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# Pesticide Fact Sheet

**Name of Chemical:** Dimethyl Disulfide  
**Reason for Issuance:** New Chemical  
**Date Issued:** July 9, 2010

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## **I. Description of the Chemical**

Generic Name:	Dimethyl disulfide
Common Name:	DMDS
Trade Names:	Paladin® Technical, Paladin®, Paladin® EC
Chemical Class:	Reduced Organosulfur Compound
EPA Chemical Code:	029088
CAS Number:	624-92-0
Registration Status:	Conditionally Registered
Pesticide Type:	Soil Fumigant
U.S. Producer:	Arkema Inc. 900 First Avenue King of Prussia, PA 19406

## **II. Use Pattern and Formulations**

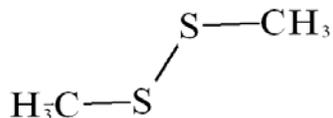
Dimethyl disulfide (DMDS) is a soil fumigant that is formulated as the technical product Paladin Technical (EPA Reg. No. 55050-3) and the two end-use products Paladin (EPA Reg. No. 55050-4) and Paladin EC (EPA Reg. No. 55050-5). Paladin contains 98.8% dimethyl disulfide and Paladin EC contains 93.8% dimethyl disulfide. Paladin is a liquid that is applied by shank injection (a tube behind a blade that slices through the soil) to raised beds and as a broadcast application. Paladin EC is an emulsifiable concentrate that is applied by drip irrigation to raised

beds. DMDS applications are made pre-plant to fields that will be used to grow berry (blueberry and strawberry), cucurbit vegetable (cucumber, squash, and melon), fruiting vegetable (tomato, pepper, and eggplant), field-grown ornamental, and forest tree nursery crops. The DMDS end-use products are applied in liquid form; the DMDS subsequently volatilizes. These treatments are intended to control weeds such as nutsedge (purple and yellow), chickweed, lambsquarters, purslane, and grasses; soil-borne plant pathogens such as *Verticillium* spp., *Fusarium* spp., *Pythium* spp., *Sclerotinia* spp., and *Rhizoctonia* spp.; and nematodes such as Root Knot (Southern, Northern, and Colombian), Stubby Root, Lesion, Stunt, and Sting. The insecticidal mode of action is creation of mitochondrial dysfunction. The maximum allowable application rate per acre, via either application method, is 455 pounds per acre. The treated areas are covered by high barrier plastic tarp immediately after treatment. The tarps covering treated areas may not be cut or removed for at least 12 days after the treatment is made. A summary of the directions for use for DMDS is contained in Table 1. Dimethyl disulfide, when co-applied with chloropicrin, is expected to serve as a methyl bromide replacement fumigant. The uses on the accepted product labels are considered to be non-food uses.

<b>Table 1. Summary of Labeled Uses and Application Methods for Paladin™ and Paladin EC™ DMDS Formulations</b>						
<b>Use</b>	<b>Product</b>	<b>Single App. Rate (lbs. a.i./A)</b>	<b>Number of Apps.</b>	<b>Seasonal Max. App. Rate (lbs. a.i./A)</b>	<b>Interval Between Apps. (days)</b>	<b>Application Method(s)</b>
Fruiting Vegetables: <ul style="list-style-type: none"> <li>• Tomatoes</li> <li>• Peppers</li> <li>• Eggplant</li> </ul>	Paladin® and Paladin® EC	455	1	455	N/A	<ul style="list-style-type: none"> <li>• Drip Irrigation</li> <li>• Shank Injection to Raised Beds</li> <li>• Broadcast Shank Injection</li> </ul>
Curcubit Crops: Cucumbers Squash Melons	Paladin® and Paladin® EC	355 - 455	1	355 - 455	N/A	<ul style="list-style-type: none"> <li>• Drip Irrigation</li> <li>• Shank Injection to Raised Beds</li> <li>• Broadcast Shank Injection</li> </ul>
Small Fruit Crops: <ul style="list-style-type: none"> <li>• Blueberries</li> <li>• Strawberries</li> </ul> Field Grown Ornamentals  Forest Nursery Crops	Paladin® and Paladin® EC	310 - 455	1	310 - 455	N/A	<ul style="list-style-type: none"> <li>• Drip Irrigation</li> <li>• Shank Injection to Raised Beds</li> <li>• Broadcast Shank Injection</li> </ul>

### III. Product Chemistry

#### A. Structure of DMDS:



#### B. Physicochemical Properties of DMDS:

Name or Parameter	Value/Description
Molecular formula	C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>
Molecular weight	94.2 g/mol
IUPAC name	(Methyldisulfanyl)methane
Physical state	Pale yellow liquid
Odor	Like pungent garlic, propane, decaying fish, or decomposing materials
Melting point/range	-84.7 °C
Boiling point/range	109-110 °C
Density	1.062 g/mol @ 20 °C
Water solubility	1-10 g/L @ 20 °C
Solvent solubility	Completely miscible with n-hexane at all temperatures.
Vapor pressure	29.0 mm Hg @ 25 °C 22.5 mm Hg @ 20 °C
Dissociation constant (pK <sub>a</sub> )	This substance does not dissociate.

### IV. Toxicology Profile

Guideline No./ Study Type	Classification	Results
870.1100 Acute Oral Toxicity – Rat	Acceptable/Guideline.	LD <sub>50</sub> combined = 190 mg/kg (150-240 mg/kg) Toxicity Category II
870.1200 Acute Dermal Toxicity - Rabbit	Acceptable/Guideline.	LD <sub>50</sub> > 2000 mg/kg Toxicity Category III; no deaths
Special Inhalation Toxicity 24-hour Inhalation Toxicity - Rat	Acceptable/Non-Guideline	Port-of-Entry: NOAEL = 9 ppm; LOAEL = 12.5 ppm, based on the incidence of microscopic lesions (degeneration in the olfactory epithelium) of the nasal tissues, the incidence of degeneration in multiple nasal levels, and inflammation of the olfactory and respiratory epithelia. Systemic: NOAEL = 18 ppm (highest dose tested); LOAEL not established.

**Table 3: DMDS Toxicity Profile**

<b>Guideline No./ Study Type</b>	<b>Classification</b>	<b>Results</b>
Special Inhalation Toxicity Study 1-Day & 5-Day Inhalation Toxicity - Rat	Acceptable/Non-Guideline	Day 1: Port-of Entry: NOAEL not established (<50 ppm) LOAEL = 50 ppm (0.19 mg/L), based on changes (acute inflammation, degeneration, and hyperplasia) in the nasal tissues in both sexes. Day 5: Systemic: NOAEL not established; LOAEL = 50 ppm (0.19mg/L), based on decreased body weights and body weight gains. Port-of Entry: NOAEL not established (<50 ppm); LOAEL = 50 ppm (0.19 mg/L), based on changes (acute inflammation, degeneration, and hyperplasia) in the nasal tissues in both sexes. Relative lung weights increased at 300 and 600 ppm. Regeneration of the olfactory epithelium occurred in nasal levels II through VI.
870.1300 Acute Inhalation Toxicity - Rat	Acceptable/Guideline	LC50 for males >3.18 mg/L (3.18-6.19 mg/kg) LC50 for females = 5.22 mg/L (4.56-5.97 mg/L) Combined LC50 = 4.91 mg/L (4.38-5.52 mg/L) Toxicity Category IV
870.2400 Primary Eye Irritation - Rabbit	Acceptable/Guideline	Transient corneal opacity, reversible within 7 days. Toxicity Category III
870.2500 Primary Skin Irritation - Rabbit	Acceptable/Guideline	Primary Irritation Score at 48 hours 2.02. Toxicity Category IV
870.2600 Dermal Sensitization – Guinea Pig	Acceptable/Guideline	Buehler protocol with 10 induction treatments. Not a dermal sensitizer.
870.3200 28-Day Dermal Toxicity - Rabbit	Acceptable/Guideline	(Highest dose discontinued after Day 16 due to mortality.) Irritation: NOAEL not established.; LOAEL = 10.6 mg/kg/day, based on erythema, edema, and ischemic necrosis, with increased severity and incrustation at mid-dose and severe erythema at highest dose tested. Systemic : NOAEL = 10.6 mg/kg/day.; LOAEL = 106 mg/kg/day, based on lethargy with mortality, myocarditis and myocardial degeneration, lung lesions, decreased body weight and food consumption, and hemolytic anemia at highest dose tested.
870.3465 13-Week Inhalation Toxicity - Rat	Acceptable/Guideline	Port-of-entry: NOAEL not established.; LOAEL = 10 ppm (0.04 mg/L), based on minimal to moderate atrophy and microcavitation of the olfactory epithelia and respiratory squamous metaplasia in the anterior nasal cavity. Systemic: NOAEL = 10 ppm (0.04 mg/L); LOAEL = 50 ppm (equivalent to 0.19 mg/L) based on: clinical signs of toxicity (soiled fur and piloerection), and decreased body weights, body weight gains, and food consumption in both sexes. Recovery Group: squamous cell metaplasia still evident in the 50 and 250 ppm groups.
870.3700 Inhalation Developmental Toxicity - Rat	Acceptable/Guideline	Maternal: LOAEL = 50 ppm (0.19 mg/L), based on rough haircoat, and decreased body weights, weight gains, and food consumption; NOAEL = 15 ppm (0.06 mg/L). Developmental: LOAEL = 50 ppm (0.19 mg/L), based on

