

Lab Safety Plan for HVPE & HT-MOCVD Room (Rm109)

1. Basic Information

1.1 Laboratory Locations Covered by this Plan. Nanophotonics Center (Engineering & Technology Lab Building) Rm 109 (HVPE & HT-MOCVD Room).

1.2 Location of (M)SDSs, and any Other Laboratory Documents for this Room

In the Literature Holder mounted on the wall next to the door

2. Emergency Assistance Information

2.1 Group's Emergency Contact Information

Prof. Jing Li 806-401-9289

Weiping Zhao 806-317-5636

2.2 Advisors

Prof. Hongxing Jiang 806-834-5739 (Office)

Prof. Jingyu Lin 806-834-5383 (Office)

2.3 Secretary

Qing Feng 806-834-2094 (Office)

2.4 TTU Environmental Health and Safety (EH&S)

Daytime Emergencies (M-F, 8:00 am -5:00 pm) 806-742-3876

Non-daytime Emergencies (24 hrs/day, 7 days/week) 806-742-3328

2.5 TTU Emergency Maintenance

Any Time 806-742-3328

2.6 TTU Police (UPD)

Emergency 9-911

Non-Emergency 806-742-3931

3. Required Training for Working in this Room

3.1 Safety Awareness Training

3.2 Hazard Communication

3.3 Chemical Hygiene Plan Training

3.4 Laboratory Safety

4. Personal Protective Equipment

Personnel protective equipment (PPE) items are the best protection for individuals working in a laboratory.

4.1 Proper footwear and clothing. Lab coat is required for working in this room. Slippers and shoes with meshes are not allowed in this room.

4.2 Gloves are required when working with exposure to the inside of HVPE or HT-MOCVD system, including cleaning the interior of the reactors, taking out and loading sources, load samples, cleaning particle traps of the exhaust system.

4.3 It is also important to not wear gloves when using telephones, keyboards, etc. in the lab. Gloves are always single-use items and should be discarded in trash when finished

5. Standard Operating Procedures (Attached)

6. Record of Training (in the literature holder mounted on the wall next to the door)

STANDARD OPERATION PROCEDURES

FOR HVPE & HT-MOCVD SYSTEM

We require at least 1 person in HVPE, HT-MOCVD Room while operating the system.

General Operation Procedures for HVPE system

Step 1 Turn on the exhaust system (EGC 405 system) in the inside compartment.

Step 2 Make sure the gas sources, NH₃ and HCl, located in the Gas Cabinet in the inside compartment is ready to deliver. Make sure the gas sources are sufficient and free of any Alarms.

Step 3 Check if there are any Alarms showing up from the computer control program. If there are, fix them.

Step 4 Unload the susceptor from the reaction chamber. This action need the fulfillment of the following conditions: enough N₂ purge through the chamber already; the pressure of the chamber reached the atmosphere pressure. Then "Unload enable" sign on the computer control program will turn green.

Step 5 Load sample onto the susceptor. Then move the susceptor up to the process chamber.

Step 6 Modify and check through the growth recipe with the software "Recipe Editor", according to the purpose of the growth.

Step 7 Exit the process control program. Then re-open and load the modified new recipe with the process control program. Start the recipe and the material growth process.

Step 8 During the growth, the growth conditions, such as gas flow rates, temperature, pressure, susceptor rotation, need to be monitored.

Step 9 After the growth done, disconnected the power of exhaust system (EGC 405).

Step 10 Unload the susceptor and take out the sample. It is recommended to take pictures during loading and taking out the sample, for our records.

Procedure for turning on the MOCVD system

Step 1 (Very important for everyone's safety):

1. Check and make sure that exhaust fans are on and operating. If they are not on, **do not** operate MOCVD until they have been returned to operation.

Step 2 (power on the MOCVD system):

1. Turn on the chiller placed behind the MOCVD system.
2. Turn on the power supply for the RF generator.
3. Power on the main controller of the MOCVD by pushing two buttons on the right middle of the main control panel and by switching in three bar-switches on the right bottom of the main control panel.

Step 3 (pump Hydrogen purifier):

1. Turn on the small pump by pushing the S-pump button placed on the glove box.
2. Open the red valve (connecting the tube from MO sources to the small pump) located at the front of the small pump
3. Open the green valve located at near Hydrogen cylinder (behind the MOCVD).

Whenever this green valve open hydrogen cylinder has to be closing.

4. open two green valves located at up behind hydrogen purifier
5. Wait for 2 min to see the temperature increase from the front panel of hydrogen purifier
6. close two green valves in #4.
7. close the green valve in # 3 and then close the red valve in #2

8. Turn off the small pump by pushing the S-pump button.

Step 4 :

1. open the 5.0 grade Nitrogen cylinder and open the screw valve by rotating, finally adjusting outlet pressure

2. Repeat #1 for 5.0 Hydrogen and for normal nitrogen.

Step 4(Hydrogen purifier)

1. Open two red valves located at each end of oxygen trap.

2. open the green valve located at the next to the red valve after oxygen trap.

3. open the screw valve by rotating located on the front of the hydrogen purifier.

4. open the green valve located at down behind hydrogen purifier

5. set the flow rate of breed gas to around 0.5l/min. The setting valve is on the right down of the hydrogen purifier front side.

EMERGENCY PROCEDURES:

IF HYDROGEN ALARM(ON PURIFIER) SOUNDS

1. **CLOSE TMGa(if open)**

- a. Turn off Valve H1 on switch board-if in computer program switch to manual first.
- b. Close valves on TMGa source.
- c. Turn off valve H2 on switch board
- d. Same procedure for any MO Source open

2. Switch to Nitrogen flow(if hydrogen was flowing)

- a. Turn off valve A1 and open Valve A3

3. Turn off RF generator

4. Shut down Hydrogen

a. Close ultra pure hydrogen valve and bleed valve on Purifier

b. Close all Hydrogen feed valves(hand operated)

c. Close valve on Hydrogen Tank.

In case of severe Emergency call 911.

GENERAL PRECAUTIONS:

1. Never leave the machine when it is running.

2. Always check to make sure the exhaust fans are operating.

3. Always have an eye on the temperature(during high temperature growth) and on the system pressure.

4. In case of any abnormalities resort to emergency shut down.

5. Never touch the RF coil when the MOCVD is operating.
6. Always wear a robe and lab footwear and goggles while inside the MOCVD room and doing growth.
7. If you have a doubt on the operating procedures do not hesitate to ask the seniors.
8. The MOCVD ROOM IS SUPPOSED TO BE KEPT CLEAN OF DUST ALL THE TIME. Lock the door whenever you use it.

Procedures for handling the MO Sources:

1. Always use the MO sources in accordance with the Material Safety Data sheet. So go through it before you start work.
2. The MO sources are spontaneously combustible so pack them careful after use and store them in the big yellow cabinets provided for that purpose.
3. Keep the MO sources under inert atmosphere and keep their containers dry always as it is dangerous when they are wet.

TRAINING RULES FOR NEW STUDENTS IN MOCVD GROWTH

1.The training phase for a new student in the MOCVD growth typically last for about an year wherein the new student has to spend time observing a senior operate the system. The new student is required to make a note of all the controls/processes involved in the lab notebook provided.

2.Always read the Material Safety and Data Sheets before you enter the lab to watch/learn how to operate the MOCVD system.

3.When you are new, never touch or try to operate anything unless you have the go ahead from our Advisors and the person who has trained you.

4.During the training period, make sure you operate any equipment only under an experienced person's supervision. NEVER operate it even though YOU feel comfortable doing it.

5.Understand the safety precautions to be followed while dealing with the M.O.sources and the other gases that we use in the MOCVD room.

6.Be very careful when you are turning on/off any of the valves when you are new because a fraction of second in negligence and you will be putting yourself and others around you in risk.

7.Make a note of the procedures involved in operating the MOCVD in the lab note book provided to you. This should serve

as a reference manual too when you start running the machine independently.

8. Make a sketch of the MOCVD system and the gas flow lines in the lab note book so that you will understand the flow better and the important valves/lines to watch out for.

9. Always be attentive when you are in the room and do not take your eyes off the system pressure/flow meters.

10. Follow proper dress code and when in doubt always consult with the seniors.

SAFETY PRECAUTIONS FOR MOCVD SYSTEM

Do not operate an MOCVD system if you are alone in room 115. We require at least 2 people in room 115 while operating the system.

The first and foremost area where one has to be careful while operating the system is while Turning on/Turning off the system.

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MO Bubbler change procedure

The following bubbler change steps are intended to be an official record of how we change the bubblers of the MOCVD machines at our facility and also as a reference for new students who work on our MOCVD.

The bubbler change steps are explained taking TMGa (trimethyl gallium) as an example.

WEARING A LAB COAT, GLOVES, FACE MASK, SAFETY GOGGLES, AND PROPER FOOTWEAR IS A MUST

In order to change the TMGa source and replace it with a new one:

1. Pump down the gas at low pressure
2. Close both Hydrogen (H_2) and Nitrogen (N_2)
3. Open Ga-1, Ga-3 valves and the corresponding mass flow controller (MFC) keeping the butterfly valve open
4. Keep pumping down until you notice that the MFC reading becomes quite low
5. Fill with N_2 by closing the butterfly valve
6. Now open the Ga source after closing Ga-1
7. Carefully remove the TMGa source from the chiller. After it is removed from the system, weight it, and mark down the weight and the date it was taken out of the system. Carefully place it in the MO source drum and seal the drum
8. Now install the new TMGa source. Always use new washers while replacing a MO source
9. After installing the new MO source, open Ga-3 valve
10. Close N_2 and pump down
11. After a few minutes open H_2 for a few seconds and close it (keeping butterfly valve open). Repeat for 3 -4 times
12. Now close Ga-3 valve and H_2 and fill with N_2 and then close the butterfly valve



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Terra Centre – 600 Fourth Street
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Anhydrous Ammonia

MSDS Number 2001 (Revised April 23, 2008)

10 Pages

1. CHEMICAL PRODUCT and EMERGENCY TELEPHONE CONTACT

Product Name:..... Anhydrous Ammonia
Chemical Family:..... Inorganic Nitrogen Compound
Synonyms:..... Ammonia, Liquid Ammonia, Nitro-Sil, Spirit of Hartshorn, NH₃
Formula:..... NH₃
Product Use:..... Fertilizers; Fibers and Plastics; Explosives; Animal Feed; SCR NO_x Control

EMERGENCY TELEPHONE NUMBER

CHEMTREC (U.S.):..... 800-424-9300
CANUTEC (Canada):..... 613-996-6666

2. COMPOSITION/INFORMATION ON INGREDIENTS

Ingredient Name/CAS Number	Concentration	Exposure Limits
Ammonia #7664-41-7	99-100%	25 ppm TWA 35 ppm STEL 50 ppm PEL 300 ppm IDLH

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Colorless gas and liquid (liquid under pressure). Vapor is toxic and irritating to eyes, nose, throat and skin. Liquid will burn skin and eyes and cause frostbite. Vapor is flammable under limited conditions. Use water to control fire and disperse vapors. Do not put water on liquid ammonia.

NFPA Hazard Classification	Health Hazard (Blue)	3
	Flammability (Red)	1
	Reactivity (Yellow)	0

POTENTIAL HEALTH EFFECTS

Primary Routes of Entry: Inhalation, skin contact/absorption and eye contact.

