acifluorfen
5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoic acid

NOMENCLATURE
Common name: acifluorfen (ANSI, BSI, ISO, WSSA)
Other name(s): acifluorfen-sodium; LS-80-1213; MC 10978; RH-6201; (Acid) 5-(2-chloro-α,α,α-trifluoro-p-toloyloxy)-2-nitrobenzoic acid (IUPAC); (Na salt) sodium 5-(2-chloro-α,α,α-trifluoro-p-toloyoxy)-2-nitrobenzoic acid (IUPAC)
Trade name(s): BLAZER®, ULTRA BLAZER®, GALAXY™, STORM®, TACKLE®
Chemical family: diphenylether; nitrodiphenylether; nitrophenylether

CHEMICAL AND PHYSICAL PROPERTIES
Chemical structure: acifluorfen acid

Molecular formula: Acid C_{14}H_{10}ClF_{3}NO_{3}; Na salt C_{14}H_{10}ClF_{3}NaNO_{3}
Molecular weight: Acid 361.66 g/mole; Na salt 383.64 g/mole
Description: Acid Light tan to brown solid; Na salt Light yellow solid
Density: Acid 1.55 g/mL; Na salt 1.16-1.2 g/mL
Melting point: Acid 142-160 C; Na salt 124-125 C
Boiling point: 217 C (1.01 x 10^5 Pa)
Vapor pressure: < 1.01 x 10^-3 Pa (25 C)
Stability: Decomposes at 235 C without boiling; not hydrolyzed at pH 3-9 and 40 C; Decomposed by UV light with a half-life of ~ 110 h.
Solubility:
- Acid
  - water, 120 mg/mL (23-25 C)
  - organic solvents g/100 mL (25 C):
    - acetone 40-48
    - ethanol 32-39
- Sodium salt
  - water 250,000 mg/L (25 C)
  - organic solvents g/100 mL (25 C)
    - acetone >50

absorption/translocation: Readily absorbed by leaves of most species, although absorption is reduced at low relative humidity (5). Very little foliar-absorbed
Acifluorfen translocates basipetally. Absorption by roots and acropetal translocation to leaves also are limited (4).

**Metabolism in plants:** Soybean tolerance appears to be due to rapid cleavage of the other bond by homogluthathione, producing the S-(3-carboxy-4-nitrophenyl) homogluthathione conjugate and 2-chloro-4-trifluoromethylphenol, followed by further metabolism (2). Metabolism appears to be much slower in susceptible weed species than in tolerant soybeans (4).

**Non-herbical biological properties:** None known

**Mechanism of resistance in weeds:** No known cases of resistance

**BEHAVIOR IN SOIL**

**Sorption:**

$K_d$: Average is 113 mL/g (estimated) (7)

**Transformation:**

- **Photodegradation:** Readily photodegrades with a half-life of 2-2.5 d in water and 4.5 d on soil.
- **Other degradation:** Microbially degraded.

**Persistence:** Half-life is ~ 14-60 d depending on edaphic conditions. Factors that promote microbial activity enhance breakdown. Acifluorfen residues do not persist in the environment.

**Mobility:** Field-aged residues show negligible leaching.

**Volatilization:** Negligible

**TOXICOLOGICAL PROPERTIES**

Toxicity tests were conducted with technical grade acifluorfen Na salt unless otherwise indicated.

**Acute toxicity:**

- Oral $LD_{50}$ rat, 1540 mg/kg; Dermal $LD_{50}$ rabbit, > 2000 mg/kg; 4-h inhalation $LC_{50}$ rat, 6.91 mg/L; Skin irritation rabbit, moderate; Skin sensitization guinea pig, no; Eye irritation rabbit, severe

**BLAZER:** Oral $LD_{50}$ rat, 4790 mg/kg; Dermal $LD_{50}$ rabbit, 3250 mg/kg; 4-h inhalation $LC_{50}$ rat, 33 mg/L; Skin irritation rabbit, moderate, Skin sensitization guinea pig, no; Eye irritation rabbit, severe

**GALAXY:** Oral $LD_{50}$ rat, > 1210 mg/kg; Dermal $LD_{50}$ rabbit, > 2000 mg/kg; Skin irritation rabbit, none; Skin sensitization guinea pig, yes; Eye irritation rabbit, severe

**STORM:** Oral $LD_{50}$ rat, > 1470 mg/kg; Dermal $LD_{50}$ rabbit, > 2000 mg/kg; 4-h inhalation $LC_{50}$ rat, 5.5 mg/L; Skin irritation rabbit, none; Skin sensitization

**guinea pig, yes; Eye irritation rabbit, severe**

**Subchronic toxicity:**

- 90-d dietary, rat: NOEL male 1080 mg/kg/d, female 4320 mg/kg/d
- 90-d dietary, dog: NOEL 5400 mg/kg/d

**Chronic toxicity:**

- 24-mo dietary, rat: NOEL 180 mg/kg/d

**Teratogenicity:** NA

**Reproduction:** NA

**Mutagenicity:**

- Gene mutation: Ames test, negative; Mouse lymphoma, negative

**Wildlife:**

- Bobwhite quail, oral $LD_{50}$ 325 mg/kg, 8-d dietary $LC_{50}$ > 5620 mg/kg; Mallard duck, oral $LD_{50}$ 4187 mg/kg, 8-d dietary $LC_{50}$ > 5520 mg/kg; Daphnia 48-h $LC_{50}$ 77 mg/L; Bluegill sunfish 96-h $LC_{50}$ 62 mg/L; Rainbow trout 96-h $LC_{50}$ 17 mg/L.