**Table 3: DMDS Toxicity Profile**

<b>Guideline No./ Study Type</b>	<b>Classification</b>	<b>Results</b>
		decreased fetal body weights and multiple skeletal developmental retardations; NOAEL = 15 ppm (0.06 mg/L). Port-of-Entry: NOAEL not established.
870.3700 Inhalation Developmental Toxicity - Rabbit	Acceptable/Guideline	Maternal: LOAEL not established; NOAEL = 135 ppm (0.52 mg/L), the highest dose tested. Developmental: LOAEL not established; NOAEL = 135 ppm (0.52 mg/L), the highest dose tested. Port-of-Entry: LOAEL is 15 ppm, based on macroscopic lung lesions (dark red discoloration or areas) at all concentrations; NOAEL not established.
870.3800 Inhalation 2- Generation Reproductive Toxicity - Rat	Acceptable/Guideline	Parental: LOAEL = 20 ppm (0.079 mg/L), based on decreased body weight, body weight gains, and food consumption in F1 males; NOAEL = 5 ppm (0.019 mg/L). Offspring: LOAEL not established (>80 ppm); NOAEL = 80 ppm (0.308 mg/L), the highest dose tested. Reproductive: LOAEL not established; NOAEL = 80 ppm (0.308 mg/L) the highest dose tested. Port-of-Entry: NOAEL and LOAEL not evaluated.
870.3800 Lactational Inhalation Phased Exposure (Range-Finding) - Rat	Acceptable/Non- guideline	(This study evaluated a critical period of exposure during lactation.) Maternal: LOAEL = 80 ppm (0.308 mg/L), based on decreased body weight gains and food consumption; NOAEL = 20 ppm (0.078 mg/L). Offspring: LOAEL not established; NOAEL = 80 ppm (0.308 mg/L). Reproductive: LOAEL not established; NOAEL = 80 ppm (0.308 mg/L).
870.5100 Bacterial Reverse Mutation Test (Ames Assay)	Unacceptable/guideline (Purity information not provided.)	Evidence of slight cytotoxicity (reduced number of revertants) was observed with one strain at 5000 µg/plate. There were no marked increases in the mean number of revertants/plate in any strain. There was no evidence of induced mutant colonies over background up to the limit dose for this test system.
870.5100 Bacterial Reverse Mutation Test (Ames Assay)	Acceptable/guideline	DMDS was tested up to the limit dose (5000 µg/plate). No evidence of compound precipitation or cytotoxicity was observed at any concentration in any strain. There were no marked increases in the mean number of revertants/plate in any strain. There was no evidence of induced mutant colonies over background at concentrations up to the limit dose for this test system.
870.5300 <i>In Vitro</i> Gene Mutation Assay- Chinese Hamster Ovary Cells	Unacceptable/guideline	No conclusions can be reached on the results of this study because of the problems associated with nominal vs. actual concentrations, which precluded a comparative evaluation of the data from both trials.
870.5375 <i>In Vitro</i> Chromosomal Aberration in Human Peripheral Blood Lymphocytes	Acceptable/guideline	There was no evidence of chromosome aberrations induced over background in the presence or absence of S9-activation up to cytotoxic concentrations.
870.5395	Acceptable/guideline	DMDS is considered negative in this test system up to a

<b>Table 3: DMDS Toxicity Profile</b>		
<b>Guideline No./ Study Type</b>	<b>Classification</b>	<b>Results</b>
Micronucleus Assay - Mouse		concentration causing overt toxicity and cytotoxicity to the bone marrow in the treated animals.
870.5395 Micronucleus Assay- Rat	Acceptable/guideline	All animals survived to scheduled sacrifice. The following clinical signs of toxicity were noted in one or both sexes of the treated animals during exposure: hypoactivity, lacrimation, and clear material around the mouth. No treatment-related increases in the MPCE frequency were observed in any treatment group when compared to controls.
870.5550 In Vitro Unscheduled DNA Synthesis - Primary Rat Hepatocytes	Acceptable/guideline	Dimethyl disulfide was tested up to the limit of solubility (200 µg/mL). There was no evidence that unscheduled DNA synthesis, as determined by radioactive tracer procedures (nuclear silver grain counts) was induced.
870.6200 Inhalation Acute Neurotoxicity - Rat	Acceptable/Guideline	Systemic: LOAEL = 100 ppm (lowest dose tested) (0.39 mg/L), based on decreased total session locomotor activity in males and decreased total session motor activity in females; NOAEL not established. Port-of-entry: LOAEL = 100 ppm (0.39 mg/L), based on closed eyelids at 100 ppm and red deposits on the mouth in females at 200 ppm; NOAEL not established.
870.6200 Inhalation Subchronic Neurotoxicity - Rat	Acceptable/Guideline	Port-of-entry: LOAEL = 20 ppm (0.08 mg/L), based on degeneration of the nasal olfactory epithelium at levels II thru IV; NOAEL = 5 ppm (0.02 mg/L). Systemic: LOAEL = 80 ppm (0.31 mg/L), based on decreased total motor activity in males, and decreases in body weight, overall body weight gain, and food consumption; NOAEL = 20 ppm (0.08 mg/L).
Non-guideline Developmental Neurotoxicity (Range-Finding) - Rat	Acceptable/Non-guideline	Port-of-Entry: NOAEL not established. Maternal: NOAEL = 20 ppm (0.078 mg/L); LOAEL = 80 ppm (0.309 mg/L), based on decreased body weight gains and food consumption. Offspring: NOAEL = 20 ppm (0.078 mg/L); LOAEL = 80 ppm (0.309 mg/L), based on decreased body weights and body weight gains.

DMDS, like the other soil fumigants, has the potential to move off-site following field applications, resulting in exposure to bystanders near treated areas and to people far away from treated areas through ambient air. Exposure to DMDS may also occur to those handling the pesticide or working in treated fields. Acute inhalation exposures to bystanders and workers appear to present the greatest risk concern.

DMDS has a robust inhalation toxicity database with studies varying from acute to repeat exposure studies. Port-of-entry irritation, nasal irritation, is the most sensitive endpoint for DMDS. Systemic toxicity was only observed at higher concentrations in the form of decreased food consumption and body weights. Irritation typically increased in severity and progressed deeper in the nose with increasing concentrations. Repeat inhalation studies suggest nasal irritation is driven by concentration since lower LOAELs were not observed in repeat exposure studies. The concentration at which nasal irritation occurs is similar for a single exposure as for

longer-term exposures. The acute inhalation port-of-entry NOAEL is therefore appropriate for longer-term scenarios.

The odor of DMDS has been described in the literature as pungent garlic, propane, decaying fish, or decomposing materials. A literature review conducted by the registrant suggests that the mean odor threshold for DMDS is 7 to 12 ppb (0.007 - 0.012 ppm), which is approximately three orders of magnitude below the concentration at which nasal irritation is observed in rodent inhalation studies. This suggests that individuals near a treated field are likely to detect the odor of DMDS before it reaches a concentration at which it would begin to produce nasal irritation. However, the time required for a person to detect the odor and the variability and aversion to the odor among various individuals is not currently known for DMDS.

