



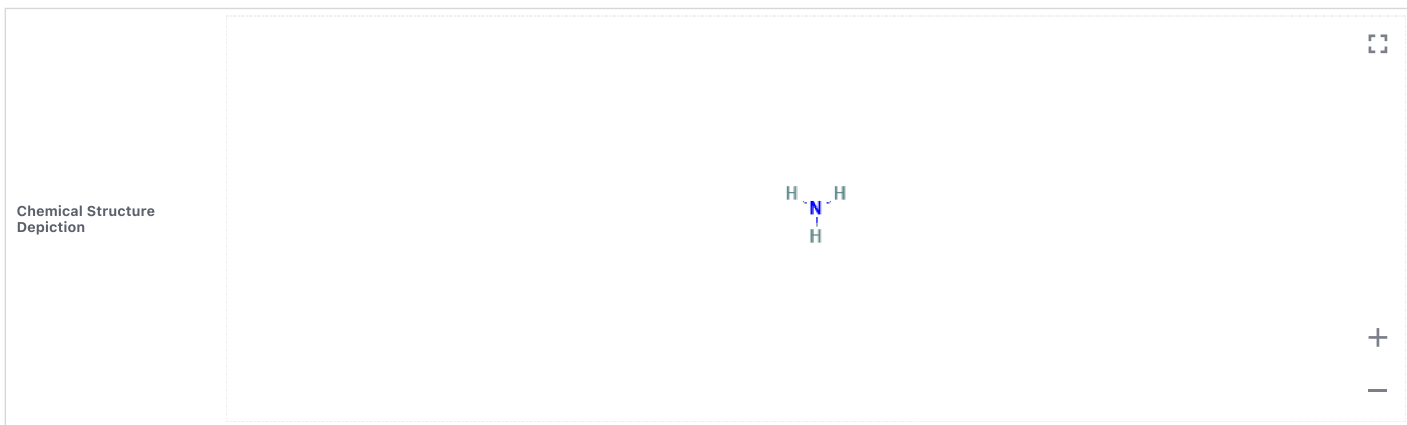
Ammonia

PubChem CID	222
Structure	 2D Find Similar Structures
Chemical Safety	 Corrosive Acute Toxic Environmental Hazard Laboratory Chemical Safety Summary (LCSS) Datasheet
Molecular Formula	H ₃ N or NH ₃
Synonyms	ammonia 7664-41-7 azane Ammonia gas Spirit of hartshorn <input type="button" value="More..."/>
Molecular Weight	17.031
Dates	Modify 2022-05-14 Create 2004-09-16
<p>Ammonia occurs naturally and is produced by human activity. It is an important source of nitrogen which is needed by plants and animals. Bacteria found in the intestines can produce ammonia. Ammonia is a colorless gas with a very distinct odor. This odor is familiar to many people because ammonia is used in smelling salts, many household and industrial cleaners, and window-cleaning products. Ammonia gas can be dissolved in water. This kind of ammonia is called liquid ammonia or aqueous ammonia. Once exposed to open air, liquid ammonia quickly turns into a gas. Ammonia is applied directly into soil on farm fields, and is used to make fertilizers for farm crops, lawns, and plants. Many household and industrial cleaners contain ammonia.</p> <p>▶ CDC-ATSDR Toxic Substances Portal</p> <p>Ammonia, anhydrous appears as a clear colorless gas with a strong odor. Shipped as a liquid under its own vapor pressure. Density (liquid) 6 lb / gal. Contact with the unconfined liquid can cause frostbite. Gas generally regarded as nonflammable but does burn within certain vapor concentration limits and with strong ignition. Fire hazard increases in the presence of oil or other combustible materials. Although gas is lighter than air, vapors from a leak initially hug the ground. Prolonged exposure of containers to fire or heat may cause violent rupturing and rocketing. Long-term inhalation of low concentrations of the vapors or short-term inhalation of high concentrations has adverse health effects. Used as a fertilizer, as a refrigerant, and in the manufacture of other chemicals. Rate of onset: Immediate Persistence: Minutes Odor threshold: 17 ppm Source/use/other hazard: Explosives manufacture; pesticides; detergents industry.</p> <p>▶ CAMEO Chemicals</p> <p>Ammonia is an inorganic compound composed of a single nitrogen atom covalently bonded to three hydrogen atoms that is an amidase inhibitor and neurotoxin. It is both manufactured and produced naturally from bacterial processes and the breakdown of organic matter. Ammonia is used in many industrial processes, and as a fertilizer and refrigerant. It is characterized as a colorless gas or compressed liquid with a pungent odor and exposure occurs by inhalation, ingestion, or contact.</p> <p>▶ NCI Thesaurus (NCIt)</p>	

