NATIONAL PESTICIDE INFORMATION CENTER

1.800.858.7378

npic.orst.edu
npic@ace.orst.edu
fax: 541.737.0761

Thank you for visiting the National Pesticide Information Center's fact sheets.

Some of the information in the following fact sheet (scroll down) is out-of-date. NPIC has started a *NEW* set of fact sheets, and malathion is high on our list of priorities. If you would like to be notified when NPIC releases new publications, send an email to npicupdates@ace.orst.edu with "subscribe" in the subject line.

Check out our new technical fact sheet on resmethrin!

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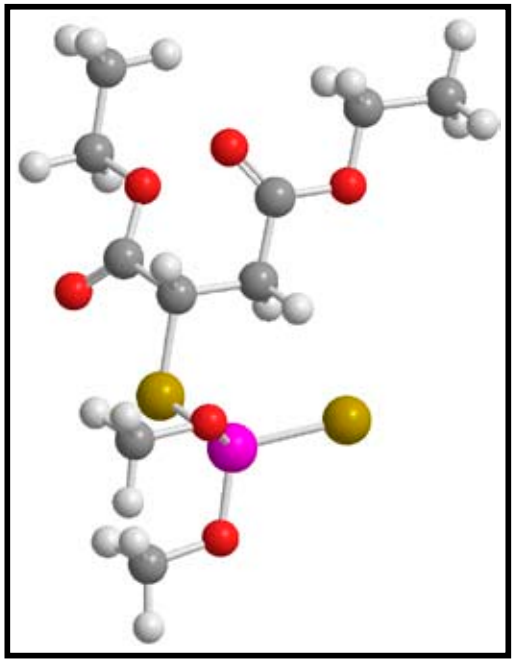
Molecular Structure - Malathion



NPIC Technical Fact Sheets are designed to provide information that is technical in nature for individuals with a scientific background or familiarity with the regulation of pesticides by the U.S. Environmental Protection Agency (U.S. EPA). This document is intended to be helpful to professionals and to the general public for making decisions about pesticide use.

National Pesticide Information Center

Malathion

(Technical Fact Sheet)

For less technical information, please refer to the General Fact Sheet.

The Pesticide Label: Labels provide directions for the proper use of a pesticide product. *Be sure to read the entire label before using any product.* A signal word on each product label indicates the product's potential hazard.

CAUTION - low toxicity **WARNING - moderate toxicity** **DANGER - high toxicity**

What is malathion?

- Malathion is a non-systemic, broad-spectrum insecticide registered for use in the United States in 1956 (1).
- Malathion belongs to a class of insecticides known as organophosphates (OPs). Its structure places it in the subclass of OPs known as phosphorothionothiolates (2).
- Malathion is a yellow to brown liquid with a skunk- or garlic-like odor. It is slightly soluble in water (145 mg/L at 20 °C) and is miscible in organic solvents except some petroleum hydrocarbons. Malathion is slightly volatile with a vapor pressure of 1.78×10^{-4} mm Hg at 25 °C. It is corrosive to some metals and may damage plastic and rubber (3).
- Malathion products are used to control a variety of insects outdoors. Examples of product formulations include dusts, emulsifiable concentrates, wettable powders, and solutions (4).
- Signal words for malathion products range from Caution to Danger (5). The signal word reflects the combined toxicity of malathion and other ingredients in each product. See the **Pesticide Label** box.

How does malathion work?

- Malathion disrupts nervous system function by inhibiting the cholinesterase enzyme (4). Cholinesterase normally terminates nerve transmissions by cleaving the neurotransmitter acetylcholine (6, 7).
- Inhibition of cholinesterase results in acetylcholine accumulation. Small excess acetylcholine results in overstimulation of the nervous system, and further excess may have the opposite effect (6).
- The cholinesterase inhibitory activity of malathion is due primarily to the metabolite malaoxon. Both malathion and malaoxon are detoxified by carboxyesterase enzymes (4).
- Carboxyesterase activity is greater in mammals than insects. The lower activity in insects results in malaoxon accumulation and accounts for the higher toxicity of malathion in insects relative to mammals (4).