Although DMDS is highly volatile, a specially designed 28-day repeat dermal rabbit study is available that indicates repeat dermal exposure to DMDS is severely irritating and may cause severe systemic toxicity including death (secondary to dermal irritation). It is noted, however, that this study was designed to keep DMDS on the skin instead of volatilizing as would typically occur. Severe irritation in the form of erythema, edema, and ischemic necrosis was observed at the lowest concentration tested beginning on the second day of application. Although studies indicate that DMDS is a toxicity category III for skin, severe irritation was also observed in the acute dermal rabbit study (cracking/thickening/sloughing of the skin on Day 7 until Day 14). Therefore, DMDS should be handled with extreme care since any dermal exposure will likely lead to severe irritation and toxicity. The Agency is requiring that handlers who may come in contact with DMDS liquid must wear personal protective equipment (PPE) due to the potential for severe irritation of DMDS to skin.

There is neither a pharmacokinetic nor a metabolism study available for DMDS and the metabolic pathway has not been determined. The insecticidal mode of action acts through the dysfunction of mitochondria. The mammalian mode of action or metabolic pathway has not been determined. Based on the lack of systemic toxicity in any of the DMDS toxicity studies, a rat metabolism study would not provide significant information for risk assessment.

## **V. Toxicological Endpoints**

Based on the specific toxicity profile of DMDS, the 24-hour acute inhalation rat study was selected for estimating inhalation risk for all durations of exposure. The port-of-entry NOAEL (No observable adverse effect level) is 9 ppm. The port-of-entry LOAEL (lowest observable adverse effect level) of 12.5 ppm was based on the incidence of microscopic lesions of the nasal tissues, the incidence of degeneration in multiple nasal levels and inflammation of the olfactory and respiratory epithelia. Since nasal irritation is dependent upon concentration and not duration of exposure, a single HEC is appropriate for all durations and both occupational and non-occupational scenarios.

Based on the use of the inhalation reference concentration (RfC) methodology, the acute, short- and intermediate-term non-occupational and occupational human equivalent concentration (HEC) is 1.65 ppm. EPA's RfC methodology incorporates pharmacokinetic differences between

rats and humans; therefore the interspecies extrapolation factor is reduced to 3x. EPA uses a 10x factor to account for intraspecies variability. Therefore, a margin of exposure (MOE) of 30 defines HED's level of concern (LOC).

<b>Table 4: Summary of Toxicological Dose and Endpoints for Use in DMDS Human Health Inhalation Risk Assessment</b>					
<b>Risk Assessment</b>		<b>Study</b>	<b>NOAEL/LOAEL</b>	<b>Endpoint</b>	<b>HEC*</b>
Acute Inhalation	Non-occupational	24 hr Inhalation	NOAEL= 9 ppm LOAEL = 12.5 ppm	Inflammation & nasal irritation in all 6 levels in male rats	HEC* = 1.65 ppm UF** = 30
	Occupational	24 hr Inhalation	NOAEL= 9 ppm LOAEL = 12.5 ppm	Inflammation & nasal irritation in all 6 levels in male rats	HEC* = 1.65 ppm UF** = 30
Short- and Intermediate-Term Inhalation (1-6 months)	Non-occupational	24 hr Inhalation	NOAEL= 9 ppm LOAEL = 12.5 ppm	Inflammation & nasal irritation in all 6 levels in male rats	HEC* = 1.65 ppm UF** = 30
	Occupational	24 hr Inhalation	NOAEL= 9 ppm LOAEL = 12.5 ppm	Inflammation & nasal irritation in all 6 levels in male rats	HEC* = 1.65 ppm UF** = 30
Long-term Inhalation (> 6 months)	Use pattern does not result in long-term exposure				
Cancer	Not required.				

\*HEC = Human equivalent concentration

\*\*UF = Uncertainty factor

## **VI. Uncertainty Factors**

When conducting inhalation risk assessments, the magnitude of the uncertainty factors (UFs) applied is dependent on the methodology used to calculate risk. For the studies in this risk assessment that provide animal inhalation data UFs are based on the RfC methodology developed by the Agency for the derivation of inhalation RfCs and HECs for use in margin of exposure (MOE) calculations. Since the RfC methodology takes into consideration pharmacokinetic differences but not the pharmacodynamic differences the UF for interspecies extrapolation was reduced to 3X to account for the pharmacodynamic differences between animals and humans which are not accounted for by the RfC methodology. The UF for intraspecies variation is retained at 10X so the UF for these DMDS risk assessments is 30X.

## **VII. Exposure Assessments**

### Dietary (Food and Drinking Water)

Although DMDS will be used as an agricultural pesticide, it is considered a non-food use chemical since it is applied pre-plant and it is quickly degraded or metabolized into non-toxic degradates in the soil. Furthermore, DMDS residues must dissipate in the soil prior to planting. Therefore, this fumigant does not require food tolerances and is not subject to the amendments of the Federal Food, Drug, and Cosmetic Act (FFDCA) and the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) promulgated under the Food Quality Protection Act (FQPA) of 1996. As a result, a risk assessment has not been conducted for the dietary exposure scenario. Based on environmental fate data and modeling estimates the Agency does not expect the pesticidal uses of DMDS to adversely impact ground water or surface water.

### **Bystander and Occupational**

Releases of fumigants, such as DMDS, can be categorized in two distinct manners including bystander exposures from single application sites (i.e., treated farm fields) such as area sources (hereon discussed as near field sources) and by ambient air monitoring data where residues could result from many applications within a region (hereon discussed as ambient sources). Risks from near field sources were evaluated using monitoring data and modeling techniques. Risks from ambient air were evaluated using surrogate methyl bromide monitoring data from California.

The Agency utilized the Probabilistic Exposure and Risk Model for FUMigants (PERFUM) to assess DMDS bystander exposures and risks. DMDS PERFUM analyses were performed for 1, 5, 10, 20, and 40 acre fields (proposed DMDS labels restrict application to 40 acres per day) using 100%, 90%, 80%, 70%, 60%, and 50% of the maximum proposed label application rate. The Agency utilized all eight available field volatility studies in the PERFUM analyses even though use of high barrier tarps are required on the label (only two of the eight volatility studies used high barrier tarps). No emissions data are available to reflect the use of high barrier tarps for the broadcast shank injection and raised bed drip irrigation application scenarios and as a result, the conservative approach of using the poly tarped studies were to estimate buffers for these scenarios was used. PERFUM results show that for a 40 acre field treated at the maximum application rate, the 95% whole field buffer typically ranges from approximately 265 meters to  $\geq$  1440 meters for raised bed shank injection applications, from 1265 meters to  $\geq$  1440 meters for broadcast shank injection applications, and from 580 meters to  $\geq$  765 meters for raised bed drip irrigation applications depending on the sealing method and meteorological dataset examined.

With regard to potential multiple sources of exposure from ambient air, no direct ambient air monitoring data are available for DMDS. In order to qualitatively characterize the potential for exposure to DMDS in ambient air, HED has compared the DMDS inhalation toxicity endpoints to the ambient air levels that were quantified for methyl bromide. In all cases, this comparison resulted in risks that do not exceed HED's level of concern for DMDS (MOEs  $>$  30). This comparison should be considered conservative in nature because there is less potential for exposure with DMDS than with methyl bromide because of the environmental fate

characteristics of DMDS relative to methyl bromide (i.e., DMDS is not as volatile as methyl bromide, DMDS dissipates/degrades faster in the environment than methyl bromide).

Risks to occupational handlers (for soil fumigations), including tractor drivers, co-pilots, shovelers, soil sealers, tarp punchers and tarp removers, involved in preplant field fumigation were evaluated using DMDS-specific handler monitoring data. Acute inhalation risks to handlers exceed the Agency's level of concern (MOE < 30) for many of the sample points at the baseline level (no respirator). However, with the addition of an organic vapor respirator (assumed to have a protection factor of 10), all of the handler risks do not exceed the Agency's level of concern.

### **VIII. Environmental Risk Assessment**

DMDS is expected to dissipate in the environment principally by volatilization into the air, with a lesser amount moved by leaching into ground water, because of its high vapor pressure and solubility. DMDS may be transported in runoff water in bedded tarped applications as well as after tarp removal in broadcast applications. It gradually degrades in soil and water but parent DMDS remains the main stressor molecule for both aquatic and terrestrial organisms. Spray drift will not occur because of the application methods and volatile nature of the chemical.

#### **Risk to Terrestrial Species**

The risk quotients for mammals and birds are shown in Table 5. Risk quotients do not exceed LOCs for any entity of mammals or birds. Inhalation risk quotients for mammal species (LD50 = 17 ppm or 65,496 µg/m<sup>3</sup>) and avian species (LD50 = 1.73 mg/l or 1.73 x 10<sup>6</sup> µg/m<sup>3</sup>). Inhalation exposure was estimated using the PERFUM model on the basis of volatile flux measured from bedded DMDS applications with VIF tarp applied.