1 Structures



1.1 2D Structure



▶ PubChem

2 Names and Identifiers



2.1 Computed Descriptors



2.1.1 IUPAC Name



azane

Computed by Lexichem TK 2.7.0 (PubChem release 2021.05.07)

▶ [PubChem](#)

2.1.2 InChI



InChI=1S/H3N/h1H3

Computed by InChI 1.0.6 (PubChem release 2021.05.07)

▶ [PubChem](#)

2.1.3 InChI Key



QGZKDVFNNGYKY-UHFFFAOYSA-N

Computed by InChI 1.0.6 (PubChem release 2021.05.07)

▶ [PubChem](#)

2.1.4 Canonical SMILES



N

Computed by OEChem 2.3.0 (PubChem release 2021.05.07)

▶ [PubChem](#)

2.2 Molecular Formula



H3N

▶ [CAMEO Chemicals](#); [PubChem](#)

NH3

▶ [ILO International Chemical Safety Cards \(ICSC\)](#); [Wikipedia](#)

2.3 Other Identifiers



2.3.1 CAS



7664-41-7

▶ [CAMEO Chemicals](#); [CAS Common Chemistry](#); [ChemIDplus](#); [EPA Acute Exposure Guideline Levels \(AEGs\)](#); [EPA Chemicals under the TSCA](#); [EPA DSSTox](#); [European Chemicals Agency \(ECHA\)](#); [Hazardous Substances](#)

69718-51-0

▶ [CAS Common Chemistry](#)

2.3.2 Related CAS



71187-51-4

Compound: Ammonia, tetramer

▶ [CAS Common Chemistry](#)

71187-52-5

Compound: Ammonia, pentamer

▶ [CAS Common Chemistry](#)

63016-67-1

Compound: Ammonia, dimer

▶ [CAS Common Chemistry](#)

71187-50-3

Compound: Ammonia, trimer

▶ [CAS Common Chemistry](#)

2.3.3 Deprecated CAS



208990-07-2, 214478-05-4, 8007-57-6, 558443-52-0, [1026405-88-8](#)

▶ [ChemIDplus](#)

2.3.4 European Community (EC) Number



[231-635-3](#)

▶ [European Chemicals Agency \(ECHA\)](#)

[921-643-1](#)

▶ [European Chemicals Agency \(ECHA\)](#)

[921-933-8](#)

▶ [European Chemicals Agency \(ECHA\)](#)

2.3.5 ICSC Number



[0414](#)

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

2.3.6 RTECS Number



[BO0875000](#)

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

2.3.7 UN Number



[2073](#)

▶ [CAMEO Chemicals; The National Institute for Occupational Safety and Health \(NIOSH\)](#)

[1005](#)

▶ [CAMEO Chemicals; DOT Emergency Response Guidebook; ILO International Chemical Safety Cards \(ICSC\); NJDOH RTK Hazardous Substance List; The National Institute for Occupational Safety and Health \(NIOSH\)](#)

[2672](#)

▶ [CAMEO Chemicals; The National Institute for Occupational Safety and Health \(NIOSH\)](#)

