

## 4. CHEMICAL AND PHYSICAL INFORMATION

### 4.1 CHEMICAL IDENTITY

Beryllium is a naturally occurring element found in earth's surface rocks at levels of 1–15 mg/kg. It appears in Group IIA of the periodic table and has two common oxidation states, Be(0) and Be(+2). Because of its high reactivity, beryllium is not found as the free metal in nature. There are approximately 45 mineralized forms of beryllium. The important beryllium minerals in the world are beryl ( $3\text{BeO}\cdot\text{Al}_2\text{O}_3\cdot\text{SiO}_2$ ) and bertrandite ( $\text{Be}_4\text{Si}_2\text{O}_7(\text{OH})_2$ ). Beryl has been known since ancient times as the gemstones: emerald (green), aquamarine (light blue), and beryl (yellow). Information concerning the chemical identity of elemental beryllium and beryllium compounds is listed in Table 4-1.

### 4.2 PHYSICAL AND CHEMICAL PROPERTIES

The physical and chemical properties of beryllium and beryllium compounds are listed in Table 4-2.

Consistent with the high charge-to-radius ratio, beryllium has a strong tendency to form compounds with covalent bonds; even compounds with the most electronegative elements (e.g.,  $\text{BeF}_2$ ) have substantial covalent character. Although beryllium belongs to Group IIA of the periodic table, it is chemically very similar to aluminum, which also has a high charge-to-radius ratio. Like aluminum, the hydroxide of beryllium is amphoteric (Cotton and Wilkinson 1980; Drury et al. 1978; EPA 1998).

The interaction of cosmic-ray particles in the atmosphere produces a number of radionuclides including beryllium-7 (Be-7) and beryllium-10 (Be-10). The radioactive half-life of Be-7 is 53.29 days and the radioactive half-life of Be-10 is  $1.51 \times 10^6$  years (UNSCEAR 2000).

**Table 4-1. Chemical Identity of Beryllium and Beryllium Compounds<sup>a</sup>**

Characteristic	Beryllium	Beryllium chloride	Beryllium fluoride	Beryllium hydroxide	Beryllium oxide
Synonym(s)	Beryllium-9; glucinium; glucinum; beryllium metallic	Beryllium dichloride	Beryllium difluoride	Beryllium hydrate; beryllium dihydroxide	Beryllia; beryllium monoxide
Registered trade name(s)	No data	No data	No data	No data	Thermalox 995
Chemical formula	Be	BeCl <sub>2</sub>	BeF <sub>2</sub>	Be(OH) <sub>2</sub>	BeO
Identification numbers:					
CAS registry	7440-41-7	7787-47-5	7787-49-7	13327-32-7	1304-56-9
NIOSH RTECS	DS1750000	DS2625000	DS2800000	DS3150000	DS4025000
EPA hazardous waste	P015 <sup>b</sup>	No data	No data	No data	No data
OHM/TADS	72116604 <sup>c</sup>	7217359 <sup>c</sup>	7800049 <sup>c</sup>	No data	No data
DOT/UN/NA/IMCO shipping	UN1567/IM06.1	NA1566/IM06.1	NA1566/IM06.1	UN1566/IM06.1	UN1566/IM06.1
HSDB	512	357	355	350	1607
NCI	No data	No data	No data	No data	No data

Table 4-1. Chemical Identity of Beryllium and Beryllium Compounds<sup>a</sup> (continued)

Characteristic	Beryllium phosphate (3H <sub>2</sub> O)	Beryllium nitrate	Beryllium sulfate	Beryllium carbonate (basic)
Synonym(s)	Beryllium orthophosphate <sup>d</sup>	Nitric acid, beryllium salt	Sulfuric acid, beryllium salt	Basic beryllium <sup>e</sup> carbonate; bis[carbonato(2-)] dihydroxy triberyllium <sup>e</sup>
Registered trade name(s)	No data	No data	No data	No data
Chemical formula	Be <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> ·3H <sub>2</sub> O <sup>d</sup>	Be(NO <sub>3</sub> ) <sub>2</sub>	BeSO <sub>4</sub>	(BeCO <sub>3</sub> ) <sub>2</sub> <sup>-</sup> Be(OH) <sub>2</sub> <sup>e</sup>
Identification numbers:				
CAS registry	35089-00-0 <sup>d</sup>	13597-99-4 (anhydrous) 13510-48-0 (tetrahydrate)	13510-49-1 (anhydrous) 14215-00-0 (2H <sub>2</sub> O) 7787-56-6 (4H <sub>2</sub> O)	66104-24-3 <sup>e</sup>
NIOSH RTECS	No data	DS3675000 (anhydrous)	DS48000000 (anhydrous)	No data
EPA hazardous waste	No data	No data	No data	No data
OHM/TADS	No data	7217227 <sup>c</sup> (anhydrous)	7217228 <sup>c</sup> (anhydrous)	No data
DOT/UN/NA/IMCO shipping	No data	UN2464/IM05.1	UN1566/IM06.1	No data
HSDB	No data	1431	347	No data
NCI	No data	No data	No data	No data

<sup>a</sup>All information obtained from HSDB 2000 except where noted

<sup>b</sup>EPA Hazardous waste list P015 applies to beryllium powder only

<sup>c</sup>OHM/TADS 1990

<sup>d</sup>Weast 1985

<sup>e</sup>IARC 1980

CAS = Chemical Abstracts Services; DOT/UN/NA/IMCO = Department of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

