



Pesticide Fact Sheet

Name of Chemical: Phosphine
Reason for Issuance: Conditional Registration
Date Issued: December 1999

DESCRIPTION OF CHEMICAL

Generic Name: Phosphine

Common Name: Phosphine gas, Hydrogen phosphide, Phosphorus trihydride

Trade Names: ECO₂FUME™

EPA Chemical Code: 066500

Chemical Abstracts
Service (CAS)

Number: 7803-51-2

Year of Initial
Registration:

1999

Pesticide Type: Insecticide

Chemical Family: Inorganic phosphine

U.S. and Foreign
Producers:

CYTEC Industries Inc
West Paterson, NJ 07424

USE PATTERNS AND FORMULATIONS

The end-use product, ECO₂FUME™ is a cylinderized, compressed gas containing a mixture of 2% phosphine by weight (2.6% by volume) in carbon dioxide (98% by weight). Carbon dioxide (in addition to being an active ingredient itself) is used as a propellant and a flame inhibitor, making the product non-flammable in air. Phosphine is a colorless gas which is odorless when pure, but technical grade material usually has an odor described as “fishy” or “garlicky”. The odor is believed to be due to the presence of substituted phosphines and diphosphines (World Health Organization, 1988). This odor cannot be relied upon as a warning of phosphine gas exposure.

Phosphine gas is used indoors to control a broad spectrum of insects for non-food/non-feed commodities in sealed containers or structures. There are no homeowner or agricultural row crop uses for this product. The end-use product is a poisonous liquefied gas under pressure, and is a Restricted Use Pesticide (RUP) due to the acute inhalation toxicity of phosphine gas. The end-use product is withdrawn from the cylinder as a liquid, but dispensed as a gas. In expanding from a liquid to a gas, it increases in volume by hundreds of times. Proper dispensing equipment and training in fumigation is necessary and required to ensure a safe and effective fumigation. During fumigation applicators must placard or post all entrances to the facility with signs warning of the presence of toxic gas. This placarding must be done in accordance with the product Application Manual.

ECO₂FUME™ is used as an aid in the control of the following insects:

Almond Moth	Angoumois Grain Moth
Bean Weevil	Cadelle
Carpet Beetle	Cereal Leaf Beetle
Cigarette Beetle	Confused Flour Beetle
Dermestid Beetle	Dried Fruit Beetle
Dried Fruit Moth	European Grain Moth
Flat grain Beetle	Fruit Fly
Granary Weevil	Greater Wax Moth
Hairy Fungus Beetle	Hessian Fly
Indian Meal Moth	Khapra Beetle
Lesser Grain Borer	Maize Weevil
Mediterranean Flour Moth	Pink Bollworm
Raisin Moth	Red Flour Beetle
Rice Weevil	Rusty Grain Beetle
Saw-toothed Grain Beetle	Spider Beetle
Tobacco Moth	Warehouse Beetle
Yellow Meal Worm	

The following non-food/non-feed items may be treated with ECO₂FUME™: Animal hide; processed or unprocessed cotton, wool or other natural fibers or cloth; clothing, feathers, furs, human hair, rubberized hair, vulcanized hair, mohair, leather products; tobacco (and tobacco products); wood, cut trees, wood chips and wood and bamboo products; paper and paper products; non-food flour; non-food starch; dried plants and flowers. There are no food or animal feed uses registered for phosphine gas (ECO₂FUME™) at this time.

The rate at which phosphine is dispensed using ECO₂FUME™ is not dependent on temperature or humidity, but on the dispensing equipment used. Unlike metal phosphide fumigants, the phosphine is not generated through a chemical reaction and both the release of the product and the termination of its administration into sealed containers or structures are instantaneous.

ECO₂FUME™ is applied at a concentration of 200-500 ppm, which is maintained for a period of 2-14 days depending upon the temperature found within the immediate surroundings of the target pest.

The use directions and limitations for this product are lengthy and detailed for this product and therefore the Agency is requiring the product to have a label and a separate Application Manual. The label and Application Manual contains numerous limitations; only the major limitations or use restrictions are included here:

1. Phosphine gas (ECO₂FUME™) is a Restricted Use Pesticide due to the acute inhalation toxicity of phosphine gas. This product is for retail sale to and use only by certified applicators for uses covered by the applicator's certification or persons trained in accordance with the manual, working under the direct supervision and in the physical presence of the applicator. Physical presence means on site or on the premises. Read and follow the label and the Application Manual which contains complete instructions for the safe use of this pesticide.
2. Worker exposure to phosphine must not exceed the 8 hour TWA of 0.3 ppm during the application or a maximum concentration of 0.3 ppm after application is completed. This includes reentry into the structure. Respiratory protection must be available at the application site.
3. Post "DANGER" signs on all entrances to fumigated areas. See the Application Manual for the specific wording required.
4. Notify appropriate company employees and provide relevant safety information (MSDS sheets, first aid procedures, etc.) to local officials annually for use in the event of an emergency.
5. Protect or remove materials containing metals such as copper, silver, gold, and their alloys and salts from corrosive exposure to phosphine. (Thus, small electric motors, smoke detectors, brass sprinkle heads, batteries, fork lifts, temperature monitoring devices, etc. Electric and

electronic equipment must be protected or removed before fumigation.)

