WHO/Food and Agriculture Organization of the United Nations

WHO/FAO DATA SHEETS ON PESTICIDES

No. 93

METALDEHYDE

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CLASSIFICATION:

Primary use: Molluscicide
Secondary use: Control of fish, leeches and frogs
Chemical group: Acetaldehyde polymer

1.0 GENERAL INFORMATION

1.1 COMMON NAME: metaldehyde (BSI, E-ISO, F-ISO, JMAF)

1.1.1 Identity: Metaldehyde is a cyclic polymer of acetaldehyde. The technical material contains higher oligomers of the polymerized acetaldehyde, but is mainly the tetramer which is described by the IUPAC and CAS nomenclature.

IUPAC name: r-2, c-4, c-6, c-8-tetramethyl-1,3,5,7-tetroxocane
CAS name: 2,4,6,8-tetramethyl-1,3,5,7-tetraoxacyclooctane
CAS registry number: 108-62-3 (the homopolymer is 9002-91-9)
Molecular formula: C₈H₁₆O₄ (tetramer)
Relative molecular mass: 176.2 (tetramer)

Structural formula:

```
CH₃
O     O
  O   O
CH₃   CH₃
```

1.1.2 Synonyms and trade names: Antimilice; Ariotox; Cekumeta; Deadline; Halizan; Limatox; Limeol G; Meta; metacetaldehyde; Metason; Mfaslug; Namekil; Slug Death; Slug Fest Colloidal 25; Slugit; Slug-Tox.

1.2 SYNOPSIS: Metaldehyde is a molluscicide, effective by contact and stomach action. Of moderate mammalian toxicity, poisoning is characterized by CNS depression and convulsions. Several cases of deliberate or accidental ingestion by man, pets or domestic animals are reported in the literature.
1.3 SELECTED PROPERTIES

**Physical characteristics:** The pure tetramer forms colourless crystals which fracture easily, giving a powdery appearance. Metaldehyde is tasteless, but has a characteristic of formaldehyde odour. The density is 1.27 g/cm³. Burning with a smokeless flame and having a flashpoint of 36-40 °C, the original use of metaldehyde was as a fuel tablet for portable stoves. Melting point: 246 °C (in sealed tube). Sublimates at 110-120 °C.

**Solubility:**
- water at 17 °C 200 mg/litre
- water at 30 °C 260 mg/litre

Soluble in benzene and chloroform; slightly soluble in diethyl ether and ethanol, insoluble in aceton and acetic acid.

**Stability:** Subject to depolymerisation, which is rapid above 80 °C, strong acids also cause depolymerisation. Careful storage in a cool place is required to prevent depolymerization. Soldered tinplate containers are unsuitable for storage of metaldehyde. Avoid prolonged storage.

**Vapour pressure:** The vapour pressure is low at room temperature.

1.4 AGRICULTURE, HORTICULTURE AND FORESTRY

1.4.1 **Common formulations:** Formulated as solutions and dusts, pastes, foam, granules, particulates, and suspensions. May be formulated in a protein rich bait.

1.4.2 **Susceptible pests:** Slugs and snails.

1.4.3 **Use pattern:** Does not need to be ingested for effect and can be used on migration routes away from the food source. Dusts and liquid formulations can be applied to lawns and ornamentals or as a soil dressing before the emergence of vegetable crops. Formulations should not be applied to crops after the emergence of the edible parts of the plant. Solid formulations and baits can be applied in discrete piles around the base of plants. Cool moist conditions ensure activity of the target pest but rainfall after application decreases effectiveness.

1.4.4 **Unintended effects:** Dust and spray may cause discoloration of flower blooms. Particularly palatable to dogs; several incidents of poisoning of pets and domestic animals have been reported.

1.5 **PUBLIC HEALTH USE:** No recommended usage reported.
1.6 **HOUSEHOLD USE:** Household usage has been prohibited in some countries.

2.0 **TOXICOLOGY AND RISKS**

2.1 **TOXICOLOGY - MAMMALS**

2.1.1 **Absorption:** Metaldehyde is absorbed from the gastrointestinal tract and may be absorbed from the skin or lungs.

2.1.2 **Mode of action:** It is postulated that metaldehyde decomposition to acetaldehyde is responsible for the CNS effects and other toxic symptoms observed. The concentration of several CNS neurotransmitters was affected by metaldehyde administration to mice. However, it is not clear whether these changes were the cause of the toxic effect.

