3. CHEMICAL AND PHYSICAL INFORMATION

CHEMICAL IDENTITY

Aluminum appears in the second row of Group III of the periodic table. It generally has two oxidation states: Al(O) and Al(+3). Because of its high reactivity, aluminum is not found as the free metal in nature. Information regarding the chemical identity of aluminum and compounds is located in Table 3- 1.

PHYSICAL AND CHEMICAL PROPERTIES

Information regarding the physical and chemical properties of aluminum is located in Table 3-2. In addition to the compounds listed in Table 3-2, aluminum in the form or alumina (Al_2O_3), combined with silica and other chemical compounds is a major component of clay minerals (Dombrowski 1993; Sennett 1993). The large number of types of clays and the variability in their composition make it impossible to include in this document.

Table 3-1. Chemical Identity of Aluminum and Compounds[a]

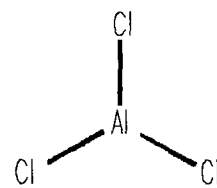
Characteristic	Information	Information	Information
Chemical name	Aluminum	Aluminum chloride	Aluminum chlorhydrate[b]
Synonym(s)	Aluminum; alumina fibre; metana; aluminum bronze; aluminum dehydrated; aluminum flake; aluminum powder	Aluminum trichloride; trichloroaluminum[c]; aluminum chloride (1:3)	Aluminum chlorohydroxide; aluminum hydroxychloride[d]; aluminum chloride, basic; aluminum chloride hydroxide; polyaluminum chloride
Registered trade name(s)	Aluminum-27; Jisc 3108/3110; Metana; Noral Aluminum; Pap-1	Pearsall	Astringen; Chlorhydrol; Locron[d]
Chemical formula	Al[d]	$AlCl_3$[d]	$AlClH_5O_5$ or $Al_2(OH)_5Cl{\bullet}2H_2O$[d] or $(Al(OH)_2Cl)_x$ or $Al_6(OH)_{15}Cl_3$; $[Al_2(OH)_5Cl]_x$ [e]
Chemical structure	Al		Not available

Table 3-1. Chemical Identity of Aluminum and Compounds[a] *(continued)*

Characteristic	Information	Information	Information
Chemical name	Aluminum	Aluminum chloride	Aluminum chlorhydrate[b]
Identification numbers:			
CAS registry	7429-90-5[d]	7446-70-0[d]	1327-41-9[d]; 11097-68-0; 84861-98-3[f]
NIOSH RTECS	BD330000	BD0525000	BD0549500[f]; BD0550000[g]
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	UN 1309; UN 1383; UN 1396; IMO 4.1; IMO 4.2; IMO 4.3	UN 1726; UN 2581; IMO 8.0	No data
HSDB	507	607	No data
NCI	No data	No data	No data

Table 3-1. Chemical Identity of Aluminum and Compounds[a] *(continued)*

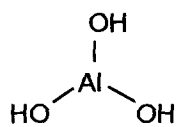
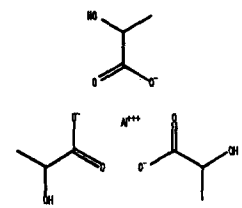
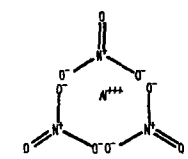
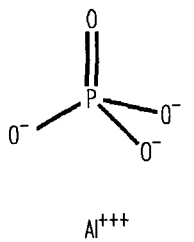
Characteristic	Information	Information	Information
Chemical name	Aluminum hydroxide	Aluminum lactate	Aluminum nitrate
Synonym(s)	α-Alumina trihydrate; alumina hydrate; alumina hydrated; aluminum oxide trihydrate; aluminum oxide hydrate; aluminum (III) hydroxide; hydrated alumina; hydrated aluminum oxide[a]; aluminum hydrate; aluminum trihydrate; hydrated alumina[d]	Aluctyl; aluminum, tris (2-hydroxypropanoato-O^1,O^2)[f]; propanoic acid, 2-hydroxy-, aluminum complex; aluminum tris (.alpha.-hydroxypropionate)	Aluminum trinitrate; aluminum (III) nitrate (1:3); nitric acid, aluminum salt; nitric acid, aluminum (3+) salt
Registered trade name(s)	Alcoa 331/c 30BF/C 330/ C 333; Alugel; Alumigel; BACO AF260; British Aluminum AF260; Calmogastrin; Higilite H 31S/ H 32/ H 42; Hychol 705; Hydrafil; Hydral 705/710; Martinal A/A-S/F-A; Reheis F 1000	No data	No data
Chemical formula	AlH_3O_3 or $Al(OH)_3$[d]; $AL_2O_3.3H_2O$[e]	$C_9H_{15}AlO_9$[d]	AlN_3O_9[d]; $AlN_3O_9 \cdot 9H_2O$[e]
Chemical structure			

