

Praxair Experimental Product Material Safety Data Sheet (See section 15, under TSCA, for important restrictions on product use.)

1. Chemical Product and Company Identification

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| Product Name: Corrosive liquids, flammable, n.o.s. [tetrakis(ethylmethylamino)hafnium] (MSDS No. P-6283-C) | Trade Names: Praxair® TEMAH |
| Chemical Name: Tetrakis(ethylmethylamino)hafnium | Synonyms: Tetrakis(ethylmethylamido)-hafnium, hafnium(IV)ethylmethylamide, TEMAH |
| Chemical Family: Metal amide complex | Product Grades: Not applicable. |
| Telephone: | Emergencies: 1-800-645-4633* CHEMTREC: 1-800-424-9300* Routine: 1-800-PRAXAIR |
| | Company Name: Praxair, Inc. 39 Old Ridgebury Road Danbury, CT 06810-5113 |

**Call emergency numbers 24 hours a day only for spills, leaks, fire, exposure, or accidents involving this product. For routine information, contact your supplier, Praxair sales representative, or call 1-800-PRAXAIR (1-800-772-9247).*

2. Hazards Identification

EMERGENCY OVERVIEW

**WARNING! Corrosive, flammable liquid and vapor.
Harmful if inhaled.
May cause liver damage.
May be fatal if ingested.
Decomposes to form flammable by-products.
May irritate skin, eyes, respiratory tract, and mucous membranes.
May cause dizziness and drowsiness.
Reacts with water and moisture in the air.
Self-contained breathing apparatus and protective clothing
must be worn by rescue workers.
Under ambient conditions, this is pale yellow liquid with a
slight amine odor.**

OSHA REGULATORY STATUS: This material is considered hazardous by the OSHA Hazard Communications Standard (29 CFR 1910.1200).

POTENTIAL HEALTH EFFECTS:

Effects of a Single (Acute) Overexposure

Inhalation. Vapors may cause coughing, shortness of breath, and central nervous system (CNS) depression with headache, dizziness, drowsiness, vertigo, nausea, vomiting, fatigue, dullness, blurred vision, ataxia, and unconsciousness.

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Skin Contact. Liquid or vapor may irritate the skin. With prolonged or repeated exposure, harmful amounts may be absorbed through the skin.

Swallowing. Hafnium compounds may be fatal if ingested. May cause CNS depression with dizziness, drowsiness, headache, dullness, fatigue, ataxia, and unconsciousness. Can cause liver damage.

Eye Contact. Liquid or vapor may cause mild to severe irritation with stinging sensation, redness, pain, blurred vision, and corneal inflammation (keratitis).

Effects of Repeated (Chronic) Overexposure. Repeated or prolonged exposure of the skin may cause dermatitis (inflammation of the skin).

Other Effects of Overexposure. Zirconium impurity may cause allergic rash.

Medical Conditions Aggravated by Overexposure. The skin-irritating properties of tetrakis(ethylmethylamino)hafnium may aggravate an existing dermatitis. Respiratory irritation may aggravate an existing asthma or other upper respiratory or pulmonary disease.

CARCINOGENICITY: Tetrakis(ethylmethylamino)hafnium is not listed by NTP, OSHA, or IARC.

POTENTIAL ENVIRONMENTAL EFFECTS: No known effects. For further information, see section 12, Ecological Information.

3. Composition/Information on Ingredients

See section 16 for important information about mixtures.

| COMPONENT | CAS NUMBER | CONCENTRATION |
|--|-------------|---------------|
| Tetrakis(ethylmethylamino)hafnium <i>*The symbol > means "greater than."</i> | 352535-01-4 | >99%* |

4. First Aid Measures

INHALATION: Immediately remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, qualified personnel may give oxygen. Closely monitor the victim for wheezing, coughing, or pain. Get immediate medical attention, even if no symptoms are present. Call a physician.

SKIN CONTACT: Remove contaminated clothing and wash skin with soap and water. Wash clothing before reuse. Discard contaminated shoes and gloves. If irritation persists or contact has been prolonged, call a physician.

SWALLOWING: Keep the victim calm, and get immediate medical aid. If patient is fully conscious, wash out mouth with water. Do not induce vomiting. Get medical attention without delay.

