# Environmental Fate of Cyfluthrin

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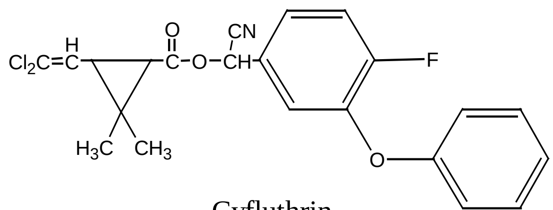
This document reviews the environmental fate of cyfluthrin, chemical name Cyano(4-fluoro-3-phenoxy-phenyl)methyl3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropane-carboxylate. Products containing the active ingredient cyfluthrin include Attatox, Bay FCR 1272, Baythroid, Baythroid H, Contur, Laser, Solfac, and Tempo among many others.




Cyfluthrin
cyano (4-fluoro-3-phenoxyphenyl)methyl-3-(2,2-dichloroethenyl)-2,2-dimethyl-cyclopropanecarboxylate

## General Information and Mode of Action

Cyfluthrin is a nonsystemic synthetic pyrethroid insecticide used to control chewing and sucking insects. Through contact and stomach poisoning, it attacks the nervous system; resulting in swift debilitation and has a long residual effect. Insects that come into contact with cyfluthrin die of starvation and desiccation due to being weakened by the chemical and thus, ceasing to feed. Its uses are extensive, including: agricultural crops, stored products, public health situations (i.e. cockroaches, mosquitoes, and flies), ornamentals, turf, and domestic pests. Target insects include ants, silverfish, cockroaches, grain beetles, fleas, flies, European corn borer, Colorado potato beetle, and many others (Farm Chemical Handbook, 1993; EXTOXNET, 2001; Hamman and Fuchs, 1981).

Cyfluthrin is a clear liquid, dark amber in color, with an oily to pasty consistency, and has a faint aromatic solvent odor at room temperature. It is thermally stable at room temperature. Four diastereoisomeric pairs of enantiomers make up cyfluthrin:

I (R)-α-cyano-4-fluoro-3-phenoxybenzyl (1R)-cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate + (S)-α, (1S)-cis-;
II (S)-α, (1R)-cis + (R)-α, (1S)-cis-;
III (R)-α, (1R)-trans- + (S)-α, (1S)-trans-; and
IV (S)-α, (1R)-trans- + (R)-α, (1S)-trans- (Tomlin, 1997; Hamman and Fuchs, 1981).

## Physical-Chemical Properties [a]

| | |
|---|---|
| Molecular weight | 434.29 |
| Water solubility | $2.0 \times 10^{-3}$ ppm (20°C) |
| Vapor pressure | $3.24 \times 10^{-8}$ mm Hg (25°C) |
| Hydrolysis half-life | 193 days (25°C at pH 7) |
| Aqueous photolysis half-life | 12.2 days (25°C at pH 5) |
| Anaerobic half-life | 33.6 days (loam) |
| Aerobic half-life | 63 days (25°C at pH 5.9; sandy loam) |
| Soil photolysis half-life | 2-16 days (28°C at pH 6.6; sandy loam) |
| Field dissipation half-life | ~ 13.5 days (pH 5.8; sandy loam) |
| Henry's law constant | $4.93 \times 10^{-6}$ atm $m^3$/mole (20°C) |
| Octanol-water coefficient ($K_{OW}$) | $4.58 \times 10^5$ - $6.4 \times 10^5$ |
| Soil adsorption coefficient: | |
| $K_D$ | 9.4 - 28 |
| $K_{OC}$ | $6.24 \times 10^4$ |