Table 3-1. Chemical Identity of Aluminum and Compounds[a] *(continued)*

Characteristic	Information	Information	Information
Chemical name	Aluminum hydroxide	Aluminum lactate	Aluminum nitrate
Identification numbers:			
CAS registry	21645-51-2[d]	18917-91-4[d]	13473-90-0[d]
NIOSH RTECS	BD0940000	BD2214000[f]	BD1040000
EPA hazardous waste	No data	No data	No data
OHM/TADS	7216580	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	UN 1438; IMO 5.1
HSDB	575	No data	574
NCI	No data	No data	No data

Table 3-1. Chemical Identity of Aluminum and Compounds[a] *(continued)*

Characteristic	Information	Information	Information
Chemical name	Aluminum oxide[h]	Aluminum phosphate	Aluminum phosphide
Synonym(s)	Activated aluminum oxide; α-aluminum, α aluminum oxide; alumina; aluminum sesquioxide; aluminum trioxide; β-aluminum oxide; γ-alumina; γ-aluminum oxide[f]	Aluminum orthophosphate[d]; phosphoric acid; aluminum salt (1:1); aluminum phosphate tribasic[c]	Aluminum monophosphide; Quick-Phos; Quick-Fume[c]; AlP; Celphos; Detia; Phostoxin[d]
Registered trade name(s)	Almite; Alon; Aloxite; Alumite; Alundum; Campalox; Dispol Alumina; Exolon XW 60; Faserton; Hypalox II; Ludox CL; Martoxin; Microgrit WCA; Poraminar[f]	Alaphos (ingredient); Ukocid (ingredient); Phosphaljel (ingredient); Phosphalugel (ingredient); Phosphalutab (ingredient)	Celphos; Delicia; Delicia Gastoxin; Detia GAS EX-B/EX-T; Phostoxin; Detia phospine pellets[i]
Chemical formula	Al_2O_3[d]	$AlPO_4$[d]	AlP[d]
Chemical structure	Not available		

Al^{+++}

Table 3-1. Chemical Identity of Aluminum and Compounds[a] *(continued)*

Characteristic	Information	Information	Information
Chemical name	Aluminum oxide[h]	Aluminum phosphate	Aluminum phosphide
Identification numbers:			
CAS registry	1344-28-1[d]	7784-30-7[d]	20859-73-8[d]
NIOSH RTECS	BD1200000	No data	BD1400000
EPA hazardous waste	No data	No data	P006
OHM/TADS	No data	No data	8500249[i]
DOT/UN/NA/IMCO shipping	No data	No data	UN 1397; UN 3048; IMO 4.3; IMO 6.1
HSDB	506	No data	6035
NCI	No data	No data	No data

Table 3-1. Chemical Identity of Aluminum and Compounds[a] *(continued)*

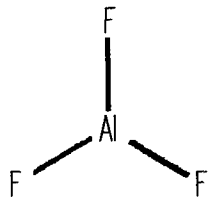
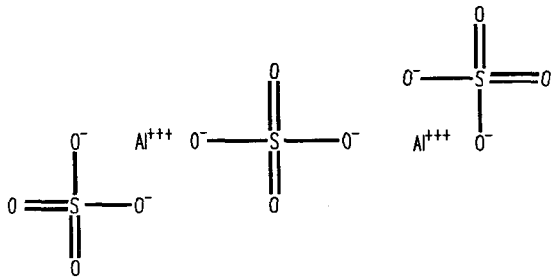
Characteristic	Information	Information
Chemical name	Aluminum fluoride	Aluminum sulfate
Synonym(s)	Aluminum trifluoride[d]; aluminum fluoride monohydrate[c]; Aluminum fluorure (French)	*Alum; peral alum; pickle alum; cake alum; filter alum;* papermakers' alum; patent alum[e]; aluminum sulfate (2:3); aluminum trisulfate; dialuminum sulfate; dialuminum trisulfate; sulfuric acid, aluminum salt (3:2)
Registered trade name(s)	No data	cake alum; patent alum[e]
Chemical formula	AlF_3[d]	$Al_2(SO_4)_3$[d]
Chemical structure		