EYE CONTACT: Immediately flush eyes thoroughly with water for at least 15 minutes. Hold the eyelids open and away from the eyeballs to ensure that all surfaces are flushed thoroughly. Seek the advice of a physician, preferably an ophthalmologist, immediately.

NOTES TO PHYSICIAN: *There is no specific antidote. Treatment of overexposure should be directed at the control of symptoms and the clinical condition of the patient.*

Exposure to zirconium, present as an impurity at <1%, has caused granulomatous lesions of probable allergic epitheloid origin in susceptible individuals.

5. Fire Fighting Measures

FLAMMABLE PROPERTIES: May emit toxic, flammable, and corrosive fumes and vapors on reaction with water or upon thermal decomposition.

SUITABLE EXTINGUISHING MEDIA: Use dry chemical powder. Do NOT use water or water-based foams.

PRODUCTS OF COMBUSTION: CO, CO₂, hafnium oxide, zirconium oxide, and organic fumes.

PROTECTION OF FIREFIGHTERS: WARNING! Corrosive, flammable liquid and vapor. Evacuate all personnel from danger area. Use self-contained breathing apparatus and protective clothing. Remove sources of ignition if without risk. Move containers away from fire area if without risk. If this material is on fire, extinguish flames with the recommended media. On-site fire brigades must comply with OSHA 29 CFR 1910.156.

Specific Physical and Chemical Hazards. Heat of fire may cause container to burst. May emit toxic, flammable, and corrosive fumes when heated. Reacts with water and moisture in the air. Fumes and vapors may spread from leak. Vapors are heavier than air and may collect in low spots.

Protective Equipment and Precautions for Firefighters. Firefighters should wear self-contained breathing apparatus and full fire-fighting turnout gear.

6. Accidental Release Measures

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED:

WARNING! Corrosive, flammable liquid and vapor.

Personal Precautions. Immediately evacuate all personnel from danger area. Use self-contained breathing apparatus and protective clothing where needed. Remove all sources of ignition if without risk. Shut off flow if without risk. Reacts with water and moisture in the air. Vapors may spread from leak. Vapors are heavier than air and may collect in low spots. Ventilate area or move container to a well-ventilated area.

Environmental Precautions. Prevent waste from contaminating the surrounding environment. Keep personnel away. Discard any product, residue, disposable container, or liner in an environmentally acceptable manner, in full compliance with federal, state, and local regulations. If necessary, call your local supplier for assistance.”

7. Handling and Storage

PRECAUTIONS TO BE TAKEN IN HANDLING: Protect containers from damage. Do not breathe vapor. Use only with adequate ventilation or respiratory protection. Do not get liquid or vapor in eyes, on skin, or on clothing. Have safety showers and eyewash fountains immediately available. **Reacts with water and moisture.** Keep away from acids, alcohol, oxidizing agents, flammables, and strong bases. Reaction with moisture in a sealed container could build pressure and create an explosion hazard. **Do not eat, drink, or smoke in areas where this material is stored or used.** After working with this product, wash face and hands thoroughly with soap and water before eating, drinking, smoking, applying cosmetics, or using the toilet.

PRECAUTIONS TO BE TAKEN IN STORAGE: Store and use with adequate ventilation. Store in a cool, dry area under inert atmosphere and away from direct sunlight. Store only in the DOT-approved container in which product was received. Never store tetrakis

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(ethylmethylamino) hafnium in open containers. Keep containers closed. Store only where temperature will not exceed 125°F (52°C). Store full and empty containers separately. Use a first-in, first-out inventory system to prevent storing full containers for long periods.

8. Exposure Controls/Personal Protection

| COMPONENT | OSHA PEL | ACGIH TLV-TWA (2005) |
|-----------------------------------|----------|--------------------------|
| Tetrakis(ethylmethylamino)hafnium | N.E.* | 0.5 mg/m ³ ** |

N.E. Not Established.

*The OSHA PEL for hafnium is 0.5 mg/m³.

**Hafnium and compounds, as Hf

TLV-TWAs should be used as a guide in the control of health hazards and not as fine lines between safe and dangerous concentrations.

IDLH = Not available.