<b>Species</b>	<b>Toxicity Endpoint (µg/m<sup>3</sup>)</b>	<b>EEC (µg/m<sup>3</sup>)</b>	<b>RQ</b>
Mammals	LD50 = 65,496	720	0.011
Birds	LD50 = 1.73 x 10 <sup>6</sup>	720	0.0004

#### **Risk to Terrestrial Plants**

Risk to terrestrial plants is expected from exposure to air concentrations. Risk may be estimated from toxicity values from EECs calculated from the PERFUM model along with submitted toxicity endpoints reflecting exposure from air concentrations if available. However, additional data from the toxicity study is needed to complete the assessment.

#### **Risk to Aquatic Organisms**

Acute RQ values are derived from peak EECs and toxicity values for each surrogate species. RQs are presented for both drip irrigation and shank injection for each use. Drip irrigation RQs (.003 - .212) exceed the endangered species LOC ( $\geq 0.05$ ) for freshwater fish and freshwater invertebrates for FL cucumber, FL strawberry and GA onion uses.

Drip irrigation RQs do not exceed the endangered species LOC for freshwater fish and freshwater invertebrates for CA tomato, FL tomato, FL pepper, CA onion, CA nursery, MI nursery, NJ nursery, and OR Christmas tree uses. Drip irrigation RQs do not exceed the acute risk LOC for any uses for any surrogate aquatic species.

Drip irrigation RQs do not exceed the endangered species LOC for estuarine/marine fish and estuarine/marine invertebrates. Shank injection RQs do not exceed either the acute or endangered species LOC for any use for any surrogate aquatic species.

There is no potential for acute risk for any surrogate species using the shank injection method. No modeled uses resulted in LOC exceedances.

There is potential chronic risk to freshwater and estuarine/marine fish based on the uncertainty due to the persistence of DMDS in water and absence of chronic toxicity data.

### **Risk to Aquatic Plants**

RQs for non-listed species are estimated for vascular plants (*Lemna*) and nonvascular plants (*Anabaena*) using the EC<sub>50</sub>. There was no RQ exceedance for vascular plants using *Lemna* as a surrogate or for non-vascular plants using *Anabaena* as a surrogate for either drip irrigation or shank injection for any uses.

RQs are estimated for listed species using the EC<sub>05</sub> toxicity value. RQs exceeded the LOC for drip irrigation for listed nonvascular plants for CA tomato, FL tomato, FL pepper, FL cucumber, FL strawberry, GA onion, MI nursery, NJ nursery, or OR Christmas tree uses. No RQs exceeded the plant LOC for non-vascular plants for CA onion and CA nursery uses. No RQs for shank injection for nonvascular plants exceeded the LOC for any uses.

## **VII. Data Gaps**

The following data gaps exist. All of them are conditions of the registrations of the DMDS products.

- Field Volatility from Soil study (Guideline Number (GLN) 835.8100) (for flux from fields following broadcast shank, raised-bed shank, and raised-bed drip irrigation applications that are covered by high barrier tarp)
- Estimation of Inhalation Exposure, Outdoor Sites (GLN 835.1399) (occupational inhalation exposure for broadcast shank, raised-bed shank, and raised-bed drip irrigation applications)

that are covered by high barrier tarp)

- Environmental Chemistry Methods and Independent Laboratory Validations for Soil, Water, and Air
- Aerobic Aquatic Metabolism study (GLN 835.4400)
- Anaerobic Aquatic Metabolism study (GLN 835.4500)
- Vegetative Vigor study (GLN 850.5400) (upgrade a previously submitted study)
- Aquatic Freshwater Invertebrate Life-Cycle Toxicity study (GLN 850.1300)
- Aquatic Saltwater Invertebrate Life-Cycle Toxicity study (GLN 850.1350)
- Freshwater Fish Early Life-Stage Toxicity study (GLN 850.1400)
- Saltwater Fish Early Life-Stage Toxicity study (GLN 850.1400)

## **VII. Labeling Requirements**

Restricted Use Product

Buffer zones are required around the application block where DMDS is applied.

Personal Protective Equipment includes respirators.

### Surface and Ground Water Advisory for Tarped Scenario

Do not apply directly to water or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when cleaning equipment or disposing of equipment washwater or rinsate.

Dimethyl disulfide has certain properties and characteristics in common with chemicals that have been detected in groundwater (dimethyl disulfide is highly soluble in water and has low adsorption to soil).

To address this concern for ground water quality and surface runoff, after broadcast applications tarps must be sliced or removed before noon and only when rainfall is not expected within 12 hours. (Falling temperatures typically found in the late afternoon and evening will not promote dissipation of remaining DMDS under the sliced tarp and rainfall may cause any remaining dimethyl disulfide under the sliced tarp to leach into ground water.)

### Air Stagnation and Temperature Inversions

Prior to fumigation, and on a daily basis for those fumigations lasting for more than 24 hours, the National Weather Service weather forecast for the day of the application and the 48-hour period following the fumigation must be checked to determine if unfavorable weather conditions exist or are predicted (see Identifying Unfavorable Weather Conditions section) and whether fumigation should proceed.

Do not apply if an air stagnation advisory is in effect.

Do not apply if there are light wind conditions observed (under 2 mph) or if the wind speed is forecast to remain below 5 mph during the application.

Do not apply if still or stagnant wind conditions are forecast to persist for more than 18 consecutive hours after the start of the application.

Detailed local forecasts for weather conditions, wind speed, and air stagnation advisories may be obtained on-line at: <http://www.nws.noaa.gov>, on weather radio, or by contacting your local National Weather Service Forecasting Office.

#### Identifying Unfavorable Weather Conditions

Unfavorable weather conditions block upward movement of air, which results in trapping fumigant vapors near the ground. The resulting air mass can move off-site in unpredictable directions. These conditions typically exist prior to sunset and continue past sunrise and persist as late as noontime. Unfavorable conditions are common on nights with limited cloud cover and light to no wind and their presence can be indicated by ground fog or smog and can also be identified by smoke from a ground source that flattens out below a ceiling layer and moves laterally in a concentrated cloud. Measurement of wind speed can be determined by taking measurements every minute for a ten-minute period. The wind speed is the average of the one-minute measurements over this ten-minute period.

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Disclaimer: The information in this Pesticide Fact Sheet is a summary only and may not to be used to satisfy any data requirements for pesticide registration or registration review.

## GLOSSARY OF TERMS AND ABBREVIATIONS

a.i./A	Active ingredient per acre
atm·m <sup>3</sup> /mol	Atmospheres cubic meters per mole, the Henry's Law Constant
°C	Degrees Celsius
DMDS	Dimethyl disulfide
DT90	Time required for 90% of an applied chemical to dissipate
EC25	The effective concentration – the concentration of the chemical in water at which an effect is seen in 25% of the exposed population
EC <sub>05</sub>	The effective concentration – the concentration of the chemical in water at which an effect is seen in 5% of the exposed population
EC <sub>50</sub>	The effective concentration – the concentration of the chemical in water at which an effect is seen in 50% of the exposed population
EDSP	Endocrine Disruptor Screening Program
EEC	Estimated environmental concentration
EPA	Environmental Protection Agency
EUP	Experimental Use Permit
FFDCA	Federal Food, Drug and Cosmetics Act
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
g/L	Grams per liter
g/mol	Grams per mole
gal/A	Gallons per acre
GLN	Guideline Number
h	Hour(s)
HEC	Human equivalent concentration
IUPAC	International Union of Pure and Applied Chemistry
K <sub>d</sub>	Partition coefficient
lb/A	Pound per acre
LC50	Median Lethal Concentration. A statistically derived concentration of a substance that can be expected to cause death in 50% of test animals. It is usually expressed as the weight of substance per weight or volume of air or feed, e.g., mg/L, mg/kg, or ppm.
LD <sub>50</sub>	Median Lethal Dose. A statistically derived single dose that can be expected to cause death in 50 % of test animals when administered by the route indicated (oral, dermal, or inhalation). It is expressed as a weight of substance per unit weight of animal, e.g., mg/kg.
LDPE	Low-density polyethylene
LOAEL	Lowest observed adverse effect level
LOC	Level of concern
µg	Microgram(s)
µg/L	Micrograms per liter
µg/m <sup>3</sup>	micrograms per cubic meter
µg/mL	Micrograms per milliliter
µg/plate	Micrograms per plate
mmHg	Millimeters of mercury
mg/kg	Milligrams per kilogram

mg/kg/day	Milligrams per kilogram per day
mg/L	Milligrams per liter
mg/m <sup>3</sup>	Milligrams per cubic meter
mL/g	Milliliters per gram
MOE	Margin of exposure
n	Number of samplesz
NOAEL	No observed adverse effect level
PERFUM	Probabilistic Exposure and Risk model for FUMigants
pH	An approximation of the negative logarithm (base 10) of the molar concentration of dissolved hydronium ions
pK <sub>a</sub>	Dissociation constant
PPE	Personal protective equipment
ppm	Parts per million
PRZM/EXAMS	Pesticide Root Zone Model/EXposure Analysis Modeling System, Tier II surface water computer model
REI	Restricted Entry Interval
RfC	Reference concentration
RQ	Risk quotient
RUP	Restricted Use Pesticide
SCI-GROW	Screening Concentration In GROundWater, Tier I ground water computer model
torr	A unit of pressure equal to 0.001316 atmosphere
TRV	Toxicity reference value
UF	Uncertainty factor
VIF	Very impermeable film

