Purification of technical: NA
Analytical methods: Adding dilute cupric chloride solution to a dilute solution of metham produces a yellow color detectable by a spectrophotometer. Methyl isothiocyanate can be determined by GC.
Historical: Fumigating soil with metham was discovered in 1950 by Dorman and Lindquist. U.S. patent 2,766,554 was issued to Stauffer Chemical Company in 1956. Other Stauffer patents include U.S. patent 2,791,605 and British patent 769,690. VAPAM was first marketed in 1955 by Stauffer and later by Du Pont. Fungicidal properties of metham were first reported in 1951 (2) and again in 1956 (3).

MSMA
monosodium methylarsonate

NOMENCLATURE
Common name: MSMA (WSSA); MAA (methylarsonic acid) (WSSA) is the parent acid, methylarsonic acid
Other name(s): MAA = methylarsonic acid = parent acid of MSMA and DSMA (disodium salt); monosodium acid methane arsonate; sodium hydrogen methylarsonate (IUPAC)
Trade name(s): ANSAR® 6.6; ARSONATE LIQUID; BUENO® 6; CHECK MATE; DACONATE 6; DACONATE® SUPER BRAND; MSMA 6.6; MSMA 6 PLUS; SUPERBRAND ARSONATE; MSMA 6 EC; TRIMEC® PLUS; MSMA PLUS; MSMA 6.6; MSMA 6 PLUS; MERGE 823; MESAMATE; SILVISAR; TRANS-VERT; WEED-E-RAD; WEEDHOE; 120 HERBICIDE
Chemical family: arsenical; organic arsenical

CHEMICAL AND PHYSICAL PROPERTIES
Chemical structure:
monosodium methane arsonate (MSMA)

\[
\begin{align*}
\text{CH}_3\text{As} & \quad \text{O} \\
\text{O} & \quad \text{Na} \\
\text{OH} & \quad \text{OH} \\
\text{methylarsonic acid (MAA)}
\end{align*}
\]

Molecular formula: MSMA: \(\text{CH}_3\text{AsNaO}_4\); MAA: \(\text{CH}_3\text{AsO}_3\)
Molecular weight: MSMA: 161.95 g/mole; MAA: 139.97 g/mole
Description: MSMA: Clear, odorless, light-yellow as a 51% w/v aqueous technical (purified dry technical

is extremely difficult to maintain and is virtually unavailable); MAA: White crystalline solid as the purified dry technical.

Density: MSMA: 1.535 g/mL (25 C) for the 51% w/v aqueous technical, unknown for the pure dry technical; MAA 0.95 g/mL.

Melting point: MSMA: (116-121 C) for the pure dry technical; MAA (161 C)

Boiling point: (110 ± 2 C) for the 51% w/v aqueous technical; unknown for the pure dry technical

Vapor pressure: MSMA: 1.33 x 10⁻³ Pa (20 C); MAA 9.99 x 10⁻⁶ Pa (25 C)

Stability: Dry purified technical is extremely hygroscopic and is unstable except in an anhydrous atmosphere.

Solubility:
MSMA
water 1,040,000 mg/L (25 C)
organic solvents g/100 mL (25 C):
n-hexane 0.00526
methanol 16

MAA
water 361,160 mg/L (25 C)

\(pK_a\): 4.1 (1) and 9.02
 \(K_{ow}\): <1

HERBICIDAL USE
MSMA can be applied POST at 2.52 kg ai/ha in turf, POST at 2.22 kg ai/ha in cotton, and POST at 2.77 kg ai/ha in non-crop areas. Weeds controlled in turf include crabgrass spp., dallisgrass, and other grasses. MSMA also controls johnsongrass, nutsedge, foxtails, cocklebur, pigweeds, and others. A surfactant is required for satisfactory efficacy. The Ca salt formulation of methane arsonate (CALAR) was developed because of greater turf tolerance than MSMA.
USE PRECAUTIONS

Fire hazard: Formulated products are non-combustible
Corrosiveness: Formulated products are mildly corrosive.
Storage stability: Completely stable; solid formulations are somewhat hygroscopic and should be stored dry
Cleaning glassware/spray equipment: Flush with water
Emergency exposure: Wash eyes and skin with water for 15 min. If ingested, induce vomiting and lavage with water, followed by a saline cathartic, such as sodium sulfate. BAL (dimercaprol) is antidotal. Symptoms of mild poisoning include a salty taste, burning of throat, colicky stomach pains, and garlicky odor of breath or skin. Acute poisoning may occur with oral doses >30 g ai for an adult and symptoms include headache, vomiting, diarrhea, dizziness, stupor, convulsions, paralysis, and death.
Incompatibilities: Water high in Ca, Mg, and Fe may cause precipitation; these cations form insoluble methanearsonate salts.