## Toxicity [b]

| | |
|---|---|
| *Daphnia magna* $LC_{50}$, 48 hr | 0.16 ppb |
| Mysid shrimp $LC_{50}$, 96 hr | 0.0025 ppb |
| Rainbow trout $LC_{50}$, 96 hr | 0.302 ppb |
| Bluegill Sunfish $LC_{50}$, 48 hr | 0.998 ppb |
| Fathead Minnow $LC_{50}$, 96 hr | 2.49 ppb |
| Bobwhite quail $LD_{50}$, 8 days | >5,000 ppm |
| Mallard duck $LD_{50}$, 8 days | >5,000 ppm |
| Rat acute oral $LD_{50}$, Female | 1271 ppm |
| Rat acute oral $LD_{50}$, Male | 869 ppm |

[a] DPR Pesticide Chemistry database (2001)

[b] DPR Ecotox database (2001)

# Environmental Fate

## Air

When applied aerially or by broadcast spray, there is possibility for drift. However, cyfluthrin is relatively non-volatile, as indicated by its low vapor pressure ($3.24 \times 10^{-8}$ mm Hg) and low Henry's law constant ($4.93 \times 10^{-6}$ atm $m^3$/mole). In addition, the strong tendency to partition to soil reduces the potential for volatilization as a major route of dissipation.

## Water

With low water solubility and a high $K_{OC}$, cyfluthrin has a strong tendency to absorb to soil. Although cyfluthrin may not be readily degraded in water at a neutral pH, the aqueous hydrolysis half-life decreases with an increase in pH. Anderson (1986) reports a hydrolysis half-life in water of approximately 4 days at pH 8.3-8.6, with a significant slowing of degradation after one week. At pH 9, the hydrolysis half-life is 2 days (DPR Pesticide Chemistry database, 2001). A relatively short aqueous photolysis half-life of 12.2 days at pH 7 suggests that an important route for the dissipation of cyfluthrin is through aqueous photolysis.

In a study by Heimbach et al. (1992), concentrations of cyfluthrin decreased rapidly, with maximum levels between 4 hours to 1 day post application in artificial ponds. In natural ponds, maximum levels were detected between 1 and 2 days post application and then rapidly declined. Cyfluthrin was not detectable at 2 days post application in either the artificial or natural ponds.

Cyfluthrin degrades abiotically through hydrolysis. The major degradation product is 4-fluro-3-phenoxybenzoic acid (FPB acid), which is formed by the first breakdown products; permethric acid and the cyanhydrin of 4-fluro-3-phenoxybenzaldehyde (FPB ald). Other degradation products include FPB ald, 4'-OH-FPBacid, 'amide'-baythroid (2-amino-1-(4-fluro-3-phenoxyphenyl)-2-oxoethyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate), and "acid"-baythroid (α-[[[3-(2,2-dichloroethynl)-2,2-dimethylcyclopropyl]carbonyl]oxy]-4-fluro-3-phenoxybenzenacetic acid (Anderson, 1986; Preiss et al, 1984).

## Soil

Cyfluthrin is hydrophobic and has a high $K_{OC.}$ Consequently cyfluthrin has a low tendency to leach in soil. In addition, cyfluthrin mobility during runoff events will be low, except under conditions of high sediment transport. Under these conditions, cyfluthrin may move off-site with suspended sediment. Lin (1992) reported that 0.3 % of the initial application moved off-site during a rain event following application to cotton in a fine sandy loam. At another site, Lin (1992) found that 0.21% of total application moved off-site after 4 rain events. Shehata et al. (1987) reports that the concentration of applied cyfluthrin or the volume of leaching water did not affect cyfluthrin's binding behavior or leachability.

As with most pyrethroids, the persistence of cyfluthrin is highly variable due to various environmental conditions. In example, the persistence of cyfluthrin in soil was found to be unaffected by soil moisture but affected by organic matter and redox potential (Smith et al., 1995). Degradation of cyfluthrin was more rapid at higher pHs, thus, cyfluthrin was observed to be more persistent in acidic soils than in alkaline soils (Shehata et al., 1987).