**Use classification:** General use

**SYNTHESIS AND ANALYTICAL METHODS**

**Synthesis:** NA

**Purification of technical:** NA

**Analytical methods:** Product analysis by gas chromatography (GC). Residue analysis by GC or high performance liquid chromatography (HPLC).

**Historical:** Acifluorfen was introduced as a herbicide independently by Mobil Chemical Company and by Rohm and Haas Company. It was later acquired by BASF AG.

**MANUFACTURER(S) AND INFORMATION SOURCE(S)**

**Information source(s):** BASF; United Phosphorus

**Reference(s):**

**lactofen**
2-ethoxy-1-methyl-2-oxoethyl 5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoate

**NOMENCLATURE**
Common name: lactofen (ANSI, WSSA)
Other name(s): PPG-844; ethyl C-[5-(2-chloro-α,α,α-trifluoro-p-tolyloxy)-2-nitrobenzoyl]-DL-lactate (IUPAC)
Trade name(s): COBRA®
Chemical family: diphenylether; nitrodiaphenylether; nitropheny leth

**CHEMICAL AND PHYSICAL PROPERTIES**
Chemical structure:

\[
\text{\begin{center}
\begin{align*}
\text{F}_2\text{C} & \quad \text{O} \\
\text{Cl} & \quad \text{O} \\
\text{H} & \quad \text{O} \\
\text{C} & \quad \text{C} & \quad \text{O} \\
\text{C} & \quad \text{C} & \quad \text{O} \\
\text{H} & \quad \text{O} & \quad \text{CH}_2 \text{-CH}_3 \\
\end{align*}
\end{center}
}\]

Molecular formula: \(C_{16}H_{15}ClF_N_3O_7\)
Molecular weight: 461.76 g/mole
Description: White crystalline solid (when pure), faint aromatic odor
Density: 1.39 g/mL (25 C)
Melting point: 43.9 - 45.5 C
Boiling point: NA
Vapor pressure: 5.3 x 10^{-7} Pa (20 C); 1 x 10^{-6} Pa (25 C)
Stability: Decomposes at 275 C; unstable at pH 9

Solubility:
- water 0.1 mg/L (22 C)
- organic solvents g/100 mL (25 C)
- acetone miscible (≥18 C)
- 2-propanol 1.92 (4 C)
- isopropanol 20
- xylene miscible (≥18 C)
- kerosene 1.27 (23 C)

\(pK_a\): None (non-ionizable)
\(K_{ow}\): NA

**HERBICIDAL USE**
Lactofen can be applied POST at 0.07-0.22 kg ai/ha in soybeans, POST-directed at 0.22 kg ai/ha in cotton, and POST at 0.11-0.22 kg ai/ha in southern pine seedlings. It controls many annual broadleaf weeds such as jimsonweed, wild mustard, nightshade spp., ragweed spp., pigweed spp., and cocklebur. Oil adjuvants, surfactants, and fertilizer adjuvants are added to enhance control.

**USE PRECAUTIONS**
Fire hazard: COBRA is combustible; flash point is (40 C)
Corrosiveness: COBRA is non-corrosive to mild steel or other materials normally used in spray equipment.

**Storage stability:** COBRA does not freeze above 0 C. Cobra had excellent stability in 2-yr tests conducted over a range of normal storage conditions.

**Cleaning glassware/spray equipment:** Rinse equipment with water.

**Emergency exposure:** If ingested, do not induce vomiting; drink large quantities of milk, egg whites, gelatin solution, or, if these are not available, water; consult a physician.

**Incompatibilities:** No known incompatibilities with other herbicides or liquid fertilizers.

**BEHAVIOR IN PLANTS**
Mechanism of action: Inhibition of the enzyme protoporphyrinogen oxidase (PPG or Protox) (more details on page 12)

Symptomology: Leaves of susceptible plants become chlorotic and then desiccated and necrotic within 1-2 d. Youngest expanded leaves of soybeans also may show chlorosis and necrosis, especially at higher rates. Sublethal rates may produce foliar bronzing, usually on young expanded leaves or on needles of pine seedlings. Droplet drift may cause bleached spots or flecks on leaves.

Absorption/translocation: Readily absorbed by leaves of most species. Very little foliar-absorbed lactofen translocates basipetally. Absorption by roots and acropetal translocation to leaves also are limited.

Metabolism in plants: Readily metabolized by plants; no measurable residues have been detected longer than 24 d after treatment.

Non-herbicidal biological properties: None known

Mechanism of resistance in weeds: No known cases of resistance

**BEHAVIOR IN SOIL**
Sorption: Strongly absorbed to OM

\(K_{ow}\): Average is 10,000 mL/g (estimated) (3)

Transformation:
Photodegradation: Half-life was 23 d. Photodegradation losses probably do not contribute greatly to field dissipation because of rapid breakdown by microbes.