What types of products contain malathion?

- Agricultural insecticides for food and non-food crops
- Residential products used on vegetable gardens, ornamental plants, and lawns
- Mosquito-abatement insecticides
- Insecticides used in the Cotton Boll Weevil and Mediterranean Fruit Fly (Medfly) Eradication Programs

NOTE: Some head lice products contain malathion – these are regulated by the U.S. Food and Drug Administration (FDA) (4). This fact sheet **does not** address head lice products.

How toxic is malathion?

Animals

- Malathion is very low in toxicity when ingested. The acute oral LD50 in rats is 5400 mg/kg in males and 5700 mg/kg in females (4, 8). See boxes on **Laboratory Testing**, **Toxicity Category,** and **LD50/LC50**.

- Malathion is very low in toxicity when inhaled. The acute inhalation LC50 in rats is > 5.2 mg/L (4, 8).

- Malathion is low in toxicity when applied to the skin. The acute dermal LD50 in rats is > 2000 mg/kg (4, 8).

- Impurities in malathion products can potentiate the toxicity of malathion to rats (6, 7). These impurities may result from poor manufacturing or improper product storage (6). Malathion impurities may be directly toxic or may synergize malathion toxicity (9).

- In a skin irritation study, malathion caused slight skin irritation in rabbits. The EPA classifies malathion as very low in toxicity for skin effects (4).

- In studies with guinea pigs, malathion did not cause skin sensitization (4).

- In an eye irritation study with rabbits, malathion caused slight eye irritation that cleared within 7 days (4). Malathion caused no eye effects in a study with rats (10). The U.S. EPA classifies malathion as low in toxicity for eye effects (4).

Exposure: Effects of malathion on human health and the environment depend on how much malathion is present and the length and frequency of exposure. Effects also depend on the health of a person and/or certain environmental factors.

Laboratory Testing: Before pesticides are registered by the U.S. EPA, they must undergo laboratory testing for short-term (acute) and long-term (chronic) health effects. Laboratory animals are purposely fed high enough doses to cause toxic effects. These tests help scientists judge how these chemicals might affect humans, domestic animals, and wildlife in cases of overexposure. When pesticide products are used according to the label directions, toxic effects are not likely to occur because the amount of pesticide that people and pets may be exposed to is low compared to the doses fed to laboratory animals.

Toxicity Category (*Signal Word*) (12)

	High Toxicity (*Danger*)	**Moderate Toxicity (*Warning*)**	**Low Toxicity (*Caution*)**	**Very Low Toxicity (*Caution*)**
Oral LD50	Less than 50 mg/kg	50 - 500 mg/kg	500 - 5000 mg/kg	Greater than 5000 mg/kg
Dermal LD50	Less than 200 mg/kg	200 - 2000 mg/kg	2000 - 5000 mg/kg	Greater than 5000 mg/kg
Inhalation LC50	Less than 0.05 mg/l	0.05 - 0.5 mg/l	0.5 - 2 mg/l	Greater than 2 mg/l
Eye Effects	Corrosive	Irritation persisting for 7 days	Irritation reversible within 7 days	Minimal effects, gone within 24 hrs
Skin Effects	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation

- In a 21-day dermal study, scientists exposed rabbits to doses of malathion at 0, 50, 300, or 1000 mg/kg/day for 6 hours/day, 5 days/week for 3 weeks. Scientists detected decreased cholinesterase activity at the two highest doses (300 and 1000 mg/kg/day) but no clinical signs of inhibition. One rabbit died at the highest dose (1000 mg/kg/day). The no observed effect level (NOAEL) for cholinesterase inhibition was 50 mg/kg/day. The systemic toxicity NOAEL was 300 mg/kg/day (11).

- In a 90-day inhalation study, investigators exposed male and female rats to malathion at doses of 0, 0.1, 0.5, or 2 mg/L for 6 hours/day, 5 days/week for 13 weeks. Investigators noted cholinesterase inhibition and respiratory system lesions at all doses (11).