### Studies Submitted in Support of the Registration of Dimethyl Disulfide

MRID	Citation
46903500	Cerexagri, Inc (2006) Submission of Product Chemistry, Toxicity, Environmental Fate and Residue Data in Support of the Experimental Use Permit of Dimethyl Disulfide for Use on Strawberry, Tomato, Carrot and Radish. Transmittal of 20 Studies.
46903501	Conway, S. (2006) Dimethyl Disulfide Manufacturing Process. Project Number: QC0047R0/QTR. Unpublished study prepared by Cerexagri, Inc. 17 p.
46903502	Diepenhorst, P. (2005) Dimethyl Disulfide TC, Analytical Profile of Five Batches: Final Report. Project Number: DL/05/053. Unpublished study prepared by Cerexagri, Inc. 24 p.
46903503	Bos, M. (2005) Validation of SOP DLA-256.4 Version 0 "Dimethyl Disulfide TC Determination of Water Content by GC-TCD": Final Report DL/05/039. Unpublished study prepared by Cerexagri, Inc. 29 p.
46903504	Bos, M. (2005) Validation of SOP DLA-256.1 Version 0 "Dimethyl Disulfide TC Purity by Capillary Gas Chromatography": Final Report. Project Number: DL/05/005. Unpublished study prepared by Cerexagri, Inc. 57 p.
46903505	Diepenhorst, P. (2006) Appearance of DMDS: Final Report. Project Number: DL/05/099. Unpublished study prepared by Cerexagri, Inc. 11 p.
46903506	Diepenhorst, P. (2005) Vapour Pressure, Boiling Point and Melting Point of Dimethyl Disulfide TC: Final Report. Project Number: DL/05/078. Unpublished study prepared by Cerexagri, Inc. 16 p.
46903507	Diepenhorst, P. (2006) pH 1% Aqueous Suspension of DMDS TC: Final Report. Project Number: DL/06/009. Unpublished study prepared by Cerexagri, Inc. 11 p.
46903508	Bos, M. (2005) UV/Visible, IR and MS Spectral Data of Dimethyl Sulfide TC: Final Report. Project Number: DL/05/077. Unpublished study prepared by Cerexagri, Inc. 20 p.
46903509	Diepenhorst, P. (2006) Relative Density, Solubility in Organic Solvents and Partition Coefficient Pow of DMDS: Final Report. Project Number: DL/05/098. Unpublished study prepared by Cerexagri, Inc. 20 p.
46903510	Diepenhorst, P. (2006) Water Solubility, Henry's Law Constant, Dissociation Constant in Water and Surface Tension of DMDS: Final Report. Project Number: DL/05/097. Unpublished study prepared by Cerexagri, Inc. 21 p.
46903511	Diepenhorst, P. (2006) Physical, Chemical and Technical Properties of DMDS (ATOMAL01) Batch SSUS01: Final Report. Project Number: DL/06/058. Unpublished study prepared by Cerexagri, Inc. 26 p.
46903512	Swanson, D. (2006) DMDS Soil Fumigant Formulation Process. Project Number: QC0046R0/QTR. Unpublished study prepared by Cerexagri, Inc. 12 p.
46903513	Diepenhorst, P. (2006) Physical, Chemical and Technical Properties of DMDS (ATOMAL02) Batch SSUS02. Project Number: DL/06/031. Unpublished study prepared by Cerexagri, Inc. 29 p.
46903516	Kirkpatrick, D. (2005) Acute Inhalation Toxicity Study of Dimethyl Disulfide (DMDS) in Albino Rats. Project Number: WIL/160120, WIL/160120M, WIL/160120F. Unpublished study prepared by WIL Research Laboratories, Inc. 300 p.
46903523	Nemec, M. (2005) An Inhalation Prenatal Development Toxicity Study of Dimethyl Disulfide in Rabbits: Final Report. Project Number: WIL/160119. Unpublished study prepared by WIL Research Laboratories, Inc. 400 p.

46903524	Barfknecht, T. (1985) Ames Salmonella/Microsome Plate Test (EPA/OECD) Dimethyldisulfide. Project Number: PH/301/PW/003/85. Unpublished study prepared by Pharmakon Research International, Inc. 15 p.
46903529	Nemec, M. (2005) An Acute Neurotoxicity Study of Dimethyl Disulfide in Rats: Final Report. Project Number: WIL/160118, WIL/160118N, WIL/160118F. Unpublished study prepared by WIL Research Laboratories, Inc. 1029 p.
46903530	Nemec, M. (2006) A Subchronic Inhalation Neurotoxicity Study of Dimethyl Disulfide in Rats: Final Report. Project Number: WIL/160123. Unpublished study prepared by WIL Research Laboratories, Inc. 1432 p.
46903532	Li, F. (2006) Hydrolysis of Dimethyl Disulfide in Aqueous Media. Project Number: KP/2006/02. Unpublished study prepared by Cerexagri, Inc. 116 p.
46903535	Reibach, P. (2006) Dimethyldisulfide Field Residue Study in Strawberry, Tomato, and Carrot or Radish: Final Report. Project Number: KP/2004/05, 2004/05/CA/01, 2004/05/CA/02. Unpublished study prepared by Cerexagri, Inc., Research for Hire and Agresources, Inc. 340 p.
46917000	Cerexagri, Inc. (2006) Submission of Toxicity and Fate Data in Support of the Experimental Use of Dimethyl Disulfide. Transmittal of 15 Studies.
46917001	Olson, D. (1985) DMDS: Acute Oral LD50 Study. Project Number: T/5147A. Unpublished study prepared by Product Safety Laboratories. 12 p.
46917002	Olson, D. (1986) DMDS: Acute Dermal Toxicity Limit Test. Project Number: T/6224, 12505, TR87/104. Unpublished study prepared by Product Safety Laboratories. 10 p.
46917003	Olson, D. (1985) DMDS: EPA Primary Eye Irritation. Project Number: T/5148, TR/86/117. Unpublished study prepared by Product Safety Laboratories. 14 p.
46917004	Olson, D. (1985) DMDS: EPA Primary Skin Irritation. Project Number: T/5149, TR/86/116, S/1544. Unpublished study prepared by Product Safety Laboratories. 10 p.
46917005	Olson, D. (1985) DMDS: Guinea Pig Sensitization (Buehler). Project Number: T/5151, S/1545, TR/86/119. Unpublished study prepared by Product Safety Laboratories. 16 p.
46917006	Prinsen, M. (1990) Repeated-Dose (28-Day) Dermal Toxicity Study with Dimethyl Disulfide (DMDS) in Rabbits. Project Number: V89/371. Unpublished study prepared by TNO-CIVA Toxicology and Nutrition Inst. 340 p.
46917007	Collins, C. (1992) DMDS: 90-Day Inhalation Toxicity Study in the Rat with a 4 Week Recovery Period. Project Number: 514/7. Unpublished study prepared by Hazleton Uk. 517 p.
46917008	Barker, L. (1991) Dimethyl Disulfide (DMDS) Inhalation Teratology Study in the Rat. Project Number: 514/9. Unpublished study prepared by Hazleton UK. 172 p.
46917009	Olson, D. (1990) In Vitro Assay for the Induction of Point Mutations in the HGPRT-Locus of the Chinese Hamster Ovary Cells by Dimethyldisulfide (DMDS). Project Number: V/89/257. Unpublished study prepared by Institute Civo Toxicology & Nutrition. 32 p.
46917010	Vogel, N. (1990) Chromosome Analysis of Cultured Human Lymphocytes Following in vitro Treatment with DMDS. Project Number: V/89/045. Unpublished study prepared by Institute Civo Toxicology & Nutrition. 29 p.
46917011	Bichet, N. (1990) Dimethyldisulfide: In vitro DNA Repair Test on a Rat Hepatocytes in Primary Culture. Unpublished study prepared by Sanofi Recherche. Project Number: RA860891026/PN1. 58 p.