General Acute Exposure: Anhydrous ammonia reacts with moisture in mucosal surfaces (eyes, skin, and respiratory tract) to produce ammonium hydroxide, which may cause caustic injury. The severity of injury depends upon the concentration and duration of exposure. The extent of injury ranges from mild cough to laryngeal edema and life-threatening pulmonary edema.

Inhalation:

Acute Exposure: Ammonia is toxic and a severe irritant of the respiratory tract. It may cause a running nose, coughing, chest pain, cessation of respiration and death. It may cause severe breathing difficulties, which may be delayed in onset. **ADDITIONAL MEDICAL INFORMATION:** Bronchospasm, laryngitis, tracheitis, wheezing, dyspnea, and laryngeal stridor may be noted. Mucosal burns to the tracheobronchial tree, Pulmonary Edema, and associated hypoxemia frequently occur following exposure to concentrated ammonia.

Skin:

Acute Contact: Ammonia is a severe irritant of the skin. Skin exposure to high concentrations of the gas may cause burning and blistering. Contact with liquid may cause severe skin burns. **ADDITIONAL MEDICAL INFORMATION:** Concentrated ammonia may produce liquefaction necrosis and deep penetrating burns.

Eye:

Acute Contact: Exposure to the eyes (>700 ppm) may cause temporary or permanent blindness. **ADDITIONAL MEDICAL INFORMATION:** Eye exposure may result in conjunctivitis, lacrimation and/or corneal irritation. Total corneal epithelial loss may occur.

Neurologic:

Acute Exposure: An altered mental status (coma) may be seen, but is not characteristic unless hypoxemia occurs.

Gastrointestinal:

Acute Exposure: Nausea and vomiting occurs frequently following ingestion. Swelling of the lips, mouth, and larynx, and oral or esophageal burns may occur if concentrated ammonia solutions are ingested.

Genitourinary:

Acute Exposure: Urinary retention may occur.

Note to the Physician: Pneumonitis should be anticipated after inhalation or ingestion. If severe exposure is suspected, observe for 48-72 hours for delayed pulmonary edema.

Carcinogenicity:

NTP: Not Listed
IARC: Not Listed
OSHA: Not Regulated

Medical Conditions Aggravated by Exposure: Chronic respiratory or skin disease

4. FIRST AID MEASURES

First Aid for Eyes: Immediately flush eyes with copious amounts of tepid water for at least 15 minutes. If irritation, pain, swelling, excessive tearing, or light sensitivity persists, the patient should be seen in a health care facility and referral to an ophthalmologist considered.

First Aid for Skin: Immediately flush exposed area with copious amounts of tepid water for at least 15 minutes followed by washing area thoroughly with soap and water. The patient should be seen in a health care facility if irritation or pain persists.

First Aid for Inhalation: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty in breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. If trained to do so administer supplemental oxygen with assisted ventilation as required. Administer artificial respiration if patient is not breathing.

First Aid for Ingestion: Call a physician. If conscious, give the patient 4 to 8 ounces of milk or water to drink immediately. Do not induce vomiting.

Caution: Clothing frozen to the skin should be thawed before being removed.

5. FIRE FIGHTING MEASURES

Flash Point:	Not Applicable
Lower Flammable Limit:	15.5 % Volume in Air
Upper Flammable Limit:.....	27.0 % Volume in Air
Autoignition Temperature.....	1204° F (651° C)

Extinguishing Media: Stopping the flow of gas rather than extinguishing the fire is usually the best procedure to follow when escaping gas is burning.

Small Fire:..... Dry chemical or CO₂

Large Fire:..... Water spray, fog or foam

Special Fire Fighting Procedures:

- a. Do not get water inside container.
- b. Move container from fire area if you can do it without risk.
- c. Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks due to exploding potential when tanks are involved in a fire.
- d. Isolate area until gas has dispersed.
- e. Use water spray or foam to control vapors.
- f. Positive pressure self-contained breathing apparatus (SCBA) should be used when there is a potential for inhalation of vapors and/or fumes.
- g. Chemical protective clothing that is safe for use with ammonia involved in a fire should be worn.

CAUTION:

- a. With proper training, structural fire fighter's protective clothing and SCBA used in conjunction with water spray will provide limited protection for short-term exposure to ammonia vapors.
- b. Liquid ammonia may cause protective equipment to become brittle.
- c. Use of welding or flame cutting equipment on or in ammonia container is not recommended unless all ammonia has been purged, rinsed with water, and any oil residue removed.

Runoff from fire control or dilution water may cause pollution.

6. ACCIDENTAL RELEASE MEASURES

Spill or Leak Measures: Stop leak if you can do so without risk. Keep unnecessary people away, isolate hazard area and deny entry. Stay upwind, out of low areas, and ventilate closed spaces before entering. Evaluate the affected area to determine whether to evacuate or shelter-in-place by taping windows and doors, shutting off outside air intakes (attic fans, etc.), and placing a wet towel or cloth over the face (if needed). With proper training, self-contained breathing apparatus (SCBA) and structural firefighter's protective clothing used in conjunction with water spray will provide limited protection in outdoor releases for short-term exposure. Fully encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire. Use water spray or foam to control vapors. Mixing of water and liquid ammonia will increase vaporization rate. Do not put water on liquid ammonia unless more than 100 volumes of water are available for each volume of liquid ammonia.

CAUTION:

- a. Personal protective clothing may become brittle when exposed to liquid ammonia.
- b. Runoff from vapor control or dilution may cause pollution.

Determining Spill Size: Generally, a small spill is one that involves a single, small container (55-gallon capacity or less), or a small (non-continuing) leak from a larger tank or vessel.

Small Spill:

- a. Flush area with flooding amounts of water.
- b. First isolate 100 feet in all directions and then protect persons downwind 0.1 miles during daylight and 0.1 miles at night.

Large Spill:

- a. Dike far ahead of liquid spill for later disposal.
- b. Follow local emergency protocol for handling.
- c. First isolate 200 feet in all directions, than protect persons downwind 0.4 miles during daylight and 1.4 miles at night.

7. HANDLING AND STORAGE

Follow the current ANSI-K61.1 Standard, "Safety Requirements for the Storage and Handling of Anhydrous Ammonia", or applicable Ammonia Manufacturing Industry Standards. (See Section 15 for information on Equipment, Pressure Vessels and Testing).

Handling Precautions: Use proper personal protective equipment when working with or around ammonia. See Section 8.

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

Respiratory Protection Requirements:

- <25 ppm: No protection required.
- 25 to 35 ppm: Protection required if the daily TWA is exceeded.
- 35 to 50 ppm: Protection required if exposed for more than 15 minutes.
- 50 to 250 ppm: Minimum of an air-purifying respirator equipped with ammonia canister(s) or cartridge(s).
- 250 to 300 ppm: Minimum of a full-face air-purifying respirator equipped with ammonia canister(s) or cartridge(s).
- >300 ppm: A fresh air supply system must be used (i.e. positive pressure self contained breathing apparatus).

Skin Protection Requirements: Skin protection is required for exposure to liquid, mist, and > 1000 ppm of ammonia gas or vapors. Neoprene or rubber gauntlet-type gloves, ammonia resistant clothing (overalls, jacket, and boots) or vapor suit, as required.

Eye Protection Requirements: Use chemical (indirectly vented) goggles when there is a potential for contact with liquid or mist. A full-face shield is recommended in addition to goggles for added protection.

Other Protective Equipment: Safety shower and eyewash fountain should be provided in the ammonia handling area. In agricultural distribution, provide easily accessible shower and/or at least 100 gallons of clean water in open top container (check regulations). When transporting, provide at least 5 gallons of readily accessible, clean water and personal protective equipment.

Engineering Controls: Maintain adequate ventilation to keep ammonia concentrations below applicable standards when possible.

NOTE: See Section 2 for regulatory exposure limits.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical Form:	Gas (liquid under pressure)
Color:	Colorless gas and liquid, forms white vapor in contact with moisture
Odor:	Strong pungent penetrating odor, ammonia.
Boiling Point:	-28.1° F (-33° C) at 1 atm
Melting point:	-107.9° F (-78° C)
Ph:	Approximately 12.0 (neat)
Solubility:	510 - 530 g/L @ 20° C
Specific Gravity:	0.6818 @ -33.35° C and 1 atm
Vapor Density:	0.597 @ 0° C (0.60 @ 60° F)
Vapor Pressure:	7,600 mm Hg @ 25° C (93 psig @ 60° F)
% Volatile by Volume:	100
Molecular Weight:	17.03
Density:	0.696 g/L @ 20° C (5.14 lb./gal. @ 60° F)
Critical Temperature:	271° F (133° C)
Critical Pressure:	1636 psia

10. REACTIVITY

Stability: This is a stable material.
Hazardous Polymerization: Will not occur.

Decomposition: Hydrogen is released on heating above 850° F (454° C). The decomposition temperature may be lowered to 575° F (300° C) by contact with certain metals such as nickel. At 1290° F (690° C) or in the presence of an electric spark, ammonia decomposes into nitrogen and hydrogen gases, which may form a flammable mixture in the air.

Incompatibilities:

- Ammonia has potentially explosive or violent reactions with interhalogens, strong oxidizers, Nitric Acid, Fluorine, and Nitrogen Oxide.
- Ammonia forms sensitive explosive mixtures with air and hydrocarbons, Ethanol and Silver Nitrate, and Chlorine; and explosive products are formed by the reaction of ammonia with Silver Chloride, Silver Oxide, Bromine, Iodine, Gold, Mercury, and Tellurium Halides.
- Ammonia is incompatible or has potentially hazardous reactions with Silver, Acetaldehyde, Acrolein, Boron, Halogens, Perchlorate, Chloric Acid, Chlorine Monoxide, Chlorites, Nitrogen Tetroxide, Tin, and Sulfur.

NOTE: The incompatibilities above are a partial list taken from two books by Sax & Lewis: "Dangerous Properties of Industrial Materials", 7th. ed., 1989 and "Hawley's Condensed Chemical Dictionary", 11th. ed. 1987, both published by Van Nostrand Reinhold Company, New York. It is recommended that if additional information is required, the reader refer to these and other published information.

11. TOXICOLOGICAL INFORMATION

Toxicity

Acute Inhalation Toxicity

LC₅₀ Rat, mouse:..... 4,200 - 19,060 mg NH₃/m³ (1 hr)

Acute Toxicity, Other Routes

LC₅₀ Rat, mouse:..... 45.5 - 195.1 mg NH₃/kg bw (I hr intravenous)

Corrosiveness / Irritation

Skin Irritation / Corrosion:..... Corrosive to skin

Eye Irritation / Corrosion:..... Subacute and chronic exposure to 200 – 1,000 ppm produced eye damage. 100 – 200 ppm produced moderate to severe irritation.

Repeated Dose Toxicity

Rats, guinea pigs, rabbits, etc:.....No mortality (Inhalation up to 770 mg/m³)

Genetic Toxicity *in vitro*

Salmonella typhimurium, etc:.....Negative (Bacterial gene mutation assay)

Chick fibroblasts:.....Induced chromosomal clumping, polyploidy, and arrested spindle formation. No data showing that ammonia is mutagenic in mammals. (Cytogenetic assay)

Genetic Toxicity *in vivo*

Drosophila melanogaster:.....No evidence for mutagenicity

Carcinogenicity

All:.....No carcinogenic effects

Toxicity to Reproduction

Pig:.....Temporarily depressed mean daily gain (MDG) at 35 mg/kg in gilts (One generation study)

Human Experience

Inhalation, human volunteers:.....Nasal and pulmonary irritation at concentrations of about 100 ppm and higher.

