Massachusetts Chemical Fact Sheet

n-Propyl Bromide

nPB, 1-Bromopropane or 1-BP

This fact sheet is part of a series of fact sheets developed by the Toxics Use Reduction Institute (TURI) to help Massachusetts companies and communities understand uses and health and environmental effects of individual chemicals, as well as the availability of safer alternatives.

N-propyl bromide (nPB), or 1-bromopropane, is a solvent that is used in vapor degreasing, metal cleaning, and dry cleaning, as a solvent carrier in adhesives, and as a chemical intermediate. The US Environmental Protection Agency (EPA) classifies nPB as a volatile organic compound (VOC).

nPB has been used increasingly as an alternative for other solvents that have become more strictly regulated, such as methylene chloride, perchloroethylene (perc), and trichloroethylene (TCE). This trend is of concern because evidence has emerged linking nPB to a range of human health hazards.

nPB has been reportable under the Toxics Use Reduction Act (TURA) since 2010. **Effective January 2016, nPB is designated as a Higher Hazard Substance under TURA.** Under this designation, Massachusetts facilities in TURA-covered sectors with ten or more employees are subject to reporting, planning and fee requirements if they use 1,000 pounds or more of nPB annually.

nPB FACTS	
Synonyms	nPB; 1-Bromopropane; 1-BP, n-Propyl Bromide; Propyl bromide
Chemical Formula	C_3H_7Br
CAS Number	106-94-5
Vapor Pressure	110.8 mm Hg at 20°C
Solubility	Soluble in cold water (2.5g/l@ 20°C), diethyl ether, acetone, and ethanol
Flashpoint/ Flammability	• Vapors of nPB may form a flammable mixture at concentrations between 3 and 9%; flash point varies from 10°C to none, depending on the test method. • US authoritative sources provide variable information about nPB, listing it with a National Fire Protection Association rating of either 2 or 3 (where level 4 is highest), depending on the source.[a] • As typically used, nPB is not more of a flammability concern than many other halogenated solvents. Always keep solvents away from open flame or sparks.
Description	Colorless liquid at room temperature and pressure and has a pungent odor. It is found in products in liquid or spray form and is sometimes marketed as a "green" solvent.

[a]Sources: Chemical Hazards Response Information System (CHRIS), "1-Bromopropane," June 1999, Listed in ToxPlanet, a division of Timberlake Ventures, Inc. Cornelius, NC, accessed October 2016; HazMap, US National Library of Medicine, accessed October 2016.

Health and Environmental Impacts

N-propyl bromide is a hazardous chemical. The National Institute for Occupational Safety and Health and the Occupational Safety and Health Administration recently issued a Hazard Alert for nPB.[1] Individuals can be exposed to nPB via two primary routes: inhalation of vapor or mists and skin contact.

Acute (Short-Term) Health Effects

The following effects have been reported among workers with high exposures to nPB:[2,3,4]

- Eye, nose, throat, or lung irritation
- Headache, fatigue, dizziness, nausea, malaise

Chronic (Long-Term) Health Effects

Studies of both short- and long-term worker exposure to nPB indicate effects on the peripheral and central nervous systems, and hematological (blood) effects. Animal studies indicate similar nervous system effects, as well as effects on the liver, male and female reproductive systems, and on the developing fetus. nPB also causes cancer in animals.

Neurotoxicity: Peripheral and central nervous system toxicity have been observed in workers exposed to nPB, and in animals. In several studies, exposed workers exhibited the following symptoms:[1,5,6]

- Joint pain or leg weakness and pain leading to difficulty with standing and walking (stumbling);
- Muscle twitching or numbness, tingling, and prickling in the hands or feet, loss of vibration sense;
- Anxiety, apathy, insomnia, and memory and concentration difficulties.