Other degradation: Degrades quickly under aerobic conditions, but more slowly in anaerobic conditions. Lactofen is rapidly hydrolyzed in water at pH but is stable at pH values of 5 and 7. Non-microbial degradation appears to be insignificant.

Persistence: Average field half-life is 3 d (3). Lactofen usually dissipates in ≤7 d in most soils. Soil activity sometimes lasts for 2-3 wk on sensitive species.
Residues do not injure rotational crops planted the following season.

Mobility: Immobile in soil. Degradation products of lactofen are highly mobile in sandy soil and have low to moderate mobility in soil with high OM and clay contents.

Volatile: Negligible losses

TOXICOLOGICAL PROPERTIES

Toxicity tests were conducted with technical grade lactofen unless otherwise indicated.

Acute toxicity:
- Oral LD$_{50}$ rat, 5960 mg/kg; Dermal LD$_{50}$ rabbit, > 2000 mg/kg; 4-h inhalation LC$_{50}$ rat, >3.6 mg/L;
- Skin irritation rabbit, slight; Skin sensitize guinea pig, no; Eye irritation, NA

COBRA:
- Oral LD$_{50}$ rat, 2533 mg/kg; Dermal LD$_{50}$ rabbit, >2000 mg/kg; 4-h inhalation LC$_{50}$ rat, 6650 mg/L; Eye irritation rabbit, severe

Subchronic toxicity:
- 90-d dietary, rat: NOEL 10 mg/kg/d (200 mg/kg), LOEL 50 mg/kg/d (1000 mg/kg)

Chronic toxicity:
- 18-mo dietary, mouse: LOEL 1.5 mg/kg/d (10 mg/kg); increased liver weight and hepatocytomegaly; increased combined incidence of liver adenomas and carcinomas at 250 mg/kg
- 24-mo dietary, rat: Systemic NOEL 25 mg/kg/d (500 mg/kg), LOEL 50 mg/kg/d (1000 mg/kg); kidney and liver pigmentation; increased incidence of liver neoplastic nodules and foci of cellular alteration of 2000 mg/kg
- 12-mo dietary dog: NOEL 5 mg/kg/d (200 mg/kg), LOEL 25/75 mg/kg/d (1000/3000 mg/kg); renal dysfunction, and increased Hgb, Hct, red blood cells, and cholesterol

Teratogenicity:
- Rat: NOEL 50 mg/kg/d, LOEL 150 mg/kg/d; maternal post implantation loss and reduced body weight, fetal bent ribs; not teratogenic
- Rabbit: NOEL 4 mg/kg/d, LOEL 20 mg/kg/d; reduced maternal food consumption; not teratogenic

Reproduction:
- Rat: NOEL 2.5 mg/kg/d (50 mg/kg), LOEL 25 mg/kg/d (500 mg/kg); reduced mean pup weight; increased pup heart and liver weight

Mutagenicity:
- Gene mutation: Ames test, negative in Study 1, positive in Study 2
- Structural chromosome aberration: Unspecified test, negative
- DNA damage/repair: Unspecified test, negative; UDS, negative

Wildlife:
- Bobwhite quail oral LD$_{50}$ >2510 mg/kg, 8-d dietary LC$_{50}$ >5620 mg/kg; Mallard duck 8-d dietary LC$_{50}$ >5620 mg/kg; Honey bee topical LD$_{50}$ >160 μg/bee; Daphnia 48-h LC$_{50}$ 2 mg/L; Bluegill sunfish 96-h LC$_{50}$ >560 mg/L; Rainbow trout 96-h LC$_{50}$ >0.1 mg/L

COBRA:
- Daphnia 48-h LC$_{50}$ 5.1 mg/L; Bluegill sunfish 96-h LC$_{50}$ 0.49 mg/L; Rainbow trout 96-h LC$_{50}$ 0.85 mg/L

Use classification: General use

SYNTHESIS AND ANALYTICAL METHODS

Synthesis: NA
Purification of technical: NA
Analytical methods: See the "Pesticide Analytical Manual" published by the Food and Drug Administration.

Historical: Introduced by PPG Industries

MANUFACTURER(S) AND INFORMATION SOURCE(S)

Industry source(s): Valent

Reference(s):

**flumioxazin**

2-[7-fluoro-3,4-dihydro-3-oxo-4-(2-propynyl)-2H-1,4-benzoxazin-6-yl]-4,5,6,7-tetrahydro-1H-isoxindole-1,3(2H)-dione

**NOMENCLATURE**

Common name: flumioxazin (ANSI, ISO, WSSA)
Other name(s): V-53482, S-53482 (code names), flumizin
Trade name(s): SUMISOYA; VALOR®
Chemical family: dicarboximide; N-phenylphthalimide

**CHEMICAL AND PHYSICAL PROPERTIES**

Chemical structure:

![Chemical structure of flumioxazin]