Ecotoxicity

Acute Toxicity to Fish

LC₅₀ Many species:..... 0.09 – 3.51 mg un-ionized NH₃/L (96 hr)

Acute Toxicity to Aquatic Invertebrates

LC₅₀ *Daphnia magna*:..... 2.94 mg un-ionized NH₃-N/L (48 hr)

Toxicity to Aquatic Plants

LOEC Benthic diatoms:..... 0.5 – 1.0 mg N/L (Up to 25 days)

LOEC *Chlorella vulgaris*:..... 500 mg N/L (21 days)

Toxicity to Bacteria

EC₅₀ *Photobacterium phosphoreum*:..... 1.49 mg un-ionized NH₃/L (5 min)

Chronic Toxicity to Fish

NOEC Many species:0.025 – 1.2 mg un-ionized NH₃/L (Varied 12 days – 5 years)

Chronic Toxicity to Aquatic Invertebrates

NOEC *Daphnia magna* and others:.....0.163 – 0.42 mg un-ionized NH₃/L (Varied 21 days – 76 weeks)

Toxicity to Terrestrial Plants

LOEC Many species3 – 250 ppm (Varied 4 min – 16 hrs)

Toxicity to Other Non-Mammalian Terrestrial Species

LD₅₀ *G. Domesticus*:.....2.72 mM (1 hr injections)

Source: TFI Product Testing Program April 2003

12. ECOLOGICAL INFORMATION

- a. Ammonia is harmful to aquatic life in very low concentrations and may be hazardous if it enters water intakes.
- b. Local health and wildlife authorities, as well as operators of water intakes in the vicinity, should be notified of water releases.
- c. Waterfowl toxicity may occur at elevated concentrations.
- d. Ammonia does not concentrate in the food chain.
- e. The conversion of ammonia to nitrites/nitrates by bacteria in aquatic systems can reduce the concentration of dissolved oxygen (referred to as nitrogenous oxygen demand).

Effect on water treatment process: Chlorination will produce chloramines, which are more readily detected by taste and odor.

Note: See Ecotoxicity information in section 11.

13. DISPOSAL CONSIDERATIONS

Reclaim as fertilizer if possible. Waste must be disposed of in accordance with federal, state, and local environmental control regulations.

14. TRANSPORTATION INFORMATION

U.S. DOT and Canadian TGD Act

Shipping Name:..... Ammonia, anhydrous

Shipping Class/Division:..... 2.2 (U.S.); 2.3 (8) (Canada)

Hazard Class: Non-Flammable Gas (U.S.); Toxic Gas (Canada)

Product Identification Number (PIN): UN1005

DOT Placard: Non-Flammable Gas 2.2, color: green (U.S.); Class 2.3 or UN1005, color: white (Canada)

DOT Special Provision: 13, "Inhalation Hazard"

OSHA Label Required: Yes

RQ (Reportable Quantity):..... 100 pounds

STCC Number: 4904210

15. **REGULATORY INFORMATION**

Controlled Products Regulations Classification: A: Compressed Gas; E: Corrosive

OSHA: This product is considered a hazardous material under criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1910.1200 (Toxic; Corrosive), and is listed as a Highly Hazardous Chemical subject to the requirements of the Process Safety Management Standard 29 CFR 1910.119.

CAA Chemical Accident Prevention: Ammonia is considered a regulated substance subject to the Chemical Accident Prevention provisions of 40 CFR Part 68. The threshold quantity for this substance is 10,000 lbs.

SARA TITLE III:

- a. EHS (Extremely Hazardous Substances) List: Listed (EPA, 1992a)
- b. SARA RQ (Reportable Quantity): 100 pounds
- c. TPQ (Threshold Planning Quantity): 500 pounds
- d. Regulation: "Emergency Planning and Notification" - 40 CFR Part 355 (Appendices A and B).
- e. Section 313: "Specific Toxic Chemical Listings" - 40 CFR Part 372
Ammonia is subject to the reporting requirements of Section 313 "Specific Toxic Chemical Listings" 40 CFR Part 372. Terra is required by 40 CFR 372.45 to notify certain customers as to which of its mixture or trade name products contain those chemicals. The purpose of that notification is to ensure that facilities that may be subject to the reporting requirements of Section 313 and that use products of unknown formulation will have knowledge that they are receiving products that contain chemicals subject to those reporting requirements.

CERCLA Hazardous Substances List:

- a. CERCLA RQ (Reportable Quantity): 100 pounds
- b. Regulation: "Designation, Reportable Quantities, Notification" - 40 CFR 302

TSCA Inventory: Listed (RTECS)

Chemical Facility Anti-Terrorism Standard (CFATS) / 6 CFR Part 27:

Ammonia (anhydrous) is listed in Appendix A as a Chemical of Interest (COI) due to threat of "Release"

Screening Threshold Quantity (STQ): 10,000 pounds

Equipment, Pressure Vessels, Testing, Etc.: All equipment used to handle, store, transfer or apply anhydrous ammonia must be properly engineered, constructed and maintained in compliance with all applicable regulations and standards. Pressure vessels, piping and appurtenances should be regularly inspected and tested using methods designed to reveal external and internal deterioration or defects that may impair the integrity of the equipment such that an unintended release of anhydrous ammonia may result. Consult with your State Department of Agriculture and other experts, as applicable, concerning the methods that would be most appropriate given the particular circumstances. Refer to 29 CFR 1910.111, *Storage and Handling of Anhydrous Ammonia*; 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Materials*; and the current ANSI standard K61.1, *Safety Requirements for the Storage and Handling of Anhydrous Ammonia*, for additional information.

16. OTHER INFORMATION

- Dec. 18, 1995: The MSDS was rewritten to comply with ANSI Standard Z400.1-1993.
- July 1, 2003: Added toxicity information from the TFI Product Testing Program April 2003.
- October 4, 2006: Added NFPA hazard classification information and updated isolation / protective action distances per ERG 2004.
- Dec. 19, 2006: Added Equipment, Pressure Vessel and Testing Information.
- August 24, 2007: Reviewed and revised.
- January 2, 2008: Revised 15. Regulatory Information to add CFATS requirements
- April 23, 2008: Revised 14. Transportation Information to change Canadian TDG requirements

The information and recommendations herein are taken from data contained in independent, industry-recognized references including but not limited to NIOSH, OSHA, ANSI, NFPA, DOT ERG, the TFI Product Testing Program, Global Engineering Documents, MEDITEXT, HAZARDTEXT, SARATEXT, CHRIS, OHM/TADS, and IRIS. Terra Industries Inc. makes no guarantee, warranty or other representation concerning this substance, since conditions of its use are beyond the control of the company. Terra Industries Inc. disclaims any liability for loss or damage incurred in connection with the use of this substance.



CP2MG SSG (BIS CYCLOPENTADIENYL MAGNESIUM)

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Product name CP2MG SSG (BIS CYCLOPENTADIENYL MAGNESIUM)	Chemical description Bis(cyclopentadienyl)magnesium
Synonym CP2MG Select Semiconductor Grade	Chemical formula (C5 H5)2 Mg
CAS number 1284-72-6	Chemical family Magnesium alky
Supplier Akzo Nobel Polymer Chemicals LLC 300 South Riverside Plaza Chicago, IL 60606 USA	
Medical/Handling Emergency + 1-914-693-6946 Dobbs Ferry, NY USA	Transportation Emergency CHEMTREC - USA: 1-800-424-9300 CANUTEC - CANADA: 1-613-996-6666
Product use Semiconductors	Product/technical Information 1-800-828-7929
Date of first issue - -	Date of last issue / Revision # 10-20-2000 / 1.00

2. COMPOSITION/INFORMATION ON INGREDIENTS

Ingredient	Percentage(s)	CAS number
Bis(cyclopentadienyl)magnesium (Cp2Mg)	100.00	1284-72-6

3. HAZARDS IDENTIFICATION

Emergency overview White crystals. DANGER! EXTREMELY FLAMMABLE. CATCHES FIRE IF EXPOSED TO AIR. CAUSES SKIN AND EYE BURNS. REACTS VIOLENTLY WITH WATER. Metal alkyls are pyrophoric. The metal alkyl reacts spontaneously with air and/or moisture resulting in ignition. In case of fire, reignition of the metal alkyl may occur after the fire has been extinguished.
Health effects Skin and eye contact are the primary routes of exposure to this product. Inhalation of the metal alkyl in this product is unlikely due to the highly reactive nature of the metal alkyl with air and its low vapor pressure. This material will react with moisture in or on the skin to produce thermal burns. This product will react with moisture in the eyes to produce severe thermal burns. Ingestion will result in burning of the mouth, throat and any part of the gastrointestinal system with which the material comes in contact. Nausea and vomiting may occur.

Carcinogenicity	
Description	Applicable
IARC	no
NTP	no



CP2MG SSG (BIS CYCLOPENTADIENYL MAGNESIUM)

OSHA	no
ACGIH	no

4. FIRST AID MEASURES

Inhalation

Remove victim to fresh air while protecting yourself from exposure with an appropriate respirator. Remove any contaminated clothing to prevent further inhalation exposure. Use gloves to avoid contaminating yourself. If not breathing, clear victim's airway and start artificial respiration. Avoid inhaling expired air. Artificial respiration may be supplemented by the use of a bag-mask respirator or manually triggered oxygen supply capable of delivering one liter per second or more. If victim is breathing, supplemental oxygen may be given from a demand-type or continuous-flow inhaler, preferably with a physician's advice. Monitor breathing and pulse. If victim stops breathing, restart artificial respiration. If heart has stopped, begin cardiopulmonary resuscitation immediately. Keep person warm and at rest. Get medical attention immediately.

Skin

Immediately, without delay, very gently blot excess chemical from skin while wearing impervious gloves and air tight safety goggles. If victim is wearing air tight safety goggles, do not remove them. Take care not to contaminate the victim's healthy skin and eyes. Wash all affected areas with plenty of water for at least 15 minutes. Do not break open blisters or remove skin. If clothing is stuck to the skin after flushing with water, do not remove it. Do not attempt to neutralize with chemical agents. Wash or discard contaminated clothing and shoes. Obtain medical advice immediately.

Eye

Immediately flush eyes with large quantities of running water for a minimum of 15 minutes. If the victim is wearing contact lenses, remove them. Take care not to contaminate the victim's healthy skin and eyes. Hold the eyelids apart during the flushing to ensure rinsing of the entire surface of the eye and lids. DO NOT let victim rub eye(s). Do not attempt to neutralize with chemical agents. Get medical attention immediately. Oils or ointments should not be used at this time. Continue flushing for an additional 15 minutes if a physician is not immediately available.

Ingestion

Do NOT induce vomiting. Call a physician or a poison control center immediately. Give victim plenty of water to drink. Never give anything by mouth to an unconscious or convulsing person. Get medical attention immediately.

Note to physician

There are no data available that address medical conditions that are generally recognized as being aggravated by exposure to this product.

Attending physician should treat exposed patients symptomatically. Treat thermal burns, if present. Flush eyes with buffered or plain irrigating solutions. If any ulceration or conjunctival injury is present, have an ophthalmologist examine the patient.