Table 3-1. Chemical Identity of Aluminum and Compounds[a] *(continued)*

Characteristic	Information	Information
Chemical name	Aluminum fluoride	Aluminum sulfate
Identification numbers:		
CAS registry	7784-18-1[d]	10043-01-3[d]
NIOSH RTECS	BD0725000	BD1700000
EPA hazardous waste	No data	No data
OHM/TADS	7216579	7216581
DOT/UN/NA/IMCO shipping	No data	NA 9078; NA 1760
HSDB	600	5067
NCI	No data	No data

Table 3-1. Chemical Identity of Aluminum and Compounds[a] *(continued)*

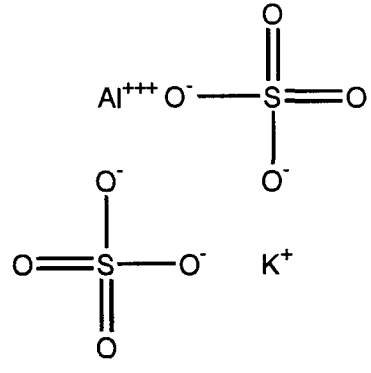
Characteristic	Information	Information	Information
Chemical name	Aluminum carbonate	Aluminum potassium sulfate	Alchlor
Synonym(s)	No data	Sulfuric acid, aluminum potassium salt (2:1:1)[j]	No data
Registered trade name(s)	No data	No data	No data
Chemical formula	$Al_2O_3 \cdot CO_2$; normal aluminum carbonate $Al_2(CO_3)_3$ is not known as an individual compound[e]	$AlKO_8S_2$[j]	$Al_2(OH)_5Cl \cdot nH_2O \cdot mC_2H_6O_2$; $Al_2(OH)_5Cl \cdot nH_2O \cdot mC_3H_8O_2$; $Al_2(OH)_4Cl_2 \cdot nH_2O \cdot mC_2H_6O_2$; $Al_2(OH)_4Cl_2 \cdot nH_2O \cdot mC_3H_8O_2$[k]
Chemical structure	No data		No data
Identification numbers:	No data	No data	No data
CAS registry	No data	10043-67-1	No data
NIOSH RTECS	No data	No data	No data
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data

Table 3-1. Chemical Identity of Aluminum and Compounds[a] *(continued)*

Characteristic	Information	Information	Information
Chemical name	Aluminum carbonate	Aluminum potassium sulfate	Alchlor
HSDB	No data	No data	No data
NCI	No data	No data	No data

[a]All information obtained from HSDB 1995, except where noted.
[b]Aluminum chlorhydrate is the common name for several different compounds, all containing aluminum, chloride, and hydroxyl ions; therefore, there are several chemical formulas and CAS numbers.
[c]Chemfinder 1997
[d]Budavari et al. 1989
[e]Lewis 1993
[f]RTECS 1989
[g]Sax and Lewis 1989
[h]According to Cotton and Wilkinson (1988), the structure of Al_2O_3 involves complicated crystalline, three dimensional arrays, which are prohibitively difficult to represent here. Anhydrous Al_2O_3 comes in α and γ forms. In α Al_2O_3, the oxide ions form a hexagonal close-packed array and the aluminum ions are distributed symmetrically among the octahedral interstices. The γ Al_2O_3 structure is sometimes regarded as a "defect" spinel structure; that is, as having the structure of spinel with a default of cations.
[i]OHM/TADS 1989
[j]Budavari et al. 1996
[k]Kroschwitz 1993

CAS = Chemical Abstracts Service; DOT/UN/NA/IMO = Dept. 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 3-2. Physical and Chemical Properties of Aluminum and Compounds

	Information		
Property	Aluminum	Aluminum chloride	Aluminum chlorohydrate
Molecular weight	26.98	133.34	174.46
Color	Tin-white, with bluish tint[a]	White when pure, ordinarily gray or yellow-to-greenish[a]	Glassy[a]
Physical state	Malleable, ductile metal[a]; crystalline solid[b]	White or yellowish crystals[b]	Solid[a]
Melting point	660 °C[a]	Volatilizes without melting[a]; 190 °C at 2.5 atm[b]; 381 °F (194 °C) at 5.2 atm[c]	No data
Boiling point	2,327 °C[a]; 2,450 °C[b]; 4,473 °F (2,467°C)[c]	182.7 °C at 752 mmHg[d]; sublimes readily at 178 °C[b]; sublimes at 358 °F (181 °C)[c]	No data
Density at 25 °C	2.70[a]	2.44[b]	No data
Odor	Metallic odor when dust is inhaled[c]	Strong odor of HCL[a]	No data
Odor threshold:			
Water	No data	1.5 ppm (HCL)[e]	No data
Air	No data	No data	No data
Solubility:			
Water at 25 °C	Insoluble[f]; rapidly oxidized by H_2O at 180 °C[b]	Reacts explosively with water evolving HCL gas[b]	Dissolves in H_2O, forming slightly turbid colloidal solutions (up to 55% w/w)[a]
Organic solvents	Soluble in alkalies, acids[g]	Freely soluble in benzophenone, C_6H_6, nitrobenzene, CCl_4, $CHCl_3$,[a]; soluble in alcohol and ether[h]	No data