46917012	Willems, M. (1989) Examination of Dimethyl Disulfide in the Micronucleus Test. Project Number: V/89/366. Unpublished study prepared by Institute Civo Toxicology & Nutrition. 36 p.
46917013	Kirkpatrick, D. (2006) Acute Inhalation Toxicity Study of Dimethyl Disulfide in Bobwhite Quail: Final Report. Project Number: WIL/160124. Unpublished study prepared by WIL Research Laboratories, Inc. 182 p.
46917014	Volkel, W. (2006) Adsorption/Desorption of DMDS on One Soil. Project Number: 858327. Unpublished study prepared by RCC Ltd. 60 p.
46917015	Volkel, W. (2006) Adsorption/Desorption of DMDS on Soils. Project Number: 856203. Unpublished study prepared by RCC Umweltchemie Ag. 70 p.
47052800	Arkema, Inc. (2007) Submission of Product Chemistry, Environmental Fate, Toxicity, Exposure and Risk, and Residue Data in Support of the Applications for Registration of Accolade Technical, Accolade, and Accolade EC. Transmittal of 43 Studies.
47052801	van Beijnen, A. (2005) Hazard Assessment Studies: Explosivity, Oxidizing Properties, Flash-Point and Autoflammability of Dimethyl disulfide (DMDS) TC: Final Report. Project Number: DL/05/003. Unpublished study prepared by Cerexagri B.V. 33 p.
47052802	Freedlander, R. (2007) UV-Vis Absorption Spectrum of Dimethyl Disulfide and Initial Estimation of Theoretical Photolysis Rate. Project Number: V7082/01, KP/2007/03. Unpublished study prepared by TNO Voeding. 30 p.
47052803	Reibach, P. (2007) The Calculation of the Rate Constant for the Atmospheric Gas-Phase Reaction Between Photochemically Produced Hydroxyl Radicals and Dimethyldisulfide (CAS #624-92-0) by AOPWIN v1.91. Project Number: KP/2007/02, V7082/03, 031/10822/01/01. Unpublished study prepared by TNO Voeding. 18 p.
47052804	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL01) in Stainless Steel Drums for 1 Year at Ambient Storage Conditions: Interim Report. Project Number: DL/06/037. Unpublished study prepared by Cerexagri B.V. 24 p.
47052805	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL01) in Carbon Steel Drums for 1 Year at Ambient Storage Conditions: Interim Report. Project Number: DL/06/038. Unpublished study prepared by Cerexagri B.V. 24 p.
47052806	Collins, C. (1994) DMDS: 90 Day Inhalation Immunotoxicity Study in the Rat with a 4 Week Recovery Period. Project Number: 514/11, 6630/514/11, P5003D. Unpublished study prepared by Hazleton Laboratories Europe Ltd. 280 p.
47052807	Nemec, M. (2006) A Two-Generation Reproductive Toxicity Inhalation Study of Dimethyl Disulfide in Rats: Final Report. Project Number: WIL/160122. Unpublished study prepared by WIL Research Laboratories, Inc. 3307 p.
47052808	Nemec, M. (2006) Inhalation Prenatal Developmental Toxicity Study of Dimethyl disulfide in Rats: Final Report. Project Number: WIL/160128. Unpublished study prepared by WIL Research Laboratories, Inc. 421 p.
47052809	Nemec, M. (2007) A Lactational Inhalation Phased-Exposure Study of Dimethyl Disulfide in Rats: Revised Final Report. Project Number: WIL/160126. Unpublished study prepared by WIL Research Laboratories, Inc. 904 p.
47052810	Weinberg, J. (2007) Mammalian Erythrocyte Micronucleus Assay of DMDS in Rats: Final Report. Project Number: WIL/160129. Unpublished study prepared by WIL Research Laboratories, Inc. 127 p.

47052811	Wagner, V.; VanDyke, M. (2007) Bacterial Reverse Mutation Assay: Dimethyl disulfide: Final Report. Project Number: AB40SB/503/BTL. Unpublished study prepared by Bioreliance. 59 p.
47052812	Nemec, M. (2006) A Range - Finding Inhalation Developmental Neurotoxicity Study of Dimethyl Disulfide in Rats: Final Report. Project Number: WIL/160125. Unpublished study prepared by WIL Research Laboratories, Inc. 365 p.
47052813	Gallagher, S.; Beavers, J. (2006) Dimethyl Disulfide: An Acute Oral Toxicity Study with the Northern Bobwhite. Project Number: 524/101A. Unpublished study prepared by Wildlife International Ltd. 81 p.
47052814	Scheerbaum, D. (2007) Dimethyl disulfide TC: Fish (Rainbow trout), Acute Toxicity Test, Semi-Static, 96 h. Project Number: 060109AL, FAR106601, FAR10630. Unpublished study prepared by Dr. U. Noack-Laboratorien. 38 p.
47052815	Scheerbaum, D. (2007) Dimethyl disulfide TC: Fish (Rainbow Trout), Acute Toxicity Test, Semi-Static, 96 h. Project Number: 060109AL, FAZ106301, FAZ10630. Unpublished study prepared by Dr. U. Noack-Laboratorien. 38 p.
47052816	Noack, M. (2007) Dimethyl Disulfide TC: Acute Immobilization Test (Semi-static, 48 h) to Daphnia magna. Project Number: 060109AL, DAI106301, DAI10630. Unpublished study prepared by Dr. U. Noack-Laboratorien. 38 p.
47052817	Scheerbaum, D. (2007) Dimethyl Disulfide TC: Alga, Growth Inhibition Test with Pseudokirchneriella subcapitata, 72 h. Project Number: 060109AL, SPO106301, SPO10630. Unpublished study prepared by Dr. U. Noack-Laboratorien. 44 p.
47052818	Hamwijk, C. (2007) Dimethyl Disulfide Photolysis in the Environment. Project Number: V7083/02, KP/2007/04. Unpublished study prepared by TNO. 94 p.
47052819	Conway, S.; Reibach, P. (2007) Aerobic Soil Metabolism of Dimethyl disulfide. Project Number: KP/2004/07. Unpublished study prepared by Cerexagri Inc. 100 p.
47052820	Skorzynski, S. (2007) Anaerobic Soil Metabolism of Dimethyl Disulfide. Project Number: KP/2006/24. Unpublished study prepared by Cerexagri Inc. 67 p.
47052821	Bennett, R.; Artz, S. (2007) Field Volatility of Dimethyl Disulfide (DMDS) Following Shank Application and Immediate Covering. Project Number: KP/2004/06, AR24008, 1561W. Unpublished study prepared by Cerexagri, Inc., Pacific Agricultural Research Corp. and Access Research and Consulting, Inc. 517 p.
47052822	Bennett, R.; Betz, L. (2006) Field Volatility of Dimethyl Disulfide (DMDS) Following Fumigation Using Drip Irrigation on Raised Beds. Project Number: KP/2005/03. Unpublished study prepared by Cerexagri, Inc. 1048 p.
47052823	Bennett, R.; Smyser, B. (2007) Field Volatility of Dimethyl Disulfide (DMDS) Following Fumigation Using Broadcast Shank Application. Project Number: KP/2005/05. Unpublished study prepared by Cerexagri, Inc., Pacific Agricultural Research Corp. and Access Research and Consulting, Inc. 1357 p.
47052824	Bennett, R.; Schmuckler, M. (2007) Field Volatility of Dimethyl Disulfide (DMDS) Following Shank Fumigation on Raised Beds and Immediate Covering with Tarpaulin. Project Number: KP/2005/07, AR25047, XENO6/20. Unpublished study prepared by Cerexagri, Inc., Pacific Agricultural Research Corp. and Access Research and Consulting, Inc. 1657 p.
47052827	Bennett, R.; Smyser, B. (2007) Evaluation of Workers Exposure Activities Associated with Fumigation Using Dimethyl Disulfide when Using Broadcast Shank Application. Project Number: KP/2005/06, AR25042. Unpublished study prepared by Cerexagri, Inc., Pacific Agricultural Research

