SAFETY DATA SHEET

1. Identification

Product identifier: Hafnium Oxide

Other means of identification:
- SDS number: H-MSDS0004
- Synonyms: Hafnium oxide (HfO2) * Hafnium dioxide

Manufacturer/Importer/Supplier/Distributor Information

Manufacturer
- Company name: Materion Advanced Chemicals Inc.
- Address: 407 N 13th Street
- 1316 W. St. Paul Avenue
- Milwaukee, WI 53233
- United States
- Telephone: 414.212.0257
- E-mail: advancedmaterials@materion.com
- Contact person: Noreen Atkinson
- Emergency phone number: Chemtrec 800.424.9300

2. Hazard(s) identification

Physical hazards: Not classified.

Health hazards: Not classified.

Environmental hazards: Not classified.

OSHA defined hazards: Not classified.

Label elements

Signal word: Warning

Hazard statement: May cause damage to organs (respiratory system) through prolonged or repeated exposure.

Precautionary statement
- Prevention: Not available.
- Response: Get medical advice/attention if you feel unwell.
- Storage: Not available.
- Disposal: Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazard(s) not otherwise classified (HfOC)

Supplemental information: The Safety Information Sheet Chemicals of hazardous chemical can be obtained through phone, email or on the company website.

None.

3. Composition/information on ingredients

Substances

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Common name and synonyms</th>
<th>CAS number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hafnium oxide</td>
<td>Hafnium oxide (HfO2)</td>
<td>12055-23-1</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Hafnium dioxide</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Material name: Hafnium Oxide

342  Version #: 02  Revision date: 07-14-2015  Issue date: 05-17-2015
DSD: Directive 67/548/EEC.
M: M-factor
vPvB: very persistent and very bioaccumulative substance.
PBT: persistent, bioaccumulative and toxic substance.
*Designates that a specific chemical identity and/or percentage of composition has been withheld as a trade secret. #: This substance has been assigned Community workplace exposure limit(s).

4. First-aid measures

Inhalation  Move to fresh air. If breathing is difficult, remove to fresh air and keep at rest in a position comfortable for breathing. Call a physician if symptoms develop or persist.

Skin contact  Rinse skin with water/shower.

Eye contact  Rinse with water. Get medical attention if irritation develops and persists.

Ingestion  Get medical advice/attention if you feel unwell. Rinse mouth. If ingestion of a large amount does occur, call a poison control center immediately.

Most important symptoms/effects, acute and delayed  Liver enlargement. Jaundice. Prolonged exposure may cause chronic effects.

Indication of immediate medical attention and special treatment needed  Provide general supportive measures and treat symptomatically. Treat symptomatically.

General information  Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves. If you feel unwell, seek medical advice (show the label where possible). Show this safety data sheet to the doctor in attendance.

5. Fire-fighting measures

Suitable extinguishing media  Water.

Unsuitable extinguishing media  None known.

Specific hazards arising from the chemical  Not applicable.

Special protective equipment and precautions for firefighters  Wear suitable protective equipment.

Fire fighting equipment/instructions  In the event of fire, cool tanks with water spray.

Specific methods  Cool containers exposed to flames with water until well after the fire is out.

General fire hazards  No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures  Local authorities should be advised if significant spillages cannot be contained. Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Keep out of low areas. Wear appropriate personal protective equipment. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ensure adequate ventilation.

Methods and materials for containment and cleaning up  Stop the flow of material, if this is without risk. Dike far ahead of spill for later disposal. Prevent entry into waterways, sewer, basements or confined areas. Following product recovery, flush area with water. For waste disposal, see section 13 of the SDS.

Environmental precautions  Prevent further leakage or spillage if safe to do so. Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling  Avoid prolonged exposure. Handle and open container with care.

Conditions for safe storage, including any incompatibilities  Store in a cool, dry place out of direct sunlight. Use care in handling/storage.
8. Exposure controls/personal protection

Occupational exposure limits

<table>
<thead>
<tr>
<th>Material</th>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hafnium oxide (CAS 12055-23-1)</td>
<td>TWA</td>
<td>0.5 mg/m³</td>
</tr>
</tbody>
</table>

US. NIOSH: Pocket Guide to Chemical Hazards

<table>
<thead>
<tr>
<th>Material</th>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hafnium oxide (CAS 12055-23-1)</td>
<td>TWA</td>
<td>0.5 mg/m³</td>
</tr>
</tbody>
</table>

Biological limit values

No biological exposure limits noted for the ingredient(s).

Control parameters

Follow standard monitoring procedures.

Individual protection measures, such as personal protective equipment

Eye/face protection

Eye wash fountain is recommended. Not normally needed.

Skin protection

Hand protection

Not normally needed.

Other

Not available.

Respiratory protection

When workers are facing concentrations above the exposure limit they must use appropriate certified respirators.

Thermal hazards

Not available.

General hygiene considerations

Wash hands before breaks and immediately after handling the product. Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Appearance

Physical state

Solid.