**Table 4-2. Physical and Chemical Properties of Beryllium and Beryllium Compounds<sup>a</sup>**

Property	Beryllium metal	Beryllium fluoride	Beryllium hydroxide	Beryllium oxide	Beryllium carbonate (basic)
Molecular weight	9.012	47.01	43.03 <sup>b</sup>	25.01	112.05
Color	Gray	Colorless	White <sup>c</sup>	White	White
Physical state	Solid; hexagonal structure <sup>d</sup>	Glassy, hygroscopic mass <sup>d</sup>	Amorphous powder or crystalline solid <sup>d</sup>	Light, amorphous powder <sup>d</sup>	Powder
Melting point	1,287–1,292 EC <sup>e</sup>	555 EC <sup>b</sup>	Decomposes (loses water) when heated <sup>f</sup>	2,508–2,547 EC <sup>b</sup>	No data
Boiling point	2,970 EC <sup>e</sup>	1,175 EC <sup>b</sup>	Not applicable	3,787 EC <sup>b</sup>	No data
Density	1.846 g/cm <sup>3</sup> <sup>e</sup>	1.986 g/cm <sup>3</sup> (25 EC) <sup>b</sup>	1.92 g/cm <sup>3</sup> <sup>b</sup>	3.016 g/cm <sup>3</sup> <sup>c</sup>	No data
Odor	None	None	None	None	None
Odor threshold:	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Solubility:					
Water	Insoluble <sup>g</sup>	Very soluble <sup>g</sup>	0.8x10 <sup>-4</sup> mol/L <sup>g</sup> (3.44 mg/L)	Very sparingly <sup>g</sup>	Insoluble (cold) decomposes (hot)
Other solvent(s)	Soluble in dilute acid and alkali	Slightly soluble in alcohol <sup>d</sup>	Soluble in hot concentrated acid and alkali <sup>d</sup>	Soluble in concentrated acids <sup>d</sup>	Soluble in acid, alkali
Partition coefficients:					
Log K <sub>ow</sub>	No data	No data	No data	No data	No data
Log K <sub>oc</sub>	No data	No data	No data	No data	No data
Vapor pressure	1 mmHg (1,520 EC)	No data	No data	No data	No data
Henry's law constant	No data	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data	No data
Conversion factors <sup>h</sup>					
Explosive limits	No data	No data	No data	No data	No data

Table 4-2. Physical and Chemical Properties of Beryllium and Beryllium Compounds<sup>a</sup> (continued)

Property	Beryllium chloride	Beryllium nitrate (tetrahydrate)	Beryllium phosphate (trihydrate)	Beryllium sulfate	Beryllium sulfate (tetrahydrate)
Molecular weight	79.92	205.08 <sup>b</sup>	271.03	105.07	177.13
Color	Colorless	White <sup>b</sup>	White <sup>b</sup>	Colorless <sup>b</sup>	Colorless <sup>b</sup>
Physical state	Needles	Crystals <sup>b</sup>	Solid <sup>b</sup>	Tetragonal crystals	Tetragonal crystals
Melting point	405 EC	60.5 EC <sup>b</sup>	100 EC (loses H <sub>2</sub> O) (decomposes) <sup>b</sup>	550–600 EC (decomposes)	100 EC (loses 2H <sub>2</sub> O)
Boiling point	520 EC	142 EC (decomposes) <sup>b</sup>	No data	Not applicable	400 EC (loses 4H <sub>2</sub> O)
Density	1.899 g/cm <sup>3</sup> (25 EC)	1.557 g/cm <sup>3</sup> <sup>b</sup>	No data	2.443 g/cm <sup>3</sup>	1.713 g/cm <sup>3</sup> (10.5 EC)
Odor	None	None <sup>b</sup>	None <sup>b</sup>	None	None
Odor threshold:	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Solubility:					
Water	Very soluble	166 parts/100 parts H <sub>2</sub> O (20 EC) <sup>b</sup> (1.66x10 <sup>5</sup> mg/L)	Soluble	Insoluble	39.1 parts/100 parts H <sub>2</sub> O (20 EC) <sup>b</sup> (3.91x10 <sup>5</sup> mg/L)
Other solvent(s)	Very soluble in alcohol, ether, pyridine; slightly soluble in benzene and chloroform	No data	Soluble in acetic acid	No data	Slightly soluble in H <sub>2</sub> SO <sub>4</sub> , insoluble in alcohol
Partition coefficients:					
Log K <sub>ow</sub>	No data	No data	No data	No data	No data
Log K <sub>oc</sub>	No data	No data	No data	No data	No data
Vapor pressure	No data	No data	No data	No data	No data
Henry's law constant	No data	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data	No data

**Table 4-2. Physical and Chemical Properties of Beryllium and Beryllium Compounds<sup>a</sup> (continued)**

Property	Beryllium chloride	Beryllium nitrate (tetrahydrate)	Beryllium phosphate (trihydrate)	Beryllium sulfate	Beryllium sulfate (tetrahydrate)
Flammability limits	No data <sup>h</sup>	No data <sup>h</sup>	No data <sup>h</sup>	No data <sup>h</sup>	No data <sup>h</sup>
Conversion factors					
Explosive limits	No data	No data	No data	No data	No data

<sup>a</sup>All information obtained from Weast 1985 except where noted

<sup>b</sup>Dean 1985

<sup>c</sup>Hawley 1981

<sup>d</sup>Windholz 1983

<sup>e</sup>Ballance et al. 1978

<sup>f</sup>Walsh and Rees 1978

<sup>g</sup>EPA 1987

<sup>h</sup>These compounds do not exist in the atmosphere in the vapor phase; therefore, an air conversion factor is not applicable.