- Researchers fed dogs malathion for 1 year at doses of 0, 62.5, 125, or 250 mg/kg/day. The dogs exhibited decreased cholinesterase activity at all doses but no clinical signs of toxicity. The systemic toxicity NOAEL was 250 mg/kg/day (8, 11).

LD50/LC50: A common measure of acute toxicity is the lethal dose (LD50) or lethal concentration (LC50) that causes death (resulting from a single or limited exposure) in 50 percent of the treated animals. LD50 is generally expressed as the dose in milligrams (mg) of chemical per kilogram (kg) of body weight. LC50 is often expressed as mg of chemical per volume (e.g., liter (L)) of medium (i.e., air or water) to which the organism is exposed to. Chemicals are considered highly toxic when the LD50/LC50 is small and practically non-toxic when the value is large. However, the LD50/LC50 does not reflect any effects from long-term exposure (i.e., cancer, birth defects, or reproductive toxicity) that may occur at levels below those that cause death.

Humans (See box on **Human Studies**)

- In an experimental study, volunteers ingested up to 16 mg malathion/person/day for 47 days and displayed no significant effect on cholinesterase activity. When consuming 24 mg malathion/person/day for 56 days, volunteers displayed reduced cholinesterase activity three weeks after the dosing period of the study. The casual relation of cholinesterase inhibition to malathion was uncertain given the timing of inhibition relative to dosing (6).

- Researchers conducted a study with male volunteers inhaling malathion products at 1.4, 5.7, or 23 mg malathion/L for 1 hour/exposure, two exposures/day for 42 consecutive days (84 total exposures/male). Researchers detected no effect on cholinesterase activity and no adverse effects (6).

- Scientists exposed volunteers to malathion dust products at 0, 0.9, 4.5, or 9 g malathion/person/day. The dust was applied to the volunteers and their clothing five times a week for 8 or more weeks. Volunteers complained of odor and skin irritation. Scientists noted decreased cholinesterase activity at the highest dose (9 g malathion/person/day) but determined that it was not statistically significant (6).

Human Studies: Results from human studies are presented for information purposes only. The U.S. EPA presently does not use data from human studies in its risk assessments (EPA has asked the National Academy of Sciences to make "recommendations regarding the particular factors and criteria EPA should consider to determine the potential acceptability ...") of data from human studies. "... During the Academy's consideration of the issues and until a policy is in place, the Agency will not consider or rely on any such human studies in its regulatory decision making, whether previously or newly submitted. ..." – **Quotes from:** Environmental News R-246, U.S. EPA, December 14, 2001.

- Researchers conducted a study evaluating the health effects associated with treating areas by ground applications of malathion and the organophosphate diazinon, followed by aerial malathion treatments. The applications occurred from April 1998 to September 1998 in an area containing approximately 132,000 people. There were 230 reports of pesticide-related illness, and researchers classified 123 of these as probable or possible cases. The most commonly-reported signs and symptoms were associated with the respiratory, gastrointestinal, and neurological systems (13).

- In a separate study, researchers evaluated health effects associated with aerial applications of malathion. The applications occurred from December 1989 to June 1990 in an area containing approximately 1.5 million people. The applications generated 1874 reports of pesticide-related illness. The majority of complaints (1,575), dealt with respiratory tract irritation, headaches, gastrointestinal tract symptoms, and malaise. The other 299 complaints dealt with skin rashes (14).

- Researchers associated human malathion poisoning in 1976 with product impurities (6). The U.S. EPA concludes that current malathion products have potential impurities or degradates that are less toxic than malathion or are present at levels that do not pose a health concern (4).

- The signs and symptoms associated with malathion poisoning may include headaches, nausea, vomiting, dizziness, muscle weakness, lethargy, and anxiety. In severe or life threatening poisonings, respiratory distress, diarrhea, tremors, confusion, seizures, and coma may occur. Signs relatively specific to organophosate poisoning include pinpoint pupils, eye tearing, increased sweating and salivation, and localized muscle contractions (15).

Is malathion metabolized and eliminated from the body?