Form

Solid.

Color

Not available.

Odor

Not applicable.

Odor threshold

Not available.

pH

Not available.

Melting point/freezing point

Not available.

Initial boiling point and boiling range

9752 °F (5400 °C)

Flash point

Not available.

Evaporation rate

Not available.

Flammability (solid, gas)

Not applicable.

Upper/lower flammability or explosive limits

Flammability limit - lower (%)

Not available.

Flammability limit - upper (%)

Not available.

Explosive limit - lower (%)

Not available.

Explosive limit - upper (%)

Not available.

Vapor pressure

399.97 kPa at 25 °C

Vapor density

Not available.

Relative density

Not available.
Solubility(ies)
  Solubility (water) Not available.
Partition coefficient
(n-octanol/water) Not available.
Auto-ignition temperature Not applicable.
Decomposition temperature Not available.
Viscosity Not available.
Other information
  Molecular formula HfO2
10. Stability and reactivity
Reactivity Not available.
Chemical stability Material is stable under normal conditions.
Possibility of hazardous reactions No dangerous reaction known under conditions of normal use.
Conditions to avoid None under normal conditions.
Incompatible materials None known.
Hazardous decomposition products No hazardous decomposition products are known.
11. Toxicological information
Information on likely routes of exposure
  Inhalation Due to lack of data the classification is not possible.
  Skin contact Due to lack of data the classification is not possible.
  Eye contact Due to lack of data the classification is not possible.
  Ingestion Due to lack of data the classification is not possible.
Symptoms related to the physical, chemical and toxicological characteristics Liver enlargement. Jaundice.
Information on toxicological effects
Acute toxicity Not available.
Skin corrosion/irritation Due to lack of data the classification is not possible.
Serious eye damage/eye irritation Due to lack of data the classification is not possible.
Respiratory or skin sensitization
  Respiratory sensitization Due to lack of data the classification is not possible.
  Skin sensitization Due to lack of data the classification is not possible.
Germ cell mutagenicity Due to lack of data the classification is not possible.
Carcinogenicity This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA.
US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)
  Not listed.
Reproductive toxicity Due to lack of data the classification is not possible.
Specific target organ toxicity - single exposure Due to lack of data the classification is not possible.
Specific target organ toxicity - repeated exposure May cause damage to organs (respiratory system) through prolonged or repeated exposure.
Aspiration hazard Due to lack of data the classification is not possible.
Chronic effects Prolonged inhalation may be harmful. May cause damage to organs through prolonged or repeated exposure.
Further information

This product has no known adverse effect on human health.

12. Ecological information
Ecotoxicity
No ecotoxicity data noted for the ingredient(s).

Persistence and degradability
No data is available on the degradability of this product.

Bioaccumulative potential
Not available.

Mobility in soil
Not available.

Other adverse effects
Not available.

13. Disposal considerations
Disposal instructions
Contract with a disposal operator licensed by the Law on Disposal and Cleaning. This material and its container must be disposed of as hazardous waste. Do not allow this material to drain into sewers/water supplies. Do not contaminate ponds, waterways or ditches with chemical or used container. Dispose of contents/container in accordance with local/regional/national/international regulations. Dispose of contents/container (in accordance with related regulations). Collect entire waste and then charge to a licensed industrial waste management professional with manifests for industrial waste.

Hazardous waste code
Not regulated.

Waste from residues / unused products
Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions). Not applicable.

Contaminated packaging
Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT
Not regulated as dangerous goods.

IATA
Not regulated as dangerous goods.

IMDG
Not regulated as dangerous goods.

15. Regulatory information

US federal regulations
CERCLA/SARA Hazardous Substances - Not applicable.

All components are on the U.S. EPA TSCA Inventory List.

This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)
Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)
Not listed.

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)
Not listed.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories
Immediate Hazard - No
Delayed Hazard - No
Fire Hazard - No
Pressure Hazard - No
Reactivity Hazard - No

SARA 302 Extremely hazardous substance
Not listed.
SARA 311/312 Hazardous chemical
SARA 313 (TRI reporting) Not regulated.

Other federal regulations
- Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List Not regulated.
- Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 88.130) Not regulated.
- Safe Drinking Water Act (SDWA) Not regulated.

US state regulations
California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins.

US. California Controlled Substances. CA Department of Justice (California Health and Safety Code Section 11100) Not listed.
US. Massachusetts RTK - Substance List Not regulated.
US. New Jersey Worker and Community Right-to-Know Act Not regulated.
US. Pennsylvania RTK - Hazardous Substances Not regulated.
US. Pennsylvania Worker and Community Right-to-Know Law Not listed.
US. Rhode Island RTK Not regulated.
US. California Proposition 65 Not Listed.