Molecular formula: C₂₇H₂₀FN₅O₄
Molecular weight: 354.34 g/mole
Description: Yellowish-brown, odorless
Density: 1.51 g/mL (20°C)
Melting point: 201.8°C – 203.8°C
Boiling point: NA
Vapor pressure: 3.21 x 10⁻⁴ Pa
Stability: Stable at room temperature
Solubility: In water, 1.79 mg/L (25°C)

\[ pK_a \text{ of } \text{non-ionizable} \]
\[ K_{ow} = \log K_{ow} = 2.55 \text{ (20°C)} \]

**HERBICIDAL USE**

Flumioxazin is used preemergence for broadleaf weed control in soybeans and peanuts. In soybean conventional-tillage herbicide programs, flumioxazin controls problem broadleaf weeds such as common ragweed, common lambsquarters, velvetleaf, pigweed, black nightshade, tall and common waterhemp, and prickly sida. Flumioxazin aids rapid burndown and offers residual control (4 to 6 weeks) of broadleaf weeds including common ragweed, common lambsquarters and velvetleaf in no-till and reduced-tillage herbicide programs in soybeans.

**USE PRECAUTIONS**

Fire hazard: Technical and formulated flumioxazin are non-flammable and non-explosive.
Corrosiveness: Formulated products are non-corrosive to containers.
Storage stability: Good stability. Store in cool, dry place and avoid excess heat. Store in original containers only. Keep out of reach of children and animals. Do not contaminate water, food or feed by storage or disposal.

Cleaning glassware/spray equipment: Clean glassware and equipment with a solution of soap and water. Avoid contamination of water by cleaning of equipment or disposal of wastes. Large spills should be covered to prevent dispersal.
Emergency exposure: If ingested, drink 1-2 glasses of water. Do not induce vomiting or give anything by mouth to an unconscious individual. Contact a medical doctor. If inhaled, remove to fresh air. If breathing discomfort occurs, contact a medical doctor. For skin and eye exposure wash with plenty of soap and water or flush with water for at least 15 min. If irritation occurs or persists get medical attention.
Incompatibilities: Flumioxazin has been found to be physically compatible with most commercially available herbicides.

**BEHAVIOR IN PLANTS**

Mechanism of action: Inhibition of the enzyme protoporphyrinogen oxidase (PPG or Protox) (more details on page 12)
Symptomology: Plants emerging from soils treated with the herbicide flumioxazin become necrotic and die shortly after exposure to sunlight. Foliar contact with flumioxazin causes rapid desiccation and necrosis of exposed plant tissues.
Absorption/translocation: Flumioxazin is taken up by the roots and foliage of treated plants. Shoot-root soil placement studies indicate that flumioxazin is absorbed primarily by the roots of treated plants following soil applications. Symplastic phloem movement is assumed to be limited, because of the rapid foliar desiccation caused by this herbicide.

Metabolism in plants: Flumioxazin is believed to be rapidly metabolized in tolerant plants such
as soybeans and peanuts, leading to a number of metabolic transformations. Details about the exact metabolic reactions transforming flumioxazin are not available.

Non-herbicidal biological properties: None known

Mechanism of resistance in weeds: Development of weed resistance to this herbicide has not been observed.

**BEHAVIOR IN SOIL**

Sorption: NA

Transformation:
- **Photodegradation:** Flumioxazin is not susceptible to photodegradation once applied to soil. However, flumioxazin is susceptible to photodecomposition and has a half-life of 3.2 d in an aquatic system.
- **Other degradation:** Based on laboratory tests, loss of flumioxazin in soil appears to be primarily by microbial degradation. The half-life or aerobic soil metabolism of flumioxazin is 11.9 to 17.5 d. The hydrolytic degradation of flumioxazin in soil water has a half-life of 3.4 to 5.1 d (pH 5.0); 21.4-24.6 h (pH 7.0) and 14.6-22.0 min (pH 9.0).

Persistence: Not persistent in soil

Mobility: Based on column leaching studies and the short aerobic soil half-life, the potential for flumioxazin or its degradation products to leach in field agricultural soil is low.

Volatilization: Not susceptible to volatility once applied to soil

**TOXICOLOGICAL PROPERTIES**

Toxicity tests were conducted with technical grade and formulated flumioxazin.

Acute toxicity:
- **WP formulation:** Oral LD$_{50}$ rat, >5000 mg/kg; Dermal LD$_{50}$ rabbit, >2000 mg/kg; 4-h inhalation LC$_{50}$ rat, >0.969 mg/L; Primary eye irritation rabbit, minimal clearing in 48 h; Skin irritation rabbit, slight at 72 h; Skin sensitization guinea pig, negative

Subchronic and Chronic toxicity:
Technical flumioxazin has been tested extensively in rats, mice and dogs. Results from these studies show that this herbicide is not carcinogenic.

Adverse effects observed in animals exposed to high doses of technical flumioxazin for long periods of time included effects on blood, liver and kidney.

**Teratogenicity:**
Flumioxazin (technical) produced adverse effects on the offspring of rats exposed during pregnancy. However, it did not produce any adverse effects on the offspring of rabbits exposed during pregnancy.

**Reproduction:**
Reproduction toxicity was observed in a two-generation study with rats exposed to high levels of flumioxazin.

**Mutagenicity:**
Flumioxazin (technical) does not present a genetic hazard.

**Wildlife:**
Flumioxazin is practically nontoxic to bees and avian species. It is slightly to moderately toxic to freshwater fish and moderately to highly toxic to aquatic invertebrates.