ENGINEERING CONTROLS:

Local Exhaust. Inadequate; see SPECIAL.

Mechanical (General). Inadequate; see SPECIAL.

Special. Use only in a closed system. This material is air- and moisture-sensitive. It should be maintained under a dry, inert atmosphere and used in an enclosed device such as a glove box.

Other. See SPECIAL.

PERSONAL PROTECTIVE EQUIPMENT:

Skin Protection. Wear work gloves when handling containers; rubber where contact with product may occur.

Eye/Face Protection. Wear safety glasses when handling containers. Select eye protection in accordance with OSHA 29 CFR 1910.133.

Respiratory Protection. Respirators must be acceptable to MSHA and NIOSH. Respiratory protection must conform to OSHA 29 CFR 1910.134. Select per OSHA 29 CFR 1910.134 and ANSI Z88.2.

9. Physical and Chemical Properties

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|---|---|
| APPEARANCE: | Pale yellow liquid |
| ODOR: | Slight amine odor |
| ODOR THRESHOLD: | Not available. |
| PHYSICAL STATE: | Liquid at normal temperature and pressure |
| pH: | Not applicable. |
| MELTING POINT: | <-58°F (<-50°C) |
| BOILING POINT at 0.0039 psi (0.2 mm Hg): | 149°F (65°C) |
| FLASH POINT (test method): | Not available. |
| EVAPORATION RATE (Butyl Acetate = 1): | Not available. |
| FLAMMABILITY: | Flammable |
| FLAMMABLE LIMITS IN AIR , % by volume: | LOWER: Not available. UPPER: Not available. |
| VAPOR PRESSURE: | Not available. |

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| VAPOR DENSITY: | Not available. |
| SPECIFIC GRAVITY: | Not available. |
| SOLUBILITY IN WATER: | Reacts |
| PARTITION COEFFICIENT: n-octanol/water: | Not available. |
| AUTOIGNITION TEMPERATURE: | Not available. |
| DECOMPOSITION TEMPERATURE: | Not available. |
| PERCENT VOLATILES BY VOLUME: | Not available. |
| MOLECULAR WEIGHT: | 410.9 |
| MOLECULAR FORMULA: | $C_{12}H_{32}HfN_4, [(CH_3CH_2)(CH_3)N]_4Hf$ |

10. Stability and Reactivity

CHEMICAL STABILITY: Unstable Stable

This material is stable as shipped and stored under a blanket of dry nitrogen or helium under normal conditions, i.e., 70°F (21.1°C).

CONDITIONS TO AVOID: Ignition sources, heat, moisture, oxidizing agents.

INCOMPATIBLE MATERIALS: Water, air, alcohol; acids; strong bases

HAZARDOUS DECOMPOSITION PRODUCTS: Thermal decomposition may produce CO, CO₂, hafnium oxide, zirconium oxide, and organic fumes.

POSSIBILITY OF HAZARDOUS REACTIONS: May Occur Will Not Occur

11. Toxicological Information

ACUTE DOSE EFFECTS: No known effects.

STUDY RESULTS: None known.

12. Ecological Information

ECOTOXICITY: No known effects.

OTHER ADVERSE EFFECTS: No adverse ecological effects expected. Tetrakis (ethylmethylamino)hafnium does not contain any Class I or Class II ozone-depleting chemicals.

13. Disposal Considerations

WASTE DISPOSAL METHOD: Do not attempt to dispose of residual or unused quantities. Return cylinder to supplier.

14. Transport Information

DOT/IMO SHIPPING NAME: Corrosive liquids, flammable, n.o.s. [tetrakis(ethylmethylamino)hafnium]

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|---|-------------------------------|--------------------------------------|-------------------------|
| HAZARD CLASS: 8 | PACKING GROUP/Zone: II | IDENTIFICATION NUMBER: UN2920 | PRODUCT RQ: None |
| SHIPPING LABEL(s): CORROSIVE, FLAMMABLE LIQUID | | | |
| PLACARD (when required): CORROSIVE | | | |

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MARINE POLLUTANTS: Tetrakis(ethylmethylamino)hafnium is not listed as a marine pollutant by DOT.

15. Regulatory Information

The following selected regulatory requirements may apply to this product. Not all such requirements are identified. Users of this product are solely responsible for compliance with all applicable federal, state, and local regulations.