In various field dissipation studies, cyfluthrin showed low persistence; its field dissipation half-life is approximately 13.5 days at pH 5.8 in sandy loam soil (DPR Pesticide chemistry database, 2001). Stout and Leidy (2000) report that the mean residues of microencapsulated cyfluthrin declined from maximal levels after three days, but residues were detectable through day 45. In a rotational crop field study, cyfluthrin was found at 0.36 ppm residue in silty soil and ranging from 0.06-0.24 ppm for clay soils on the day of application. At planting and harvest (day 135 and 330 post application), the total residue in clay was detected at less than 0.01 ppm (Leslie, 1988). In a study conducted on loam and sandy loam soils, the dissipation half-life of cyfluthrin ranged from 3.9 days to 23.8 days. At day 29 post-application, no measurable residues were found. By day 60, the FPB acid and $Cl_2Ca$ (3–(2,2-dichlorovinyl)-2,2-dimethyl cyclopropane carboxylic acid) metabolites had dissipated to less than 0.01 ppm (Grace and Cain, 1990), suggesting that they are also not persistent. Wagner et al. (1983) also observed rapid aerobic degradation in both loam and sandy loam soils with half-lives of 56 and 63 days, respectively. The major degradation products found in cyfluthrin were: 4-fluoro-3-phenoxybenzaldehyde (FPB ald), 4-fluoro-3-phenoxy benzoic acid (FPBacid), $Cl_2Ca$ and 'amide'-Baythroid. Trace amounts of 'acid'-Baythroid, 4-fluoro-3-phenoxybenzenemethanol (FPB alc), and 4'-OH-FPBacid were also detected in several studies. Cyfluthrin completely degrades with mineralization to $CO_2$ (Grace and Cain, 1990; Gronberg and Pfankuche, 1983; Wagner et al., 1983;)

**Biota**

*Vegetation* - A nonsystemic insecticide, cyfluthrin has a low tendency to penetrate into plant tissues and the translocation of cyfluthrin appears negligible, with very low concentrations found in other parts of the plants (Tomlin, 1997). In a three-year replicated study, no significant difference was found in photosynthesis, stomatal conductance, or transpiration rates of alfalfa or soybean due to cyfluthrin. However, the rate of photosynthesis of alfalfa increased one hour post application in one replicate year, suggesting a possible, immediate, but short-lived, increase in the rate of photosynthesis in alfalfa (Haile et al., 1999). The major metabolites of cyfluthrin in plants are 3-phenoxy-4-fluorobenzylalcohol and FPB acid (Preiss et al., 1984).

In a dislodgeable residue study, rapid dissipation was reported. On applications of cyfluthrin to cotton leaves, dislodgeable residues ranged from 0.0217 $\mu g/cm^2$ 8-10 hours post-application. Residues declined to 0.0007 $\mu g/cm^2$ 27 days post-application (Loeffler, 1986).

*Animals and Fish* – Following an experimental application (for assessment of hazards to aquatic ecosystems) of 12.5 g cyfluthrin/hectare to artificial ponds, there were no mortalities in trout nor did it affect their development (Heimbach et al., 1992). An exposure of 0.13 ppb cyfluthrin to bluegill sunfish resulted in mean fish tissue residues being greater than 20 ppb at day 0 to 63 ppb day 28. The bioconcentration factor reached a maximum of 854 on day 14 (Carlisle and Roney, 1984). Although extremely toxic to fish and other aquatic organisms, cyfluthrin is relatively non-toxic to upland game birds and water fowl. It is also toxic to the honeybee, $LC_{50}$ of 0.037 mg/bee. Cyfluthrin was found to be eliminated quickly in mammals, with 98% of the administered amount being excreted via urine and feces after 48 hours (Tomlin, 1997; EPA Fact Sheet, 1987).

*Soil Biota* - Tu (1995) reported an increase in bacterial populations during 2 weeks post application but observed no effects on fungal populations, oxidation of soil, or levels of nitrification or denitrification. It was concluded that soil indigenous microbes were able to tolerate cyfluthrin when it was applied to control soil pests.