BEHAVIOR IN PLANTS

Mechanism of action: Not well understood; rapid desiccation indicates cell membrane destruction
Symptomology: Foliar chlorosis and necrosis (desiccation)
Absorption/translocation: Readily absorbed by foliage and is translocated in the xylem. MSMA also is mobile in the apoplastic; little translocation to shoots after root absorption from nutrient solution
Metabolism in plants: Certain species metabolize MSMA to cacodylic acid. MSMA can be conjugated with sugars, amino acids, other organic acids, and other molecules. MSMA is not demethylated to form inorganic arsenicals and is not reduced to trivalent arsenic compounds in beans.
Non-herbical biological properties: Some fungicidal action; see U.S. Patent 3,106,509.
Mechanism of resistance in weeds: Organical arsenical-resistant cocklebur biotypes have been reported, but the mechanism of resistance is unknown.

BEHAVIOR IN SOIL

Sorption: Strongly adsorbed to soil; fixed by Fe and Al hydrous oxides in soil; sorption increases as size of clay fraction decreases.
$K_{oc}$: Average is 7000 mL/g (estimated)
$K_d$: Sand 250 mL/g; silty loam 2580 mL/g; silty clay 1170 mL/g; sandy loam 2190 mL/g
$K_f$: Sand 0.5 mL/g; silty loam 11.4 mL/g; silty clay 18.7 mL/g; sandy loam 39.4 mL/g
$K_h$: Sand 0.39 mL/g; silty loam 13.3 mL/g; silty clay 20 mL/g; sandy loam 34.8 mL/g
$1/n$: Sand 1.13; silty loam 0.695; silty clay 0.769; sandy loam 0.677

Transformation:
Photodegradation: Little to no losses when applied to soil; half-life was 990 d when irradiated on soil and 1155 d for the non-irradiated check; photolysis half-life is >30 d in water
Other degradation: Some breakdown by soil microbes; primarily degraded to arsenite with small amounts of cacodylic acid produced under aerobic laboratory conditions with a Hanford sandy loam

Persistence: Moderate to somewhat long residual with an average field half-life of 180 d

Field experiments: In a Hanford fine sandy loam in the San Joaquin Valley of California under high irrigation, MSMA had a half-life of 55 d while its metabolite cacodylic acid had a half-life of 88 d.
Lab experiments: Isolated bacteria degraded 20% of applied MSMA in 11 d. Degradation was 0.6-12.5% after 160 d in both aerobic and anaerobic conditions.

Mobility: Medium to low mobility on sandy soil and is largely immobile on other soils. Even under heavy irrigation in a medium texture soil, MSMA primarily is found in the top 15 cm while its metabolite cacodylic acid is found only in the top 15 cm. MSMA did not leach in a Decatur clay loam, but leached to 51 cm in a Norfolk sandy loam.

Volatilization: No losses

TOXICOLOGICAL PROPERTIES

Toxicity tests were conducted with dry technical grade methylarsonic acid (MAA) unless otherwise indicated.

Acute toxicity:
MSMA 51% w/v aqueous technical: Oral $LD_{50}$ rabbit, 2833 mg/kg; Dermal $LD_{50}$ rabbit, >2000 mg/kg; 4-h inhalation $LC_{50}$ rat, 2.2 mg/L (male >2.23 mg/L, female 2.18 mg/L); Skin irritation rabbit, mild; Skin sensitization guinea pig, no; Eye irritation rabbit, mild

ARSONATE LIQUID: Oral $LD_{50}$ rat, 1738 mg/kg; Dermal $LD_{50}$ rabbit, 2500 mg/kg; 4-h inhalation $LC_{50}$ rat, >20 mg/L; Skin irritation rabbit, mild; Eye irritation rabbit, mild

Subchronic toxicity: NA

Chronic toxicity:
24-mo dietary, mouse: NOEL male 200 mg/kg, female 50 mg/kg; reduced body weight gain and increased water uptake at 400 mg/kg
12-mo dietary, dog: NOEL 2 mg/kg/d; diarrhea, vomiting, excessive salivation, and slightly decreased body weight at 35 mg/kg/d

