

3. CHEMICAL AND PHYSICAL INFORMATION

There are many compounds, complexes, and alloys of antimony that occur naturally or are man-made. The chemical identity and physical chemical properties of all of these forms of antimony cannot be discussed in detail.

3.1 CHEMICAL IDENTITY

Antimony is in the fourth row of group 5A in the periodic table, residing between arsenic and bismuth. It displays four oxidation states: Sb(-3), Sb(0), Sb(+3), and Sb(+5). The +3 state is the most common and stable. Antimony is sometimes referred to as a metalloid, indicating that it displays both metallic and nonmetallic characteristics.

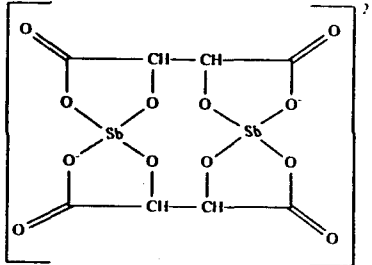
Metallic antimony is the only allotropic form of antimony that is stable under normal conditions. Two unstable allotropes exist: yellow and black amorphous forms (Herbst et al. 1985). Metallic antimony is a very brittle, moderately hard metal (Herbst et al. 1985). It is occasionally found uncombined in nature (Carapella 1978). Antimony has two stable isotopes with mass numbers 121 and 123, with natural abundances of 57.25% and 42.75%, respectively (Carapella 1978). One radioactive isotope, Sb125, is a fission product released in nuclear explosions or nuclear fuel reprocessing plants and has a half-life of 2.7 years (Weast 1988). Data on the chemical identity of antimony, antimony pentasulfide, antimony pentoxide, antimony potassium tartrate, antimony trichloride, antimony trioxide, antimony trisulfide, and stibine are shown in Table 3-1.

3.2 PHYSICAL AND CHEMICAL PROPERTIES

The physical and chemical properties of antimony, antimony pentasulfide, antimony pentoxide, antimony potassium tartrate, antimony trichloride, antimony trioxide, antimony trisulfide, and stibine are given in Table 3-2. Antimony metal is stable under ordinary conditions and is not readily attacked by air or water (Herbst et al. 1985). It is a poor conductor of heat and electricity (Weast 1988). Antimony is positioned after hydrogen in the electrochemical series and therefore will not displace hydrogen ions from dilute acids. It is not affected by cold, dilute acids (Windholz 1983). Simple antimony cations (i.e., Sb^{+3} and Sb^{+5}) do not occur in solution, but hydrolyzed forms (e.g., $Sb(OH)_6^-$) are found. The dominant species in the pH range typical of natural environments are $Sb(OH)_3$, in the case of trivalent antimony, and $Sb(OH)_6^-$ for pentavalent antimony (Bodek et al. 1988). In oxidizing environments, $Sb(OH)_6^-$ is the dominant species for pH greater than 3, whereas $Sb(OH)_3$ is dominant under relatively reducing conditions. The concentration of antimony is too low in natural water for Sb_2O_3 or Sb_2O_5 to precipitate out.

Antimony trioxide is dimorphic, existing as a cubic form, senarmonite, and an orthorhombic form, valentinite. The cubic form is stable at temperatures below 570°C (Freedman et al. 1978). Antimony trioxide is

TABLE 3-1. Chemical Identity of Antimony and Compounds

Characteristic	Antimony	Antimony pentasulfide	Antimony pentoxide	Antimony potassium tartrate
Synonym(s)	Antimony black; stibium; antimony regulus	Antimonial saffron; antimonite sulfide; antimony red; antimony; golden antimony sulfide; antimony persulfide ^a	Antimonic oxide; antimony pentaoxide; diantimony pentoxide; stibic anhydride; antimonic anhydride; antimonic acid ^a	Antimony potassium tartrate; potassium antimony tartrate; tartox; tartrated antimony; Potassium antimony tartrate; tartar emetic
Registered trade name(s)	No data	No data	No data	No data
Chemical formula	Sb ^a	S ₅ Sb ₂ ^a	O ₅ Sb ₂ ^b	C ₈ H ₄ K ₂ O ₁₂ Sb ₂ ·3H ₂ O ^b
Chemical Structure	Sb	No data	No data	 <p style="text-align: right;">2K⁺·3H₂O</p>
Identification Numbers				
CAS registry	7440-36-0	1315-04-4	1314-60-9	28300-74-5
NIOSH RTECS	CC4025000	CC6125000 ^a	CC6300000 ^a	CC6825000
EPA hazardous waste	No data	No data	No data	No data
OHM/TADS	7216595	No data	No data	7217219
DOT/UN/NA/IMCO shipping	UN 2871	No data	No data	UN 1551
HSDB	508	No data	No data	1428
NCI	No data	No data	No data	No data