**Summary**

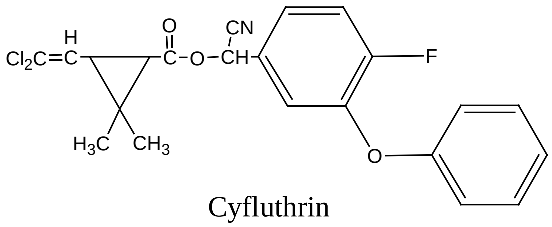
A nonsystemic synthetic pyrethroid, cyfluthrin is used in the control of chewing and sucking insects. It poisons the stomach and attacks the nervous system, weakening the insect and thus, starving it. Although primarily used in agriculture, cyfluthrin is also used in public health situations, and for domestic pests.

A low vapor pressure of $3.24 \times 10^{-8}$ mm Hg indicates that cyfluthrin is non-volatile in air while a low Henry's law constant of $4.93 \times 10^{-6}$ atm $m^3$/mole indicates a low volatility in water. A high $K_{OW}$ ranging from $4.58 \times 10^5$ - $6.4 \times 10^5$ suggests a strong tendency to partition from water to soil. In various soils, cyfluthrin has been observed to degrade rapidly and has shown little leaching potential. The hydrolysis half-life of 193 days at pH 7 suggests that cyfluthrin is not readily degraded in water; however, its degradation will increase with an increase in pH. In vegetation, cyfluthrin does not penetrate significantly into plant tissues, and does not appear to affect photosynthesis, stomatal conductance, or transpiration rates. Cyfluthrin is extremely toxic to fish, other aquatic organisms, and honeybees, but is relatively non-toxic to mammals.

Although cyfluthrin displays high aquatic toxicity in laboratory studies, the tendency to sorb strongly to suspended sediment and dissolved organic materials in field aquatic systems probably reduces cyfluthrin's bioavailability, hence cyfluthrin's aquatic toxicity. However, the extent to which bioavailability is mitigated, and the aquatic toxicity of a hydrophobic pyrethroid is reduced in the water column or in sediments is uncertain, and remains a subject of on-going study and debate (EPA SAP, 1999)