2.1.3 **Excretion products:** Metaldehyde probably undergoes decomposition to acetaldehyde in the acidic environment of the stomach. However, acetaldehyde was not found in plasma or urine of metaldehyde treated dogs (600 mg/kg b.w./day). Urinary excretion of metaldehyde was less than 1% of the dose.

2.1.4 **Toxicity, single dose:**

**Oral LD\textsubscript{50}**

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<tr>
<td>Rat</td>
<td>227-690 mg/kg b.w.</td>
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<tr>
<td>Mouse</td>
<td>200 mg/kg b.w.</td>
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<tr>
<td>Guinea pig</td>
<td>175 - 700 mg/kg b.w.</td>
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<td>Rabbit</td>
<td>290 - 1250 mg/kg b.w.</td>
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**Dermal LD\textsubscript{50}**

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<td>Rat</td>
<td>&gt; 2275 mg/kg b.w.</td>
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**4-hour inhalation LC\textsubscript{50}**

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<tr>
<td>Rat</td>
<td>200 (\mu)g/m(^3)</td>
</tr>
<tr>
<td>Mouse</td>
<td>203 (\mu)g/m(^3)</td>
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Mice receiving an oral dose of 1000 mg/kg b.w. died within two hours of exposure. Signs of poisoning, apparent 10 minutes after dosing, were sedation, shivering, whole body tremors, tonic-clonic convulsions and death. In cattle, horses and dogs mild poisoning was evidenced by salivation, ataxia and hypernea. In severe poisoning symptoms observed included convulsions, sweating, tachycardia and muscle spasms. Death was usually attributable to respiratory failure.

2.1.5 **Toxicity, repeated dose:** No published information available.

2.1.6 **Dietary studies:**

**Long-term:** Male and female Wistar rats received 200, 1000 or 5000 mg/kg diet for 107 weeks. In the top dose group, 5/25 females developed hind-limb paralysis. In one rat the onset was 19 days but for the other rats the onset was >550 days. Single incidences of late onset hind-limb paralysis were also observed in each sex at 1000 mg/kg b.w. and in a single male rat at 200 mg/kg b.w. Death or morbidity followed the onset of paralysis. Lesions of the spinal cord were observed in some of the female rats in the top dose group (see 2.1.11 Neurotoxicity). Sporadic changes in haematology and serum chemistry were observed during the study but at week 105 no one parameter was significantly different from that of control rats. The relative liver weight was increased in male rats receiving 5000 mg/kg diet.

2.1.7 **Carcinogenicity:** No increased incidence of tumour formation was observed in the rat long term dietary study described above.

2.1.8 **Teratogenicity:** No increased incidence of malformations was observed in the reproduction study described below.

2.1.9 **Reproduction:** A three generation reproduction study with Wistar rats receiving, 1000 or 5000 mg/kg diet demonstrated an adverse effect on reproduction. Hind-limb paralysis and mortality were observed in females of all generations (including parental) receiving 5000 mg/kg diet. A low incidence of hind-limb paralysis was observed in the females of the F1 and F2 generations at 1000 mg/kg diet. Fertility, viability and lactation indices were reduced in all generations at the top dose. The onset of maternal hind-limb paralysis at or about delivery had an adverse effect on the latter two parameters. Increased relative liver weights were observed in some offspring.

2.1.10 **Mutagenicity:** No mutagenic effect was observed in several strains of *Salmonella typhimurium*, with or without metabolic activation.

2.1.11 **Neurotoxicity:** CNS depression, convulsions and violent muscular contractions have been reported for several mammalian species following acute exposure to metaldehyde. In repeated exposure, incidences of hind-limb paralysis have been observed in rats. Histopathological examination revealed fracture or dislocation of vertebrae and subsequent transverse lesions of the spinal cord. In the
reproduction study cited above, pregnancy exacerbated the condition. Lesions usually occurred between the fifth and ninth thoracic vertebrae, and were not caused by osteomalacia, but were, possibly, secondary to uncontrolled body movement and subsequent mechanical damage.

2.1.12 Modification of toxicity: In mice intraperitoneal administration of 10 mg/kg b.w. diazepam or 0.5 mg/kg clonidine hydrochloride decreased the toxicity or an oral dose of 100 mg metaldehyde/kg b.w. administered 20 minutes previously. A dose of 0.5 mg diazepam/kg b.w. was without protective effect.

2.2 TOXICOLOGY - MAN

2.2.1 Absorption route: Metaldehyde is absorbed from the gastrointestinal tract and may be absorbed from the skin or lungs.