	Corp. and Access Research and Consulting, Inc. 342 p.
47052828	Bennett, R. (2007) Evaluation of Worker Exposure Activities Associated with Fumigation Using Dimethyl Disulfide when Using Raised Bed, Shank Application. Project Number: KP/2005/08, AR25048, XEN06/21. Unpublished study prepared by Cerexagri, Inc., Pacific Agricultural Research Corp. and Access Research and Consulting, Inc. 361 p.
47052830	Tauber, R. (2006) Evaluation of Storage Stability Study for Dimethyl Disulfide (DMDS) on Carbon Tubes. Project Number: KP/2005/46, XEN05/81. Unpublished study prepared by ALS Laboratory Group, Environmental. 72 p.
47052831	Freedlander, R. (2007) Waiver Request for Dimethyl Disulfide Soil Dissipation Study. Project Number: KP/2007/07. Unpublished study prepared by Cerexagri, Inc. 10 p.
47052832	Piccirillo, V. (2007) Evaluation of the Subchronic Toxicity and Potential Immunotoxicity of Dimethyl Disulfide (DMDS) In Rats Following Inhalation Exposures. Project Number: VJP/3402/07/003. Unpublished study prepared by VJP Consulting, Inc. 8 p.
47052833	Piccirillo, V. (2007) Assessment of Acute and Short-To-Intermediate Toxicologic Endpoints for Dimethyl Disulfide Following Inhalation Exposures. Project Number: VJP/3402/07/005. Unpublished study prepared by VJP Consulting, Inc. 8 p.
47052834	Piccirillo, V. (2007) Summary and Evaluation of the Results from a Two-Generation Reproduction Study in Rats Following Inhalation Exposure to Dimethyl Disulfide. Project Number: VJP/3402/07/002. Unpublished study prepared by VJP Consulting, Inc. 10 p.
47052835	Bennett, R. (2007) Flashpoint of DMDS (ATOMAL02): (Accolade). Project Number: TNO/DV/2006/C287, KP/2007/05. Unpublished study prepared by TNO. 18 p.
47052836	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL02) in Stainless Steel Drums for 1 Year at Ambient Storage Conditions: Interim Report: (Accolade). Project Number: DL/06/039. Unpublished study prepared by Cerexagri B.V. 29 p.
47052837	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL02) in Carbon Steel Drums for 1 Year at Ambient Storage Conditions: Interim Report: (Accolade). Project Number: DL/06/040. Unpublished study prepared by Cerexagri B.V. 29 p.
47052838	Swanson, D. (2006) DMDS EC: Soil Fumigant Formulation Process: (Accolade EC). Project Number: QC0045R0/QTR. Unpublished study prepared by Cerexagri, Inc. 12 p.
47052839	Diepenhorst, P. (2006) Physical, Chemical and Technical Properties of DMDS (ATOMAL04) Batch SSUS04: (Accolade EC): Final Report. Project Number: DL/06/032. Unpublished study prepared by Cerexagri B.V. 30 p.
47052840	Bennett, R. (2007) Flashpoint of DMDS (ATOMAL04): (Accolade EC). Project Number: TNO/DV/2006/C288, KP/2007/06. Unpublished study prepared by TNO. 18 p.
47052841	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL04) in Stainless Steel Drums for 1 Year at Ambient Storage Conditions: (Accolade EC): Interim Report. Project Number: DL/06/041. Unpublished study prepared by Cerexagri B.V. 32 p.
47052842	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL04) in Carbon Steel Drums for 1 Year at Ambient Storage Conditions: (Accolade EC): Interim Report. Project Number: DL/06/042. Unpublished study prepared by Cerexagri B.V. 32 p.
47052843	Gilotti, A. (2007) Acute Toxic Class Determination (Oral): (Accolade EC). Project Number: MB/06/15172/01, 06/C/9006. Unpublished study prepared by MB Research Laboratories. 21 p.

47052844	Gilotti, A. (2007) Acute Dermal Toxicity/LD50 in Rats: (Accolade EC). Project Number: MB/06/15172/02, 1100A. Unpublished study prepared by MB Research Laboratories. 26 p.
47052845	Cerven, D. (2007) Acute Eye Irritation in Rabbits: (Accolade EC). Project Number: MB/06/15172/04, 1200/02. Unpublished study prepared by MB Research Laboratories. 22 p.
47052846	Cerven, D. (2007) Acute Dermal Irritation in Rabbits: (Accolade EC). Project Number: MB/06/15172/03, 1130/02. Unpublished study prepared by MB Research Laboratories. 23 p.
47075400	Cerexagri, Inc. (2007) Submission of Risk and Exposure Data in Support of the Applications for Registration of Accolade Technical, Accolade, and Accolade EC. Transmittal of 3 Studies.
47075401	Bennett, R. (2007) Evaluation of Worker Exposure During Application Activities and During Cultivation and Planting Activities After Application of Dimethyldisulfide. Project Number: KP/2004/08, AR24009, 1581W. Unpublished study prepared by Pacific Agricultural Research Corp., Access Research and Consulting, Inc. and Paragon Research Services. 331 p.
47075402	Bennett, R.; Artz, S. (2007) Evaluation of Worker Exposure Activities Associated with Application of Dimethyldisulfide When Using Drip Irrigation on Raised Beds. Project Number: KP/2005/04, AR25035, XEN05/34. Unpublished study prepared by Cerexagri, Inc., Pacific Agricultural Research Corp. and Access Research and Consulting, Inc. 315 p.
47075403	Tauber, R. (2005) Validation of Method KP-227RO for the Determination of Dimethyldisulfide from Sorbent Charcoal Tubes. Project Number: XEN0/17, KP/2005/17. Unpublished study prepared by Enviro-Test Laboratories. 111 p.
47307500	Arkema, Inc. (2007) Submission of Product Chemistry and Toxicity Data in Support of the Applications for Registration of Accolade, Accolade EC, and Accolade Technical. Transmittal of 5 Studies.
47307501	Li, F. (2007) Volatility of Dimethyl Disulfide in Aqueous Media. Project Number: KP/2007/16. Unpublished study prepared by Cerexagri, Inc. 36 p.
47307502	Cheplick, J. (2007) Exposure Assessment of Dimethyldisulfide Movement to Ground Water and Surface Water Associated with Shank Injection and Drip Irrigation on Agricultural Crops. Project Number: WEI/286/13, KP/2004/35. Unpublished study prepared by Waterborne Environmental, Inc. (WEI). 29 p.
47307503	Minderhout, T.; Kendall, T.; Krueger, H. (2007) Dimethyl Disulfide: A 96-hour Shell Deposition Test with the Eastern Oyster ( <i>Crassostrea virginica</i> ): Final Report. Project Number: 524A/118. Unpublished study prepared by Wildlife International, Ltd. 61 p.
47307504	Minderhout, T.; Kendall, T.; Krueger, H. (2007) Dimethyl Disulfide: A 96-hour Static-Renewal Acute Toxicity Test with the Sheepshead Minnow ( <i>Cyprinodon variegatus</i> ): Final Report. Project Number: 524A/117, 524/042007/SHE/96H3/100P/609. Unpublished study prepared by Wildlife International, Ltd. 55 p.
47307505	Minderhout, T.; Kendall, T.; Krueger, H. (2007) Dimethyl Disulfide: A 96-hour Static-Renewal Acute Toxicity Test With the Saltwater Mysid ( <i>Americamysis bahia</i> ): Final Report. Project Number: 524A/116A, 524/042007/MYS/96H3/100P/607. Unpublished study prepared by Wildlife International, Ltd. 56 p.
47325900	Arkema Inc. (2008) Submission of Product Chemistry Data in Support of the Application for Registration of Accolade Technical, Accolade EC and Accolade. Transmittal of 6 Studies.
47325901	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL01) in Stainless Steel Drums for 1 Year at Ambient Storage Conditions: Final Report. Project Number: DL06/037. Unpublished study prepared by Cyhexatin Task Force C/O Eif Atochem Agri SA. 25 p.

