Environmental Fate of Hydramethylnon

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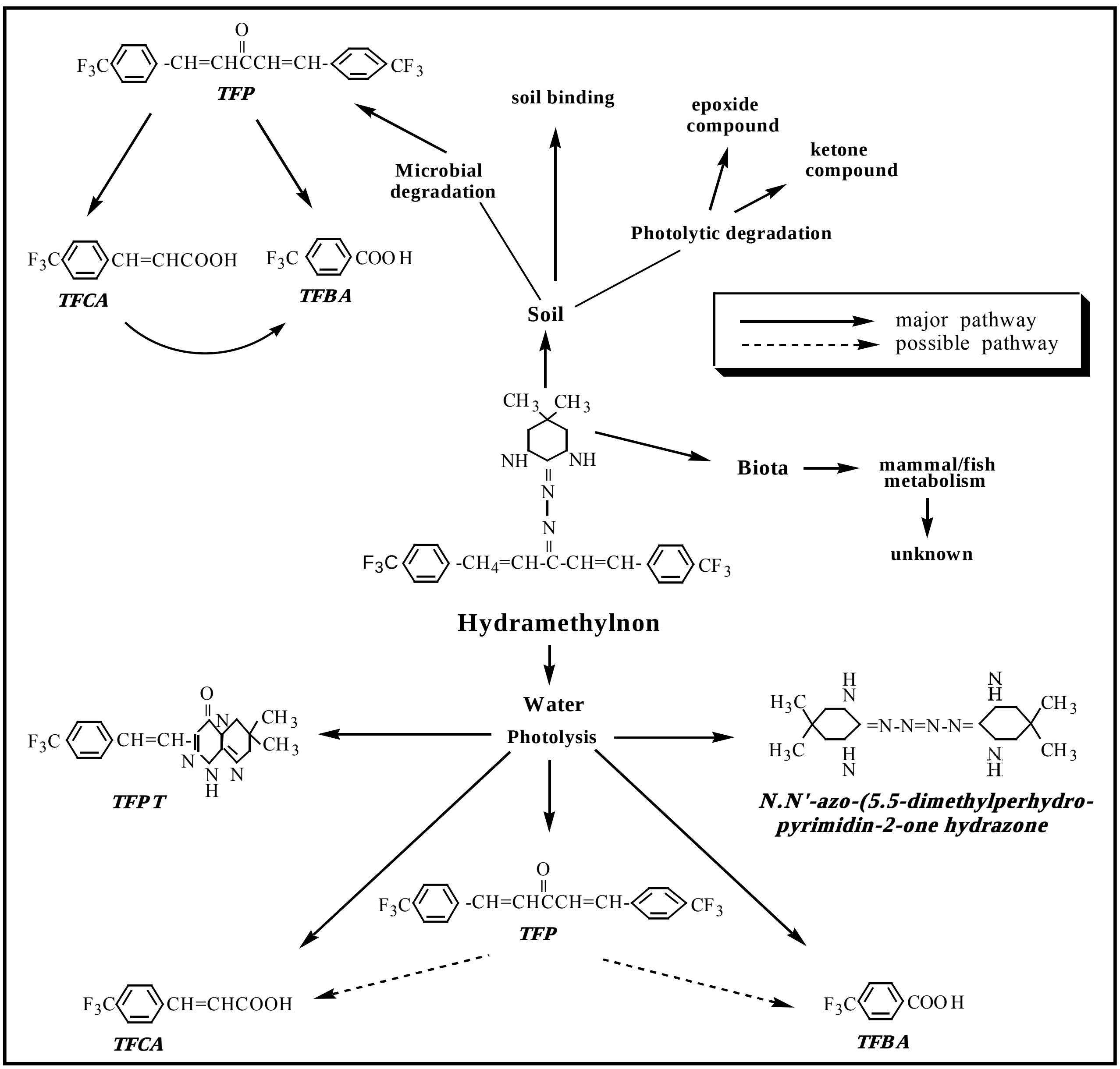
This document reviews all routes of environmental fate for hydramethylnon (HMN) with an emphasis on its use in controlling red imported fire ants. HMN is an amidinohydrazone insecticide. Chemical name: 5,5-dimethylperhydropyrimidin-2-one 4-trifluromethyl-alpha-(4-trifluoromethylstyryl)-cinnamylidenehydrazone