16. Other information, including date of preparation or last revision
Issue date 05-17-2015
Revision date 07-14-2015
Version # 02
Emergency telephone numbers

Austria - VergiftungsInformationsZentrale, +431.406.43.43
Belgium - Centre Antipoisons - +070.245.24.245
Bulgaria - Телефон за спешни случаи / факс, +359.2.9154.409
Cyprus - +357.22405611
Czech Republic - Toxikologické informační středisko, +420.224.919.293
Denmark - Akuthjælp ved forgiftning, +82.12.12.12
Estonia - Mürgistustebekeskuse, 16662
Finland - Myrkytystietokeskus, +(0)9.471.977
France - numéro ORFILA, +33.(0)1.45.42.59.59
Germany - GIZ-Nord Poisons Centre, +49.(0)551.383.1876
Greece - +30.210.64.79.286
Hungary - Az Egészségügyi Toxikológiai Tájékoztató Szolgálat, +36 1 476 6464
Iceland - +354.591.2000
Ireland - National Poisons Information Centre - +353.01.8092566
Italy - Istituto Superiore di Sanità, 064990.2423
Latvia - Valsts Toksikoloģijas centra Saindēšanās un zāļu informācijas centrs, +371.67042473
Liechtenstein - +423.236.61.95
Lithuania - Neatidėliotina informacija apsinuodijus, +370 5 236 20 52
Luxembourg - +352 42 59 91 600
Malta - 2545 0000
Netherlands - NVIC, 030-2748888
Norway - Giftinformasjonen, 22.59.13.00
Poland - Biuro ds. Substancji Chemicznych, +48 42 2538 424
Portugal - 808.250.143
Romania - Biroul RSI si Informare Toxicologica, 021.318.36.06
Slovakia - NTIC, +421.2.5477.4166
Slovenia - Kemična urad Republike Slovenije + 386.14.00.60.51
Spain - Servicio de Información Toxicológica, + 34.91.562.04.20
Sweden - 112

HMIS® is a registered trade and service mark of the NPCA.
References

ACGIH
EPA: AQUIRE database
NLM: Hazardous Substances Data Base
US. IARC Monographs on Occupational Exposures to Chemical Agents
Korea. Accidental Release Prevention Substances (Presidential Decree of Toxic Chemical Control Law, Executive Order No. 19203)
Korea. Dangerous Substances Threshold Quantity (Presidential Decree of Dangerous Substances Safety Management Act No. 18406, Schedule 1)
Korea. Harmful Substances Prohibited from Manufacturing (Presidential Decree on the Industrial Safety and Health Act (No. 13053), Article 29)
Korea. Harmful Substances Requiring Permission for Manufacture or Use (Presidential Decree on the Industrial Safety and Health Act (No. 13053), Article 30)
Korea. Observational Chemicals (Ministerial Decree of TCCL Article 6)
Korea. OELs. Regulation for Permitted Concentration of Hazardous Substances (Ministry of Labor (MOL) Public Notice No. 1986-45, as amended)
Korea. Prohibited Chemical Substances (TCCL Article 11)
Korea. Regulated volatile organic compounds (VOCs) (MOE Notice No. 2001-36, March 8, 2001, as amended)
Korea. Restricted Chemical Substances (TCCL Article 11)
Korea. Toxic Chemical Control Law (TCCL), Existing Chemicals Inventory (KECI)
Korea. Toxic Chemical Control Law (TCCL), pre-1997 List
Korea. Toxic Chemicals (TCCL Article 10)
Korea. Toxic Release Inventory (TRI) Chemicals (TCCL Article 14)
Taiwan. Dangerous Materials (Rules on Hazard Communication of Dangerous Materials and Toxic Materials)
Taiwan. Industrial Precursor Chemicals (Categories and Regulations Governing Inspection and Declaration of Industrial Precursor Chemicals, MOEA Decree No. 87, as amended)
Taiwan. OELs. (Standards on Workplace Atmosphere of Dangerous and Hazardous Materials)
Taiwan. Toxic Chemical Substances (TCS) (List of Toxic Chemical Substances announced by the Environmental Protection Administration)
Taiwan. Toxic Materials (Rules on Hazard Communication of Dangerous Materials and Toxic Materials)
HSDB® - Hazardous Substances Data Bank
IARC Monographs. Overall Evaluation of Carcinogenicity
National Toxicology Program (NTP) Report on Carcinogens
ACGIH Documentation of the Threshold Limit Values and Biological Exposure Indices
Japan Society for Occupational Health, Recommendation of Occupational Exposure Limits
GOST 30333-2007 - Chemical production safety passport. General requirements
JIS Z 7250: 2010 Safety data sheet for chemical products-Content and order of sections
JIS Z 7251: 2010 Labeling of chemicals based on GHS

Disclaimer

Additional information is given in the Material Safety Data Sheet.
This document has been prepared using data from sources considered to be technically reliable and the information is believed to be correct. Materion makes no warranties, expressed or implied, as to the accuracy of the information contained herein. Materion cannot anticipate all conditions under which this information and its products may be used and the actual conditions of use are beyond its control. The user is responsible to evaluate all available information when using this product for any particular use and to comply with all Federal, State, Provincial and Local laws, statutes and regulations.