5. FIRE-FIGHTING MEASURES

Flash point Pyrophoric! (ignites in air.)	Autoignition temperature Ignites spontaneously in air
Flash Method N/A	Explosion limits lower: N/D upper: N/D
Extinguishing media THE MOST EFFECTIVE FIRE EXTINGUISHING AGENT IS DRY CHEMICAL POWDER PRESSURIZED WITH NITROGEN. Vermiculite or dry sand may also be used. CAUTION: REIGNITION MAY OCCUR. DO NOT USE FOAM, WATER (except as explained below), CARBON TETRACHLORIDE OR CHLOROBROMOMETHANE extinguishing agents as product either reacts violently or liberates toxic fumes and vapors on contact with these agents.	



CP2MG SSG (BIS CYCLOPENTADIENYL MAGNESIUM)

Fire fighting procedures

Protecting against fire by strict adherence to safe operating procedures and proper equipment are the best ways to minimize the possibility of fire damage. Immediate action should be taken to confine the fire. All lines and equipment which could contribute to the fire should be shut off.

Standard fireman's bunker gear is recommended for fighting metal alkyl fires. If the fire cannot be controlled with extinguishing agents, keep a safe distance, protect adjacent property and allow burn until consumed.

Human exposure must be prevented and nonessential personnel evacuated from the immediate area.

Breathing vapors from metal alkyl/hydrocarbon fires should be avoided by using proper respiratory equipment.

A NIOSH approved, positive-pressure/pressure demand, air-supplied, full-face respirator should be used.

Fire and explosion hazards

Metal alkyls are pyrophoric. The metal alkyl reacts spontaneously with air and/or moisture resulting in ignition. In case of fire, reignition of the metal alkyl may occur after the fire has been extinguished.

This material reacts with air, water and compounds containing active hydrogen such as alcohols and acids.

Compounds containing oxygen or organic halide may react upon contact with this product.

Do not cut, grind, drill or weld on or near the container (even empty) of this product because an explosion may result. Keep away from heat, sparks and flame.

Hazardous products of combustion

Products of complete combustion are carbon dioxide, water and magnesium oxide. Additionally, products of incomplete combustion may include carbon monoxide, elemental carbon and hydrocarbons (alkanes and alkenes).

NFPA ratings

Hazard	Rating
Health	3
Flammability	3
Reactivity	3
Other	-W

6. ACCIDENTAL RELEASE MEASURES

Methods for cleaning up

Appropriate personal protective equipment (PPE) should be worn while working with spilled material. Block off source of spill. Spilled material will likely give off smoke and fumes. Ignition may occur immediately.

Spill may be washed away cautiously with large quantities of water. Use water spray to reduce vapors.

CAUTION: Water may cause ignition/ reignition to occur. Dike water for later disposal. Do not allow contaminated water to enter waterways.

7. HANDLING AND STORAGE

Handling

Electrically grounded tanks and containers should always be used as should non-sparking, electrically grounded hand tools and appliances. Ground or bond to ground all vessels when transferring to prevent the accumulation of static electricity. See National Electric Code.

Storage

Store under an inert atmosphere. Nitrogen with less than 5 ppm each moisture and oxygen is recommended.

Containers should be stored in a cool, well-ventilated area away from flammable materials and sources of heat.

Exercise due caution to prevent damage or leakage from the container.

Maximum storage temperature

not determined

General comments

Under inert conditions the product is not corrosive to metals commonly used in construction. Some plastics and elastomers may be attacked. Contact Akzo Nobel Polymer Chemicals LLC for specific recommendations regarding suitable materials for use with this product.



CP2MG SSG (BIS CYCLOPENTADIENYL MAGNESIUM)

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Respiratory protection

This material is normally handled under nitrogen and closed process conditions. In an emergency where adequate ventilation is not available and conditions could generate fume, mist or aerosol, inhalation must be prevented through the use of NIOSH-approved organic vapor/ acid gas respirators with dust, mist and fume filters to reduce potential for exposure. Where exposure potential necessitates a higher level of protection, use a NIOSH-approved, positive-pressure/ pressure-demand, air-supplied respirator.

When using respirator cartridges or canisters, they must be changed frequently (following each use or at the end of the workshift) to assure breakthrough exposure does not occur.

Skin protection

Skin contact must be prevented through the use of fire-retardant clothing. During sampling, disconnecting lines or opening connections, additional protective outerwear including a full-face shield, impervious gloves, aluminized suit, a hard hat, steel toed safety shoes that cover the ankles and chemical safety glasses should also be worn.

Eye protection

Because eye contact with this product may cause severe and possibly permanent damage, chemical goggles and/or a full face shield must be worn whenever handling this product.

Ventilation protection

This material is normally handled under closed process conditions.

Other information

This product should not be used until all personnel handling it have been thoroughly trained. Contact Akzo Nobel Polymer Chemicals LLC, Chicago, IL. Additional information on safety and handling of organometallics is available in the Akzo Nobel Polymer Chemicals LLC brochure on metal alkyls.

During the development of safe handling procedures, consideration should be given to the need for cleaning of equipment and piping systems to render them nonhazardous before maintenance and repair activities are performed. Waste resulting from these procedures should be handled in an environmentally safe manner.

All food and smoking materials should be kept in a separate area away from the storage/use location. Eating, drinking and smoking should be prohibited in areas where there is a potential for exposure to this material. Before eating, hands and face should be thoroughly washed.

Safety showers, with quick opening valves which stay open, and eye wash fountains, or other means of washing the eyes with a gentle flow of cool to tepid tap water, should be readily available in all areas where this material is handled or stored. Water should be supplied through insulated and heat-traced lines to prevent freezeups in cold weather.

Applicable exposure limits

Other than any exposure limits which may be displayed in Section 8, there are no other known exposure limits applicable to this product.

Agency	Value/Unit of measurement
PEL = Permissible Exposure Limit TLV = Threshold Limit Value TWA = Time Weighted Average STEL = Short Term Exposure Limit CEIL = Ceiling Exposure Limit REL = Recommended Exposure Limit WEEL = Workplace Environmental Exposure Limit IDLH = Immediate Dangerous to Life and Health	

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor White crystals.	pH value not determined
Odor threshold (ppm) not determined	Relative vapor density (air=1) not determined



CP2MG SSG (BIS CYCLOPENTADIENYL MAGNESIUM)

Volatile % approx. 100 % by weight	Vapor pressure (mm Hg) approx. 0.043 @ 25 C
Boiling point/range > 572.00 °F 300.00 °C @ 760 mm Hg (Decomposes)	Evaporation rate not determined
Melting point/range 348.80 °F 176.00 °C	
Cloud point not determined	Pour point not determined
Flash point Pyrophoric! (ignites in air.)	Solubility in water Reacts violently
Flash method N/A	Solubility in other solvents Miscible in sat hydrocarbons
Autoignition temperature Ignites spontaneously in air	
Specific Gravity/Density not determined	Partition coefficient n-octanol/water not determined
Bulk density not determined	
	Explosion limits lower: N/D upper: N/D

10. STABILITY AND REACTIVITY

Stability This product is stable when stored under a dry, inert atmosphere and away from heat. Nitrogen containing less than 5 ppm each moisture and oxygen is recommended. This product is not sensitive to impact.
Incompatibilities This product may react violently with air, water, and compounds containing active hydrogen such as alcohols and acids. Compounds containing oxygen or organic halide may react vigorously upon contact with the product.
Polymerization Hazardous polymerization is not expected to occur.
Decomposition Magnesium alkyls from Akzo Nobel Polymer Chemicals LLC are thermally stable products. Most show little or no decomposition at temperatures at least up to 140 C (284 F). Products of thermal decomposition include magnesium hydride and olefins.
Conditions to avoid Avoid contact with incompatible material, excessive heat and flames.

11. TOXICOLOGICAL INFORMATION

Oral LD50	Ingestion toxicity data are not available for this product.
Dermal LD50	Dermal toxicity data are not available for this product.
Inhalation LC50	Inhalation toxicity data are not available for this product.
Skin	Chronic dermal exposure effects for this product are not known. Skin contact with this product will cause severe chemical burns.



CP2MG SSG (BIS CYCLOPENTADIENYL MAGNESIUM)

Eye	The acute eye effects of this product have not been determined. However, severe chemical and thermal burns can occur and may cause permanent eye damage.
Chronic toxicity/carcinogenicity	<p>Chronic ingestion effects of this product are not known. Ingestion will result in burns of the mouth, throat, esophagus and digestive tract.</p> <p>Chronic inhalation exposure effects for this product are not known.</p> <p>The carcinogenic/mutagenic properties of this product are not known.</p> <p>The reproductive toxicity of this product is not known.</p> <p>The neurotoxic effects of this product are not known.</p> <p>Overexposure to this product may affect the skin, eyes and respiratory system.</p>
Other toxicological information	No other toxic effects for this product are known.

12. ECOLOGICAL INFORMATION

Ecotoxicological information	The ecological toxicity of this product is not known.
Bioaccumulation	Chemical fate information on this product is not known.
Other information	Other ecological information on this product is not known.

13. DISPOSAL CONSIDERATIONS

<p>Waste disposal in accordance with regulations</p> <p>Incineration by controlled feed of air and product is a suitable disposal procedure. Alternately, deactivation can be achieved by diluting the product with hydrocarbon (heptane, etc.) to less than 5 weight percent metal alkyl concentration and treating the hydrocarbon solution with water under a nitrogen atmosphere in a vented and agitated container. Always add the diluted metal alkyl solution to a large excess of water. Allow for the generation of heat and flammable hydrocarbons when treating with water. Conduct water treatment in the absence of air to avoid possible ignition of flammable material. The products from hydrolysis are hydrocarbons and magnesium oxide.</p> <p>Consult RCRA hazardous waste regulations prior to deactivation for potential treatment permitting considerations.</p> <p>Should the unused product become a waste material, it would meet the characteristics of an ignitable and reactive waste per 40 CFR 261, Subpart C. It is the responsibility of the waste generator to determine if his wastes are hazardous by characteristics or listing.</p> <p>Note: A technical bulletin (No. 95-90) is available from Akzo Nobel Polymer Chemicals LLC describing details of disposal of laboratory quantities of metal alkyls.</p>
<p>Container disposal</p> <p>Bubbler cylinders containing residue are returnable to Akzo Nobel Polymer Chemicals LLC, 730 Battleground Road, Deer Park, TX 77536. Return shipments of containers are to be in compliance with DOT regulations.</p>



CP2MG SSG (BIS CYCLOPENTADIENYL MAGNESIUM)

14. TRANSPORT INFORMATION

Shipping description	METAL ALKYLs, WATER-REACTIVE, N.O.S. (BIS(CYCLOPENTADIENYL)MAGNESIUM) 4.2; UN2003; I North American Emergency Response Guide NO. 135
Required labels	Primary Label: SPONTANEOUSLY COMBUSTIBLE Subsidiary Label: DANGEROUS WHEN WET
Environmentally hazardous substance	This product does not contain an environmentally hazardous substance per 49 CFR 172.101, Appendix A.

15. REGULATORY INFORMATION

Products and/or components listed below are subject to the following:

Hazard classes	
Description	Applicable
HMIS Hazard Rating Source	HMIS
HMIS Health	3
HMIS Flammability	3
HMIS Reactivity	3
WHMIS Hazard Class	B-6; D-2B; E; F

Other regulatory information
 Bis(cyclopentadienyl)magnesium is on the TSCA inventory.

16. OTHER INFORMATION

Other information
 No other information is available.

