral exposure. (3)

Chronic Effects (Noncancer):

- Chronic exposure to white phosphorus in humans results in necrosis of the jaw, termed "phossy jaw." Progressive symptoms begin as a local inflammation or irritation and proceed to swelling, ulceration, and destruction of the jawbone with perforation to the sinus or nasal cavities and externally to the cheek. (1,2,4,5,9)
- In one occupational study, anemia and leukopenia were observed. (4)
- Animal studies have reported effects on the blood from inhalation exposure to white phosphorus. (2)
- The Reference Dose (RfD) for white phosphorus is 0.00002 milligrams per kilogram body weight per day (mg/kg/d) based on reproductive effects (parturition mortality and forelimb hair loss in rats). The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancer effects during a lifetime. It is not a direct estimator of risk but rather a reference point to gauge the potential effects. At exposures increasingly greater than the RfD, the potential for adverse health effects increases. Lifetime exposure above the RfD does not imply that an adverse health effect would necessarily occur. (5)
- EPA has low confidence on the study on which the RfD was based because it does not provide unequivocal evidence of an adverse effect at the doses tested and lacked adequate assessment of developmental indices; low confidence in the database because studies indicate significant white phosphorus-related body weight and/or bone changes, but they have design deficiencies that lower the confidence in the reported observations; and, consequently, low confidence in the RfD. (5)
- EPA has not established a Reference Concentration (RfC) for white phosphorus. (5)
- The California Environmental Protection Agency (CalEPA) has calculated an inhalation reference exposure level of 0.00007 milligrams per cubic meter (mg/m^3) based on a route to route extrapolation of EPA's RfD. The CalEPA reference exposure level is a concentration at or below which adverse health effects are not likely to occur. (9)
- ATSDR has calculated an acute inhalation minimal risk level (MRL) of 0.02 mg/m^3 for white phosphorus smoke based on respiratory effects in humans. The MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. (4)

Reproductive/Developmental Effects:

- No information is available on the reproductive or developmental effects of white phosphorus in humans.
- An animal study reported a high maternal mortality rate from oral exposure to white phosphorus. (5)

Cancer Risk:

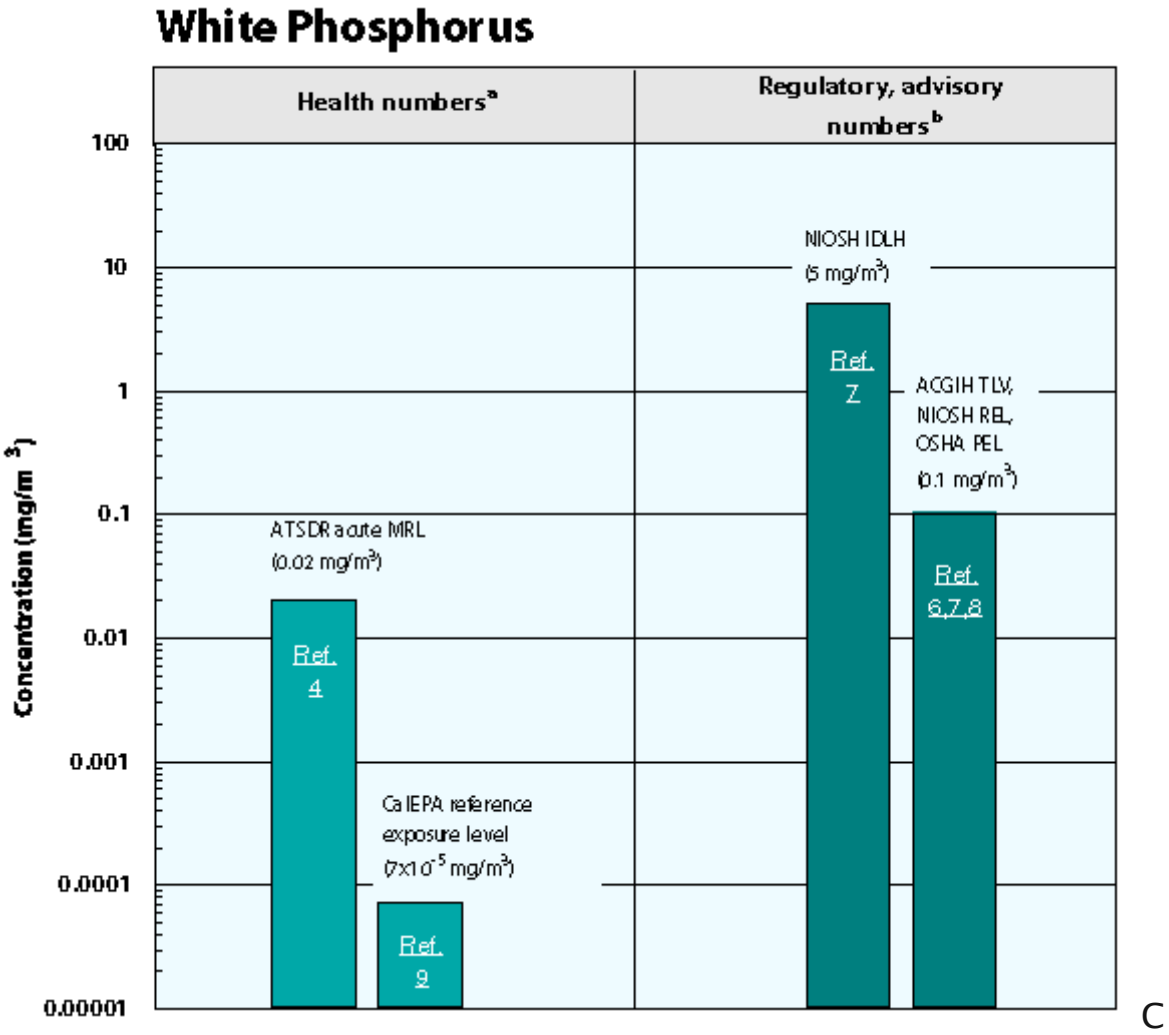
- No information is available on the carcinogenic effects of white phosphorus in humans or animals. (5)
- EPA has classified white phosphorus as a Group D, not classifiable as to human carcinogenicity. (5)

Physical Properties

- White or yellow white phosphorus is either a yellow or colorless, volatile crystalline solid that darkens when exposed to light and ignites in air to form white fumes and greenish light. (1)
- The chemical symbol for white phosphorus is P; the vapor has the formula P_4 and the molecular weight is 124.0 g/mol. (2)
- White phosphorus has a garlic-like odor. (4)
- The vapor pressure for white phosphorus is 0.026 mm Hg at 20 °C and the log octanol water partition coefficient (log Kow) is 3.08. (2,4)

Conversion Factors:
To convert concentrations in air (at 25 °C) from ppm to mg/m^3: mg/m^3 = (ppm) × (molecular weight of the compound)/(24.45). For white phosphorus: 1 ppm = 5.1 mg/m^3.

Health Data from Inhalation Exposure



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ACGIH TLV --American Conference of Governmental and Industrial Hygienists' threshold limit value expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects.
NIOSH IDLH -- National Institute of Occupational Safety and Health's immediately dangerous to life or health concentration; NIOSH recommended exposure limit to ensure that a worker can escape from an exposure condition that is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from the environment.

NIOSH REL--NIOSH's recommended exposure limit; NIOSH-recommended exposure limit for an 8- or 10-h time-weighted-average exposure and/or ceiling.
OSHA PEL--Occupational Safety and Health Administration's permissible exposure limit expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects averaged over a normal 8-h workday or a 40-h workweek.

The health and regulatory values cited in this factsheet were obtained in December 1999.
[a] Health numbers are toxicological numbers from animal testing or risk assessment values developed by EPA.
[b] Regulatory numbers are values that have been incorporated in Government regulations, while advisory numbers are nonregulatory values provided by the Government or other groups as advice. OSHA numbers are regulatory, whereas NIOSH and ACGIH numbers are advisory.

Summary created in April 1992, updated January 2000

References

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