^aAll information obtained from HSDB 1989,1991 except where noted

^bWindholz 1983

^cFreedman et al. 1978

^dAvento and Touval 1980

^eWeast 1989

^fDean 1985

^gRTECS 1991

^hCotton and Wilkinson 1966

CAS = Chemical Abstracts Service; 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 3-1 (Continued)

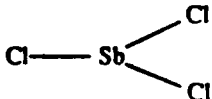
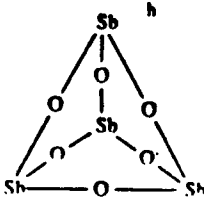
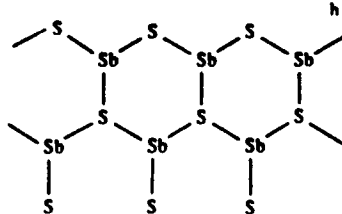
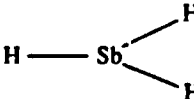
Characteristic	Antimony trichloride	Antimony trioxide	Antimony trisulfide	Stibine
Synonym(s)	Antimonous chloride; antimony butter; antimony(III) chloride; trichlorostibine; chlorid antimony	Antimonious oxide; antimony oxide; diantimony trioxide ^b ; flowers of antimony ^b ; antimony sesquioxide ^c ; senmarmontite; valentinite; antimony white; antimony peroxide; timothox; exitelite	Antimonous sulfide; antimony glance; antimony orange; antimony crimson; antimony sesquisulfide; antimony sulfide; antimony vermilion; stibite; antimony needles;	Antimony hydride; antimony trihydride; hydrogen antimonide
Registered trade name(s)	No data	HP ^d ; LP ^d ; KR ^d ; White Star ^d ; White Star M ^d ; KR-LTS ^d ; Thermoguard S ^d ; Thermoguard L ^d ; H grade ^d ; L Grade ^d ; Fire Shield H ^d ; Fire Shield L ^d ; Montana Brand ^d	No data	No data
Chemical formula	Cl ₃ Sb	O ₃ Sb ₂	S ₃ Sb ₂	H ₃ Sb
Chemical structure				
Identification numbers:				
CAS registry	10025-91-9	1309-64-4	1345-04-6	7803-52-3
NIOSH RTECS	CC4900000	CC5650000	CC9450000	WJ0700000
EPA hazardous waste	No data	No data	No data	No data
OHM/TADS	7217220	7217222	No data	No data
DOT/UN/NA/IMCO shipping	UN 1733	UN1549; antimony compounds, inorganic, solid, NOS; NA 9201; antimony trioxide	UN 1549; antimony compounds, inorganic, solids, NA 1325 Antimony sulfide, solid	UN 2676
HSDB	439	436	1604	785
NCI	No data	C55152	No data	No data