U.S. FEDERAL REGULATIONS:

EPA (ENVIRONMENTAL PROTECTION AGENCY)

CERCLA: COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT OF 1980 (40 CFR Parts 117 and 302):

Reportable Quantity (RQ): None

SARA: SUPERFUND AMENDMENT AND REAUTHORIZATION ACT:

SECTIONS 302/304: Require emergency planning based on Threshold Planning Quantity (TPQ) and release reporting based on Reportable Quantities (RQ) of Extremely Hazardous Substances (EHS) (40 CFR Part 355):

TPQ: None

EHS RQ (40 CFR 355): None

SECTIONS 311/312: Require submission of MSDSs and reporting of chemical inventories with identification of EPA hazard categories. The hazard categories for this product are as follows:

IMMEDIATE: Yes

PRESSURE: No

DELAYED: Yes

REACTIVITY: Yes

FIRE: Yes

SECTION 313: Requires submission of annual reports of release of toxic chemicals that appear in 40 CFR Part 372.

Tetrakis(ethylmethylamino)hafnium is not subject to reporting under Section 313.

40 CFR 68: RISK MANAGEMENT PROGRAM FOR CHEMICAL ACCIDENTAL RELEASE PREVENTION: Requires development and implementation of risk management programs at facilities that manufacture, use, store, or otherwise handle regulated substances in quantities that exceed specified thresholds.

Tetrakis(ethylmethylamino)hafnium is not listed as a regulated substance.

TSCA: TOXIC SUBSTANCES CONTROL ACT: Tetrakis(ethylmethylamino)hafnium is not listed on the TSCA inventory.

CAUTION: This material is supplied under a "Low Volume Exemption" (40 CFR 723) of the Toxic Substances Control Act. As such, its use is restricted to the formation of thin-film precursors for microelectronic devices.

OSHA: OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION:

29 CFR 1910.119: PROCESS SAFETY MANAGEMENT OF HIGHLY HAZARDOUS CHEMICALS: Requires facilities to develop a process safety management program based on Threshold Quantities (TQ) of highly hazardous chemicals.

Tetrakis(ethylmethylamino)hafnium is not listed in Appendix A as a highly hazardous chemical.

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STATE REGULATIONS:

CALIFORNIA: Tetrakis(ethylmethylamino)hafnium is not listed by California under the SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT OF 1986 (Proposition 65).

PENNSYLVANIA: Tetrakis(ethylmethylamino)hafnium is subject to the PENNSYLVANIA WORKER AND COMMUNITY RIGHT-TO-KNOW ACT (35 P.S. Sections 7301-7320).

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| 16. Other Information |
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Be sure to read and understand all labels and instructions supplied with all containers of this product.

OTHER HAZARDOUS CONDITIONS OF HANDLING, STORAGE, AND USE: *Corrosive, flammable liquid and vapor. Use only with compatible materials and equipment.*

Mixtures. When you mix two or more gases or liquefied gases, you can create additional, unexpected hazards. Obtain and evaluate the safety information for each component before you produce the mixture. Consult an industrial hygienist or other trained person when you evaluate the end product. Remember, gases and liquids have properties that can cause serious injury or death.

HAZARD RATING SYSTEMS:

NFPA RATINGS:

HEALTH = 3
FLAMMABILITY = 2
INSTABILITY = 2
SPECIAL = ~~W~~

HMIS RATINGS:

HEALTH = 3
FLAMMABILITY = 2
PHYSICAL HAZARD = 2

NOTE: The hazards of this material have not been fully investigated

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Praxair asks users of this product to study this MSDS and become aware of product hazards and safety information. To promote safe use of this product, a user should (1) notify employees, agents, and contractors of the information in this MSDS and of any other known product hazards and safety information, (2) furnish this information to each purchaser of the product, and (3) ask each purchaser to notify its employees and customers of the product hazards and safety information.

The opinions expressed herein are those of qualified experts within Praxair, Inc. We believe that the information contained herein is current as of the date of this Material Safety Data Sheet. Since the use of this information and the conditions of use of the product are not within the control of Praxair, Inc., it is the user's obligation to determine the conditions of safe use of the product.

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