Hydramethylnon Degradation



Physical Properties

Molecular weight *	494.5 g
Water solubility *	0.005 - 0.007 ppm (at 20^o C, pH 7.45)
Hydrolysis half-life	30 days (at 25^o C)
Vapor pressure	6 x 10^{-8} mmHg (at 25^o C)
Henry's Law constant	1.95 x 10^{-7} atm m^3/g mole
Soil photolysis half-life	5 days (at 27^o C)
Aqueous photolysis half-life	< 1 hour (at 25 ^{o} C, pH 7.9)
Soil adsorption coefficient: Kd Koc	Varied soil types, pH of 6.5 to 7.1 1.04 x 10^3 – 1.72 x 10^3 cm^3/g 9.5 x 10^4 – 3.6 x 10^5 cm^3/g
Octanol-water coefficient log (Kow)	203 - 212
Aerobic half-life	383 days (at 25^o C)
Anaerobic aquatic half-life **	455 - 552 days

* Data from the Agrochemicals Handbook, 1993.
** Data from EPA RED, 1998.
All other data from DPR PestChem Database (Kollman and Segawa, 1995)

Toxicity

Rat	Acute oral LD_{50}	1131 - 1300 mg/kg
Rabbit	Dermal LD_{50}	> 5,000 mg/kg
Mallard Duck	Acute oral LD_{50}	>2,510 mg/kg
Bobwhite quail	Acute oral LD_{50}	1,828 mg/kg
Rainbow trout	LC_{50}	0.16 mg/L (96h)
Channel catfish	LC_{50}	0.10 mg/L (96h)
Bluegill sunfish	LC_{50}	1.70 mg/L (96h)

Farm Chemicals Handbook 1997; The Pesticide Manual, 10th edition 1994

General Information and Mode of Action

Common trade names of hydramethylnon (HMN) are Amdro®, Combat®, and Maxforce®. It is also known as CL 217,300 and AC 217, 300. HMN is used for the control of fire ants, cockroaches, and termites. It is used in residential and commercial buildings, and on landscape areas, lawns, pastures, rangelands, golf courses and commercial grounds. It is produced in ready-to-use bait as a yellow-orange, odorless, granular/powder form and a gelatin form. HMN is normally formulated in a soybean oil attractant and placed on corn-grit carrier. The bait is spread with a granular spreader at a rate of 1 to 2 pounds of bait per acre.

HMN is an amidinohydrazone insecticide. It is selectively toxic to insects with chewing or sponging mouthparts and functions as a slow acting stomach toxicant (Lovell 1979). It is relatively nontoxic to insects that use other modes of feeding and to insects where exposure is limited to cuticular contact. In insects, HMN has been found to inhibit mitochondrial electron transport, which causes a decrease in physical activity, as well as a decrease in respiration (Hollingshause 1987).

HMN is a slow acting toxicant allowing time for foraging ants to distribute the bait to other members of the colony before they are killed. The bait is carried by the ant to the mound, and then into the nest as food for the colony and queen. Within 24 hours of treatment lethargy sets in, and morbundity within 72-96 hours.

Physical and Chemical Properties

HMN is a yellowish, odorless solid. It is stable to a temperature of 185°C to 190°C. It has a low water solubility of 0.005 to 0.007 ppm at 20°C. Combined with the high soil adsorption coefficient (Koc) of $9.5 \times 10^4 – 3.6 \times 10^5$ cm^3/g there is a low potential for leaching in soil. Also, HMN has a high tendency to photodegrade in water and on soil, which suggests that it has a low potential for bioacculmulation in the environment, despite a high Kow of $2.03 \times 10^2 – 2.12 \times 10^2$.