TABLE 3-2. Physical and Chemical Properties of Antimony and Compounds

Property	Antimony	Antimony pentasulfide	Antimony pentoxide	Antimony potassium tartrate
Atomic/molecular weight	121.75	403.80	323.5 (anhydrous)	333.93
Color	Silvery white	yellow	yellow	colorless
Physical state	Solid	Solid	Solid	Solid
Valence state	0	+5	+5	+3
Melting point, °C	630.5	75°C decomposes	380°C decomposes ^f	100°C(-1/2H ₂ O)
Boiling point, °C	1,750; 1,325 ^b ; 1,635 ^d	No data	No data	No data
Density (g/cm ³)	6.684 (25°C); 6.688 (20°C) ^b	4.12	3.78	2.6
Odor	No data	Odorless ^d	No data	Odorless ^e
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Taste	No data	No data	No data	Sweetish, metallic ^d
Taste threshold	No data	No data	No data	No data
Solubility:				
Water	Insoluble	Insoluble	Very slightly soluble	83 g/L (cold)
Organic solvents	No data	Insoluble in alcohol	No data	Insoluble in alcohol Soluble in glycerine
Partition coefficients:				
Log octanol/water	No data	No data	No data	No data
Log K _{oc}	No data	No data	No data	No data
Vapor pressure, mmHg	1 (886°C) ^e	No data	No data	No data
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data
flash point	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors				
ppm to mg/m ³	None ^g	None ^g	None ^g	None ^g
Explosive limits	No data	No data	No data	No data

*All information obtained from Weast 1988 except where noted

^bHerbst et al. 1985

^cFreedman et al. 1978

^dWindholz 1983

^eHSDB 1989, 1991

^fSAX 1984

^gSince these substances exist in the atmosphere in the particulate state, the concentration is expressed as mg/m³.

TABLE 3-2 (Continued)

Property	Antimony trichloride	Antimony trioxide	Antimony trisulfide	Stibine
Atomic/molecular weight	228.11	291.50	339.69	124.77
Color	Colorless	White (senarmontite); Colorless (valentinite)	Black (stibnite) Yellow-red (amorphous)	Colorless ^c
Physical state	Solid	Solid	Solid	Gas
Valence state	+3	+3	+3	-3
Melting point, °C	73.4	656	550	-88
Boiling point, °C	283, 222.6 ^c	1,550 sublimes; 1,425 ^c	1,150	-17 ^c
Density (g/cm ³)	3.140 (25°C)	5.2 (senarmontite); 5.67 (valentinite)	4.64 (stibinite) 4.12 (amorphorus solid)	2.204 (-17°C) ^c
Odor	Sharp, unpleasant	Odorless ^e	No data	Disagreeable, like hydrogen sulfide ^c
Odor threshold:				
Water	No data	No data	No data	No data
Air	No data	No data	No data	No data
Taste	No data	No data	No data	No data
Taste threshold	No data	No data	No data	No data
Solubility:				
Water	6,016 g/L (0°C)	Very slightly soluble	1.75 mg/L (18°C)	4.1 g/L (0°C)
Organic solvents	Soluble in ABS alcohol, tartaric acid, methylene chloride, benzene, acetone	Soluble in tartaric acid; acetic acid, hydrochloric acid	Soluble in alcohol Insoluble in acetic acid	Soluble in carbon disulfide ethanol ^c
Partition coefficients:				
Log octanol/water	No data	No data	No data	No data
Log K _{oc}	No data	No data	No data	No data
Vapor pressure, mmHg	1 mmHg (49.2°C, sublimes)	1 mmHg (574°C) ^e	No data	No data
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data
flash point	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors				
ppm to mg/m ³	None ^f	None ^f	None ^f	1 ppm stibine = 5.1 mg/m ³
Explosive limits	No data	No data	No data	No data

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amphoteric; it is soluble in bases and hydrochloric and some organic acids, but not dilute sulfuric or nitric acids (Cotton and Wilkinson 1966). Nitric acid and other strong oxidizing agents convert antimony trioxide to antimony pentoxide, Sb_2O_5 , which is acidic (Carapella 1978; Cotton and Wilkinson 1966).

Antimony forms complex ions with organic and inorganic acids; one of the best known is the tartrate. In the presence of sulfur, stable complexes such as $\text{Sb}_2\text{S}_4^{2-}$ may form (Bodek et al. 1988).

Stibine, SbH_3 , is a gaseous antimony compound in which antimony is in the -3 valence state. It is formed by the action of acids on metal antimonides or antimony alloys, reduction of antimony compounds, or the electrolysis of acidic or basic solutions where antimony is present in the cathode. As such, there is a danger of stibine being liberated from overcharged lead storage batteries in which antimony is alloyed into the lead. Stibine slowly decomposes into metallic antimony and hydrogen. It is readily, and sometimes violently, oxidized by air to form antimony trioxide and water (Freedman et al. 1978).