6. Prior to applying this product, you must inspect the structure to determine if it can be made sufficiently gas tight.

This product is registered as a Restricted Use Pesticide due to its very high acute inhalation properties. Special training on how to operate the associated equipment to dispense the phosphine gas is required.

SCIENCE FINDINGS

SUMMARY SCIENCE STATEMENTS

The Agency has previously based its evaluation of fumigation usage of phosphine in the U.S. upon phosphine gas generated as the active ingredient in aluminum and magnesium phosphide. Adequate product chemistry, toxicological, ecological effects, and environmental fate data have been submitted and reviewed to support the conditional registration of ECO2FUME™ for the non-food/feed uses listed above.

ECO₂FUME™ is classified in Toxicity Category I [DANGER] based on acute effects via the inhalation route of exposure, as one would expect for a fumigation gas. Phosphine is a powerful respiratory poison. The 4-hour LC₅₀ for phosphine in rats is 11 ppm. No significant exposure to phosphine gas is expected via the oral or dermal routes. Acute inhalation toxicity exposure is the route of concern. Acute toxicity data for other routes of exposure were waived with the requirement that eye protection would be required.

In rats exposed to phosphine at 10 ppm, 6 hours/day for 3 days, there was 80% mortality in females but no mortality in males. Both sexes of rats exhibited coagulative necrosis in the tubules of the kidney and pulmonary congestion was observed in the female rats that died. A LOEL of 10 ppm for a four-week study was based on lethality (80% deaths for females) due to the sharp dose-response curve for acute toxicity. In a 13-week subchronic inhalation study, Fischer 344 rats were exposed to phosphine at levels up to and including 3.0 ppm for 6 hours/day, 5 days/week. A LOEL for subchronic exposure was not established in this study; the NOEL was 3 ppm (highest dose tested).

In a two year combined chronic/carcinogenicity study, Charles River Fischer CDF rats were exposed to phosphine gas in chambers at levels of 0, 0.3 ppm, 1 ppm and 3 ppm. There were no adverse effects observed throughout the study that was relatable to the phosphine exposures. The NOEL for this 104-week study was 3.0 ppm, the highest dose tested. The Agency does not believe that phosphine or a mixture of phosphine with carbon dioxide will pose a carcinogenic concern.

In a developmental study, pregnant CD derived Sprague Dawley female rats were exposed in

inhalation chambers to concentration of phosphine gas at levels of 0, 0.03 ppm, 0.3 ppm, 3.0 ppm, 5.0 ppm or 7.5 ppm, 6 hours per day on gestation days 6 through 15. The highest exposure group (7.5 ppm) was terminated after 10 days due to high mortalities (14/24) The only abnormalities were increased resorptions in litters of high dose (7.5 ppm) dams. Increased resorptions were not observed in the 0.3, 3.0, 5.0 ppm groups. All other observations were comparable to those for the control females and pups. The maternal NOEL is 5 ppm and the maternal LOEL is 7.5 ppm, based on the high incidence of maternal death. Although food uses are approved for certain phosphine generating fumigants (i.e., aluminum phosphide and magnesium phosphide), the general requirement for a reproductive toxicity study in rodents was waived since residues of phosphine are not expected on food or drinking water and because these developmental effects were expected to occur at doses above that at which the acute effects would result in maternal death.

Phosphine gas is not mutagenic in bacteria but is clastogenic in vitro. Negative results in an Ames test and positive results in a Chinese hamster ovary cell chromosomes assay are consistent with the in vitro test results for zinc phosphide. Studies conducted in vivo indicate that phosphine is not clastogenic in mice or rats and does not cause dominant lethal mutations in mice following exposure for up to two weeks.

Under normal environmental conditions phosphine exists as a gas. The solubility of phosphine in water at normal atmospheric pressure is approximately 340 ppm (World Health Organization, 1988) and the Ostwald solubility constant (the ratio of the concentration in solution to the concentration in the gas phase at equilibrium) is 0.201 (Fluck, 1983). Because of its high vapor pressure (40 mm Hg at -129.4 C) and Henry's Law Constant (0.1 atm m³/mol), phosphine at the soil surface is expected to rapidly dissipate into the atmosphere (World Health Organization, 1988) .