# Cyfluthrin Degradation

## Photolysis in water

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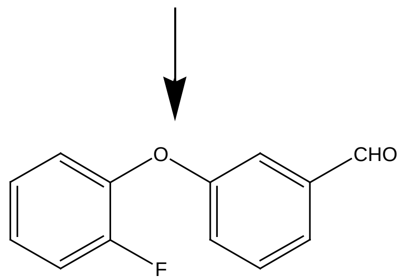
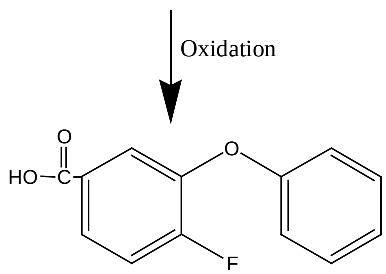
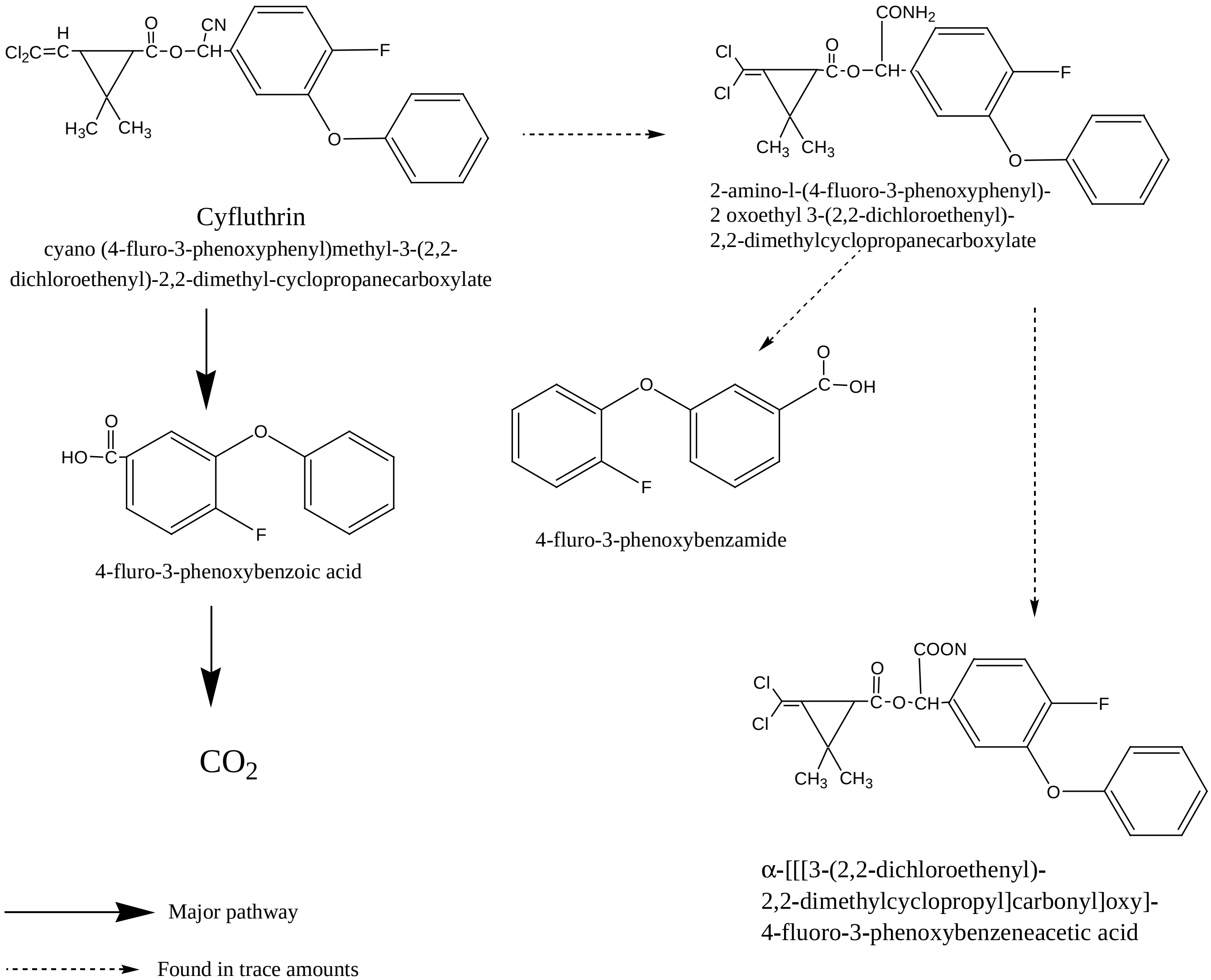



4-fluro-3-phenoxybenzaldehyde

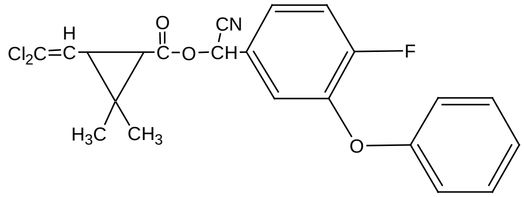



4-fluro-3-phenoxybenzoic acid

# Soil Degradation – Aerobic



# Soil Degradation – Anaerobic



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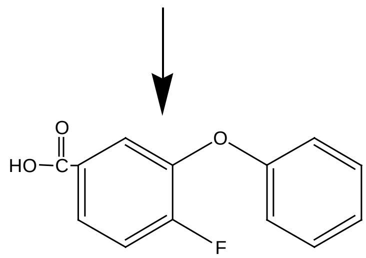

4-fluro-3-phenoxybenzoic acid

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