Symptoms persisted for months and, in some cases, years after exposure.[5]

Developmental and Reproductive Effects: The National Toxicology Program's (NTP) Center for the Evaluation of Risks to Human Reproduction (CERHR) released a report on nPB in 2003.[7] This expert panel concluded that nPB is a developmental and reproductive toxicant based on animal studies. As reviewed in this report, nPB affected a number of reproductive endpoints that can result in impaired fertility or

sterility in both females and males. nPB also caused delayed growth in the offspring of animals exposed during pregnancy. While no epidemiological study has examined the developmental and reproductive effects of nPB in humans, some case studies of female workers occupationally exposed to nPB reported altered menstrual periods.[7] These effects have not been observed in all studies.[8] The European Union characterizes nPB with the risk phrases R60 (may impair fertility) and R62 (possible risk of harm to the unborn child).[9]

Liver toxicity: Animal studies suggest that exposure may harm the liver.[10]

Immunosuppression: Animal studies suggest that exposure may suppress the immune system.[11]

Hematological effects: Studies of workers indicate that exposures can result in lowered red blood cell count.[1]

Cancer: Evidence from a 2-year inhalation cancer study conducted by NTP shows that nPB can cause cancer in animals.[10] Based on evidence from animal studies, NTP classified nPB as *reasonably anticipated to be a human carcinogen* and the International Agency for Research on Cancer (IARC) of the World Health Organization classified nPB as a *possible human carcinogen*.[12,13] Because nPB is a newer solvent, and cancer takes a long time to develop, studies of cancer associated with nPB exposure among workers or the public have not been conducted.

Worker Exposure Limits

No federal or Massachusetts agency has established safe exposure limits for workers using nPB, although NIOSH is in the process of developing a Recommended Exposure Limit (REL).[14] In 2014, the American Conference of Governmental Industrial Hygienists (ACGIH) lowered its Threshold Limit Value (TLV) for nPB from 10 ppm to 0.1 ppm as a time weighted average (TWA).[15] This change was based on evidence of nervous system damage in workers exposed to low levels of nPB as well as the potential of nPB to cause cancer.[16] Employers and workers should err on the side of caution by keeping exposures to nPB as low as possible.

Environmental Fate

EPA recommends that nPB be disposed of similarly to other halogenated solvents in order to avoid damage to aquatic life.[17] The LC50 (lethal concentration at which 50% of test animals die) is 67 mg/L (slightly toxic) for fathead minnows.[17] According to EPA, nPB has a low tendency to concentrate in living organisms, is moderately mobile in soil, and tends to volatilize and break down easily in water.[17]

Uses

nPB is effective in dissolving fats/oils, waxes and resins. As a degreasing agent, nPB is used in operations such as metal finishing and metal working; precision cleaning; auto parts cleaning; dry cleaning; and removing solder flux residue in electronic parts manufacturing. nPB is also used as a chemical processing intermediate in the synthesis of pharmaceuticals, insecticides, quarternary ammonium compounds, flavors and fragrances, and as a solvent for extracting tar from asphalt. Some facilities using nPB as a drop-in substitute have had problems with equipment corrosion. Similar to other halogenated solvents, nPB must be stabilized to prevent the buildup of acid breakdown products, and to inhibit reaction with metals. If not properly stabilized, nPB breaks down into hydrobromic acid, which can corrode equipment and potentially emit very toxic hydrogen bromide gas. Chemicals used as stabilizers are often claimed trade secret by manufacturers, but may include 1,3-dioxolane and 1,2-butylene oxide.

In 2013, three Massachusetts facilities reported nPB use under TURA. Two used nPB in industrial cleaning applications and one used it in an adhesive formulation. Together, they used 51,669 lbs and released 15,530 lbs of nPB to the environment.

EPA's Significant New Alternatives Policy (SNAP) program, which evaluates and regulates substitutes for ozone depleting chemicals, considers nPB an acceptable substitute for chlorofluorocarbon -113 and for methyl chloroform when used as a solvent in industrial cleaning equipment for metals, electronics, and precision cleaning.[17] However, EPA issued a proposed rule in 2007 finding nPB unacceptable as an aerosol solvent or as an adhesive carrier under SNAP.[17]

PRODUCTS CONTAINING nPB (2012)

Employers or employees may only know nPB products by their trade names. The following list shows some common trade names for nPB-containing products. **This list is not comprehensive, and product formulations may change at any time. Please note that this list was last updated in 2012.** If there is a question as to whether a specific product contains nPB, check the Safety Data Sheet (SDS). A number of additional nPB-containing products are no longer on the market, but may still be present in your workplace.