Phosphine in the atmosphere is rapidly degraded (World Health Organization, 1988). The half-life in air is approximately five hours with the mechanism of degradation being photoreaction with hydroxy radicals. The dark half-life is approximately 28 hours. The expected reaction products of phosphine in air are oxyacids of phosphorous and inorganic phosphate which are non-volatile.

Several published laboratory studies suggest that phosphine below the soil surface is quickly adsorbed and degraded (Hilton and Robinson, 1972; Eiseman et. al., 1997; Berck and Gunther, 1970). Gaseous phosphine added to soil headspace at 1000 mg/kg dry soil in closed containers degrades 50% after approximately five days in air dried soil and 11 days in water saturated soil (Hilton and Robinson, 1972). Smaller quantities of phosphine may be removed by soil through a faster mechanism because phosphine added at a lower concentration (0.35 micrograms/kg) was undetectable in 50 minutes (Eiseman, Glindemann, Bergman and Kusch, 1997). Diffusion through the soil environment is expected to be slow because phosphine is sorbed in seconds when pushed through several types of soil in a nitrogen carrier (Berck and Gunther, 1970). The interaction of phosphine with soil appears to be mixed chemisorption

(irreversible) and physisorption (reversible), with the extent of each dependent on soil type. Phosphine gas trapped below the surface will degrade to phosphates in a matter of days. Phosphine has a low exposure potential for contaminating ground and surface water.

Ecological effects or potential risk to non-targeted organisms resulting from indoor use of this fumigation gas is considered to be very minimal. Phosphine would be highly toxic to small mammals and birds that might remain in indoor sites (e.g., warehouses) during fumigation.

CHEMICAL CHARACTERISTICS

Empirical

Formula: PH₃ (CAS #: 7803-51-2)

Molecular

Weight: 34.00

Color: Colorless

Physical

State: Liquefied gas under pressure
(Gas at ambient temperature and pressure)

Boiling Point: -87.4 C

Density at (20°C):

1.405 kg/M³; 1.5 relative to air at 20C/1 atm pressure

Flammability: Non-flammable at concentrations equal to or less than 3% phosphine in carbon dioxide (v/v). This product is 2.6% v/v.

Solubility in water: 0.04%

Storage stability: > 1 year

Corrosion

Characteristics: Corrodes copper, brass, copper alloys, silver and gold

TOXICOLOGY CHARACTERISTICS

ECO₂FUME™

(End-Use Product)

Acute Inhalation

Toxicity

(rats): LC50 (4-hour) > 11 ppm (phosphine gas)

Toxicity

Category: I

PHOSPHINE TECHNICAL MATERIAL

Results of studies show that phosphine gas is highly toxic by the inhalation route. Considering the use patterns and chemical characteristics, the other acute toxicity data (81-series guideline studies) were waived for this chemical. The Agency has based the assessment for acute toxicity of end-use products for phosphine fumigation (*i.e.*, ECO₂FUME, Aluminum Phosphide, Magnesium Phosphide) on exposure to the active ingredient phosphine gas, *per se*. Accordingly, the acute toxicity endpoints presented below are the same as described above for ECO₂FUME:

Acute Inhalation

Toxicity

(rats): LC₅₀ (4-hr) > 11 ppm (for phosphine gas, *per se*)

Toxicity

Category: I

Primary Eye

Irritation: Study not required, provided eye protection required.

Toxicity

Category: Not applicable.

**Repeated
Exposures,
Short-Term
Inhalation Toxicity**

3-day

inhalation (rat): (6 hours/day) LOEL 10 ppm (lethality among females)

15-day

inhalation (rat/): (6 hours/day, 5 days/week) NOAEL= 5 ppm (the highest concentration tested).

13-week

inhalation (rat): (6 hours/day, 5 days/week) NOEL= 3 ppm (the highest concentration tested)

Developmental

Toxicity (rat): The duration of exposure was 6 hours per day on gestation days 6 through 15. Maternal Toxicity NOEL=5 ppm, Maternal Toxicity LOAEL=7.5 ppm, based on a high incidence of maternal deaths.

Developmental Toxicity NOEL=5 ppm.

Reproductive

Toxicity: This study, a requirement for a food-use pesticide, was waived since residues of phosphine are not expected in food or drinking water.

Chronic Toxicity/

Carcinogenicity

(rat):

2-Year Feeding

Study: Diets were fumigated at high rates with aluminum phosphide pellets. Actual levels of phosphine in diet were unknown, due to dissipation. This study was not considered an acceptable guideline study since toxicity, resulting from phosphine residues, is not possible when aeration is adequate. However, the study shows that toxic levels of residues were not achieved even with the high fumigation treatment rates with adequate aeration.