Bobwhite quail oral LD$_{50}$ >2250 mg/kg; 8-d dietary LD$_{50}$ >5620 mg/kg; Mallard duck oral LD$_{50}$ >2250 mg/kg; 8-d dietary, LD$_{50}$ >5620 mg/kg; Honey bee acute contact, LD$_{50}$ >105 mg/bee; Daphnia 48-h EC$_{50}$ >6 mg/L; Bluegill sunfish 96-h LC$_{50}$ >21 mg/L; Rainbow trout 96-h LC$_{50}$ 2.3 mg/L; Oyster shell deposition EC$_{50}$ 2.8 mg/L; Sheephead minnow LC$_{50}$ 2.8 mg/L; Mysis shrimp LC$_{50}$ >0.23 mg/L.

**Use classification:** General use

**SYNTHESIS AND ANALYTICAL METHODS**

Synthesis: NA

Purification of technical: NA

Analytical methods: NA

Historical: Flumioxazin was introduced in 1989 by the Valent USA Corporation.

**MANUFACTURER(S) AND INFORMATION SOURCE(S)**

Industry Source(s): Valent
Teratogenicity: NA
Reproduction: NA
Mutagenicity:
Several unidentified tests showed that oxadiargyl technical was non-mutagenic (1).
Wildlife:
Bobwhite quail oral LD$_{50}$ >2000 mg/kg; 8-d dietary LC$_{50}$ >5200 mg/kg; NOEL, 5200 mg/kg; Daphnia 48-h EC$_{50}$ <0.37 mg/L; Bluegill sunfish 96-h LC$_{50}$ <0.37 mg/L; Rainbow trout 96-h LC$_{50}$ <0.37 mg/L
Use classification: NA

SYNTHESIS AND ANALYTICAL METHODS

oxadiazon
3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethyl ethyl)-1,3,4-oxadiazol-2-(3H)-one

NOMENCLATURE
Common name: oxadiazon (ANSI, BSI, ISO, JMAF, WSSA)
Other name(s): RP 17623; 5-tert-butyl-3-(2,4-
dichloro-5-isoproxyphenyl)-1,3,4-oxadiazol-2(3H)-
one (IUPAC)
Trade name(s): DELCUT®, PHARE®, RONSTAR®;
RONSTAR® D FLO; RONSTAR® PL
Chemical family: oxadiazole

CHEMICAL AND PHYSICAL PROPERTIES
Chemical structure:

```
CH3
/       \\
|       |
\       /  \\
C==N    O
|      /\  |
\      |  /
Cl     Cl
```

Molecular formula: C$_8$H$_8$Cl$_2$N$_2$O$_3$
Molecular weight: 345.23 g/mole
Description: White crystalline powder, odorless
Density: 1.26 g/mL
Melting point: 87 C
Boiling point: NA
Vapor pressure: 1.03 x 10$^{-4}$ Pa (25 C)
Stability: Stable to UV light; decomposed at ~230 C
Solubility:
- water 0.7 mg/L (20 C)
- organic solvents g/100 mL (20 C)
- acetone ~60
- ethanol ~10
- acetophenone ~
- isophorone ~60
- amisol ~
- methanol ~10
- benzene ~
- methylene chloride ~100

Synthesis: NA
Purification of technical: NA
Analytical methods: NA
Historical: Oxadiargyl was discovered by Rhone-Poulenc Agrochimie. It is currently under development in Asian-Pacific countries.

MANUFACTURER(S) AND INFORMATION SOURCE(S)
Industry source(s): Bayer CropScience
Reference(s):

CAS #: 19666-30-9

E(14)

HERBICIDAL USE
Oxadiazon can be soil-applied (before weed emergence) at 2.24-4.48 kg ai/ha on established or newly established bermudagrass, perennial ryegrass, and fescue turf, and in various ornamentals. Oxadiazon controls many annual broadleaf and grass weeds including Florida pusley, Oxalis spp., stinging nettle, annual bluegrass, crabgrass spp., carpetweed, field sandbur, goosegrass, and green foxtail.

USE PRECAUTIONS
Fire hazard: Technical is non-flammable
Corrosiveness: Non-corrosive
Storage stability: Stable for >2yr
Cleaning glassware/spray equipment: Wash with detergent and rinse with water
Emergency exposure: Flush eyes with water for 15 min; get medical attention. No specific antidote is known; symptomatic treatment.
Incompatibilities: NA

BEHAVIOR IN PLANTS
Mechanism of action: Inhibition of the enzyme protoporphyrinogen oxidase (PPG or Protox) (more details on page 12)
Symptomology: Seedlings emerge from treated soil but then wilt, followed by necrosis and desiccation. With foliar application, leaves of susceptible plants become chlorotic and then desiccated and necrotic within 1-2 d. Sublethal rates may produce foliar "bronzing", usually on young expanded leaves. Droplet drift may cause bleached spots or flecks on
leaves.
Absorption/translocation: Soil-applied oxadiazon is readily absorbed by shoots of emerging seedling, but less so by roots. Foliar-applied oxadiazon is readily absorbed by leaves. It accumulates in older plant parts, with little movement to the growing points.
Metabolism in plants: NA
Non-herbicidal biological properties: None known
Mechanism of resistance in weeds: No known cases of resistance