2.3.8 UNII



[5138Q19F1X](#)

▶ [FDA/SPL Indexing Data](#)

2.3.9 FEMA Number



[4494](#)

▶ [Flavor and Extract Manufacturers Association \(FEMA\)](#)

2.3.10 DSSTox Substance ID



[DTXSID0023872](#)

▶ [EPA DSSTox](#)

2.3.11 Wikipedia



[Ammonia](#)

▶ [Wikipedia](#)

2.3.12 Wikidata



[Q4087](#)

▶ [Wikidata](#)

2.3.13 NCI Thesaurus Code



[C76698](#)

2.3.14 RXCUI



1299884

► NLM RxNorm Terminology

2.4 Synonyms



2.4.1 MeSH Entry Terms



Ammonia

► Medical Subject Headings (MeSH)

2.4.2 Depositor-Supplied Synonyms



ammonia	Ammoniak	CCRIS 2278	R 717	Ammoniaca	Ammoniacum gummi
7664-41-7	AM-Fol	HSDB 162	UN 1005 (anhydrous gas or >50% solution)	Amoniak	sekundaeres Amin
azane	Liquid Ammonia	Ammonia solution, strong	UN 2672 (between 12% and 44% solution)	(Aminomethyl)polystyrene	anhydrous ammonia
Ammonia gas	Ammoniak Kkonzentrierter	NH3	Ammonia, 7M in methanol	EINECS 231-635-3	Ammonium causticum
Spirit of hartshorn	Amoniak [Polish]	UN 2073 (>44% solution)	Ammonia anhydrous, 99.98%	tertiaeres Amin	(Aminomethyl)polystyrene
Nitro-sil	Ammoniac [French]	UN1005	CHEBI:16134	Aminyl radical	NH4
Ammonia, anhydrous	Ammoniak [German]	Aminomethyl Polystyrene Resin	MFCD00011418	ammonia ca	UNX
Ammoniakgas	ammoniac	Refrigerent R717	5138Q19F1X	primaeres Amin	Strong-ammonia solution
Ammonia solution	Ammoniaca [Italian]	EPA Pesticide Chemical Code 005302	Ammonia solution, strong (NF)	Ammonia inhalant	R 717 (ammonia)
Ammonia anhydrous	Caswell No. 041	UNII-5138Q19F1X	Ammonia solution, strong [NF]	Ammonia,aromatic	Ammonia (8CI,9CI)
Anhydrous ammonia	Ammonia (conc 20% or greater)	Strong Ammonia Solution	amoniaco	Ammonia-solution	Ammonia water (JP15)

► PubChem

3 Chemical and Physical Properties



3.1 Computed Properties



Property Name	Property Value	Reference
Molecular Weight	17.031	Computed by PubChem 2.1 (PubChem release 2021.05.07)
XLogP3-AA	-0.7	Computed by XLogP3 3.0 (PubChem release 2021.05.07)
Hydrogen Bond Donor Count	1	Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Hydrogen Bond Acceptor Count	1	Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Rotatable Bond Count	0	Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Exact Mass	17.026549100	Computed by PubChem 2.1 (PubChem release 2021.05.07)
Monoisotopic Mass	17.026549100	Computed by PubChem 2.1 (PubChem release 2021.05.07)
Topological Polar Surface Area	1 Å ²	Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Heavy Atom Count	1	Computed by PubChem
Formal Charge	0	Computed by PubChem
Complexity	0	Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Isotope Atom Count	0	Computed by PubChem
Defined Atom Stereocenter Count	0	Computed by PubChem
Undefined Atom Stereocenter Count	0	Computed by PubChem
Defined Bond Stereocenter Count	0	Computed by PubChem
Undefined Bond Stereocenter Count	0	Computed by PubChem
Covalently-Bonded Unit Count	1	Computed by PubChem
Compound Is Canonicalized	Yes	Computed by PubChem (release 2021.05.07)

► [PubChem](#)

3.2 Experimental Properties



3.2.1 Physical Description



Ammonia solutions (containing more than 35% but not more than 50% ammonia) appears as a clear colorless liquid consisting of ammonia dissolved in [water](#). Corrosive to tissue and metals. Although ammonia is lighter than air, the vapors from a leak will initially hug the ground. Long term exposure to low concentrations or short term exposure to high concentrations may result in adverse health conditions from inhalation. Prolonged exposure of containers to fire or heat may result in their violent rupturing and rocketing.