2-Year

Inhalation

Study: In a two year combined chronic/carcinogenicity study, Charles River Fischer CDF rats were exposed to phosphine gas in chambers at levels of 0, 0.3 ppm, 1 ppm and 3 ppm. The high dose of 3 ppm was selected because higher doses would result in high mortalities from acute effects. There were no adverse effects observed throughout the study that was relatable to the phosphine exposures. The NOEL for this 104-week study was 3.0 ppm, the highest dose tested.

Acute Inhalation

Neurotoxicity

(rat): The acute LOEL is 20 ppm based on decreased body temperatures and

decreased motor activity in males and females, and the NOEL is less than 20 ppm (the lowest concentration tested). Groups were treated at levels up to and including 40 ppm of phosphine (1% a.i. in nitrogen) for 4 hours. No phosphine-related neuropathological changes were observed in any exposure group. Based on lack of systemic toxicity, the NOEL for systemic toxicity is 40 ppm.

Subchronic
Neurotoxicity
(90-day)
Inhalation
(rat):

Animals were exposed to phosphine at levels up to and including 3 ppm for 6 hours/day, 5 days/week. The NOEL for systemic/neurobehavioral effects is tentatively set at 3 ppm (the highest concentration tested); possible effects among males in the highest exposure group were considered slight and equivocal, and there did not appear to be any treatment-related effects among females. **[NOTE: An upgraded study was submitted to EPA in Sept 98; however, the Agency has not yet reviewed this study.]**

Mutagenicity

Gene mutation- Ames test (*Salmonella typhimurium*) - Negative for induction of reverse gene mutation in all strains up to cytotoxic concentrations.

Chromosome Aberrations - Positive at 2500 and 5000 ppm without S9 activation, in an *in vitro* cytogenetic assay with Chinese hamster ovary cells. Significant, but not dose-related increases in the frequency of cells with structural chromosome aberrations were found. Significant clastogenic effects were also noted at 2500 ppm with S9 activation, but not at the highest dose tested (5000 ppm).

Unscheduled DNA Synthesis (*in vivo*; rat primary hepatocytes)- Negative.

Metabolism:

This data requirement applies to food-use registrations and no food/feed uses are being registered.

Dermal

Absorption:

Because the route of exposure anticipated for phosphine is inhalation (the product is a gas), the Agency does not expect significant dermal exposure. Therefore, dermal absorption studies are not required.

Summary of Phosphide Endpoints for Risk Assessments

EXPOSURE SCENARIO	CONCENTRATION/DOSE	ENDPOINT	STUDY
Short-Intermediate or Long-Term (Dermal)	None	The use pattern does not indicate potential exposure via the dermal route. Therefore, dermal risk assessments are not required.	
Short Term (Inhalation)	0.007 mg/L (ca. 5 ppm)	No treatment-related effects after exposure for 15 days.	15-Day exposure regimen in a 90-day inhalation - Rat
	UF=100		
Intermediate (Inhalation)	NOEL= 0.004 mg/L (ca. 3 ppm)	No evidence of toxicity at the highest tested concentration.	90-Day Inhalation - Rat
	UF=100		
Long-Term (Inhalation)	NOEL= 0.004 mg/L	No evidence of toxicity at the highest tested concentration.	Chronic Toxicity Inhalation - Rat
	UF=100		

TOLERANCE ASSESSMENT

There are no food/feed uses for ECO₂FUME™ at this time. Tolerances are not required for this non-food registration. Note: Carbon dioxide is exempt from the requirement for a tolerance (40CFR180.1049).

SUMMARY OF DATA GAPS

This registration is subject, as a condition of registration, to amending the product label to include all label restrictions and/or other conditions that may be imposed on the metallic phosphide registrants, to the extent that they may also be relevant to ECO₂FUME™ and its uses. The Agency, as part of reregistration, is currently working with this metallic phosphide Task Force and other interested parties to mitigate phosphine exposure and risk to workers and bystanders.

PUBLIC INTEREST FINDING

ECO₂FUME™ is effective at controlling a broad spectrum of economically important insect pests on non-food commodities in sealed containers or structures. Under proper use conditions, ECO₂FUME™ appears to offer greater control of application rates as compared with metal phosphide fumigants, and is expected to reduce the levels of peak concentrations of phosphine necessary for satisfactory performance within fumigated areas. This product eliminates the need for applicators to enter a closed space and dispense tablets or pellets; therefore it may greatly reduce the exposure to fumigators. This product eliminates the need to dispose of waste pellets

and or tablets when using metal phosphide products. **In addition, this product may be used as an alternative to methyl bromide, a fumigation gas that depletes stratospheric ozone.**

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