Teratogenicity:
Rat: NOEL 10 mg/kg/d; slightly decreased food consumption and body weight gain at 100 mg/kg/d
Rabbit: NOEL 3 mg/kg/d; decreased food consumption and decreased body weight gain at 7 mg/kg/d
Reproduction:
Rat: NOEL maternal 7 mg/kg/d, developmental 22 mg/kg/d; reduced body weight in males at 76 mg/kg/d

Mutagenicity:
Gene mutation: Ames test, negative with or without metabolic activation; Mouse lymphoma, negative with or without metabolic activation
Structural chromosome aberration: CHO, negative with or without metabolic activation
DNA damage/repair: Primary rat hepatocytes/UDS, negative

Wildlife:
MSMA 51% w/v aqueous technical: Bobwhite quail oral LD₅₀, 425 mg/kg, 8-d dietary LC₅₀, 1667 mg/kg; Mallard duck 8-d dietary LC₅₀ >2866 mg/kg, 8-d dietary NOEC, 2666 mg/kg; Honey bee oral LD₅₀, 68 µg/bee, topical NOEL, 36 µg/bee; Daphnia 48-h LC₅₀, 77.5 mg/L, 48-h NOEC, 12.3 mg/L; Bluegill sunfish, 96-h LC₅₀ >51 mg/L, 96-h NOEC, 167 mg/L; Rainbow trout 96-h LC₅₀ >167 mg/L; 96-h NOEC, 167 mg/L
TARGET 6.6: Bobwhite quail oral LD₅₀, 834 mg/kg, 8-d dietary LC₅₀, 3269 mg/kg; Mallard duck 8-d dietary LC₅₀ >5520 mg/kg; Honey bee oral LD₅₀, 68 µg/bee; Daphnia 48-h LC₅₀, 83 mg/L; Bluegill sunfish 96-h LC₅₀ >93.2 mg/L; Rainbow trout 96-h LC₅₀ >167 mg/L.

Use classification: General use

SYNTHESIS AND ANALYTICAL METHODS
Synthesis: MSMA (2CH₄AsNaO₃) is produced from DSMA as follows:

pelargonic acid
nonanoic acid

NOMENCLATURE
Common name: pelargonic acid (IUPAC, WSSA)
Other name(s): NA
Trade name(s): SCYTHE
Chemical family: carboxylic acid

CHEMICAL AND PHYSICAL PROPERTIES
Chemical structure:
pelargonic acid
\[\text{CH}_3(\text{CH}_2)₇\text{COOH}\]

Molecular formula: \(\text{C}_₉\text{H}_{₁₈}\text{O}_₂\)
Molecular weight: 158.24 g/mole
Description: Water-white liquid; a waxy fatty acid like odor similar to crayons
Density: 0.904 g/mL (25 C)
Melting point: 12.5 C (technical)
Boiling point: 230-237 C at atmospheric pressure

2CH₄AsO(ONa)₂ + H₂SO₄ → 2CH₄AsNaO₃ + Na₂SO₄

Purification of technical: Recrystallization from methanol

Analytical methods: Titration with HCl, using an auto-end point titrometer; total arsenic determination is done with sulfuric/nitric acid digestion followed by reduction with potassium iodide and subsequent titration with iodine to the starch-iodine blue endpoint; atomic absorption spectrophotometry at 193.7 nm can be used. For residue methods, see Official Methods of Analysis, AOAC 12th ed., 25.006-25.013.

Historical: NA

MANUFACTURER(S) AND INFORMATION SOURCES:
Industry source(s): Agrilliance; Albaugh/Agri Star; Drexel; Helena; KMG Chemical; Monterey; PBI Gordon; PROKo2; Setre Chemical; UAP-Loveland Products; Verdim (UAP-Professional Products)

Reference(s):

CAS #: 112-05-0

Vapor pressure: 2.67 \times 10^3 \text{ Pa (253} \text{ C})
Stability: Typical of straight chain carboxylic acid chemistry
Solubility: Very slightly soluble in water and readily soluble in most organic solvents.
\(pK_a\): NA
\(K_{ow}\): NA

HERBICIDAL USE
SCYTHE is a contact, non-selective, broad spectrum, foliage-applied herbicide. It only controls actively growing emerged green vegetation. It provides burndown of both annual and perennial broadleaf and grass weeds, as well as most mosses and other cryptogams. The degree of burndown and the longevity of control is less when plants are inactive, mature, or biennial/perennials. This product does not translocate and it will burn only those plant parts that are coated with spray solution. Visible effects occur