Animals

- Researchers administered malathion by oral gavage (stomach tube) to rats at single doses of 40 or 800 mg/kg, or 16 doses of 40 mg/kg/day. Rats excreted malathion and its metabolites primarily in the urine (80-90%) within the first 24 hours following exposure. Researchers detected eight metabolites with greater than 80% being the di- and monoacid derivatives of malathion. The rats converted 4-6% of the malathion to malaoxon. Researchers did not detect bioaccumulation of malathion or metabolites (4, 8).

- Malathion had a half-life of 1.4 days in blood when orally administered to rats at 467 mg/kg (8). See box on **Half-life.**

- Rats excreted more than 90% of an orally-administered malathion (280 mg/kg) within 24 hours (8).

Half-life is the time required for half of the compound to degrade.

1 half-life	**=**	**50% degraded**
2 half-lives	**=**	**75% degraded**
3 half-lives	**=**	**88% degraded**
4 half-lives	**=**	**94% degraded**
5 half-lives	**=**	**97% degraded**

Remember that the amount of chemical remaining after a half-life will always depend on the amount of the chemical originally applied.

Humans

- Scientists repeatedly administered malathion to the skin of volunteers. The average absorption of the applied dose ranged from 3.53-4.48%. Peak excretion occurred between 12 to 24 hours of an exposure with the average excretion half-life ranging from 29.9-37.1 hours (16).

- In a separate study with volunteers, investigators dermally applied malathion and noted absorption rates of 5-10% over a 5-day period (4).

Does malathion cause reproductive or teratogenic effects?

Animals

- In a two generation reproductive study, researchers fed rats malathion in the diet (males: 0, 43, 131, 394, or 612 mg malathion/kg body weight/day; females: 0, 51, 153, 451, or 703 mg malathion/kg body weight/day). They detected no fertility effects. Progeny rats displayed decreased body weights at the two highest doses (males: 394 and 612 mg/kg/day; females: 451 and 703 mg/kg/day) while adult rats displayed reduced body weights only at the highest dose (11).

- Researchers orally exposed pregnant rats to malathion on gestation days 6-15 at doses of 0, 200, 400, or 800 mg/kg/day. They detected no effect on fetal development. At the highest dose (800 mg/kg/day), they detected lower maternal body weight gains and food consumption. The NOAEL for maternal effects was 400 mg/kg/day and 800 mg/kg/day for developmental toxicity (8, 11).
- In a developmental study, scientists orally exposed pregnant rabbits to malathion on gestation days 6-18 at doses of 0, 25, 50, or 100 mg/kg/day. At the two highest doses (50 and 100 mg/kg/day), they noted lower maternal body weight gains. The NOAEL for maternal toxicity was 25 mg/kg/day. Scientists detected an increased incidence of average resorption sites per mother at the two highest doses (50 and 100 mg/kg/day). The developmental NOAEL was 25 mg/kg/day (8, 11).

Humans

- Data are not available from occupational exposure, accidental poisonings, or epidemiological studies regarding the reproductive and developmental toxicity of malathion.

Is malathion a carcinogen?

Animals

- Laboratory workers fed rats malathion in their diet for up to 24 months (males: 0, 2.4, 3.14, 26, 327, or 677 mg/kg/day; females: 0, 2.4, 3.8, 32, 386, or 817 mg/kg/day). Liver tumors occurred in female rats at all doses. Workers noted lower body weight gains in both male and female rats at the two highest doses (males: 327 and 677 mg/kg/day; females: 386 and 817 mg/kg/day). The U.S. EPA concluded that an increased incidence of liver tumors in female rats only occurred at excessive doses (11).

- Scientists administered malathion in the diet of mice for 18 months (males: 0, 17.4, 143, 1476, or 2978 mg/kg/day; females: 0, 20.8, 167, 1707, or 3448 mg/kg/day). An increased incidence of liver tumors occurred at the two highest doses for both male and females rats (males: 1476 and 2978 mg/kg/day; females: 1707 and 3448 mg/kg/day). The U.S. EPA concluded that liver tumors in the mice only occurred at excessive doses (11).