2.2.2 Dangerous doses: The following relationships between clinical effects and ingested dose have been suggested: salivation, facial flushing, fever, abdominal cramps, nausea, and vomiting from a "few" mg/kg; drowsiness, tachycardia, spasms, irritability, salivation, abdominal cramps, facial flushing, and nausea from up to 50 mg/kg; ataxia and increased muscle tone from 50-100 mg/kg, convulsions, tremor, and hyperreflexia from 100-200 mg/kg; and coma and death from about 400 mg/kg.

2.2.3 Observations on occupationally exposed workers: No information available.

2.2.4 Observations on exposure of the general population: Exposure to metaldehyde is possibly only by accidental ingestion of the compound (see 2.2.6).

2.2.5 Observations on volunteers: No information available.

2.2.6 Reported mishaps: Several incidents of metaldehyde exposure are reported in literature. Ingestion of slug-bait pellets by children accounts for the majority of the incidents reported in the United States of America between 1966-1980. In Europe, human poisonings are also associated with voluntary ingestion of tablets intended for use as fuel. Appearance of symptoms might be delayed a few hours after ingestion. Survivors of severe poisoning showed loss of memory which lasted for up to a year. Laboratory findings included acid urine despite alkali therapy and elevated serum transaminase activities. At autopsy, the main findings were fatty degeneration with zonal necrosis of the liver and swelling and desquamation of the renal tubular epithelium.
2.3 TOXICITY TO NON-MAMMALIAN SPECIES

2.3.1 Fish: 96-h LC$_{50}$ for rainbow trout and bluegill were 62 and 10 µg/litre, respectively.

2.3.2 Birds: A minimum lethal dose of 500 mg/kg b.w. for chickens and 300 mg/kg b.w. for ducks has been determined. Deaths of geese and ducks have been reported following accidental exposure.

Other species: No published information available.

3.0 FOR REGULATORY AUTHORITIES - RECOMMENDATIONS ON REGULATION OF COMPOUND

3.1 RECOMMENDED RESTRICTIONS ON AVAILABILITY

[For definition of categories see the "Introduction to Data Sheets".]

Liquid formulations >12% and solid formulation >45% - Category 3.

Other liquid and solid formulations - Category 4.

3.2 TRANSPORTATION AND STORAGE

All formulations: Should be transported in clearly labelled, leakproof containers well away from food and drink. Storage should be under lock and key, secure from access by children and other unauthorized persons. Metaldehyde is flammable; store in a cool place away from sources of heat and ignition. Avoid prolonged storage.

3.3 HANDLING

All formulations: Protective clothing (see Section 4) should be worn when handling these formulations. Eating, drinking and smoking should be prohibited during handling and before washing after handling. Washing facilities should be provided in the immediate area.

3.4 DISPOSAL AND/OR DECONTAMINATION OF CONTAINERS

Empty containers should be burned or buried in a deep pit. Care must be taken to ensure that water sources are not contaminated. If the empty containers are
burned, care must be taken to ensure that flammable residues do not cause an uncontrolled reaction. Containers may be decontaminated (see Section 4.3) but decontaminated containers must not be used for the transportation or storage of food or drink.

3.5 SELECTION, TRAINING AND MEDICAL SUPERVISION OF WORKERS

All formulations: A warning to workers to minimize contact is essential.

3.6 ADDITIONAL REGULATIONS RECOMMENDED IF DISTRIBUTED BY AIRCRAFT

Not applicable.

3.7 LABELLING

All formulations - minimum cautionary statement:

Metaldehyde is poisonous following ingestion, skin contact or inhalation of the dust or vapours. Keep the material out of the reach of children and pets. Keep well away from food and feedstuffs and their containers. If poisoning occurs call a physician. Artificial respiration may be required.

3.8 RESIDUES IN FOOD

Residue limits have not yet been set by the Joint FAO/WHO Meeting on Pesticide Residues. Residue limits and acceptable daily intakes have been set in some countries.

4.0 PREVENTION OF POISONING IN MAN AND EMERGENCY AID

4.1 PRECAUTIONS IN USE

4.1.1 General: Metaldehyde is a molluscicide of moderate toxicity. The resemblance of some formulations to food and feedstuffs, and the apparent palatability of metaldehyde increases the risk of accidental ingestion by children, pets and domestic animals.
4.1.2 **Manufacture and formulation - TLV:** Maximum air concentration of 0.003 mg/m$^3$ for ambient and 0.2 mg/m$^3$ for occupational environments has been set in the Russian Federation. Closed systems and forced ventilation should be used to reduce the exposure of workers to metaldehyde. Workers should wear adequate protection for the eyes, skin and respiratory tract (see Section 4.1.3).