Environmental Fate and Toxicity

Air: The low vapor pressure of 6×10^{-8} mmHg (DPR PestChem Database) indicates that this insecticide is non-volatile; therefore, it is unlikely to be dispersed in air over a large area. The low Henry's Law constant (1.95×10^{-7} atm m^3/mole) also indicates that it will not volatize from water to air. In a one-year study of breakdown products in air less than 3% of the initial measured dose was detected (American Cyanamid, 1992). HMN is not applied by spraying; therefore, there is low risk of contamination from drift.

Water - HMN may enter ponds and streams by direct application, erosion of soils, or runoff. Runoff can be influenced by factors such as bait formulation, which is generally on a corn grit carrier, timing of application and rainfall intensity. The low water solubility and high soil adsorption coefficient indicate a low potential to leach in soil and reach ground water. It is fairly stable to abiotic hydrolysis with a half-life of 30 days at 25°C in deionized water (American Cyanamid Company, 1992).

HMN degrades rapidly in surface water when exposed to light. The aqueous photolysis half-life is less than 1 hour (American Cyanamid Company, 1992). pH levels of 4.8 to 8.0 affected the rate of phototransformation only slightly. In the absence of light, no significant degradation was found to take place in water at any pH level, at temperatures of 10-25°C (Chakraborty et al. 1993).

HMN was found to degrade to five photoproducts in water and possibly two unidentifiables (Chakraborty et al. 1993, Mallipudi et al. 1986).

- 1,5-bis(α,α,α-trifluoro-p-tolyl)-1,4-pentadien-3-one (TFP)
- 6,7,8,9-tetrahyrdro-7,7-dimethyl-3[p(trifluromethyl)styryl] – 4H-pyrimido[2,1-c]-triazin-4-one (TFPT)
- P-(trifluoromethyl) benzoic acid (TFBA)

- N, N'-azo-(5,5-dimethylperhydropyrimidin-2-one hydrazone
- P-(trifluoromethyl) cinnamic Acid (TFCA)

Soil – HMN is generally applied as a formulation in bait using a granular spreader. Breakdown via photolysis is the major route for degradation. The soil photolysis half-life of HMN is 5 days. Two photoproducts have been identified as an epoxide compound and a ketone compound (American Cyanamid Company, 1992). Under field conditions HMN is very unstable when exposed to sunlight. Vander Meer et al. (1982) found that in daylight HMN has a half-life of 12 hours; and when exposed to heat (52^{o}C), in the absence of light, decomposition is relatively nonexistent.

The high soil adsorption coefficient causes HMN to bind to soil particles, making it unavailable for microbial degradation. Microbial degradation is very dependent on a number of soil characteristics: moisture, temperature, pH, and soil type. Also, the organic carbon content of the soil may increase adsorption and may increase or decrease microbial degradation.

In field applications some microbial degradation may occur. When ants carry the bait down to the nest, if not eaten immediately, microbial degradation can occur. *Phanerochaete chrysosporium*, a common white rot fungus, has been found to breakdown HMN with a half-life of 14-25 days. This is with no exposure to light. The microbial degradation products are TFP, FTCA and TFBA (Abernethy et al., 1993). Without microbial degradation or photodegradation HMN is persistent in soil with an aerobic half-life of 383 days (American Cyanamid Company, 1992).

Biota – For agriculture purposes HMN is formulated on a bait substance such as corn grits. It is then evenly applied over the treatment area. Based on the application procedure and formulation as a bait, high soil adsorption value, and its high photodegradation tendency, HMN has a low potential for bioaccumulation in the environment.

