

1-Bromopropane Background

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1-Bromopropane (1-BP or n-propyl bromide, Chemical Abstracts Service (CAS) Number 106-94-5) is a brominated hydrocarbon with the chemical formula C_3H_7Br (MW 123.01) and structure as shown below.



General physical characteristics: Commercial grade 1-BP is a clear, colorless liquid with sweet odor.

Special physical characteristics: 1-BP is a highly volatile organic compound with a boiling point of 71^oC; vapor pressure, 146.26 mm Hg at 20^oC; melting point, -110^oC; and specific gravity, 1.35g/cm³ at 20^oC. It is soluble in some organic solvents and slightly soluble in water.

Flammability and other hazards: 1-BP is a highly flammable liquid with flash point of 22^oC (72^oF). Its vapor is also flammable.

Occupational use: The U.S. Environmental Protection Agency (US EPA) considers 1-BP to be a high production volume chemical with widespread usage in various commercial and industrial settings. It is used mainly as a solvent for commercial and industrial applications such as degreasing (vapor, cold cleaning, and aerosol), spray adhesives, and dry cleaning. The largest use of 1-BP is as a vapor degreaser for electronics and metal followed by use as a solvent in aerosol-applied adhesive in the manufacturing of foam cushions and laminates (US EPA, 2007). It is occasionally used in dry cleaning, both in machine cleaning and as a component of spot cleaners to remove stains. In recent years, its use has increased as a substitute for suspected carcinogens or ozone-depleting chemicals and, as a result, more workers are likely exposed to 1-BP (NTP, 2013). The California Environmental Reporting System (CERS, operated by California EPA) database confirms industrial use in California, mainly as a vapor degreaser and spray adhesive.

Occupational exposure: Significant workplace exposure to 1-BP can occur via both inhalation of vapors or mists and dermal contact. According to a US EPA analysis, 8,300 to 40,300 workers may be exposed nationwide in businesses using vapor degreasers, and 400 to 9,800 workers may be exposed to 1-BP in businesses using adhesives to manufacture foam cushions and laminates (US EPA, 2007). It is unknown how many workers are exposed in California. Concentrations of 1-BP in air from all studies identified across several U.S. industrial sectors ranged from not detected to 380 ppm, with the highest concentrations during adhesive use and the lowest during vapor degreasing. Sprayers in the adhesive industry had the highest airborne exposures, which ranged from 18 to 380 ppm (8- to 12-hour time-weighted averages [TWAs]) across several studies (NTP, 2013).

Disposition: Studies in humans and laboratory animals indicate that 1-BP can be absorbed following inhalation, ingestion, or dermal contact. Occupational exposure occurs primarily by inhalation and, to a lesser extent, dermal contact. The absorbed dose is rapidly distributed and eliminated predominantly unchanged by either exhalation or excretion in urine and feces. The remaining dose is metabolized via either cytochrome P-450-catalyzed oxidation reaction or glutathione conjugation as the primary metabolic pathways. Four urinary metabolites have been identified in 1-BP-exposed workers as well as from studies in animals. Additionally, several reactive intermediate metabolites of 1-BP including α -bromohydrin, bromoacetone, propylene oxide, and glycidol have been identified in animal studies.

Health effects: Acute (short-term) adverse health effects reported among workers exposed to high levels of 1-BP include eye, nose, throat, and lung irritation as well as headache, nausea, fatigue, and dizziness (Ichihara, 2004; Majersik, 2007; Perrone, 2008). Acute skin irritation in experimental animals has also been reported (Jacobs, 1987; Palovics, 2004). Chronic (long-term) adverse health effects from 1-BP exposure described in both animal and human studies include peripheral and central nervous system toxicity and reproductive (limited human data) changes (NTP, 2003; OEHHA, 2004; Ichihara, 2004). Chronic effects observed in experimental animals include cancer and reproductive, developmental, hepatic, and renal toxicity (NTP, 2011; NTP, 2014; OEHHA, 2016; Grosse, 2016; ACGIH, 2014). It is suggested that this range of toxicity could be due to several mechanisms, including genotoxicity, oxidative stress, 1-BP metabolism to form reactive toxic metabolites, immunosuppression, cell proliferation, and chronic inflammation. In addition, the urinary metabolites glycidol and propylene oxide are both currently listed as “reasonably anticipated to be human carcinogens” by the National Toxicology Program (NTP). In 2014, NTP concluded that 1-BP is “reasonably anticipated to be a human carcinogen” based on sufficient evidence of carcinogenicity from studies in experimental animals and pathogenic mechanisms relevant to humans. NTP found 1-BP to cause an increased incidence of combined malignant and benign skin tumors in male rats, benign large intestine tumors in male and female rats, and combined malignant and benign lung tumors in female mice. NTP states that intestinal adenomas have been demonstrated to progress to carcinoma in other studies. Of note, the carcinogenic effects in these NTP studies occurred at concentrations comparable to those measured during occupational exposure. In 2016, the International Agency for Research on Cancer (IARC) classified 1-BP as “possibly carcinogenic to humans” (group 2B), based on “sufficient evidence of carcinogenicity in experimental animals” (Grosse, 2016; IARC, 2016a, in press; IARC 2016b). US EPA and the National Institute for Occupational Safety and Health (NIOSH) are reviewing the evidence for carcinogenicity and non-cancer health effects and drafting risk assessments (US EPA, 2016; NIOSH, 2016).

Occupational exposure limits (OELs):

In 2003, HESIS recommended in its initial 1-BP Health Hazard Alert a California Division of Occupational Safety and Health (Cal/OSHA) Permissible Exposure Limit (PEL) of 1 ppm including skin notation; this level was intended to protect against the reproductive and nerve toxicity of 1-BP. In 2009, Cal/OSHA proposed the current PEL of 5 ppm, taking into account HESIS' recommendation as well as cost and feasibility conclusions discussed in the Federal Register Significant New Alternative Program (SNAP) Notices for 1-BP in 2003 and 2007. Cal/OSHA adopted this PEL of 5 ppm which became effective in 2010 and is considered both technically and economically feasible for industries using 1-BP in California.

Organization	OEL (ppm, 8-hr TWA)	STEL	Ceiling	Skin Notation?***
Cal/OSHA PEL	5*	-	-	Yes
Federal OSHA PEL	-	-	-	No
ACGIH TLV	0.1**	-	-	No

ACGIH = American Conference of Governmental Industrial Hygienists; Cal/OSHA = California Division of Occupational Safety and Health; Federal OSHA = Federal Occupational Safety and Health Administration; PEL = Permissible Exposure Limit; STEL = Short Term Exposure Limit; TLV = Threshold Limit Value; TWA = Time-Weighted Average.

*Effective in 2010.

**Proposed reduction from 10 ppm to 0.1 ppm in 2011; adopted change in 2014 based on non-cancer toxicity, particularly neurologic effects.

***Substances designated by "S" in the skin notation column of Table AC-1, Title 8 CCR §5155, may be absorbed into the bloodstream through the skin, mucous membranes and/or eye, and contribute to overall exposure.

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