Cancer: The U.S. EPA has strict guidelines that require testing of pesticides for their potential to cause cancer. These studies involve feeding laboratory animals large *daily* doses of the pesticide over most of the lifetime of the animal. Based on these tests, and any other available information, EPA gives the pesticide a rating for its potential to cause cancer in humans. For example, if a pesticide does not cause cancer in animal tests at large doses, then the EPA considers it unlikely the pesticide will cause cancer in humans. Cancer tests are not conducted on human subjects.

- Researchers often use studies designed to test for mutagenicity to screen chemicals for carcinogenicity. Scientists report positive and negative mutagenicity results for malathion (8, 17). The U.S. EPA concluded that malathion does not pose a significant mutagenic hazard (4).

Humans

- The U.S. EPA classifies malathion as containing "suggestive evidence of carcinogenicity but not sufficient to assess human carcinogenic potential (11)." See box on **Cancer**.

- In a study of workers involved in a Mediterranean fruit fly eradication program, malathion exposure did not correlate with an increased mutation risk. The small sample size in the study precludes definitive conclusions (18).

- Eight epidemiological studies concluded increased incidences of mutations with malathion exposure. Confounding factors limit study interpretation (17).

What is the environmental fate and behavior of malathion?

- Malathion is relatively resistant to photolysis. It is susceptible to hydrolysis under alkaline conditions (9).

- Microbial metabolism is a major malathion degradation route in soil (9). Malathion's half-life in soil ranges from < 1-25 days. A representative soil half-life is 1 day (19).

- Malathion is mobile in soil. Its short soil persistence reduces the risk of contaminating ground water, but malathion has been detected in ground water (9).

- Biodegradation and pH significantly affect the persistence of malathion in surface water (9). In a river water field study, malathion degraded 75% and 90% in one and two weeks, respectively (9). Volatilization of malathion from water is not believed to be significant (20).

- The half-life of malathion on plants ranges from < 0.3 - 8.7 days (9, 21).

- In the environment, malathion often undergoes microbial or hydrolytic degradation to compounds of lower toxicity. However, malathion may be converted into more toxic substances under some environmental conditions (9, 22).

What effects does malathion have on wildlife?

- Malathion is slightly to moderately toxic to various bird species (14 day LD50 = 167-1485 mg/kg) (9).
- Malathion is considered moderate to very high in toxicity to fish and aquatic invertebrates. In 96-hour studies, the LC_{50} values for fish ranged from 4-11,700 µg/L and 0.5-3000 µg/L for aquatic invertebrates (9).
- Malathion is not expected to bioconcentrate in fish and aquatic invertebrates, but some aquatic organisms have displayed moderate levels of bioconcentration (20).
- Malathion is highly toxic to bees. The 48-hour LD50 values range from 0.20 to 0.38 µg/bee (9).

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For more information contact: NPIC
Oregon State University, 333 Weniger Hall, Corvallis, Oregon 97331-6502.
Phone: 1-800-858-7378 Fax: 1-541-737-0761 Email: npic@ace.orst.edu
NPIC at http:/npic.orst.edu/ EXTOXNET at http://ace.orst.edu/info/extoxnet/