Created by
 PRODUCT SAFETY 914/674-5000

The information in this material safety data sheet should be provided to all who will use, handle, store, transport or otherwise be exposed to this product. All information concerning this product and/or suggestions for handling and use contained herein are offered in good faith and are believed to be reliable as of the date of publication. However, no warranty is made as to the accuracy of and/or sufficiency of such information and/or suggestions as to the merchantability or fitness of the product for any particular purpose, or that any suggested use will not infringe any patent. Nothing in here shall be construed as granting or extending any license under any patent. Buyer must determine for himself, by preliminary tests or otherwise, the suitability of this product for his purposes, including mixing with other products. The information contained herein supersedes all previously issued bulletins on the subject matter covered. If the date on this document is more than three years old, call to make certain that this sheet is current.

MATERIAL SAFETY DATA SHEET

Date prepared: November 9, 1999

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1. Product and Company Identification

PRODUCT IDENTIFIER: **Triethylborane (TEB)**

PRODUCT USE: Chemical intermediate

MANUFACTURED BY: Callery Chemical Company
Division of Mine Safety Appliances Company
PO Box 429; Pittsburgh, PA 15230
Callery Customer Service: 1-412-967-4141
Callery 24-Hour Telephone: 1-412-967-4100
Transportation Emergency: 1-800-424-9300 in USA or 1-703-527-3887 outside USA

2. Composition/Information on Ingredients

	<u>wt%</u>	<u>Synonym(s)</u>
Triethylborane (CASRN: 97-94-9)	>99 wt%	TEB

OSHA REGULATORY STATUS: Hazardous by definition of Hazard Communication Standard, 29 CFR 1910.1200.

Indications of danger (Annex II): Highly flammable, Harmful

Nature of special risk attributed to dangerous substances (Annex III): R17, R34, R22

Safety advice concerning dangerous chemical substances (Annex IV): S6, S7/8, S23, S36, S43, S33

3. Hazards Identification

EMERGENCY OVERVIEW: Clear, colorless liquid with pungent odor. Pyrophoric liquid. Extremely flammable. Catches fire if exposed to air. Causes severe eye, skin, and respiratory tract burns. Vapor may cause respiratory tract irritation and central nervous system effects such as excitation. Harmful if swallowed.

PHYSICAL HAZARDS: Pyrophoric liquid. Extremely flammable. Catches fire if exposed to air.

POTENTIAL HEALTH EFFECTS: Causes eye, skin, and respiratory tract burns.

Primary Routes of Entry: Eye and skin contact, inhalation, ingestion

Target Organs: Eyes, skin, respiratory tract, central nervous system

Medical Conditions Generally Recognized as Aggravated by Exposure: Persons with preexisting skin and respiratory conditions may be more susceptible to the effects of this product.

Carcinogenicity: Triethylborane is not listed in the National Toxicology Program (NTP) Annual Report on Carcinogens, not found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs, and not listed as an OSHA carcinogen.

POTENTIAL ENVIRONMENTAL EFFECTS: No environmental toxicity data for the product.

4. First Aid Measures

CAUSES THERMAL BURNS! SEND TO A PHYSICIAN IN ALL CASES.

Eyes: Immediately flush eyes with plenty of water for at least 20 minutes while holding eyelids open.

Skin: Immediately flush skin with plenty of cool water for at least 20 minutes while removing contaminated clothing and shoes. Dispose of contaminated clothing and shoes in compliance with all local, state, and federal laws and regulations.

Ingestion: For any accidental contamination of the mouth, gargle with water and rinse mouth thoroughly for at least 20 minutes. If swallowed, do not induce vomiting. Give demulcent such as milk, olive oil, or margarine in small amounts up to 2 or 3 ounces. Never give anything by mouth to an unconscious person.

Inhalation: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.

(TEB)

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5. Fire Fighting Measures

FLAMMABLE PROPERTIES: Pyrophoric liquid. Extremely flammable. Catches fire if exposed to air.

Flashpoint (Setaflash closed cup): <0°C/<32°F

Flammable Limits: Spontaneous ignition in air at partial pressures of approximately one mm Hg (1300 ppm)

Autoignition Temperature: -20°C/-4°F

EXTINGUISHING MEDIA: Shut off source as soon as possible without risk. Control and confine the fire. Use water spray to control heat and protect equipment. If practical, allow fire to burn itself out. Temporary control may be obtained with foam, water spray, dry chemical, or carbon dioxide; but TEB may reignite when extinguisher is discontinued. DO NOT use halogenated fire extinguishing agents.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Catches fire if exposed to air. Detonations or violent reactions may occur when mixed with strong oxidizing agents or halogenated hydrocarbons. TEB floats on water and use of water as an extinguishing agent may spread the fire. TEB burns with a green and yellow flame and produces a dense black smoke.

PROTECTION OF FIRE FIGHTERS: Wear full protective clothing, including protective gloves and boots. For respiratory protection, wear a NIOSH approved self-contained breathing apparatus with full facepiece operated in a positive-pressure mode.

6. Accidental Release Measures

PROCEDURES FOR CLEANUP: Wear recommended personal protective equipment. Be prepared to fight fire.

Eliminate ignition sources. Spills of TEB will ignite. See Section 5, "Fire Fighting Measures". Properly dispose of all residues immediately. Handle in compliance with all local, state, and federal laws and regulations.

7. Handling And Storage

HYGIENIC PRACTICES: Do not get in eyes, on skin, or on clothing. Wash thoroughly after handling. Keep container tightly closed. Do not breathe vapor or mist. Use only with adequate ventilation. Do not take internally.

STORAGE: Do not expose to air. Handle and store in a DRY closed system under DRY nitrogen gas. Do not store residues. Properly dispose of all residues immediately.

WORK PRACTICES: Keep away heat, sparks, flame, air, oxidizers, halogenated hydrocarbons, and combustible materials. Do not expose to air. Handle and store in a DRY closed system under DRY nitrogen gas in a cool, dry, well-ventilated area. Use only with clean, completely enclosed systems that have been purged with DRY nitrogen gas to inert containers, transfer lines, vessels, tanks, etc., such that the atmosphere stays below 3% oxygen. Use packless valves, welded piping, and other leakproof construction. Maintain a leakproof system. Use non-sparking tools when opening or closing containers. Bond and ground all systems when handling. Since empty containers retain product residue, follow label warnings even after container is emptied.

PROTECTIVE MEASURES DURING REPAIR AND MAINTENANCE OF CONTAMINATED EQUIPMENT: See Section 8.

8. Exposure Controls/Personal Protection

ENGINEERING CONTROLS: Maintain a leakproof system. Use packless valves, welded piping, and other leakproof construction. Use only with clean, completely enclosed systems that have been thoroughly purged with DRY nitrogen gas including containers, transfer lines, vessels, tanks, etc., such that the atmosphere stays below 3% oxygen. Handle in a DRY closed system under DRY nitrogen gas. Provide adequate local exhaust ventilation to minimize worker exposure. Prevent electrostatic charge buildup by using common bonding and grounding techniques.

EXPOSURE CONTROLS: None established for TEB.

PERSONAL PROTECTIVE EQUIPMENT:

(TEB)

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Normal Use & Handling: When exposure to eyes and skin is possible, wear chemical protective goggles with a faceshield and flame-retardant protective clothing. Glove permeation data does not exist for this product. Exposure limits have not been established for Triethylborane. When inhalation of vapor or mist is possible, wear a NIOSH-approved self-contained breathing apparatus with full facepiece operated in a positive-pressure mode. Eye wash and safety showers must be available and in good working order.

Emergency Handling: For firefighting, wear full protective clothing, including protective gloves and boots. For chemical spills, wear special protective clothing (vapor-protective suit with additional chemical flash fire escape protection, as specified in NFPA 1991). For respiratory protection, wear a NIOSH-approved self-contained breathing apparatus with full facepiece operated in a positive-pressure mode.

9. Physical And Chemical Properties

APPEARANCE: Clear, colorless liquid

ODOR: Pungent odor

FREEZING POINT: -135°F/-93°C

BOILING POINT: 95°C/203°F

VAPOR PRESSURE @ 20°C: 42.6 mm Hg

REID VAPOR PRESSURE @ 100°F: 14 psia

DENSITY @ 25°C: 0.68 gm/cm³

VISCOSITY @ 25°C: 0.30 centipoise

HEAT OF COMBUSTION: 20,230 BTU/pound (net); 115,500 BTU/gallon (net)

STABILITY TO AIR: Liquid will ignite when exposed to air

STABILITY TO WATER: No reaction, immiscible

STABILITY TO HEAT: Slow decomposition begins above 200°F/93.3°C

MOLECULAR WEIGHT: 98

FORMULA: (C₂H₅)₃B

10. Stability And Reactivity

STABILITY (CONDITIONS TO AVOID): Stable. Keep away from heat, sparks, and flame.

INCOMPATIBILITY (SPECIFIC MATERIALS TO AVOID): Air, oxidizers, halogenated hydrocarbons, temperatures above 200°F/94°C (slow decomposition above this temperature; rate reported to be 4% in 60 hours at 212°F/100°C).

HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide, carbon dioxide, boron compounds

HAZARDOUS POLYMERIZATION: Not expected to occur.

11. Toxicological Information

TEB is pyrophoric and exposure can cause eye, skin, and mucous membrane burns.

Oral LD50 for rat of 235 mg/kg; toxic to animals when dose was administered directly into the stomach; unlikely that humans could be exposed to toxic oral dose since liquid TEB is pyrophoric. Inhalation LC50 rat of 700 ppm (four hours exposure), is not defined as toxic or highly toxic via inhalation route; vapor is pyrophoric at 1300 ppm. No dermal toxicity, skin or ocular irritation, or skin sensitization testing reported because exposure to skin and eyes would cause immediate, deep burns and subsequent scarring if not treated immediately.

Animals exposed to low non-pyrophoric concentrations of TEB in air became excited and had nasal irritation; at high concentration, some animals frothed at the mouth and/or nose, had convulsions. Death occurred in some animals but not all which showed frothing or had convulsions. Humans would be expected to have irritation of nose, throat, and mucous membranes and central nervous symptoms. Liquid splashed on the skin or in the eyes is expected to cause a fire and burns.

TOXICOLOGY DATA: For triethylborane, LD50(oral-rat)= 235 mg/kg
LC50(inh-rat)= 700 ppm/4H

12. Ecological Information

ECOLOGICAL DATA: No environmental toxicity data for the product.

13. Disposal Considerations

WASTE DISPOSAL: Do not flush to sewer. Dispose in compliance with all local, state, and federal laws and regulations.

14. Transport Information

UPS and air shipments are forbidden.

HAZARDOUS MATERIALS/DANGEROUS GOODS CLASSIFICATION:

Proper Shipping Name: Pyrophoric liquid, inorganic, n.o.s. (triethylborane)
Hazard Class: 4.2
Packaging Group: I
Identification Number: UN3194
Labels: Spontaneously combustible

15. Regulatory Information

TSCA: Triethylborane is listed on the TSCA Public Inventory.

SARA 313 INFORMATION: Triethylborane does not contain a toxic chemical or chemicals subject to the reporting requirements of section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR 372.

CERCLA/SUPERFUND: Contains no CERCLA Extremely Hazardous Substances.

EINECS: 202-620-9 for triethylborane

EUROPEAN LABEL INFORMATION:

Symbols: F, Xn

Indications of danger (Annex II): Highly flammable, Harmful

Nature of special risk attributed to dangerous substances (Annex III):

- R17 Spontaneously combustible in air.
- R34 Causes burns.
- R22 Harmful if swallowed.

Safety advice concerning dangerous chemical substances (Annex IV):

- S6 Keep under DRY nitrogen.
- S7/8 Keep container tightly closed and dry.
- S23 Do not breathe vapor.
- S36 Wear suitable protective clothing.
- S43 In case of fire, do not use halogenated fire extinguishing agents.
- S33 Take precautionary measures against static discharge.