► [CAMEO Chemicals](#)

Ammonia, anhydrous appears as a clear colorless gas with a strong odor. Shipped as a liquid under its own vapor pressure. Density (liquid) 6 lb / gal. Contact with the unconfined liquid can cause frostbite. Gas generally regarded as nonflammable but does burn within certain vapor concentration limits and with strong ignition. Fire hazard increases in the presence of oil or other combustible materials. Although gas is lighter than air, vapors from a leak initially hug the ground. Prolonged exposure of containers to fire or heat may cause violent rupturing and rocketing. Long-term inhalation of low concentrations of the vapors or short-term inhalation of high concentrations has adverse health effects. Used as a fertilizer, as a refrigerant, and in the manufacture of other chemicals. Rate of onset: Immediate Persistence: Minutes Odor threshold: 17 ppm Source/use/other hazard: Explosives manufacture; pesticides; detergents industry.

► [CAMEO Chemicals](#)

Ammonia, solution, with more than 10% but not more than 35% ammonia appears as a colorless aqueous liquid solution with a strong odor of ammonia. Both liquid and vapors extremely irritating, especially to the eyes.

► [CAMEO Chemicals](#)

GasVapor; GasVapor, Liquid; Liquid; WetSolid

► [EPA Chemicals under the TSCA](#)

Liquid

► [Human Metabolome Database \(HMDB\)](#)

COLOURLESS GAS OR COMPRESSED LIQUEFIED GAS WITH PUNGENT ODOUR.

► [ILO International Chemical Safety Cards \(ICSC\)](#)

Colorless gas with a pungent, suffocating odor. Often used in aqueous solution.

► [Occupational Safety and Health Administration \(OSHA\)](#)

Colorless gas with a pungent, suffocating odor. [Note: Shipped as a liquefied compressed gas. Easily liquefied under pressure.]

► [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

Clear, colorless, gas. Clear, colorless liquid under pressure.

► [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

3.2.2 Color/Form



Colorless gas

Haynes, W.M. (ed.). *CRC Handbook of Chemistry and Physics. 95th Edition. CRC Press LLC, Boca Raton: FL 2014-2015, p. 4-46*

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Colorless gas or compressed liquid (compressed under its own pressure)

NOAA; CAMEO Chemicals. *Database of Hazardous Materials. Ammonia, Anhydrous (7664-41-7). Natl Ocean Atmos Admin, Off Resp Rest; NOAA Ocean Serv. Available from, as of Sept 30, 2016: <https://cameochemicals.noaa.gov/>*

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.3 Odor



Sharp, cloying, repellent

Booth, N.H., L.E. McDonald (eds.). *Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982., p. 938*

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Pungent, suffocating odor

NIOSH. *NIOSH Pocket Guide to Chemical Hazards. Department of Health & Human Services, Centers for Disease Control & Prevention. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2010-168 (2010). Available from: <https://www.cdc.gov/niosh/npg>*

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Sharp, intensely irritating odor

Larranaga, M.D., Lewis, R.J. Sr., Lewis, R.A.; *Hawley's Condensed Chemical Dictionary 16th Edition. John Wiley & Sons, Inc. Hoboken, NJ 2016., p. 75*

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Very pungent odor (characteristic of drying urine).