BEHAVIOR IN SOIL
Sorption:
K\text{oc}: Average is 3200 mL/g (7). Strongly absorbed by soil colloids and organic matter.
Transformation: NA
Persistence: Moderate to long persistence with an average field half-life of 60 d (7)
Mobility: Low leaching potential due to strong adsorption to soil
Volatilization: Negligible losses

TOXICOLOGICAL PROPERTIES
Toxicity tests were conducted with technical grade oxadiazon unless otherwise indicated.
Acute toxicity:
- Oral LD\text{50} rat, >5000 mg/kg; Dermal LD\text{50} rat, >8000 mg/kg; LC\text{50} rat, >194 mg/L; Skin irritation rabbit, none; Skin sensitization guinea pig, no; Eye irritation rabbit, slight
Subchronic toxicity: NA
Chronic toxicity:
- 24-mo dietary, rat: NOEL 10 mg/kg.d
Teratogenicity: NA
Reproduction: NA
Mutagenicity: NA
Wildlife:
- Bobwhite quail oral LD\text{50}, 6000 mg/kg; Mallard duck oral LD\text{50}, >1000 mg/kg; Daphnia 48-h LC\text{50}, 0.5-8.0 mg/L; Carp 06-h LC\text{50}, 1.76 mg/L; Catfish 96-h LC\text{50} ≥15.4 mg/L; Rainbow trout 96-h LC\text{50}, 1-9 mg/L

Use classification: General use

SYNTHESIS AND ANALYTICAL METHODS
Synthesis: NA
Purification of technical: NA
Analytical methods: Metabolites can be determined by GC with thermal-conductivity detection (2). Oxadiazon residues can be determined by GC with electrical conductivity detection (3) or by mass spectrometry (8). Residues in hops can be determined by GC (5).
Historical: First reported in 1969 (1). Introduced by Rhone-Poulenc Agrochimie, British patent 1,110,500 and U.S. patent 3,385,862.

MANUFACTURER(S) AND INFORMATION SOURCE(S)
Industry source(s): Bayer CropScience
Reference(s):
Volatilization: Low vapor pressure, butafenacil can be classified as non-volatile.

TOXICOLOGICAL PROPERTIES
Butafenacil and its formulations are unlikely to present any acute risk to humans when used under normal precautionary measures for crop protection agents.

SYNTHESIS AND ANALYTICAL METHODS
Synthesis: NA

MANUFACTURER(S) AND INFORMATION SOURCES:
Industry source(s): Syngenta Crop Protection

carfentrazone-ethyl
ethyl α,2-dichloro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H,1,2,4-triazol-1-yl]-4-fluorobenzenepropanoate

NOMENCLATURE
Common name: carfentrazone-ethyl (ANSI, ISO, WSSA)
Other name(s): F-8426; ethyl (RS)-2-chloro-3-[2-chloro-5-(4-difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H,1,2,4-triazol-1-yl]-4-fluorophenylpropionate (IUPAC)
Trade name(s): ADDIT™; AIM™; AURORA™; ORATIO®, PLATFORM™; QUICKSILVER™; SHARK™; SPOTLIGHT™; TEAMWORK®,
Chemical family: aryl triazinone; triazolone

CHEMICAL AND PHYSICAL PROPERTIES
Chemical structure:

H     F
/     / \
N  /   F   \
|   /     \
|  F     \
\  /   Cl
Cl------O--------C-O----CH2-CH2-CH3
\ / \
CH3 CH3

Molecular formula: C_{15}H_{14}ClF_{2}N_{3}O_{3}
Molecular weight: 412.20 g/mole
Description: Various yellow liquid
Density: 1.46 g/mL (20 C)
Melting point: -22.1 C
Boiling point: 350-355 C (1.013 x 10^5 Pa)
Vapor pressure: 1.6 x 10^{-5} Pa (25 C); 7.2 x 10^{-5} Pa (20 C)
Stability: Stable at room temperature
Solubility:
- water 12,000 mg/L (20 C); 22,000 mg/L (25 C); 23,000 mg/L (30 C)
pK_a: None (non-ionizable)
K_{ow}: log K_{ow} = 3.36

PURIFICATION OF TECHNICAL: NA
ANALYTICAL METHODS: NA
HISTORICAL: NA

HERBICIDAL USE
AIM™ 40 WG and SHARK™ 40 WG are POST applied contact, non-residual herbicides used at 4-36 g ai/ha for control and suppression of a wide spectrum of broadleafed weeds in fallow/preplant burndown systems, field corn, seed corn, popcorn, corn silage, sweet corn, grain sorghum, rice, soybean, wheat, barley, and oats. Carfentrazone-ethyl is highly effective against a number of weed species resistant to herbicides such as imidazolinones and the sulfonylurea acetolactate synthase (ALS) inhibitors. POST-directed and layby applications of AIM™ 40 WG at 13.5-54 g ai/ha and defoliation applications at 18-27 g ai/ha in cotton are pending registrations. POST broadcast applications of AIM™ 40 WG at 28-56 g ai/ha for vine and leaf desiccation is pending registration as a harvest aid in potato.