NEW JERSEY: This product does not contain a chemical listed on the New Jersey Department of Health Hazard Right-to-Know Program Hazardous Substance List.

PENNSYLVANIA: This product does not contain a chemical subject to the Pennsylvania Worker and Community Right-to-Know Act.

16. Other Information

WARNING: This is a dangerous chemical product. By following the directions and warnings provided with this product, the dangers associated with the use of this product can be greatly reduced but never entirely eliminated. Callery Chemical Company makes no warranties, expressed or implied, with respect to this product and EXPRESSLY DISCLAIMS THE WARRANTY OF MERCHANTABILITY AND ANY WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. Users assume all risks in handling, using or storing this product.

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file: TEB-MSDS-ANSI-98-R0



TMAL SSG (TRIMETHYLALUMINUM)

1. CHEMICAL PRODUCT AND COMPANY INFORMATION

Product name TMAL SSG (TRIMETHYLALUMINUM)	Chemical description Trimethylaluminum
Synonym TMAL Select Semiconductor Grade	Chemical formula C ₃ H ₉ Al
CAS number 75-24-1	Chemical family Aluminum alkyl
Supplier Akzo Nobel Polymer Chemicals LLC 300 South Riverside Plaza Chicago, IL 60606 USA	
Medical/Handling Emergency + 1-914-693-6946 Dobbs Ferry, NY USA	Transportation Emergency CHEMTREC - USA: 1-800-424-9300 CANUTEC - CANADA: 1-613-996-6666
Product use Semiconductors	Product/technical Information 1-800-828-7929
Date of first issue 11-08-1994	Date of last issue / Revision # 06-20-2000 / 8.00

2. COMPOSITION/INFORMATION ON INGREDIENTS

Ingredient	Percentage(s)	CAS number
Trimethylaluminum	100.00	75-24-1

3. HAZARDS IDENTIFICATION

<p>Emergency overview Clear, colorless liquid DANGER! EXTREMELY FLAMMABLE. CATCHES FIRE IF EXPOSED TO AIR. CAUSES SKIN AND EYE BURNS. REACTS VIOLENTLY WITH WATER. Metal alkyls are pyrophoric. The metal alkyl reacts spontaneously with air and/or moisture resulting in ignition. In case of fire, reignition of the metal alkyl may occur after the fire has been extinguished.</p>
<p>Health effects Skin and eye contact are the primary routes of exposure to this product. Inhalation of this metal alkyl is unlikely due to the highly reactive nature of the metal alkyl with air and its low vapor pressure. This material will react with moisture in or on the skin to produce thermal and chemical burns. This product will react with moisture in the eyes to produce severe chemical and thermal burns. Ingestion will result in burning of the mouth, throat and any part of the gastrointestinal system with which the material comes in contact. Nausea and vomiting may occur.</p>

Carcinogenicity	
Description	Applicable
IARC	no
NTP	no



TMAL SSG (TRIMETHYLALUMINUM)

OSHA	no
ACGIH	no

4. FIRST AID MEASURES

Inhalation

Remove victim to fresh air while protecting yourself from exposure with an appropriate respirator. Remove any contaminated clothing to prevent further inhalation exposure. Use gloves to avoid contaminating yourself. If not breathing, clear victim's airway and start artificial respiration. Avoid inhaling expired air. Artificial respiration may be supplemented by the use of a bag-mask respirator or manually triggered oxygen supply capable of delivering one liter per second or more. If victim is breathing, supplemental oxygen may be given from a demand-type or continuous-flow inhaler, preferably with a physician's advice. Monitor breathing and pulse. If victim stops breathing, restart artificial respiration. If heart has stopped, begin cardiopulmonary resuscitation immediately. Keep person warm and at rest. Get medical attention immediately.

Skin

Very quickly and without touching the victim, wash victim down with large amounts of cold water from a hand-held hose, as if to flush away the chemical. CAUTION: Do not spray victim from the front. The flames will increase in intensity when water is first applied, but will quickly die out. Lay the victim flat on his back on a stretcher without removing the burnt clothing. Turn head to the side. Cover victim with a sterile sheet or a clean, dry cloth. Obtain medical attention immediately.

Eye

Immediately flush eyes with large quantities of running water for a minimum of 15 minutes. If the victim is wearing contact lenses, remove them. Take care not to contaminate the victim's healthy skin and eyes. Hold the eyelids apart during the flushing to ensure rinsing of the entire surface of the eye and lids. DO NOT let victim rub eye(s). Do not attempt to neutralize with chemical agents. Get medical attention immediately. Oils or ointments should not be used at this time. Continue flushing for an additional 15 minutes if a physician is not immediately available.

Ingestion

Because of the reactive nature of this material, ingestion is unlikely, however, if swallowed DO NOT INDUCE VOMITING. Call a physician or a poison control center immediately. Give victim plenty of water to drink. Never give anything by mouth to an unconscious or convulsing person. Get medical attention immediately.

Note to physician

There are no data available that address medical conditions that are generally recognized as being aggravated by exposure to this product.

Attending physician should treat exposed patients symptomatically. Chemical burns on the skin should be treated as thermal burns. Flush eyes with buffered or plain irrigating solutions. If any ulceration or conjunctival injury is present, have an ophthalmologist examine the patient.

5. FIRE-FIGHTING MEASURES

Flash point PYROPHORIC! (ignites in air)	Autoignition temperature Ignites spontaneously in air.
Flash Method Not Applicable	Explosion limits lower: Not applicable upper: Not applicable
Extinguishing media THE MOST EFFECTIVE FIRE EXTINGUISHING AGENT IS DRY CHEMICAL POWDER PRESSURIZED WITH NITROGEN. Vermiculite or dry sand may also be used. CAUTION: REIGNITION MAY OCCUR. DO NOT USE FOAM, WATER (except as explained below), CARBON TETRACHLORIDE OR CHLOROBROMOMETHANE extinguishing agents as product either reacts violently or liberates toxic fumes and vapors on contact with these agents.	



TMAL SSG (TRIMETHYLALUMINUM)

Fire fighting procedures

Protecting against fire by strict adherence to safe operating procedures and proper equipment are the best ways to minimize the possibility of fire damage. Immediate action should be taken to confine the fire. All lines and equipment which could contribute to the fire should be shut off.

Standard fireman's bunker gear is recommended for fighting metal alkyl fires. If the fire cannot be controlled with extinguishing agents, keep a safe distance, protect adjacent property and allow burn until consumed.

Human exposure must be prevented and nonessential personnel evacuated from the immediate area.

Breathing vapors from metal alkyl/hydrocarbon fires should be avoided by using proper respiratory equipment.

A NIOSH approved, positive-pressure/pressure demand, air-supplied, full-face respirator should be used.

Fire and explosion hazards

Metal alkyls are pyrophoric. The metal alkyl reacts spontaneously with air and/or moisture resulting in ignition. In case of fire, reignition of the metal alkyl may occur after the fire has been extinguished.

This material may react with air, water and compounds containing active hydrogen such as alcohols and acids. Reaction with water and air liberates flammable hydrocarbon gas and alcohol. Compounds containing oxygen or organic halide may react upon contact with the product.

Do not use welding or cutting torch on or near any container of this material, even empty, because an explosion could occur. Do not store near heat or open flame.

Hazardous products of combustion

Products of complete combustion are carbon dioxide, water and aluminum oxide. Additionally, products of incomplete combustion may include carbon monoxide, elemental carbon and hydrocarbons (alkanes and alkenes).

NFPA ratings

Hazard	Rating
Health	3
Flammability	4
Reactivity	3
Other	-W

6. ACCIDENTAL RELEASE MEASURES

Methods for cleaning up

Appropriate personal protective equipment (PPE) should be worn while working with spilled material. Block off source of spill. Spilled material will very likely give off smoke and fumes and may ignite spontaneously. After fire is extinguished or has been allowed to burn out, wash spill away with copious amounts of water (See Section 5, Fire Fighting Measures). CAUTION: Water may cause ignition/ reignition to occur. Dike water for later disposal. Do not allow contaminated water to enter waterways.

7. HANDLING AND STORAGE

Handling

Electrically grounded tanks and containers should always be used as should non-sparking, electrically grounded hand tools and appliances. Ground or bond to ground all vessels when transferring to prevent the accumulation of static electricity. See National Electric Code.

Storage

Store under an inert atmosphere. Dry nitrogen is a suitable inert gas. Containers should be stored in a cool, well-ventilated area away from flammable materials and sources of heat. Exercise due caution to prevent damage to or leakage from the container.

Maximum storage temperature

not determined



TMAL SSG (TRIMETHYLALUMINUM)

General comments

Under inert conditions the product is not corrosive to metals commonly used in construction. Some plastics and elastomers may be attacked. Contact Akzo Nobel Polymer Chemicals LLC for specific recommendations regarding suitable materials for use with this product.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Respiratory protection

This material is normally handled under nitrogen and closed process conditions. In an emergency where adequate ventilation is not available and conditions could generate mist or aerosol, inhalation must be prevented through the use of NIOSH-approved organic vapor/ acid gas respirators with dust, mist and fume filters to reduce potential for exposure. Where exposure potential necessitates a higher level of protection, use a NIOSH-approved, positive-pressure/ pressure-demand, air-supplied respirator.

When using respirator cartridges or canisters, they must be changed frequently (following each use or at the end of the workshift) to assure breakthrough exposure does not occur.

Skin protection

Skin contact must be prevented through the use of fire-retardant clothing. During sampling, disconnecting lines or opening connections, additional protective outerwear including full-face shield, impervious gloves, aluminized suit, a hard hat, steel toed safety shoes that cover the ankles and chemical safety goggles should also be worn.

Eye protection

Because eye contact with this product may cause severe and possibly permanent damage, chemical goggles and/or a full face shield must be worn whenever handling this product.

Ventilation protection

This material is normally handled under closed process conditions.

Other information

This product should not be used until all personnel handling it have been thoroughly trained. Contact Akzo Nobel Polymer Chemicals LLC, Chicago, IL. Additional information on safety and handling of organometallics is available in the Akzo Nobel Polymer Chemicals LLC brochure on metal alkyls.

During the development of safe handling procedures, consideration should be given to the need for cleaning of equipment and piping systems to render them nonhazardous before maintenance and repair activities are performed. Waste resulting from these procedures should be handled in an environmentally safe manner.

All food and smoking materials should be kept in a separate area away from the storage/use location. Eating, drinking and smoking should be prohibited in areas where there is a potential for exposure to this material.

Before eating, hands and face should be thoroughly washed.

Safety showers, with quick opening valves which stay open, and eye wash fountains, or other means of washing the eyes with a gentle flow of cool to tepid tap water, should be readily available in all areas where this material is handled or stored. Water should be supplied through insulated and heat-traced lines to prevent freezeups in cold weather.

Applicable exposure limits

Other than any exposure limits which may be displayed below, there are no other exposure limits applicable for this product or its components. The exposure limits for the aluminum alkyl shown in Section 8 refers to the "Aluminum, Alkyls, not otherwise classified, as Al" value.

