

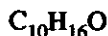
OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR CAMPHOR, SYNTHETIC

INTRODUCTION

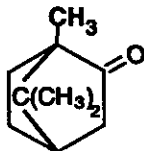
This guideline summarizes pertinent information about synthetic camphor for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

SUBSTANCE IDENTIFICATION

• Formula



• Structure



• Synonyms

2-Camphanone, 2-bornanone, gum camphor, Formosa camphor, Japan camphor, matricaria camphor, 1,7,7-trimethylbicyclo(2.2.1)-2-heptanone, laurel camphor, 2-keto-1,7,7-trimethylnorcamphane

• Identifiers

1. CAS No.: 76-22-2
2. RTECS No.: EX1225000
3. DOT UN: 2717 32
4. DOT label: Flammable Solid

• Appearance and odor

Camphor is a colorless or white crystalline mass with a penetrating, aromatic odor and slightly bitter, cooling taste. The odor threshold of camphor is reported to be 0.079 part per million (ppm) parts of air.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 152.23
2. Boiling point (760 mm Hg): 204°C (399.2°F) sublimes
3. Specific gravity (water = 1): 0.99 at 25°C (77°F)
4. Vapor density (air = 1 at boiling point of camphor): 5.2
5. Melting point: 179.8°C (355°F)
6. Vapor pressure at 20°C (68°F): 0.18 mm Hg

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Education and Information Division

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

7. **Solubility:** Slightly soluble in water; soluble in aniline, nitrobenzene, carbon disulfide, tetralin, decalin, methylhexalin, petroleum ether, the higher alcohols, and fixed and volatile oils. Also soluble in concentrated mineral acids in phenol, liquid ammonia, and liquid sulfur dioxide.

8. **Evaporation rate:** Data not available

Reactivity

1. **Conditions contributing to instability:** Heat, sparks, and open flame

2. **Incompatibilities:** Contact of camphor with strong oxidizing agents such as potassium permanganate and chromic anhydride may form explosive mixtures.

3. **Hazardous decomposition products:** Toxic gases (such as carbon monoxide) may be released in a fire involving camphor.

4. **Special precautions:** None

Flammability

The National Fire Protection Association has assigned a flammability rating of 2 (moderate fire hazard) for camphor.

1. **Flash point:** 66°C (150°F) (closed cup)

2. **Autoignition temperature:** 466°C (871°F)

3. **Flammable limits in air (% by volume):** Lower, 0.6; upper, 3.5

4. **Extinguishant:** Use dry chemical, sand, water spray, fog, or standard foam to fight fires involving camphor. Water may be ineffective, but it may be used to cool fire-exposed containers. If a leak or spill has not ignited, water spray may be used to disperse vapors and to protect persons attempting to stop the leak.

Fires involving camphor should be fought upwind from the maximum distance possible. Isolate the hazard area and deny access to unnecessary personnel. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Containers of camphor may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool containers from the sides with water until well after the fire is out. Stay away from the ends of containers. Personnel should withdraw immediately if

they hear a rising sound from a venting safety device or if a container becomes discolored as a result of fire. Dikes should be used to contain fire-control water for later disposal. If a tank car or truck is involved in a fire, personnel should isolate an area of a half mile in all directions. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving camphor. Structural firefighters' protective clothing may provide limited protection against fires involving camphor.

EXPOSURE LIMITS

• OSHA PEL

The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for camphor is 2 mg/m³ (approximately 0.3 ppm) of air as an 8-hr time-weighted average (TWA) concentration [29 CFR 1910.1000, Table Z-1].

• NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for camphor of 2 mg/m³ as a TWA for up to a 10-hr workday and a 40-hr workweek [NIOSH 1992].

• ACGIH TLV

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned camphor a threshold limit value (TLV) of 2 ppm (12 mg/m³) as a TWA for a normal 8-hr workday and a 40-hr workweek and a short-term exposure limit (STEL) of 3 ppm (19 mg/m³) for periods not to exceed 15 min. Exposures at the STEL concentration should not be repeated more than four times a day and should be separated by intervals of at least 60 min [ACGIH 1993].

• Rationale for limits

The OSHA and ACGIH limits are based on the risk of irritation associated with exposure to camphor.

HEALTH HAZARD INFORMATION

• Routes of exposure

Exposure to camphor can occur through inhalation, eye or skin contact, and ingestion.