Table 3-2. Physical and Chemical Properties of Aluminum and Compounds *(continued)*

Property	Information		
	Aluminum	Aluminum chloride	Aluminum chlorohydrate
Partition coefficients:			
Log K_{ow}	No data	No data	No data
Log K_{oc}	No data	No data	No data
Vapor pressure	1 mmHg at 1,284 °C[d]	1 mmHg at 100 °C[d]	No data
Henry's law constant at 24.8 °C	No data	No data	No data
Autoignition temperature	1,400 °F (760 °C)[c]	Not flammable[i]	No data
Flashpoint	645 °C[f]	Not combustible[c]	No data
Flammability limits in air	Flammable solid if finely divided, easily ignited[c]	Not flammable[i]	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	Combines with water with explosive violence and the liberation of much heat[a]	No data

Table 3-2. Physical and Chemical Properties of Aluminum and Compounds *(continued)*

	Information		
Property	Aluminum hydroxide	Aluminum lactate	Aluminum nitrate
Molecular weight	77.99[a]	294.18[a]	213.00[a]; 375.13 (-9 H_2O)[g]
Color	White[a]	Colorless[b]; white-yellowish	White[b]
Physical state	Bulky, amorphous powder[a]	Powder[b]	Nonahydrate, deliquescent crystals[a]
Melting point	300 °C[d]	No data	73 °C[a]
Boiling point	No data	No data	Decomposes at 135 °C[a]
Density at 25 °C	2.42[b]	No data	1.72 (-9H_2O)[g]
Odor	No data	No data	Odorless[i]
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water at 25 °C	Practically insoluble, forms gels on prolonged contact with H_2O [a]	Freely soluble in water[a]	Very soluble in water[a]; 63.7 g/100 cc at 25 °C
Organic solvents	Soluble in alkaline aqueous solutions or in HCL, H_2SO_4 [a]	No data	Very slightly soluble in acetone; almost insoluble in ethyl acetate and pyridine[a]
Partition coefficients:			
Log K_{ow}	No data	No data	No data
Log K_{oc}	No data	No data	No data
Vapor pressure at 25 °C	No data	No data	No data

Table 3-2. Physical and Chemical Properties of Aluminum and Compounds *(continued)*

	Information		
Property	Aluminum hydroxide	Aluminum lactate	Aluminum nitrate
Henry's law constant	No data	No data	No data
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	Not flammable[i]
Flammability limits in air	No data	No data	Not flammable[i]
Conversion factors: ppm (v/v) to mg/m^3 in air at 25 °C	No data	No data	No data
mg/m^3 to ppm (v/v) in air at 25 °C	No data	No data	No data
Explosive limits	No data	No data	Not flammable[i]

Table 3-2. Physical and Chemical Properties of Aluminum and Compounds *(continued)*

	Information		
Property	Aluminum oxide	Aluminum phosphate	Aluminum phosphide
Molecular weight	101.94[a]	121.95[a]	57.96[a]
Color	White[a]	White[a]	Dark gray or dark yellow[a]
Physical state	Crystalline powder[a]	Infusible powder[a]; crystals[b]	Crystals[a]
Melting point	≈2,000 °C[a]; 2030 °C[b]; 2054 °C[g]	>1,460 °C[a]	Does not melt or decompose thermally at temps up to 1,000 °C[a]
Boiling point	≈3,000 °C[g]	No data	No data
Density at:	3.4–4.0[b]	2.57[b]	2.40[a]
at 15 °C	No data	No data	2.85[a]
at 20 °C	4.0[a]	No data	No data
at 23 °C	No data	2.56[a]	No data
at 25 °C	3.97[g]	No data	No data
Odor	No data	No data	Garlic odor[d]
Odor threshold:			
Water	No data	No data	No data
Air	No data	No data	No data
Solubility:			
Water at 25 °C	Practically insoluble in water[a]; soluble in cold water 0.000098 g/100 cc[d]	Insoluble[b]	Decomposes[a]
Organic solvents	Slowly soluble in aqueous alkaline solutions; practically insoluble in nonpolar organic solvents[a]	Very slightly soluble in conc HCL and HNO_3[a]	No data