Agency	Value/Unit of measurement
Trimethylaluminum	
ACGIH TLV/TWA	2.000 mg/m ³
NIOSH REL/TWA	2.000 mg/m ³
PEL = Permissible Exposure Limit TLV = Threshold Limit Value TWA = Time Weighted Average STEL = Short Term Exposure Limit CEIL = Ceiling Exposure Limit REL = Recommended Exposure Limit WEEL = Workplace Environmental Exposure Limit IDLH = Immediate Dangerous to Life and Health	



TMAL SSG (TRIMETHYLALUMINUM)

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor Clear, colorless liquid	pH value not determined
Odor threshold (ppm) not determined	Relative vapor density (air=1) N/D
Volatile % N/D	Vapor pressure (mm Hg) 11 mm Hg @ 68 F (20 C)
Boiling point/range 261.00 °F 127.22 °C @ 760 mm Hg	Evaporation rate not determined
Melting point/range 59.00 °F 15.00 °C	
Cloud point N/D	Pour point not determined
Flash point PYROPHORIC! (ignites in air)	Solubility in water Reacts violently
Flash method Not Applicable	Solubility in other solvents Miscible with hydrocarbons
Autoignition temperature Ignites spontaneously in air.	
Specific Gravity/Density 0.74 @ 86 F (30 C)	Partition coefficient n-octanol/water not determined
Bulk density Not Applicable	
Other information Viscosity @ 86 F (30 C) = 0.9 cp. Density @ 77 F (25 C) = 0.748 g/ml.	Explosion limits lower: Not applicable upper: Not applicable

10. STABILITY AND REACTIVITY

Stability This product is stable when stored under dry, inert atmosphere and away from heat. Dry nitrogen containing less than 5 ppm oxygen and less than 5 ppm of moisture is recommended. This product is not sensitive to physical impact.
Incompatibilities This product may react violently with air, water, and compounds containing active hydrogen such as alcohols and acids. Compounds containing oxygen or organic halide may react vigorously upon contact with the product.
Polymerization Hazardous polymerization is not expected to occur.
Decomposition Product may undergo exothermic decomposition with gas (methane) evolution at temperatures above 120 C (248 F).
Conditions to avoid Avoid contact with incompatible material, excessive heat and flames.



TMAL SSG (TRIMETHYLALUMINUM)

11. TOXICOLOGICAL INFORMATION

Oral LD50	Ingestion toxicity data are not available for this product.
Dermal LD50	Dermal toxicity data are not available for this product.
Inhalation LC50	Inhalation toxicity data are not available for this product.
Skin	Chronic dermal exposure effects for this product are not known. Skin contact with this product will cause severe chemical burns.
Eye	The acute eye effects of this product have not been determined.
Chronic toxicity/carcinogenicity	<p>Chronic ingestion effects of this product are not known. Ingestion will result in burns of the mouth, throat, esophagus and digestive tract.</p> <p>Chronic inhalation exposure effects for this product are not known.</p> <p>The carcinogenic/mutagenic properties of this product are not known.</p> <p>The reproductive toxicity of this product is not known.</p> <p>The neurotoxic effects of this product are not known.</p> <p>Overexposure to this product may affect the skin and eyes.</p>
Other toxicological information	No other toxic effects for this product are known.

12. ECOLOGICAL INFORMATION

Ecotoxicological information	The ecological toxicity of this product is not known.
Bioaccumulation	This product decomposes to hydrogen, hydrocarbons and elemental aluminum.
Other information	Other ecological information on this product is not known.

13. DISPOSAL CONSIDERATIONS

<p>Waste disposal in accordance with regulations</p> <p>Incineration by controlled feed of air and product is a suitable disposal procedure. Alternately, deactivation can be achieved by diluting the product with hydrocarbon (heptane, etc.) to less than 5 weight percent metal alkyl concentration and treating the hydrocarbon solution with water under a nitrogen atmosphere in a vented and agitated container. Always add the diluted metal alkyl solution to a large excess of water. Allow for the generation of heat and flammable hydrocarbons when treating with water. Conduct water treatment in the absence of oxygen gas to avoid possible ignition of flammable material. The products from hydrolysis are ethane and aluminum oxide(hydrated).</p> <p>Consult RCRA hazardous waste regulations prior to deactivation for potential treatment permitting considerations.</p> <p>Should the unused product become a waste material, it would meet the characteristics of an ignitable (D001) and reactive (D003) waste per 40 CFR, 261, Subpart C. It is the responsibility of the waste generator to evaluate whether his wastes are hazardous by characteristics or listing.</p> <p>Note: A technical bulletin (No. 95-90) is available from Akzo Nobel Polymer Chemicals LLC describing details of disposal of laboratory quantities of metal alkyls.</p>
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TMAL SSG (TRIMETHYLALUMINUM)

Container disposal

Containers with residual semiconductor grade metal alkyls may be returned to : Akzo Nobel Polymer Chemicals LLC, 730 Battleground Road, Deer Park, Texas 77536. Return shipments of containers are to be in compliance with DOT regulations.

14. TRANSPORT INFORMATION

Shipping description	ALUMINUM ALKYLs 4.2, UN3051, PG I NORTH AMERICAN EMERGENCY RESPONSE GUIDE NO. 135 ICAO: FORBIDDEN IMO: UN3051
Required labels	Primary Label: SPONTANEOUSLY COMBUSTIBLE Subsidiary Label: DANGEROUS WHEN WET
Environmentally hazardous substance	This product does not contain an environmentally hazardous substance per 49 CFR 172.101, Appendix A.

15. REGULATORY INFORMATION

Products and/or components listed below are subject to the following:

Trimethylaluminum

Massachusetts Substance List	yes
New Jersey R-T-K Hazard. Sub.	yes
Penn. Hazardous Substance list	yes
Toxic Subst. Cont. Act -listed	yes
Domestic Substance List-Canada	yes

Hazard classes

Description	Applicable
HMIS Hazard Rating Source	HMIS
HMIS Health	3
HMIS Flammability	4
HMIS Reactivity	3
WHMIS Hazard Class	B-6, D-2B, E, F

Other regulatory information

No other regulatory information is available on this product.

16. OTHER INFORMATION

Other information

No other information is available.

Created by

PRODUCT SAFETY 914-674-5000

The information in this material safety data sheet should be provided to all who will use, handle, store, transport or otherwise be exposed to this product. All information concerning this product and/or suggestions for handling and use contained herein are offered in good faith and are believed to be reliable as of the date of publication. However, no warranty is made as to the accuracy of and/or sufficiency of such information and/or suggestions as to the merchantability or fitness of the product for any particular purpose, or that any suggested use will not infringe any patent. Nothing in here shall be construed as granting or extending any license under any patent. Buyer must determine for himself, by preliminary tests or otherwise, the suitability of this product for his purposes, including mixing with other products. The information contained herein supersedes all previously issued bulletins on the subject matter covered. If the date on this document is more than three years old, call to make certain that this sheet is current.



MATERIAL SAFETY DATA SHEET

Date of Issue: 13 March 2000
Revision: 5
ID: tmga

TRIMETHYLGALLIUM

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY.

Product Name
Trimethylgallium
Formula
(CH₃)₃Ga
Company Identification
See footer.

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substance/Preparation
Trimethylgallium
Components/Impurities
None
EC No.
215-897-6
CAS No.
1445-79-0

3. HAZARDS IDENTIFICATION

Pyrophoric liquid, decomposes violently in water. Skin contact can cause severe burns. Fumes may cause skin and eye irritation. Avoid inhalation of fumes.

4. FIRST AID MEASURES

Prompt medical attention is required in all cases of exposure to Trimethylgallium and its by-products. Rescue personnel should be equipped with appropriate protective equipment (e.g. Self-contained breathing apparatus) to avoid unnecessary exposure and must be aware of the fire and explosion potential of Trimethylgallium.

Skin

Contact may cause severe burns. Fumes may cause irritation. Immediately flush affected areas with large quantities of water. Remove affected clothing as rapidly as possible only if not stuck to skin.

Eyes

Contact may cause severe burns. Fumes may cause irritation. Persons with potential exposure to Trimethylgallium should not wear contact lenses. Flush contaminated eyes with large quantities of water for at least 15 minutes. Hold eyelids open to ensure complete flushing.

Inhalation

May cause irritation. Move exposed personnel to an uncontaminated area quickly using self-contained breathing apparatus. If breathing is difficult, give oxygen. If breathing has stopped, apply artificial respiration. Medical assistance should be sought immediately. Keep victim warm and quiet.

5. FIRE-FIGHTING MEASURES

Extinguishing Media

Always use dry powder, soda ash or lime. Never use water, foam or halogenated compounds to fight fires involving organometallic materials. Without risk, stop flow of this compound to the fire. Without risk, and if safe to do so, move container(s) away from fire area.

Exposure Hazards

In a controlled fire any unreacted Trimethylgallium may re-ignite when contact with air or water is renewed.

Special Protective Equipment for Fire-Fighters

Fire resistant clothing, self-contained breathing apparatus, face shield and safety goggles, safety shoes and fire resistant gloves.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions

Evacuate area. Use appropriate protective equipment. Purge equipment with inert gas before attempting repairs. Ensure adequate ventilation. If leak is in container call one of the emergency numbers as appropriate. (See footer).

Environmental Precautions

Try to stop release, if safe to do so. For fire-fighting measures see Section 5.

Clean up methods

Contact Epichem for specific advice.

7. HANDLING AND STORAGE

Handling

Valve outlet seals must remain in place unless container is secured and valve outlet piped to use point. Use a check valve or trap to prevent hazardous back flow into the container. Any equipment used for Trimethylgallium service must be thoroughly cleaned and prepared to eliminate contamination and must be maintained in a leak-free state. All air and moisture in the system must be eliminated before use.

Storage

Protect containers from physical damage. Do not allow temperatures to exceed (125F)51C. Store away from flammable material.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Controls

OSHA or ACGIH: None established.

OES and MEL: None established.

Ensure adequate ventilation.

Personal Protection

Self-contained breathing apparatus, fire resistant gloves, face shield and safety goggles, safety shoes, fire-resistant garments. Safety shower and eyewash.



9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point: (131.5F) 55.7C
Vapor Pressure: $\log_{10} P(\text{mmHg}) = 8.07-1703/T(K)$
Gas Density (at (70F)21C, 1 atm): Liquid
Freezing Point: (3.5F) -15.8C
Liquid Density: 1.151g/ml @ 15C
Molecular Weight: 114.82 grams
Solubility in water: Reacts violently.
Appearance: Colorless liquid which is pyrophoric.

10. STABILITY AND REACTIVITY

Conditions to avoid

Reacts pyrophorically in air.

Note: Trimethylgallium is stable indefinitely in an inert atmosphere at room temperature.

Materials to avoid

Avoid water, air or other oxidizers.

Hazardous Decomposition Products

Gallium Oxide dust, CO, CO₂

11. TOXICOLOGICAL INFORMATION

Gallium Oxide dust formed when this compound is oxidized has caused toxic effects to the liver and kidneys in test animals.

Trimethylgallium is not listed in the IARC, NTP or OSHA Subpart Z as a carcinogen or potential carcinogen.

Trimethylgallium is listed on the TSCA inventory.

12. ECOLOGICAL INFORMATION

This product does not contain any Class I or Class II ozone depleting chemicals.

13. DISPOSAL CONSIDERATIONS

Regional and National regulations should be followed during waste disposal. Contact an Epichem representative for disposal of container and any unused quantities.

14. TRANSPORT INFORMATION

UN No: 2003
CLASS: 4.2 (4.3)
PG I
ECCN#: 3C003
IMDG Code: 4243
Shipping Name: Metal alkyls, water-reactive, n.o.s.
(Trimethylgallium)

15. REGULATORY INFORMATION

Classification

Highly Flammable

Risk and Safety Phrases

R14: Reacts violently with water.