• **Summary of toxicology**

1. **Effects on Animals:** Camphor is a central nervous system toxin in animals. The toxicity can vary depending on whether the racemate or isomers were studied: *dl*, *d*, *l*, or β [NIOSH 1991]. The lethal concentration for mice exposed to camphor for 3 hr ranged from 400 to 1,760 mg/m³ [Izmerov et al. 1982]. Although camphor is only slowly absorbed from subcutaneous or intramuscular injection sites, absorption from mucous membranes and alimentary tract is rapid [NLM 1991]. The lowest lethal dose by subcutaneous administration in the mouse is 2,200 mg/kg while the lowest lethal oral dose in rabbits is 2 g/kg [NIOSH 1991]. Animals acutely poisoned may exhibit mydriasis, convulsions, and central nervous system stimulation before death [NIOSH 1991]. Death by asphyxiation occurred in dogs that ingested a lethal amount (9 to 14 g) [NLM 1991]. Prolonged (duration not specified) inhalation of camphor at a concentration of 6 mg/m³ caused injury described as severe to experimental animals; at autopsy, congestion and edema of the gastrointestinal tract, kidneys, and brain were seen [ACGIH 1991]. Subcutaneous injection of camphor in rats over an 18-month period caused no increase in the incidence of tumors, but the addition of croton oil (a known cancer promoter) to the camphor mixture caused carcinomas in 2 of 110 treated mice [ACGIH 1991].
2. **Effects on Humans:** Camphor is irritating to the nose and throat of exposed individuals; at high concentrations, it is a central nervous system stimulant and convulsant [Proctor et al. 1988]. One fatal case of camphor poisoning discussed in the literature resulted from inhalation of the vapor of heated camphor. In this case, the major symptom of overexposure was marked rigidity of the jaw muscles [ACGIH 1991]. Adults have survived ingested doses up to 1.5 grams while doses of <1 gram have been fatal. A fetal death resulted when a pregnant mother ingested camphor. Necropsy revealed severe atelectasis and central neuronal necrosis in the fetus [NLM 1991]. Serious acute overexposures to unspecified concentrations or ingested amounts can cause irritation, anxiety, headache, nausea, vomiting, excitement, restlessness, dyspnea, dizziness, confusion, delirium, hallucinations, tremors, twitching of facial muscles, spasticity, convulsions, and coma [Proctor et al. 1988; ACGIH 1991]. Death can result from respiratory failure or status epilepticus [NLM 1991]. A study of workers employed in a synthetic camphor packaging plant

revealed that daily exposure (5 days/week for up to 10 months) did not cause irritation of the eyes and nose or loss of the sense of smell if the camphor concentration was maintained at or below 2 ppm [ACGIH 1991]. At this or higher concentrations, however, exposure caused eye and nose irritation and loss of the ability to smell [Proctor et al. 1988].

• **Signs and symptoms of exposure**

1. **Acute exposure:** Camphor can cause irritation of the eyes, nose, and upper respiratory tract; anxiety; headaches; nausea; vomiting; excitement; restlessness; dyspnea; confusion; dizziness; twitching of facial muscles; spasticity; convulsions; and coma.
2. **Chronic exposure:** The signs and symptoms of chronic exposure to camphor include irritation of the eyes and nose and loss of the sense of smell.

• **Emergency procedures**

WARNING!
Seek immediate medical attention for severely affected victims or for victims with signs and symptoms of toxicity or irritation!

Keep unconscious victims warm and on their sides to avoid choking if vomiting occurs. Initiate the following emergency procedures:

1. **Eye exposure:** Irritation may result. **Immediately and thoroughly** flush the eyes with large amounts of water for at least 15 min, occasionally lifting the upper and lower eyelids.
2. **Skin exposure:** Skin irritation or absorption of toxic amounts may result. **Immediately** remove contaminated clothing and **thoroughly** wash contaminated skin with soap and water for at least 15 min.
3. **Inhalation exposure:** Move the victim to fresh air **immediately**. Have the victim blow his or her nose or use a soft tissue to remove particulates or residues from the nostrils.

If the victim is not breathing, clean any chemical contamination from the victim's lips and perform cardiopulmonary resuscitation (CPR); if breathing is difficult, give oxygen.

4. *Ingestion exposure*: Take the following steps if camphor or any material containing it is ingested:

—Have the victim rinse the contaminated mouth cavity several times with a fluid such as water.

—Have the victim drink a glass (8 oz) of fluid such as water.

—Induce vomiting by having the victim touch the back of the throat with a finger until productive vomiting ceases. Do *not* give syrup of ipecac because of the possible onset of respiratory depression and seizures.

—Do *not* force an unconscious or convulsing person to drink fluid or to vomit.

