

4. CHEMICAL AND PHYSICAL INFORMATION

4.1 CHEMICAL IDENTITY

Vanadium is a naturally occurring element that appears in group 5(B5) of the periodic table (Lide 2008). Vanadium is widely distributed in the earth's crust at an average concentration of 100 ppm (approximately 100 mg/kg), similar to that of zinc and nickel (Byerrum 1991). Vanadium is the 22nd most abundant element in the earth's crust (Baroch 2006). Vanadium is found in about 65 different minerals; carnotite, roscoelite, vanadinite, and patronite are important sources of this metal along with bravoite and davidite (Baroch 2006, Lide 2008). It is also found in phosphate rock and certain ores and is present in some crude oils as organic complexes (Lide 2008). Table 4-1 lists common synonyms and other pertinent identification information for vanadium and representative vanadium compounds.

4.2 PHYSICAL AND CHEMICAL PROPERTIES

Vanadium is a gray metal with a body-centered cubic crystal system. It is a member of the first transition series. Because of its high melting point, it is referred to as a refractory metal (Baroch 2006). When highly pure, it is a bright white metal that is soft and ductile. It has good structural strength and a low-fission neutron cross section. Vanadium has good corrosion resistance to alkalis, sulfuric and hydrochloric acid, and salt water; however, the metal oxidizes readily above 660 °C (Lide 2008). The chemistry of vanadium compounds is related to the oxidation state of the vanadium (Woolery 2005). Vanadium has oxidation states of +2, +3, +4, and +5. When heated in air at different temperatures, it oxidizes to a brownish black trioxide, a blue black tetraoxide, or a reddish orange pentoxide. It reacts with chlorine at fairly low temperatures (180 °C) forming vanadium tetrachloride and with carbon and nitrogen at high temperatures forming VC and VN, respectively. The pure metal in massive form is relatively inert toward oxygen, nitrogen, and hydrogen at room temperature (HSDB 2009). Vanadium pentoxide is an industrially important vanadium compound (Lide 2008). Table 4-2 lists important physical and chemical properties of vanadium and vanadium compounds.

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Table 4-1. Chemical Identity of Vanadium and Compounds^a

Characteristic	Vanadium	Vanadium pentoxide	Vanadyl sulfate
Synonym(s)	Vanadium, elemental	Vanadium oxide; vanadium(V) oxide; vanadic anhydride; divanadium pentoxide	Vanadic sulfate; vanadium oxide sulfate
Registered trade name(s)			
Chemical formula	V	V ₂ O ₅	VO ₂ SO ₄
Identification numbers:			
CAS registry	7440-62-2	1314-62-1	27774-13-6
EINECS	231-171-1	215-239-8	248-652-7
RTECS ^b	YW1355000	YW2450000	YW1925000
EPA hazardous waste	No data	P120	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMDG shipping	No data	UN2862	UN2931
HSDB	1022	1024	1026
NCI	No data	No data	No data

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Table 4-1. Chemical Identity of Vanadium and Compounds^a

Characteristic	Sodium metavanadate	Sodium orthovanadate	Ammonium metavanadate
Synonym(s)	Sodium vanadate(V); vanadic acid, monosodium	Sodium o-vanadate; sodium pervanadate; sodium vanadium oxide; vanadic(II) acid, trisodium salt	Ammonium vanadate(V); ammonium monovanadate; ammonium vanadium oxide; ammonium vanadium trioxide; vanadic acid, ammonium salt
Registered trade name(s)			
Chemical formula	NaVO ₃	Na ₃ VO ₄	NH ₄ VO ₃
Identification numbers:			
CAS registry	13718-26-8	13721-39-6	7803-55-6
EINECS	237-272-7	237-287-9	232-261-3
RTECS ^b	YW1050000	YW1120000	YW0875000
EPA hazardous waste	No data	No data	P119
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMDG shipping	No data	No data	UN2859
HSDB	No data	No data	6310
NCI	No data	No data	No data

^aAll information obtained from ChemIDPlus 2009 and HSDB 2009, except where noted.

^bRTECS 2009

CAS = Chemical Abstracts Service; DOT/UN/NA/IMDG = 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

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Table 4-2. Physical and Chemical Properties of Vanadium and Compounds^a

Property	Vanadium	Vanadium pentoxide	Vanadyl sulfate dihydrate
Molecular weight	50.9415	181.88	199.035 ^c
Color	Light gray or white lustrous powder, fused hard lumps or body-centered cubic crystals. Pure vanadium is bright white, soft and ductile.	Yellow to rust-brown orthorhombic crystals. Yellow-orange powder or dark-gray flakes dispersed in air. Yellow to red crystalline powder.	Blue crystalline powder ^c
Physical state	Solid ^b	Solid ^b	Solid
Melting point	1,910 °C	690 °C	
Boiling point	3,407 °C	1,750 °C (decomposes)	
Density at 18.7 °C	6.11	3.357	No data
Odor	No data	Odorless	No data
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water	Insoluble	1 g dissolves in approximately 125 mL water	Soluble in water ^c
Other solvents	Soluble in nitric, hydrofluoric, and concentrated sulfuric acids; attacked by alkali, forming water soluble vanadates	Soluble in concentrated acids, alkalies; insoluble in alcohol	No data
Partition coefficients:			
Log K _{ow}	No data	No data	No data
Log K _{oc}	No data	No data	No data
Vapor pressure	2.34x10 ⁻² mm Hg at 1,916 °C (extrapolated)	No data	No data
Henry's law constant	No data	No data	No data
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

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Table 4-2. Physical and Chemical Properties of Vanadium and Compounds^a

Property	Sodium metavanadate	Sodium orthovanadate	Ammonium metavanadate
Molecular weight	121.830 ^c	183.909 ^c	116.98
Color	Colorless, monoclinic, prismatic crystals or pale-green crystalline powder ^b	Colorless, hexagonal prisms ^b	White or slightly yellow, crystalline powder
Physical state	Solid	Solid	Solid
Melting point	630°C ^b	850–866 °C ^b	200 °C
Boiling point	No data	No data	No data
Density	No data	No data	2.326 g/cm ³
Odor	No data	No data	No data
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water	21 g/100 g water at 25 °C ^c	Soluble in water ^c	Slightly soluble in cold water
Other Solvents	No data	Insoluble in ethanol ^c	Insoluble in alcohol, ether, ammonium chloride
Partition coefficients:			
Log K _{ow}	No data	No data	No data
Log K _{oc}	No data	No data	No data
Vapor pressure	No data	No data	No data
Henry's law constant	No data	No data	No data
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	Noncombustible ^b	No data	Nonflammable ^b
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

^aAll information obtained from HSDB 2009, except where noted.

^bLewis 2007

^cLide 2008

^dVanadyl sulfate pentahydrate - Ethereal blue solid; readily soluble in water