USE PRECAUTIONS
Fire hazard: Technical and formulated carfentrazone-ethyl are non-flammable. Flash point is greater than 229 C, 110 C, and 80 C for the technical, 40 WG and 2 EC formulations, respectively. The 2 EC formulation is moderately combustible. When heated above the flash point, the 2 EC releases vapors which, when mixed with air, can burn or be explosive.
Corrosiveness: All formulated carfentrazone-ethyl products are non-corrosive.
Storage stability: Good stability. Store in cool, dry place and avoid excess heat. Store in original containers only. Keep out of reach of children and animals. Do not contaminate water, food or feed by storage or disposal.
Cleaning glassware/spray equipment: Clean glassware and equipment with a solution of soap and water. Avoid contamination of water by cleaning of equipment or disposal of wastes.
Emergency exposure: If ingested, drink 1-2 glasses of water. Do not induce vomiting or give anything by mouth to an unconscious individual. Contact a
medical doctor. If inhaled, remove to fresh air. If breathing discomfort occurs, contact a medical
doctor. For skin and eye exposure, wash with plenty of soap and water or flush with water for at least 15
min., respectively. If irritation occurs or persists get medical attention.

**Incompatibilities:** Carfentrazone-ethyl has been found to be physically compatible with most
commercially available herbicides.

**BEHAVIOR IN PLANTS**

**Mechanism of action:** Inhibition of the enzyme
proroporphyrinogen oxidase (PPG or Protox) (more
details on page 12)

**Symptomology:** Plants treated with the herbicide
carfentrazone-ethyl become necrotic and die shortly
after treatment. Initial symptoms are observed within
hours and death within a few days.

**Absorption/translocation:** Carfentrazone-ethyl is
absorbed rapidly by foliage of treated plants, with
rainfastness achieved within 15 min. of application.
Symplastic phloem movement is assumed to be
limited, based on rapid foliar desiccation, although
some species are well-controlled even without total
spray coverage.

**Metabolism in plants:** Carfentrazone-ethyl is
rapidly metabolized in plants (wheat, corn, soybean,
potatoes). Carfentrazone-ethyl undergoes a
series of reactions including hydrolysis, oxidative
decarboxylation, dechlorination, hydrolysis, and
conjugation. Principal metabolites include:
carfentrazone-ethyl-chloropropionic acid, 3-
desmethyl-carfentrazone-ethyl - chloropropionic acid,
3-hydroxymethyl-carfentrazone-ethyl-chloropropionic
acid, and carfentrazone-ethyl-propionic acid. Crop
residue studies (wheat, barley, corn, rice, sorghum,
and soybean) showed that the rapid degradation of
carfentrazone-ethyl and its metabolites. No residues
were found in any grain or soybean seed.

**Non-herbicidal biological properties:** None

**Mechanism of resistance in weeds:** Development
of weed resistance to this herbicide has not been
observed.

**BEHAVIOR IN SOIL**

**Sorption:** Not strongly adsorbed to sterile soils.
In non-sterile soils, carfentrazone-methyl is rapidly
converted to carfentrazone-ethyl propionic acid. The
free acid has low soil adsorption characteristics.

- $K_{ow}$: 750 mL/kg (25 C) for carfentrazone-ethyl
- $K_{oc}$: 15-25 mL/g (25 C, pH 5.5) for carfentrazone

**Transformation:**

- **Photodegradation:** Carfentrazone-ethyl is not
susceptible to photodecomposition or volatility
following application to soil.

- **Other degradation:** Based on laboratory tests,
loss of carfentrazone-ethyl in soil appears to be
primarily by microbial degradation.

**Persistence:** Carfentrazone-ethyl is non-persistent
in the soil. Carfentrazone-ethyl rapidly degrades by
microbial degradation and hydrolysis to carfentrazone-
ethyl-propionic acid which is low to moderately
adsorbed to soil. The $T_{1/2}$ carfentrazone-ethyl-
propionic acid is less than 0.1 d.

**Mobility:** Neither carfentrazone-ethyl, the short-
lived free acid nor any of the other metabolites of
carfentrazone-ethyl leach in the soil or contaminate
ground water.

**Volatilization:** Carfentrazone-ethyl is non-volatile.

**TOXICOLOGICAL PROPERTIES**

Toxicity tests were conducted with technical grade
carfentrazone-ethyl unless otherwise indicated.

**Acute toxicity:**

- Oral $LD_{50}$ rat (both sexes), >5000 mg/kg; Dermal
$LD_{50}$ rat (both sexes), >4000 mg/kg; Primary eye
irritation rabbit, minimal; Skin irritation rabbit;
non-irritating; Skin sensitization guinea pig, non-
sensitizing

- Carfentrazone-ethyl 40 WG: Oral $LD_{50}$ rat (both
sexes), >5000 mg/kg; Dermal $LD_{50}$ rat (both sexes),
>4000 mg/kg; Inhalation toxicity (4h) rat (both
sexes), $LC_{50}$ > 5.72 mg/L; Primary eye irritation
rabbit, minimal; Skin irritation rabbit, non-irritating;
Skin sensitization guinea pig, non-sensitizing

- Carfentrazone 2 EC: Oral $LD_{50}$ rat, 4077 mg/kg;
Dermal $LD_{50}$ rat, >4000 mg/kg; Inhalation toxicity
(4h) rat (both sexes), $LC_{50}$ >6.31 mg/L; Primary
eye irritation rabbit, minimal; Skin irritation rabbit,
non-irritating.