Degreasing, lubrication, extraction & cleaning agents	
Abzol (Albemarle)	Metalnox M6960 (Kyzen)
Alpha VaporEDGE 1000 (Cookson Electronics)	Misty Safety Solvent 2000 (Amrep)
Contact Cleaner (Blaster)	NPB Heavy Duty Cleaner Degreaser (MG Chemicals)
DrySolv (Envirotech)	Pensolv PB2000 (West Pentone)
Ensolv A, CW, EX, GCS & Ionic (Envirotech)	Solvon (Poly Systems)
Entron and Entron-Aero (Reliance)	Techtride NPB (Parts Cleaning Technologies)
GenTech (Reliance)	Triagen (Ecolink)
Hypersolve (Ecolink)	VDS-3000 (SuperKleen/Albatross)
Instant Super Degreaser II, NoFlash, Electra-X (LPS)	X-CEL, X-CEL IC (Western Chemical International)
Lenium ES, GS, XS, RV (Petroferm)	
Adhesives	
Whisper Spray (Henkel)	Endurabond Normac 900R-NPB (Blair Rubber Co)
K-Grip 501 Spray Adhesive (Maple Leaf Sales II)	Soft Seam Adhesive (Spectrum Adhesives, formerly Mid-South Adhesives)

Health concerns and increased regulation of TCE (for degreasing and metal cleaning) and perc (for garment cleaning) have resulted in increasing use of nPB as a relatively inexpensive and unregulated drop-in substitute for these two chlorinated solvents. However, as reviewed earlier, scientific evidence indicates that **nPB is not a safer substitute for TCE or perc, or for other solvents such as methylene chloride**. Workers may unknowingly be exposed to hazardous levels as nPB has been marketed as a "green" product. One study of multiple dry cleaning establishments found that nPB levels in the breathing zone of dry cleaning operators were routinely high — over twice to 10 times the exposure limit of 5 ppm (TWA) set by the California Occupational Safety and Health Standards Board.[18]

Alternatives

There are a number of alternatives to nPB for degreasing, cleaning, and adhesive applications.

Degreasing

The TURI Laboratory can help identify appropriate process- and application-specific alternatives. In addition, some facilities may be able to redesign their processes to eliminate the need for degreasing steps.

Alternatives to nPB for use in degreasing and precision cleaning operations include aqueous cleaning processes and other halogenated and non-halogenated organic solvents. For vapor degreasing, some key physical properties that dictate which alternative is appropriate include: low latent heat, low boiling point, high flash point, low surface tension and high solvency powers.

Performance evaluations conducted by the TURI Lab demonstrate that safer and feasible alternatives to solvent-based degreasing include aqueous and semi-aqueous processes, including the use of soaking or ultrasonic equipment.

Other alternatives for metal degreasing include formulations that contain hydrocarbon solvents, such as terpenes, alcohols, acetone, ketones, trans-dichloroethylene, and acetates. However, these solvents are not safer as exposure can result in acute health effects (ranging from irritation of the eyes, skin and respiratory system, dizziness, nausea, and confusion); and chronic effects (including liver and kidney problems). In addition, many such solvents are highly flammable and classified as VOCs. TCE is also an unsuitable substitute for nPB because of well-documented health effects including carcinogenicity and neurotoxicity. Hydrochlorofluorocarbons (HCFCs) and (HFCs) also pose significant hazards, such as ozone depletion (HCFCs) and global warming (HFCs). Other drop-in substitutes, such as hydrofluoroethers and volatile methyl siloxanes, are effective, but have been less studied in terms of their health and environmental impacts.

Dry Cleaning

The least toxic alternatives to nPB for both environmental and public health in dry cleaning applications are carbon dioxide (CO_2) and professional wet cleaning systems. CO_2 systems clean garments by using CO_2 as either a liquid or as a supercritical fluid in specialized equipment. However, the equipment for CO_2-based systems is increasingly difficult to obtain. In addition, CO_2-based systems require highly pressurized gas, which creates its own work health and safety hazards. Professional wet cleaning is an aqueous process that uses computer-controlled washers and dryers, specifically formulated detergents, and specialized tensioning equipment to clean and finish garments. While detergents may cause skin and eye irritation, TURI research and analysis has determined that professional wet cleaning is a safer and cost-effective alternative to solvent-based dry cleaning.[19] TURI has worked with garment cleaning facilities in Massachusetts helping them to convert from perc to professional wet cleaning. Results show good cleaning quality, fewer health hazards, and natural resource savings.[19]