5. *Rescue*: Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the material safety data sheet required by OSHA's hazard communication standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve camphor and may result in worker exposures to this substance:

—Mixing and packaging of cellulose nitrate for photographic film, cosmetics (perfumes), embalming fluid, pharmaceuticals, insect repellants, and mildew repellants

—Manufacture of plastics (especially celluloids), explosives, and incense

—Use as a plasticizer for cellulose esters and ethers, as a preservative in pharmaceuticals and cosmetics, in liniments for lumbago and related disorders, as a respiratory and circulatory stimulant, and as a topical anti-infective, counter-irritant antipruritic, and anesthetic

—Use as a catalyst or chemical intermediate in manufacturing of cumene and sulfuryl chloride, in mixing and blending of certain lacquers and varnishes, and as an odorant-flavorant during preparation and packaging of certain foods, toothpaste and powders, depilatories, deodorants, and tobacco

—Use in dentistry for the treatment of infected root canals

The following methods are effective in controlling worker exposures to camphor, depending on the feasibility of implementation:

—Process enclosure

—Local exhaust ventilation

—General dilution ventilation

—Personal protective equipment

Good sources of information about control methods are as follows:

1. ACGIH [1991]. *Industrial ventilation—a manual of recommended practice*. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. *Industrial ventilation—a self study companion*. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. *Design of industrial ventilation systems*. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. *Engineering design for control of workplace hazards*. New York, NY: McGraw-Hill.

5. Plog BA [1988]. *Fundamentals of industrial hygiene*. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control work-related health effects, medical evaluations

should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

- **Preplacement medical evaluation**

Before a worker is placed in a job with a potential for exposure to camphor, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the central nervous system.

A preplacement medical evaluation is recommended to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to camphor at or below the prescribed exposure limit. The licensed health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with convulsive disorders or diseases of the central nervous system.

- **Periodic medical examinations and biological monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to camphor exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of camphor on the central nervous system. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. No biological monitoring test acceptable for routine use has yet been developed for camphor.

- **Medical examinations recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared with those expected for a suitable reference population.

WORKPLACE MONITORING AND MEASUREMENT

A worker's exposure to airborne camphor is determined by using coconut shell charcoal tubes (100/50-mg sections, 20/40 mesh). Samples are collected at a maximum flow rate of 0.2 liter/min until a maximum air volume of 25 liters is collected. The samples are desorbed with carbon disulfide methanol (99:1). Analysis is conducted by gas chromatography using a flame ionization detector. The limit of detection for this procedure is 0.05 mg per sample. This method is described in NIOSH Method No. 1301, *NIOSH Manual of Analytical Methods* [NIOSH 1984].

PERSONAL HYGIENE

If camphor contacts the skin, workers should flush the affected areas immediately with plenty of water for 15 min, and then wash with soap and water.

Clothing contaminated with camphor should be removed immediately, and provisions should be made for safely removing this chemical from these articles. Persons laundering the clothes should be informed of the hazardous properties of camphor, particularly its potential to be an irritant of the eyes, respiratory tract, and skin.

A worker who handles camphor should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, using toilet facilities, or applying cosmetics.

Workers should not eat, drink, use tobacco products, or apply cosmetics in areas where camphor or a solution containing camphor is handled, processed, or stored.

STORAGE

Camphor should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's hazard communication standard

[29 CFR 1910.1200]. Containers of camphor should be protected from physical damage and should be stored separately from potassium permanganate, chromic anhydride, other oxidizers, heat, sparks, and open flame. Because containers that formerly contained camphor may still hold product residues, they should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving camphor, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup is complete. The following steps should be undertaken following a spill or leak:

1. Do not touch the spilled material.
2. Notify safety personnel.
3. Remove all sources of heat and ignition.
4. Ventilate potentially explosive atmospheres.
5. Cover area of the spill with dry sand, vermiculite, or other noncombustible absorbent material, mix well, and place into closed containers for later disposal. Keep container tightly sealed.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) regulatory requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

• Emergency planning requirements

Camphor is not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022].

• Reportable quantity requirements for hazardous releases

Employers are not required by the emergency release notification provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the National

Response Center of an accidental release of camphor; there is no reportable quantity for this substance.

• Community right-to-know requirements

Employers are not required by Section 313 of SARA to submit a Toxic Chemical Release Inventory Form (Form R) to EPA reporting the amount of camphor emitted or released from their facility annually.

• Hazardous waste management requirements

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Although camphor is not specifically listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) [42 CFR 355.40], EPA requires employers to treat waste as hazardous if it exhibits any of the characteristics discussed above.

Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (800) 424-9346 or at (202) 382-3000 in Washington, D.C. In addition, relevant State and local authorities should be contacted for information on their requirements for waste removal and disposal.

RESPIRATORY PROTECTION

• Conditions for respirator use

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of camphor exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should use

only respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

- **Respiratory protection program**

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's respiratory protection standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, respirator fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information about the selection and use of respirators and about the medical screening of respirator users, consult the *NIOSH Respirator Decision Logic* [NIOSH 1987b] and the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing should be worn to prevent any skin contact with camphor. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing materials to camphor permeation, although some sources recommend the use of rubber. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to camphor.

If camphor is dissolved in an organic solvent, the permeation properties of both the solvent and the mixture must be considered when selecting personal protective equipment and clothing.

Safety glasses, goggles, or face shields should be worn during operations in which camphor might contact the eyes (e.g., through dust particles or splashes of solution). Eyewash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with camphor. Contact lenses should not be worn if the potential exists for camphor exposure.

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