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Aluminium Phosphide an Ideal Fumigant

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Common fumigants

THE common fumigants now used in India are ethylene dichloride, carbon tetrachloride mixture, ethylene dibromide, methyl bromide and aluminium phosphide.

Aluminium phosphide has now emerged as the most important fumigant in the world replacing other fumigants by its efficacy, ease in handling and economy in use. It is commercially manufactured in West Germany, East Germany and India, while now extensively used in over 100 countries.

Fumigation and fumigant

Fumigation for pest control is a process of exposing pests or pest affected stocks to the fumes of chemicals at a lethal strength in a gastight space. A fumigant is a chemical which at the required temperature and pressure exists in a gaseous state in sufficient concentration to be lethal to a given pest or organism. Fumigation is the best control measure when rapid destruction of all insects in a commodity or empty warehouse, ship, flour mills, etc., is required. There are many volatile toxic chemical compounds at ordinary temperature which fall within the definition of fumigants. However, most of these gases are eliminated due to chemical instability and destructive effects on fumigated materials.

Important characteristics of an ideal fumigant

Important characteristics are that the fumigant should be :

highly toxic to all stages of insects;

having high vapour pressure;

having no adverse reaction with fumigated commodity;

with least absorption with treated commodity;

desorbed easily;

having distinct warning odour;

able to distribute uniformly

without settling down;

easy to handle and transport;

non-inflammable;

devoid of tainting;

able to treat seeds without affecting viability;

with known antidote and treatment and without addictive effects and;

economical and indigenously manufactured.

Properties of fumigants

General properties; Aluminium phosphide is a solid fumigant, while EDCT, MBR and EDB are liquid fumigants. Methyl bromide exists as gas at ordinary temperature, EDCT and ethylene dichloride are liquids at ordinary temperature. The effective use of the fumigants depends upon its evaporation, diffusion, penetration, sorption temperature, moisture content, pressure, exposure period, load factor, chemical nature of the co-

mmodity, particle size of the commodity, desorption, fumigation dosage and concentration.

Specific properties; The important commercial fumigants are now thus limited to aluminium phosphide, methyl bromide and ethylene dibromide.

Specific properties of common fumigants are given in a Table 1.

Important influencing factors in fumigations

Through respiration insects directly affect susceptibility to fumigants, since a lethal dose is absorbed by their tissues in a corresponding shorter or longer period. The rate of respiratory metabolism is increased by increase in temperature, increase in carbon dioxide content of fumigated space, decrease in oxygen content of fumigated space, and also increase in the action of fumigants on pests. Some other factors like density of insect population, pre-fumigation and post-fumigation effects, starvation effects, relative humidity, sub-lethal fumigations, repeated fumigation, length of exposure period and fumigation interval, boiling point of fumigants, relative susceptibility of different stages of insects, etc., also play important role in fumigation. There are about 40 fumigants out of which only five fumigants are only commonly used, besides some other mixtures.

Ethylene dichloride carbon tetrachloride mixture (3:1 by volume)

The EDCT mixture is a popular fumigant, due to least hazards involved in its use, inspite of many drawbacks. It is slow to vaporize and slow to kill insects. The expo-

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sure period is from 24-72 hours. Being heavy, gas diffusion is slow and requires prolonged ventilation after fumigation. Usually a commercial kill is only obtained. Commodities rich in fat absorb appreciable amounts of gas and require long periods of aeration to remove the taint. It is not suitable for milled products, oil seeds or spices. The carbon tetrachloride is feared to induce cancer and cirrhosis and therefore not favoured in some countries.

Ethylene di bromide (EDB)

It is toxic to insects and is of considerable utility in empty warehouses and empty mill fumigations. It has a high boiling point and is sorbed by many fumigated commodities resulting in poor penetration. It has limited application for cereals and milled products because it does not

penetrate well into larger masses or stacks of these commodities. The main problem is that on account of its comparatively very low volatility it is physically sorbed by fumigated materials. Considerable long aeration is required before vapours are completely dissipated. Fats and excess moisture contents in seeds greatly increases the sorption of the fumigant and affect viability. Great care needs to be taken. The problems of residual EDB in human food and animal feed may pose serious problems especially in feed which are fed without processing by heating or cooking. EDB fumigated food and feed is reported to induce sterility. Eggs laid by hens fed on EDB fumigated feed is considered only good for table purposes and not for

hatching. The size, weight and fertility of eggs are affected.

In case of bull calves at the age of 14 to 16 months semen density and motility were sharply reduced but did not affect the growth.

It should be ensured that residual vapours of EDB are fully dissipated from fumigated food-stuffs before they are consumed. EDB in the form of inorganic bromide, has an acceptable tolerance of 50 ppm.

It is more toxic to man than methyl bromide. Higher concentration can cause burning and injury to kidney and liver. EDB has a chloroform-like odour detectable at 25 ppm. The maximum acceptable concentration in air is 25 ppm. The LD 50 for rat is 18 mg/lit. It is a nerve poison and a narcotic. It causes serious injury to the central nervous system and needs very careful handling. It is imported mainly for Food Corporation of India needs.