Hydrocarbon-based solvents are another popular replacement solvent for dry cleaning operations. These solvents require process changes and present fire hazards. In addition, comprehensive toxicity testing has not been conducted. Toxicity studies to date suggest that current hydrocarbon-based solvents are safer than nPB. The volatile methyl siloxane solvent D5 (decamethylcyclopentasiloxane) is also a substitute solvent in dry cleaning, but is a combustible liquid, and so poses some flammability concerns. In addition, there is concern about persistence and bioaccumulation of D5 in the environment, and possible carcinogenicity from a study showing an increased incidence of uterine tumors in rats.[20]

Adhesives

Alternatives to nPB used as the solvent carrier in adhesive products include both non-solvent and solvent substitutes. Hot melt adhesives appear to be the least toxic alternative that are suitable for some, but not all, applications. Other non-solvent-based alternatives are available including aqueous-based carriers using latex or latex-synthetic blends. However, there are worker sensitization concerns associated with latex and some aqueous-based carriers may contain ammonia, which can irritate the eyes, respiratory tract, and skin. Additional process changes may be required if aqueous-based alternatives are used.

Some solvent adhesive formulations use acetone, and while they are generally low in toxicity they have a very low flashpoint, so systems must be in place to minimize the chance of fire or explosion. Other solvent-based formulations may contain mineral spirits, petroleum solvents, petroleum distillates, and naphthas that present additional human health and/or environmental concerns.

Solvent-based formulations using methylene chloride or TCE are undesirable alternatives to nPB-based products given

their significant human health and environmental health impacts.

Regulatory Context

Massachusetts

Effective January 2016, nPB is designated as a Higher Hazard Substance under TURA. Under this designation, Massachusetts facilities with 10 or more full time employee equivalents that manufacture, process or otherwise use 1,000 pounds or more of nPB per year, are required to report on their use and to conduct toxics use reduction planning. For more information about facility responsibilities under the TURA program, see: http://www.mass.gov/dep/toxics/toxicsus.htm.

ADDITIONAL REGULATORY CONSIDERATIONS	
Occupational Exposure Limits	• ACGIH TLV/TWA:[a] (2014): 0.1 ppm • OSHA PEL:[b] *no PEL established* • NIOSH REL:[c] *no REL established* • CA OSH PEL (2009):[d] 5 ppm
OSHA	• OSHA's Hazard Communication Standard applies to nPB. Employers are required to provide health and safety information and training to workers using nPB.[1]
EPA	• Effective January 2016, nPB has been added to the list of chemicals reportable under the Toxics Release Inventory.[21] • The Agency has not reviewed nPB to determine whether nPB should be regulated as a hazardous waste or as a toxic substance in drinking water. • EPA is currently reviewing whether nPB should be added to the list of hazardous air pollutants.[22] • EPA's proposed rule (2007) states that nPB use as an aerosol solvent or as an adhesive carrier solvent would be unacceptable.[17]
European Union	• The EU classifies nPB as R36/37/38 (irritating to the eyes, skin and respiratory system), R60 (may impair fertility), and R63 (possible risk of harm to the unborn child).[9] • nPB is listed as a Substance of Very High Concern under REACH.[23]
California	California Proposition 65 lists nPB as a developmental/reproductive toxicant.[24]
Pennsylvania	Pennsylvania lists nPB on its hazardous substance list.

[a] ACGIH's Threshold Limit Value/Time Weighted Average for inhalation exposures lasting 8 hours/day, 5 days/week. [b] OSHA's Permissible Exposure Limit (typically for an 8-hour time weighted average). [c] NIOSH's Recommended Exposure Limit. [d] CA OS&H Standards Board PEL (8-hour time weighted average). *This exposure limit was based on reproductive and developmental toxicity data and industry's technological feasibility assessments.*

Additional Information

- **Confidential technical assistance:** MA Office of Technical Assistance and Technology, 617-626-1078 or www.mass.gov/eea/ota.
- **Toxics use reduction policy and technical questions:** TURI, 978-934-3275 or www.turi.org.
- **Safer cleaning alternatives:** TURI Lab, 978-934-3133 or www.cleanersolutions.org.
- **TURA regulatory compliance:** Massachusetts Department of Environmental Protection, 617-292-5500 or www.mass.gov/dep/toxics/toxicsus.htm.
- **Safe working practices:** Massachusetts Department of Labor Standards, On-Site Consultation Program, 617-969-7177. Also see the OSHA-NIOSH Hazard Alert: http://www.cdc.gov/niosh/docs/2013-150/pdfs/2013-150.pdf.

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