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88*

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.4 Boiling Point



-28.03 °F at 760 mm Hg (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides. Washington, D.C.: U.S. Government Printing Office.*

- ▶ [CAMEO Chemicals](#)

-33.35 °C at 760 mm Hg

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88*

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

-33 °C

- ▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

-28°F

- ▶ [Occupational Safety and Health Administration \(OSHA\); The National Institute for Occupational Safety and Health \(NIOSH\)](#)

3.2.5 Melting Point



-107.9 °F (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides. Washington, D.C.: U.S. Government Printing Office.*

- ▶ [CAMEO Chemicals](#)

-77.7 °C

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88*

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

-77.7°C

- ▶ [Human Metabolome Database \(HMDB\)](#)

-78 °C

- ▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

-107.9°F

- ▶ [Occupational Safety and Health Administration \(OSHA\)](#)

-108°F

- ▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

3.2.6 Flash Point



132 °C (270 °F) - closed cup

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ Hazardous Substances Data Bank (HSDB)

NA (Gas)

▶ The National Institute for Occupational Safety and Health (NIOSH)

3.2.7 Solubility



In **water**, 4.82X10+5 mg/L at 24 °C

Dean, J.A. (ed.). *Lange's Handbook of Chemistry*. 13 ed. New York, NY: McGraw-Hill Book Co., 1985., p. 10-3

▶ Hazardous Substances Data Bank (HSDB)

In **water**, 47% at 0 °C; 38% at 15 °C; 34% at 20 °C; 31% at 25 °C; 28% at 30 °C; 18% at 50 °C

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ Hazardous Substances Data Bank (HSDB)

Soluble in **water** forming alkaline solutions; soluble in oxygenated solvents.

Ashford, R.D. *Ashford's Dictionary of Industrial Chemicals*. London, England: Wavelength Publications Ltd., 1994., p. 77

▶ Hazardous Substances Data Bank (HSDB)

15% in 95% alcohol at 20 °C; 11% in alcohol at 30 °C

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ Hazardous Substances Data Bank (HSDB)

For more Solubility (Complete) data for Ammonia (7 total), please visit the [HSDB record page](#).

▶ Hazardous Substances Data Bank (HSDB)

482 mg/mL at 24 °C

▶ Human Metabolome Database (HMDB)

Solubility in **water**, g/100ml at 20 °C: 54

▶ ILO International Chemical Safety Cards (ICSC)

34%

▶ The National Institute for Occupational Safety and Health (NIOSH)

3.2.8 Density



0.6818 at -28.03 °F (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides*. Washington, D.C.: U.S. Government Printing Office.

▶ CAMEO Chemicals

0.696 g/L (liquid)

Haynes, W.M. (ed.). *CRC Handbook of Chemistry and Physics*. 95th Edition. CRC Press LLC, Boca Raton: FL 2014-2015, p. 4-46

▶ Hazardous Substances Data Bank (HSDB)

Density of liquid: 0.6818 at -33.35 °C, 1 atm; 0.6585 at -15 °C, 2.332 atm; 0.6386 at 0 °C, 4.238 atm; 0.6175 at 15 °C, 7.188 atm; 0.5875 at 35 °C, 13.321 atm

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ Hazardous Substances Data Bank (HSDB)

Density of aqueous solutions at 20 °C/4 °C: 0.9939 (1%), 0.9811 (4%), 0.9651 (8%), 0.9362 (16%), 0.9229 (20%), 0.9101 (24%), 0.8980 (28%)

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ Hazardous Substances Data Bank (HSDB)

Density: 0.7710 g/L (gas); 0.89801 g/L at 20 °C (28% aqueous solution)

ATSDR; *Toxicological Profile for Ammonia*. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ Hazardous Substances Data Bank (HSDB)

Relative density (**water** = 1): 0.7 (-33 °C)

▶ ILO International Chemical Safety Cards (ICSC)

0.6818 at -28.03°F

- ▶ Occupational Safety and Health Administration (OSHA)

0.60(relative gas density)

- ▶ The National Institute for Occupational Safety and Health (NIOSH)

3.2.9 Vapor Density



0.6 (EPA, 1998) (Relative to Air)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides*. Washington, D.C.: U.S. Government Printing Office.