47325902	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL01) in Carbon Steel Drums for 1 Year at Ambient Storage Conditions: Final Report. Project Number: DL06/038. Unpublished study prepared by Cerexagri B.V. 25 p.
47325903	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL02) in Stainless Steel Drums for 1 Year at Ambient Storage Conditions: Final Report. Project Number: DL06/039. Unpublished study prepared by Cerexagri B.V. 31 p.
47325904	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL02) in Carbon Steel Drums for 1 Year at Ambient Storage Conditions: Final Report. Project Number: DL/06/040. Unpublished study prepared by Cerexagri B.V. 31 p.
47325905	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL04) in Stainless Steel Drums for 1 Year at Ambient Storage Conditions: Final Report. Project Number: DL06/041. Unpublished study prepared by Cerexagri B.V. 34 p.
47325906	Diepenhorst, P. (2007) Shelf-Life of DMDS (ATOMAL04) in Carbon Steel Drums for 1 Year at Ambient Storage Conditions: Final Report. Project Number: DL06/042. Unpublished study prepared by Cerexagri B.V. 34 p.
47377800	Arkema, Inc. (2008) Submission of Exposure Data in Support of the Registration of 3 Pending Products. Transmittal of 1 Study.
47377801	Blaschke, U.; Batrolome, J. (2007) Determination of Atmospheric Concentrations of Dimethyldisulphide and Occupational Exposure to Fumigators During Typical Shank Applications with Immediate Covering to Cultivated Soil in Italy, Spain and The United Kingdom in 2005. Project Number: EFA/048, EFA/048/062630. Unpublished study prepared by Huntingdon Life Sciences, Ltd. 195 p.
47381000	Arkema, Inc. (2008) Submission of Environmental Fate and Toxicity Data in Support of the Registration of Paladin Technical, Paladin and Paladin EC. Transmittal of 2 Studies.
47381001	Porch, J.; Krueger, H. (2008) Dimethyl Disulfide: A Toxicity Test to Determine the Effects of the Test Substance on Seedling Emergence of Ten Species of Plants: Final Report. Project Number: 524/102. Unpublished study prepared by Wildlife International, Ltd. 112 p.
47381002	Porch, J.; Krueger, H. (2008) Dimethyl Disulfide: A Toxicity Test to Determine the Effects of the Test Substance on Vegetative Vigor of Ten Species of Plants: Final Report. Project Number: 524/103. Unpublished study prepared by Wildlife International, Ltd. 66 p.
47471200	Arkema, Inc. (2008) Submission of Toxicity and Environmental Fate Data in Support of the Applications for Registration of Paladin Technical, Paladin and Paladin EC. Transmittal of 7 Studies.
47471201	Kirkpatrick, D. (2008) A 5-Day Inhalation Toxicity Study of Dimethyl Disulfide (DMDS) in Albino Rats with Microscopic Examination of the Upper Respiratory Tract: Final Report. Project Number: WIL/160131. Unpublished study prepared by WIL Research Laboratories, Inc. 608 p.
47471202	Porch, J.; Krueger, H. (2008) Dimethyl Disulfide: A Tier II Toxicity Test to Determine the Effects of the Test Substance on Vegetative Vigor of Ten Species of Plants: Final Report. Project Number: 524/104. Unpublished study prepared by Wildlife International, Ltd. 141 p.
47471203	Porch, J.; Krueger, H. (2008) Dimethyl Disulfide: An Acute Contact Toxicity Study with the Honey Bee: Final Report. Project Number: 524/105. Unpublished study prepared by Wildlife International, Ltd. 33 p.
47471204	Minderhout, T.; Kendall, T.; Krueger, H. (2008) Dimethyl Disulfide: A 7-Day Static Renewal Toxicity Test with Duck Weed (Lemna gibba G3): Final Report. Project Number: 524A/122. Unpublished study prepared by Wildlife International, Ltd. 71 p.

47471205	Minderhout, T.; Kendall, T.; Krueger, H. (2008) Dimethyl Disulfide: A 96-Hour Toxicity Test with the Freshwater Alga ( <i>Anabaena flos-aquae</i> ): Final Report. Project Number: 524A/123. Unpublished study prepared by Wildlife International, Ltd. 69 p.
47471206	Minderhout, T.; Kendall, T.; Krueger, H. (2008) Dimethyl Disulfide: A 96- Hour Toxicity Test with the Freshwater Diatom ( <i>Navicula pelliculosa</i> ): Final Report. Project Number: 524A/124A. Unpublished study prepared by Wildlife International, Ltd. 68 p.
47471207	Minderhout, T.; Kendall, T.; Krueger, H. (2008) Dimethyl Disulfide: A 96-Hour Toxicity Test with The Marine Diatom ( <i>Skeletonema costatum</i> ): Final Report. Project Number: 524A/125. Unpublished study prepared by Wildlife International, Ltd. 70 p.
47532200	Arkema, Inc. (2008) Submission of Exposure Data in Support of the Applications for Registration of Paladin Technical, Paladin, and Paladin EC. Transmittal of 1 Study.
47532201	Haber, L.; Parker, A.; Dourson, M. (2008) Benchmark Dose (BMD) and Categorical Regression Modeling of Acute Exposure to Dimethyl Disulfide (DMDS). Unpublished study prepared by United Phosphorus, Inc. 536 p.
47588400	Arkema, Inc. (2008) Submission of Product Chemistry Data in Support of the Applications for Registration of Paladin Technical, Paladin and Paladin EC. Transmittal of 2 Studies.
47588401	McKown, C. (2008) Literature Review - Odor Threshold of Dimethyl disulfide (DMDS). Project Number: ARKEMA/2008/01. Unpublished study prepared by Arkema, Inc. 6 p.
47588402	Tarisse, C.; Gancet, C. (2006) Measurement of DMDS' Odor Intensity Curve in Air. Project Number: TCF/06/0206/001. Unpublished study prepared by Arkema, Inc. 9 p.
47785500	Arkema, Inc (2009) Submission of Toxicity Data in Support of the Applications for Registration of Paladin EC, Paladin and Paladin Technical. Transmittal of 1 Study.
47785501	Kirkpatrick, D. (2009) A Single Exposure Inhalation Toxicity Study of Dimethyl Disulfide (DMDS) in Albino Rats with Microscopic Examination of the Upper Respiratory Tract: Final Report. Project Number: WIL/160135. Unpublished study prepared by WIL Research Laboratories, Inc. 224 p.
47786500	Arkema, Inc. (2009) Submission of Exposure and Risk Data in Support of the Application for Registration of Paladin Technical, Paladin and Paladin EC. Transmittal of 4 Studies.
47786501	Bennett, R. (2009) Evaluation of Worker Exposure During Application Activities and During Cultivation and Planting Activities After Application of Dimethylsulfide: (Addendum Report): Final Report. Project Number: KP/2004/08. Unpublished study prepared by JRF America. 127 p.
47786502	Bennett, R. (2009) Evaluation of Worker Exposure Activities Associated with Application of Dimethylsulfide when Using Drip Irrigation on Raised Beds: (Addendum Report): Final Report. Project Number: KP/2005/04. Unpublished study prepared by JRF America. 355 p.
47786503	Bennett, R. (2009) Evaluation of Worker Exposure Activities Associated with Fumigation Using Dimethylsulfide when Using Broadcast Shank Application: (Addendum Report): Final Report. Project Number: KP/2005/06. Unpublished study prepared by JRF America. 274 p.
47786504	Bennett, R. (2009) Evaluation of Worker Exposure Activities Associated with Fumigation Using Dimethylsulfide when Using Raised Bed, Shank Application: Final Report. Project Number: KP/2005/08. Unpublished study prepared by JRF America. 428 p.
47788600	United Phosphorus, Inc. (2009) Submission of Public Interest Data in Support of the Applications for Registration of Paladin Technical, Paladin and Paladin EC. Transmittal of 1 Study.
47788601	McKown, C. (2009) Public Interest Document for Paladin Technical, Paladin, Paladin EC. 1125 p.

47820000	USDA, ARS Area-Wide Pest Management Program (2009) Submission of Environmental Fate Data in Support of Risk Assessment. Transmittal of 1 Study.
47820001	Ajwa, H.; Sullivan, D.; Chellemi, D. (2009) Monitoring Chloropicrin, Dimethyl Disulfide, and Methyl Isothiocyanate Emissions from Shank Applications at Three Sites Near Tifton, Georgia. Project Number: 2009B. Unpublished study prepared by University of California and Sullivan Environmental Consulting. 148 p.
47917500	Arkema, Inc. (2009) Submission of Product Chemistry Data in Support of the Applications for Registration of Paladin Technical, Paladin, and Paladin EC. Transmittal of 1 Study.
47917501	Sances, F.; Ward, K. (2009) Determining Gas Permeability of Selected Plastic Films for the Fumigant DMDS. Project Number: ARK901. Unpublished study prepared by Pacific Agricultural Research Corp. 19 p.