R17: Spontaneously flammable in air.

S6: Keep under inert atmosphere.

S8: Keep container dry.

S43a: In case of fire use dry powder or lime - Never use water.

16. OTHER INFORMATION

Ensure operators understand the pyrophoric nature of the product. DSC data is available on request. Before using this product, it is recommended that a risk assessment and safety study be carried out. Further information on the use of this product can be obtained from the Technical Product Manager at the nearest Epichem facility.

SAFETY NOTICE: In Order to provide our customers with the highest quality material and maintain our high standards of safety, the surface temperature of the bubbler will be monitored during the transportation of our products. We would like to monitor the surface temperature of the bubbler using a tempilabel. Tempilabel is a temperature-monitoring strip ranging from 120F to 150F (49C to 66C) which will indicate the temperature during shipment. The strip will turn black at one of the four ratings shown if the temperature is reached (normally a silver centre). If the temperature monitor is changed, please notify an Epichem representative immediately and we will assist you in the proper measures to be taken. We ask for your co-operation in our efforts of quality assurance and safety. If you have any questions or comments, please contact an Epichem representative. We thank you for your co-operation. Your assistance is greatly appreciated.

Information contained in this material safety data sheet is offered without charge for use by technically qualified personnel at their discretion and risk. All statements, technical information and recommendations contained herein are based on tests and data which we believe to be reliable, but the accuracy or completeness thereof is not guaranteed no warranty of any kind is made with respect thereto. This information is not intended as a license to operate under or a recommendation to practice or infringe any patent of this Company or others covering any process, composition of matter or use.

Since the Company shall have no control of the use of the product described herein, the company assumes no liability for loss or damage incurred from the proper or improper use of such product.

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Other International Countries: Chemtrec (703) 527 3887



MATERIAL SAFETY DATA SHEET

Date of Issue: 13 March 2000
Revision: 4
ID: tmin

TRIMETHYLINDIUM

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND COMPANY.

Product Name
Trimethylindium
Formula
(CH₃)₃In
Company Identification
See footer.

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substance/Preparation
Trimethylindium
Components/Impurities
None
EC No.
222-200-9
CAS No.
3385-78-2

3. HAZARDS IDENTIFICATION

Pyrophoric solid, decomposes violently in water. Skin contact can cause severe burns. Fumes may cause skin and eye irritation. Avoid inhalation of fumes. Trimethylindium is thermally unstable above 140°C – **DO NOT HEAT ABOVE 80°C**

4. FIRST AID MEASURES

Prompt medical attention is required in all cases of exposure to Trimethylindium and its by-products. Rescue personnel should be equipped with appropriate protective equipment (e.g. Self-contained breathing apparatus) to prevent unnecessary exposure and must be aware of the fire and explosion potential of Trimethylindium.

Skin

Contact may cause severe burns. Fumes may cause irritation. Immediately flush affected areas with large quantities of water. Remove affected clothing as rapidly as possible only if not stuck to skin.

Eyes

Contact may cause severe burns. Fumes may cause irritation. Persons with potential exposure to Trimethylindium should not wear contact lenses. Flush contaminated eyes with large quantities of water for at least 15 minutes. Hold eyelids open to ensure complete flushing.

Inhalation

May cause irritation. Move exposed personnel to an uncontaminated area quickly using self-contained breathing apparatus. If breathing is difficult, give oxygen. If breathing has stopped, apply artificial respiration. Medical assistance should be sought immediately. Keep victim warm and quiet.

5. FIRE-FIGHTING MEASURES

Extinguishing Media

Always use dry powder, soda ash or lime. Never use water, foam or halogenated compounds to fight fires involving organometallic materials. Without risk, stop flow of this compound to the fire. Without risk, and if safe to do so, move container(s) away from fire area.

Exposure Hazards

In a controlled fire any unreacted Trimethylindium may re-ignite when contact with air or water is renewed.

Special Protective Equipment for Fire-Fighters

Fire resistant clothing, self-contained breathing apparatus, face shield and safety goggles, safety shoes and fire resistant gloves.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions

Evacuate area. Use appropriate protective equipment. Purge equipment with inert gas before attempting repairs. Ensure adequate ventilation. If leak is in container call one of the emergency numbers as appropriate (See footer).

Environmental Precautions

Try to stop release, if safe to do so. For fire-fighting measures see Section 5.

Clean up methods

Contact Epichem for specific advice.

7. HANDLING AND STORAGE

Handling

Valve outlet seals must remain in place unless container is secured and valve outlet piped to use point. Use a check valve or trap to prevent hazardous back flow into the container. Any equipment used for Trimethylindium service must be thoroughly cleaned and prepared to eliminate contamination and must be maintained in a leak-free state. All air and moisture in the system must be eliminated before use.

Storage

Protect containers from physical damage. Do not allow temperatures to exceed (125F)51C. Store away from flammable material.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Controls

OSHA or ACGIH:

TLV(TWA)= 0.1 mg/m³ (In and compounds)

OEL and MEL: Long term exposure limit for Indium and compounds: 0.1mg/m³ (as In) (8-Hour TWA reference period)
Short term exposure limit: 0.3 mg/m³ (15-Minute reference period)
Ensure adequate ventilation.

Personal Protection

Self-contained breathing apparatus, fire resistant gloves, face shield and safety goggles, safety shoes, fire-resistant garments. Safety shower and eyewash.



9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point: (272.8F)133.8C
Vapor Pressure: $\log_{10} P(\text{mmHg}) = 10.52 - 3014/T(K)$
Melting Point: (191F) 88C
Molecular Weight: 159.93 grams
Density: Crystal density= 1.568 (literature)
Powder density= 1.3 (experimental)
Solubility in water: Reacts violently.
Appearance: White solid which is pyrophoric.

10. STABILITY AND REACTIVITY

Conditions to avoid

Reacts pyrophorically in air.

Note: Trimethylindium is stable indefinitely in an inert atmosphere at room temperature.

THERMALLY UNSTABLE ABOVE 140°C. DO NOT HEAT ABOVE 80°C.

Materials to avoid

Avoid water, air or other oxidizers.

Hazardous Decomposition Products

Indium Oxide dust, CO, CO₂

11. TOXICOLOGICAL INFORMATION

Indium Oxide dust formed when this compound is oxidized is an irritant to skin, eyes and by inhalation.

Trimethylindium is not listed in the IARC, NTP or OSHA Subpart Z as a carcinogen or potential carcinogen.

Trimethylindium is listed on the TSCA inventory.

12. ECOLOGICAL INFORMATION

This product does not contain any Class I or Class II ozone depleting chemicals.

13. DISPOSAL CONSIDERATIONS

Regional and National regulations should be followed during waste disposal. Contact an Epichem representative for disposal of container and any unused quantities.

14. TRANSPORT INFORMATION

UN No: 2846
CLASS: 4.2
PG I
ECCN#: 3C003
IMDG Code: 4255
Shipping Name: Pyrophoric solid, organic, n.o.s.
(Trimethylindium)

15. REGULATORY INFORMATION

Classification

Highly Flammable

Risk and Safety Phrases

R14: Reacts violently with water.

R17: Spontaneously flammable in air.

S6: Keep under inert atmosphere.

S8: Keep container dry.

S43a: In case of fire use dry powder or lime - Never use water.

16. OTHER INFORMATION

Ensure operators understand the pyrophoric and potentially thermally unstable nature of the product. DSC data available on request. Before using this product, it is recommended that a risk assessment and safety study be carried out. Further information on the use of this product can be obtained from the Technical Product Manager at the nearest Epichem facility.

SAFETY NOTICE: In Order to provide our customers with the highest quality material and maintain our high standards of safety, the surface temperature of the bubbler will be monitored during the transportation of our products. We would like to monitor the surface temperature of the bubbler using a tempilabel. Tempilabel is a temperature-monitoring strip ranging from 120F to 150F (49C to 66C) which will indicate the temperature during shipment. The strip will turn black at one of the four ratings shown if the temperature is reached (normally a silver centre). If the temperature monitor is changed, please notify an Epichem representative immediately and we will assist you in the proper measures to be taken. We ask for your co-operation in our efforts of quality assurance and safety. If you have any questions or comments, please contact an Epichem representative. We thank you for your co-operation. Your assistance is greatly appreciated.

Information contained in this material safety data sheet is offered without charge for use by technically qualified personnel at their discretion and risk. All statements, technical information and recommendations contained herein are based on tests and data which we believe to be reliable, but the accuracy or completeness thereof is not guaranteed no warranty of any kind is made with respect thereto. This information is not intended as a license to operate under or a recommendation to practice or infringe any patent of this Company or others covering any process, composition of matter or use.

Since the Company shall have no control of the use of the product described herein, the company assumes no liability for loss or damage incurred from the proper or improper use of such product.

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24 Hour Emergency Contact Numbers:

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Other International Countries: Chemtrec (703) 527 3887

Chemical safety



Precautions:

- Always wear protective clothing, including a face mask, goggles, rubber gloves, and apron when handling corrosive chemicals.
- Use the chemicals only in the designated area;
- Do not transport chemicals around the room in beakers.
- Never pour chemicals back into the original container.

Storage waste chemical

Store chemicals in accordance with compatibility. Incompatible chemicals coming into contact can generate extremely violent chemical reaction resulting in catastrophic explosions.

- Store waste chemical near the floor to minimize the danger of falling from shelves.
- Store in areas that are cool, dry, and well-ventilated, and away from sunlight.
- Storage area should not be subject to rapid changes in humidity or temperature.

Disposal chemical

Appropriate and adequate disposal of waste is critical in preventing unnecessary risk to the environment, as well as lowering the likelihood of unsafe conditions

Hazardous Waste Disposal Pickup Request Form

- Select waste type –chemical/Bio waste
- Fill out the form completely
- Transaction Number will be sent by email after fill out the pick up request form. Label all containers with this transaction number.
- Once the form submitted, the pick-up will be scheduled for **Tuesday** and **Thursday** accordingly

Lab safety

Note for lab safety training/talk on Nov.20,
2011

Environmental Health & Safety website: <http://www.depts.ttu.edu/ehs/Web/>

Required documents

- SOPs for anything potentially dangerous
 - Including how to change MOCVD bubbler, dump sharp/chemical waste, use fume hood
- **Lab safety plan** – must have, in written form
 - Approved by PI
 - Risk analysis from EHS (optional)
 - eg. annual inspection, training
- MSDS
 - Storage(flammable/reactive)
 - Shipping requirements

Training

- Location of first-aid, **fire extinguishers** and **spill kits**
- Personal Protective Equipments (PPE)
 - Gloves: one time use, take care to dispose in regular trash
 - Body cover: no exposed skin
 - Shoes: full foot coverage, no cloth or absorbent materials
 - Eyewear, respirator/ventilation
- Waste management
 - Waste chemicals: separately stored in labeled containers mark with full name and date.
 - Waste sharp items: special container or sharp edge secured



Training

- Chemical Hygiene
 - Designated area - fume hood: sash below mark
 - Separate flammable/reactive/waste inside fume hood
 - Glassware: rinse after use, label if left in fume hood
 - Store chemicals accordingly
 - Separate flammable/inflammable, base / acid, HF
 - Specialized cabinet / refrigerator (EHS can provide)
 - Handle spills: call (2-3876) immediately if unsure
 - Use spill kits if comfortable
 - HF: especially dangerous, penetrate gloves in seconds.