- ▶ CAMEO Chemicals

0.5967 (Air = 1)

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013, p. 88

- ▶ Hazardous Substances Data Bank (HSDB)

Relative vapor density (air = 1): 0.60

- ▶ ILO International Chemical Safety Cards (ICSC)

0.6

- ▶ Occupational Safety and Health Administration (OSHA)

3.2.10 Vapor Pressure



400 mm Hg at -49.72 °F (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides*. Washington, D.C.: U.S. Government Printing Office.

- ▶ CAMEO Chemicals

Vapor pressure: 1 Pa at -139 °C, 10 Pa at -127 °C, 100 Pa at -112 °C; 1 kPa at -94.5 °C (solids); 10 kPa at -71.3 °C, 100 kPa at -33.6 °C (liquid)

Haynes, W.M. (ed.). *CRC Handbook of Chemistry and Physics*. 95th Edition. CRC Press LLC, Boca Raton: FL 2014-2015, p. 6-92

- ▶ Hazardous Substances Data Bank (HSDB)

7500 mm Hg at 25 °C

Daubert TE, Danner RP; *Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation*. Design Institute for Physical Property Data, American Institute of Chemical Engineers. New York, NY: Hemisphere Pub Corp (1999)

- ▶ Hazardous Substances Data Bank (HSDB)

Vapor pressure, kPa at 26 °C: 1013

- ▶ ILO International Chemical Safety Cards (ICSC)

8.5 atm

- ▶ Occupational Safety and Health Administration (OSHA); The National Institute for Occupational Safety and Health (NIOSH)

3.2.11 LogP



log Kow = -2.66 /estimate for ammonium hydroxide which is the form of ammonia in water/

US EPA; Estimation Program Interface (EPI) Suite. Ver. 4.1. Nov, 2012. Available from, as of July 5, 2016: <https://www2.epa.gov/tsca-screening-tools/>

- ▶ Hazardous Substances Data Bank (HSDB)

3.2.12 Henrys Law Constant



Henry's Law constant = 1.61X10⁻⁵ atm cu-m/mole at 25 °C

Betterton EA; pp. 1-50 in *Gaseous Pollutants: Characterization and Cycling*, Nriagu JO, Ed. John Wiley & Sons, Inc. (1992)

- ▶ Hazardous Substances Data Bank (HSDB)

3.2.13 Stability/Shelf Life



Stable under recommended storage conditions.

Sigma-Aldrich; *Safety Data Sheet for Ammonia (7664-41-7)*. Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

- ▶ Hazardous Substances Data Bank (HSDB)

3.2.14 Autoignition Temperature



1204 °F (USCG, 1999)

U.S. Coast Guard. 1999. *Chemical Hazard Response Information System (CHRIS) - Hazardous Chemical Data*. Commandant Instruction 16465.12C. Washington, D.C.: U.S. Government Printing Office.

- ▶ CAMEO Chemicals

1204 °F (651 °C)

National Fire Protection Association; *Fire Protection Guide to Hazardous Materials*. 14TH Edition, Quincy, MA 2010, p. 49-18

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

630 °C

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

3.2.15 Decomposition



Hazardous decomposition products formed under fire conditions. - Nitrogen oxides (NOx)

Sigma-Aldrich; *Safety Data Sheet for Ammonia (7664-41-7)*. Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Emits toxic fumes of ammonia and nitrous oxide when exposed to heat.

Lewis, R.J. Sr. (ed.) *Sax's Dangerous Properties of Industrial Materials*. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 229

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

When ammonia is heated to decomposition, it emits toxic fumes and nitrogen oxides.