**Subchronic toxicity:**

- 90-d dietary, mouse: NOEL male and female
4000 mg/kg (571 mg/kg/d)

- 90-d dietary rat: NOEL male 4000 mg/kg female
4000 mg/kg (284 mg/kg/d)

- 90-d dietary, dog: NOEL male and female 1500
mg/kg/d.

**Oncogenicity:**

- Mouse: NOEL male >7000 mg/kg (1091 mg/kg/d)
(high dose tested), female >7000 mg/kg (1302
mg/kg/d) (highest dose tested)

**Reproduction:**

- Rabbit: NOEL > 150 mg/kg/d; developmental >
300 mg/kg/d (highest dose tested)

- Rat: NOEL 100 mg/kg/d; developmental, >300
mg/kg/d (highest dose tested)

**Mutagenicity:**

- Gene mutation: Ames test, negative; CHO/HORT,
negative

- Structural chromosome aberration: Mouse
micro-nucleus, negative; in vitro cytogenetics
(humanlymphocytes), negative; invitrocytogenetics
(Cinese hamster lung cells), increases in
chromosome aberrations were only observed in
the absence of S9 mix at dose levels exceeding
solubility (>2000 mg/mL) with precipitating test material present.

Wildlife:
Non-hazardous to birds, no effects were observed in bobwhite quail (>2250 mg/kg) or mallard duck (>5620 mg/kg). Carfentrazone-ethyl and its formulations do not present a hazard to mammals with LD₅₀ values ranging from >2000 to >5000 mg/kg body weight. Carfentrazone-ethyl and its formulations are of low acute (35 µg/bee) and topical (>200 µg/bee) toxicity to honeybees. Carfentrazone-ethyl is low to moderately toxic to fish and Daphnia. Under field conditions, however, carfentrazone-ethyl does not present a hazard to aquatic organisms because of low use rates and its rapid hydrolysis to less toxic metabolites.

Use classification: General use

SYNTHESIS AND ANALYTICAL METHODS
Synthesis: NA

flufenpyr-ethyl
ethyl [2-chloro-4-fluoro-5-[5-methyl-6-oxo-4-(trifluoromethyl)-1(6H)-pyridazinyl] phenoxy]acetate

NOMENCLATURE
Common name: flufenpyr-ethyl (ISO 1750 provisional)
Other name(s): V-3153; S-3153; ethyl 2-chloro-5-[1,6-dihydro-5-methyl-6-oxo-4-(trifluoromethyl)pyridazin-1-yl]-4-fluorophenoxyacetate (IUPAC)
Chemical family: phenylpyrazole; pyridazinone

CHEMICAL AND PHYSICAL PROPERTIES
Chemical structure:

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\begin{center}
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\end{center}
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Molecular formula: C₁₉H₁₁ClF₄N₂O₄
Molecular weight: 408.7 g/mole
Description: Off-white powder
Density: 0.155 g/mL
Boiling point: NA
Vapor pressure: 6.80 x 10⁻⁶ Pa
Stability: Stable at ambient temperatures
Solubility: Water, 2.3 mg/L (20°C); Soluble in most organic solvents
pKₐ: None (non-ionicizable)
Kₐw: log Kₐw = 3.49

Purification of technical: NA
Analytical methods: NA
Historical: Carfentrazone-ethyl was introduced in 1992 by the FMC Corporation. It was first field tested in 1993 through 1997. It is covered by U.S. Patent 5,125,958.

MANUFACTURER(S) AND INFORMATION SOURCE(S)
Industry source(s): Agrallion; FMC
Reference(s):

CAS #: 188489-07-8

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PROTOTOPORPHRYINOXIDASE (PPG oxidase or Protox) Inhibitors

HERBICIDAL USE
Flufenpyr-ethyl is being developed for postemergence broadleaf weed control in soybean.

USE PRECAUTIONS
Fire hazard: Non-flammable
Corrosiveness: Non-corrosive
Storage stability: Stable at ambient temperatures
Emergency exposure: Ingestion: Drink 1-2 glasses of water or milk and induce vomiting by touching the back of the throat with finger. Do not induce vomiting. Eyes: Flush eyes immediately with plenty of water while holding eyelids open.
Incompatibilities: NA

BEHAVIOR IN PLANTS
Mechanism of action: Inhibition of the enzyme protoporphyrinogen oxidase (PPG or Protox) (more details on page 12)
Symptomology: Sensitive plants display symptoms within hours of application. Symptoms include contact type of necrosis and bronzing.
Absorption/translocation: Uptake by plants is via leaves and roots; limited translocation. Leaf absorption can be increased by adding a surfactant.
Metabolism in plants: NA
Mechanism of resistance in weeds: None reported.

BEHAVIOR IN SOIL
Sorption: NA
Transformation: NA