Table 3-2. Physical and Chemical Properties of Aluminum and Compounds *(continued)*

	Information		
Property	Aluminum oxide	Aluminum phosphate	Aluminum phosphide
Partition coefficients:			
Log K_{ow}	No data	No data	No data
Log K_{oc}	No data	No data	No data
Vapor pressure at 25 °C	1 mmHg at 2158 °C[d]	No data	No data
Henry's law constant	No data	No data	No data
Autoignition temperature	No data	No data	No data
Flashpoint	Non combustible[b]	No data	No data
Flammability limits in air	No data	No data	Reacts with moisture to give phosphine a flammable gas[j]
Conversion factors:			
ppm (v/v) to mg/m^3 in air at 25 °C	No data	No data	No data
mg/m^3 to ppm (v/v) in air at 25 °C	No data	No data	No data
Explosive limits	No data	No data	No data

Table 3-2. Physical and Chemical Properties of Aluminum and Compounds *(continued)*

	Information	
Property	Aluminum fluoride	Aluminum sulfate
Molecular weight	83.98[a]	342.14[a]
Color	White[b]; colorless, triclinic[d]	White, lustrous[b]
Physical state	Hexagonal crystals[a]	Crystals, pieces, granules or powder[a]
Melting point	1,291 °C[d]; sublimes (760 mmHg) at 1,272 °C[a]	Decomposes at 770 °C[b]; decomposes at 1,040 °C[g]
Boiling point	1,276 °C (sublimation point)[g]	No data
Density at 25 °C	2.88[d]	2.71[b]
Odor	No data	Odorless[d]
Odor threshold:		
Water	No data	No data
Air	No data	No data
Solubility:		
Water at 25 °C	0.559 g/100 mL at 25 °C[a]	Soluble in 1 part H_2O[a]
Organic solvents	Sparingly soluble in acids and alkalies[a]; insoluble in alcohol and acetone	Soluble in dilute acids[d]; practically insoluble in alcohol[a]
Partition coefficients:		
Log K_{ow}	No data	No data
Log K_{oc}	No data	No data
Vapor pressure at 25 °C	1 mmHg at 1,238 °C[d]	Essentially zero[d]
Henry's law constant	No data	No data
Autoignition temperature	Not flammable[i]	No data
Flashpoint	Not flammable[i]	Not flammable[i]

Table 3-2. Physical and Chemical Properties of Aluminum and Compounds *(continued)*

Property	Information	
	Aluminum fluoride	Aluminum sulfate
Flammability limits in air	Not flammable[i]	Not flammable[i]
Conversion factors:		
ppm (v/v) to mg/m^3 in air at 25 °C	No data	No data
mg/m^3 to ppm (v/v) in air at 25 °C	No data	No data
Explosive limits	Produces strong explosion on impact when mixed with sodium[d]	No data

Table 3-2. Physical and Chemical Properties of Aluminum and Compounds *(continued)*

	Information		
Property	Aluminum carbonate	Aluminum potassium sulfate	Alchlor
Molecular weight	145.97[b]	258.21[k]	No data
Color	White[b]	White[k]	No data
Physical state	Lumps or powder[b]	Powder[k]	No data
Melting point	No data	No data	No data
Boiling point	No data	No data	No data
Density at 25 °C	No data	No data	No data
Odor	No data	No data	No data
Odor threshold: Water Air	No data	No data	No data
Solubility: Water at 25 °C	Insoluble[b]	50 g/L[k]	No data
Organic solvents	Dissolves in hot hydrochloric or sulfuric acid[b]	Insoluble in alcohol[k]	No data
Partition coefficients: Log K_{ow} Log K_{oc}	No data No data	No data 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

Table 3-2. Physical and Chemical Properties of Aluminum and Compounds *(continued)*

	Information		
Property	Aluminum carbonate	Aluminum potassium sulfate	Alchlor
Flammability limits in air	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

[a]Budavari et al. 1989
[b]Lewis 1993
[c]NFPA 1994
[d]HSDB 1995
[e]Weast et al. 1989
[f]Chemfinder 1997
[g]Lide 1997
[h]Sax and Lewis 1987
[i]Weiss 1986
[j]OHM/TADS 1989
[k]Budavari et al. 1996