4.1.3 **Mixers and applicators:** Workers should wear impermeable gloves and boots, clean overalls, eye protection, and a face mask should be work during mixing operations and when applying dust or spray formulations. Mixing, if not mechanical, should always be carried out with a paddle of appropriate length. Avoid contact with the mouth, skin and eyes. Before eating, drinking or smoking, the face, hands and exposed skin should be thoroughly washed.

4.1.4 **Other associated workers:** Persons associated with the application of metaldehyde should observe the precautions described above (see Sections 3.6 and 4.1.3).

4.1.5 **Other populations likely to be affected:** The domestic uses of metaldehyde will allow potential exposure for a large population. The lower concentration of metaldehyde in domestic formulations reduces the risk, but users must still protect against deliberate ingestion by children, pets and domestic animals.

4.2 **ENTRY OF PERSONS INTO TREATED AREAS**

Unprotected persons may enter treated areas as soon as the application has dried. Contents of bait stations should be made safe from ingestion by non-target species.

4.3 **DECONTAMINATION OF SPILLAGE AND CONTAINERS**

Care must be taken during these procedures to ensure that water sources are not contaminated. Impermeable gloves and eye protection should be worn. Metaldehyde is flammable; where burning is recommended care must be taken to ensure that the operation remains controlled at all times.

Residues in containers should be emptied in a diluted form into a deep pit. The empty container may be decontaminated by scrubbing with water and detergent followed by soaking overnight in a dilute acid. Decontaminated containers must not be used for the transportation or storage of food or drink. Containers which are not decontaminated should be burned or crushed and buried below topsoil.

Spillage of liquid formulations should be collected with adsorbent material. This material, or spillage of dry formulations, should be collected and burned or buried in a deep pit. Residual contamination should be removed from the spillage site by washing with water and detergent.
4.4 EMERGENCY AID

4.4.1 Early symptoms of poisoning: Nausea, vomiting, salivation, diarrhoea and abdominal cramps may be observed with mild poisoning. In severe poisoning these symptoms may progress to muscular spasms, convulsions, tachycardia, respiratory depression and coma. Dermal and ocular exposure may cause irritation.

4.4.2 Treatment before person is seen by physician, if symptoms appear following exposure: The person should stop work immediately, remove contaminated clothing and wash the affected skin area. If the patient is fully conscious, vomiting should be induced.

5.0 FOR MEDICAL AND LABORATORY PERSONNEL

5.1 MEDICAL DIAGNOSIS AND TREATMENT IN CASES OF POISONING

5.1.1 General information: Metaldehyde is a molluscicide of moderate mammalian toxicity. Poisoning may occur following ingestion, inhalation of vapours or following dermal contact. Dermal and ocular exposures may cause irritation. Poisoning is characterized by central nervous system toxicity and acidosis.

5.1.2 Symptoms and signs: Symptoms of mild poisoning include nausea, salivation, vomiting, diarrhoea, abdominal pain, and muscle spasms. More severe poisoning may also cause tachycardia, respiratory depression and coma. Dermal and ocular contact may cause irritation.

5.1.3 Laboratory: A mixed metabolic acidosis and respiratory alkalosis may be observed.

5.1.4 Treatment: Following ingestion vomiting should be induced in the conscious patient. A gastric lavage is also indicated and an activated charcoal suspension will limit absorption. Gastric lavage and catharsis are effective treatments for up to 12-24 hours after poisoning. Give oxygen if respiration is depressed. Convulsions may be treated with diazepam, but attention must be paid to the possible further depression of respiration. Antibiotics, chlorpromazine, and additional supportive therapy for coma, hypoxia, and/or pulmonary oedema may be required. Urinary acidosis should be countered by the administration of sodium bicarbonate.

If the compound has entered the eyes they should be flushed with water. Contaminated skin should be thoroughly washed with soap and water. Treatment of irritant effects should be symptomatic.

5.1.5 Prognosis: Patients who survive, recover within 2-5 days. However, loss of memory has been reported for various durations (weeks to months) after poisoning.
5.2 SURVEILLANCE TESTS: No recommended procedures.

5.3 LABORATORY METHODS

5.3.1 Detection and Assay of Compound:

Analysis of metaldehyde following conversion to acetaldehyde, which is estimated by reaction with sodium hydrogen sulfite and titration with iodine or by reaction with hydroxyammonium chloride and acid-base titration.


REFERENCES