References

1. *Pesticide Fact Sheet Number 152: Malathion*; U.S. Environmental Protection Agency, Office of Pesticide Programs, U.S. Government Printing Office: Washington, DC, 1988.
2. Chamber, H. W. Organophosphorus Compounds: An Overview. In *Organophosphates: Chemistry, Fate, and Effects*; Chambers, J. E., Levi, P. E., Eds.; Academic: San Diego, CA, 1992; pp 3-17.
3. Malathion. In *Hazardous Substances Data Bank (HSDB)* [CD-ROM]; U.S. National Library of Medicine: Bethesda, MD, March 2000.
4. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, DC. Malathion Preliminary Risk Assessments: Health Effects. http://www.epa.gov/pesticides/op/malathion.htm (accessed Nov 2000).
5. *Pest-Bank Pesticide Product Data* [CD-ROM]: Purdue Research Foundation: West Lafayette, IN, 2000.
6. Gallo, M. A.; Lawryk, N. J. Organic Phosphorus Pesticides. In *Handbook of Pesticide Toxicology;* Hayes, W. J., Laws, E. R., Eds.; Academic: San Diego, CA, 1991; Vol. 2, pp 917-1123.
7. World Health Organization. *Organophosphorus Insecticides: A General Introduction*, Environmental Health Criteria, 63, Geneva, Switzerland, 1986.
8. Marrs, T. C. Malathion. In *Pesticide residues in food, Joint FAO/WHO Meeting on Pesticide Residues, Evaluations 1997: Part II - Toxicological and Environmental*; International Programme on Chemical Safety, World Health Organization: Geneva, Switzerland, 1998; pp 189-219.
9. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, DC. Malathion Preliminary Risk Assessments: Environmental Fate and Effects. http://www.epa.gov/pesticides/op/malathion.htm (accessed Nov 2000).
10. Boyes, W. K.; Hunter, E.; Gary, C.; Jensen, K.; Peiffer, R. L. Topical Exposure of the Eyes to the Organophosphorus Insecticide Malathion: Lack of Visual Effects. *J. Appl. Toxicol.***1999**, *19*, 473-483.
11. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, DC. Malathion Preliminary Risk Assessments: Toxicology Chapter. http://www.epa.gov/pesticides/op/malathion.htm (accessed Nov 2000).
12. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, DC. Label Review Manual. http://www.epa.gov/oppfod01/labeling/lrm/chap-08.htm (accessed Nov 2000).
13. Shafey, O.; Sekereke, H. J.; Hughes, B. J.; Heber, S.; Hunter, R. G.; Brooks, R. G. Surveillance for Acute Pesticide-Related Illness During the Medfly Eradication Program-Florida. *MMWR* **1999,** *282*, 1015-1027.
14. Schanker, H. M.; Rachelefsky, G.; Siegel, S.; Katz, R.; Spector, S.; Rohr, A.; Rodriquiz, C.; Woloshin, K.; Papanek, P. J. Jr. Immediate and delayed type hypersensitivity to malathion. *Ann. Allergy* **1992**, *69*, 526-528.
15. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington, DC. Malathion Preliminary Risk Assessments: Review of Malathion Incident Reports. http://www.epa.gov/pesticides/op/malathion.htm (accessed Nov 2000).
16. Wester, R. C.; Maibach, H. I.; Bucks, D. A.; Guy, R. H. Malathion Percutaneous Absorption after Repeated Administration to Man. *Toxicol. Appl. Pharmocol.* **1983**, *68*, 116-119.

17. Flessel, P.; Quintana, P. J. E.; Hooper, K\. Genetic Toxicity of Malathion: A Review. *Environ. Mol. Mutagen.* **1993**, *22*, 7-17.
18. Windham, G. C.; Titenko-Holland, N.; Osorio, A. M.; Gettner, S.; Reinisch, F.; Haas, R.; Smith, M. Genetic Monitoring of Malathion-Exposed Agricultural Workers. *Am. J. Ind. Med.* **1998**, *33*, 164-174.
19. Hornsby, A. G.; Wauchope, D. R.; Herner, A. E. *Pesticide Properties in the Environment*; Springer: New York, 1999; p 134.
20. Howard, P. H. *Handbook of Environmental Fate and Exposure Date for Organic Chemicals*. Lewis: Chelsea, MI, 1991; pp 474-485.
21. Bradman, M. A.; Harnly, M. E.; Goldman, L. R.; Marty, M. A.; Dawson, S. V.; Dibartolomeis, M. J. Malathion and Malaoxon Environmental Levels Used for Exposure Assessment and Risk Characterization of Aerial Applications to Residential Areas of Southern California. *J. Expos. Anal. Environ. Epidemiol*. **1994**, *4*, 49-63.
22. Brown, M. A.; Petreas, M. X.; Okamoto, H. S.; Mischke, T. M.; Stephens, R. D. Monitoring of Malathion and Its Impurties and Environmental Transformation Products on Surfaces and in Air Following an Aerial Application. *Environ. Sci. Technol.* **1993**, *27*, 388-397.