Insects: HMN is relatively nontoxic to insects that are incapable of ingesting the compound and when exposure is limited to cuticular contact. HMN is not able to penetrate the epicuticular waxes. It is highly toxic when ingested. It functions as a slow acting stomach toxicant (Lovell 1979). Hollingshaus et al. (1983) determined that the LD50 value of the tobacco budworm was 7 μg/g. Forty to fifty percent of the ingested dose was excreted in the feces, but the remaining residues were found throughout the insect. The breakdown products in the insect's system were found to be TFP and 2-hydrazino-1,4,5,6-tetrahydra-5,5-dimethyl pyrimidine hydroiodide. These also broke down further to TFBA and TFCA, and tetrahydro-5,5-dimethyl-2(1*H*)-pyrimidione respectively. HMN has also been found to inhibit mitochondrial electron transport, which causes a decrease in physical activity, as well as a decrease in respiration (Hollingshause 1987).

Plants: Plants do not uptake the pesticide through the root system. Residues detected in crops were from direct foliage contact with the HMN application. The morphology of the foliage determines the available contact area where the bait can be lodged. Narrow blades such as that of wheat foliage greatly diminished the potential for lodging (American Cyanamid Co., 1982).

Mammals: HMN can be slightly toxic when ingested, with oral LD50 of 1121 to 1300 mg/kg in rats (Farm Chemicals Handbook, 1997).

HMN metabolizes within the body of foraging ruminants (EPA Fact Sheet). Radioactive labeled HMN was given to lactating goats in doses 4 to 10 times the normal application amount. Ninety to ninety-five percent of the cumulative dose (given for a period of 8 days) was excreted in the feces (American Cyanamid Co., 1982). Because of this, the EPA has found that there are no concerns of HMN residues in milk, meat, or meat byproducts of ruminants as a result of pesticide use on pasture or rangeland grasses (EPA, RED, 1998). No HMN breakdown products in mammals were identified.

Fish: HMN can be highly toxic to fish. The LC50 are 0.16 ppm and 0.10 ppm in rainbow trout and channel catfish, respectively (Farm Chemicals Handbook, 1997). Under normal use conditions, because of HMN's low solubility and very short half-life via photodegradation in water, exposure to the chemical is not expected (EPA, RED, 1998).

Characteristics of HMN, such as, its low solubility, large KOW and large KOC, mean it will tend to accumulate in fatty tissues, such as in fish. HMN has been found to accumulate in fish tissues with a bioconcentration factor (BCF) of 1,300X in whole fish, 780X in fillet, and 1,900X in viscera (EPA, RED, 1998). However, due to these same physical properties and rapid photodegradation, aquatic organisms are unlikely to come into contact with HMN. No studies have been done to determine or identify any breakdown products in fish.

Conclusion

HMN is an amidinohydrazone insecticide. It is selectively toxic to insects with chewing or sponging mouthparts and functions as a slow acting stomach toxicant. It is relatively nontoxic to insects that use other modes of feeding and to insects where exposure is limited to cuticular contact. In insects, HMN has also been found to inhibit mitochondrial electron transport, which causes a decrease in physical activity and a decrease in respiration.

The low vapor pressure indicates that this insecticide is relatively non-volatile. The low Henry's Law constant indicates that it has low volatility from water to air. Since HMN is commonly formulated as bait and is spread with a granular spreader, it is unlikely to be volatilized in air over a large area.

The low water solubility and high soil adsorption coefficient indicate a low potential to leach in soil to ground water. It is stable to abiotic hydrolysis and degrades rapidly in water when exposed to light. The aqueous photolysis half-life is less than 1 hour.

In soil, photolysis is the major route for degradation with a half-life of 5 days. Without light HMN is very stable with an aerobic half-life of 383 days. *Phanerochaete* *chrysosporium*, a white rot fungus, has been found to breakdown HMN with a half-life of 14-25 days.

Plants do not uptake the pesticide through the root system. Residues detected in crops were from direct foliage contact with the HMN application.

HMN can be slightly toxic to mammals and mostly excreted in the feces. It is highly toxic to fish. The low water solubility, large Kow and large Koc indicate a tendency for HMN to accumulate in fatty tissues. However, under normal use conditions aquatic exposure is low because photodegradation in water is rapid.

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