Methyl bromide (bromo methale) (CH₃Br)

This is a very effective fumigant with a gas-tight structure for controlling most insects. With its low boiling point and high volatile nature, it becomes gas easily rendering it for fumigations. It is non-explosive and non-inflammable. It has high penetration power and quick desorption property. Micro-organisms like *Asperigillus* Spp and *Pencillium* Spp are also controlled during fumigation. It is highly toxic to human beings even at low concentrations,

TABLE I
Specific properties of common fumigants

	<i>Aluminium phosphide</i>	<i>Methyl bromide</i>	<i>Ethylene dibromide</i>
Odour	Carbide or garlic like	Nil at low concentration	Like Chloroform
Chemical formula	PH ₃	MBR (CH ₃ BR)	CH ₂ Br.CH ₂ Br.
Boiling point	-84.5	3.6°C	131.6°C
Freezing point	-133.8°C	-93°C	10°C
Vapour pressure	35 atm	1250mm/hg at 20°C 1824 mm/hg/at 25°C	17.4 mm Hg at 30°C
Molecular weight	34.04	94.94	187.88
Specific gravity of vapour	1.214	3.27 at 0°C	6.487
Specific gravity of liquid	0.746		2.172 at 20°C
Latent heat of evaporation	102.6 cal/g	61.52 cal/gm	46.2 cal/g
Lower exposure point	Non-flammable 1.79% of vol. in air	Non-flammable	Non-flammable
Solubility in water	26cc/100 ml at 171°C (insoluble)	1.349/100 ml at 20°C (soluble)	Soluble
Penetrability	Excellent	Very good	Poor

with cumulative effects. It is a difficult fumigant to handle since there is no warning colour odour. With its high penetration power it can be readily absorbed through the skin. It can also cause incurable burns. No specific treatment for methyl bromide is known. This fumigant is combined with fats, water, rubber and oils and thus its utility is reduced. It is a nerve poison and a narcotic. It can cause very severe injury to the central nervous system. It is now mostly imported for specific purpose by the Food Corporation.

Aluminium phosphide (PH₃)

It is now indigenously manufactured for internal requirement and export. It is a solid fumigant in compressed tablet or pellet forms. The round tablet is dark brown in colour with yellowish tinge. It is composed of pure aluminium phosphide and ammonium carbamate/carbonate. The tablet consists of a minimum 56% w/w aluminium phosphide active ingredient and maximum 44% w/w inert ingredients, measures 20 mm in diameter and 5 mm in thickness. The tablet weighs three grammes and releases about one gramme of hydrogen phosphide on exposure to moisture. In addition, carbon dioxide and ammonia are also evolved thus preventing self inflammation of phosphine gas.

After decomposition is complete, aluminium hydroxide is left behind as a harmless and non-toxic greyish white residue. The tablet evolves a typical odour of phosphine resembling that of

carbide or garlic. It is also manufactured in pellets in 0.6 gram weight for export and for rat control. The presence of phosphine can be detected, when filter paper soaked with silver nitrate solution turns from brown to black when it comes in contact with the gas. It is relatively insoluble in water, oils or fats. The permissible limit for phosphine in air is 0.30 ppm and great care is needed in handling it. Phosphine being released from tablets after sufficient exposure gap and with its distinct garlic odour, is safe to handle with reasonable care. Since all fumigation is to be done by trained personnel, it is an ideal fumigant for village, trade and co-operative stores. It is also an ideal fumigant for rat burrow fumigations. Depending upon the length and zig-zag directions one or two tablets per burrow would give good result.

A comparative field trial conducted on the efficacy and penetration power of aluminium phosphide and methyl bromide in the Borivili Food Corporation of India Depot, Bombay jointly by U. S. Department of Agriculture and Food Corporation of India in September 1977 indicated better penetration power for phosphine. "Results of the test indicate that both phosphine and methyl bromide are effective for fumigating fabric bags, but doubtful results were obtained with methyl bromide fumigated paper bags having polythene liners".

Almost ideal fumigant

It is highly toxic to all stages of insects, having remarkable penetration power for uniform satisfactory results.

Since it does not dissolve in water oils and fats, it is used safely on a large range of commodities where other fumigants cannot be used.

It is an ideal seed fumigant since the viability is not affected. It is practically free from any residual toxic hazards and no tolerance limit is therefore fixed.

It is least sorbed or absorbed and easily desorbed from treated commodity.

It is non-inflammable at the prescribed dosage and devoid of tainting on fumigated stock.

The distinct warning odour and delay in evolving phosphene provide considerable safety handling. Antidote and treatments are known unlike methyl bromide.

Above all it is indigenously manufactured with indigenous raw materials and the cost of fumigation is much less.

Ease in transport and handling is another very important advantage compared with all other fumigants.

Since the tablet contains a predetermined weight of gas, it is very convenient to administer the exact dosage. Unlike other liquid or gaseous fumigants where measuring precise quantity is difficult and cumbersome,

Aluminium phosphide thus satisfies most of the requirements to qualify as an ideal fumigant. ●