CDC; *NIOSH Emergency Response Safety and Health Database, Emergency Response Card for Ammonia (CAS #7664-41-7)*. Available from, as of May 11, 2010: <https://www.cdc.gov/niosh/ershdb/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.16 Viscosity



0.475, 0.317, 0.276 and 0.255 cP at -69, -50, -40 and -33.5 °C, respectively

Weast, R.C. (ed.) *Handbook of Chemistry and Physics*, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988., p. F-43

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.17 Corrosivity



Corrosive gas

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Corrosive to copper and galvanized surfaces

NIOSH. *NIOSH Pocket Guide to Chemical Hazards*. Department of Health & Human Services, Centers for Disease Control & Prevention. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2010-168 (2010). Available from: <https://www.cdc.gov/niosh/npg>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.18 Heat of Combustion



382.8 kJ/mol (gas)

Haynes, W.M. (ed.). *CRC Handbook of Chemistry and Physics*. 95th Edition. CRC Press LLC, Boca Raton: FL 2014-2015, p. 5-68

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.19 Heat of Vaporization



5.581 kcal/mol

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.20 pH



pH of 1.0N aqueous solution 11.6; 0.1N aqueous solution 11.1; 0.01N aqueous solution 10.6

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.21 Surface Tension



23.4 dynes/cm at 11.1 °C; 18.1 dynes/cm at 34.1 °C

Weast, R.C. (ed.) *Handbook of Chemistry and Physics*, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988., p. F-35

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.22 Ionization Potential



10.18 eV

3.2.23 Odor Threshold



Water: 1.5 mg/L; air: 5.2 uL/L; odor safety class C; C = < 50% of distracted persons perceive warning of TLV.

[PMID:6376602](#)

Amoore JE, Hautala E; *J Appl Toxicol* 3 (6): 272-90 (1983).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Odor recognition of pure ammonia in air is 4.68 x 10+1 ppm.

Fazzalari, F.A. (ed.). *Compilation of Odor and Taste Threshold Values Data. ASTM Data Series DS 48A (Committee E-18). Philadelphia, PA: American Society for Testing and Materials, 1978., p. 12*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Sharp, cloying, repellent; low threshold = 0.0266 mg/cu m; high threshold = 39.60 mg/cu m; irritating concn = 72.00 mg/cu m.

Prager, J.C. *Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995., p. 135*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Low threshold = 0.0266 mg/cu m; High threshold = 39.6 mg/cu m; Irritating concentration = 72 mg/cu m.

[PMID:3706135](#)

Ruth JH; *Am Ind Hyg Assoc J* 47: A142-51 (1986).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.24 Refractive Index



Index of refraction: 1.3944 at -77 °C/D; 1.3327 at 20 °C/D

Haynes, W.M. (ed.). *CRC Handbook of Chemistry and Physics. 95th Edition. CRC Press LLC, Boca Raton: FL 2014-2015, p. 4-137*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.25 Dissociation Constants



Aqueous ammonia: pKb 4.767, Kb 1.710X10-5 at 20 °C; pKb 4.751, Kb 1.774X10-5 at 25 °C; pKb 4.740, Kb 1.820X10-5 at 30 °C

Weast, R.C. (ed.) *Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988., p. D-163*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.2.26 Kovats Retention Index



Standard non-polar	118, 131
--------------------	----------

▶ [NIST Mass Spectrometry Data Center](#)

3.2.27 Other Experimental Properties



Critical molar volume: 69.8 cu cm/mol

Haynes, W.M. (ed.). *CRC Handbook of Chemistry and Physics. 95th Edition. CRC Press LLC, Boca Raton: FL 2014-2015, p. 6-83*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Specific heat, J/kg-K: 2097.2 at 0 °C; 2226.2 at 100 °C; 2105.6 at 200 °C

Eggeman T; *Ammonia. Kirk-Othmer Encyclopedia of Chemical Technology. (1999-2016). New York, NY: John Wiley & Sons. Online Posting Date: April 16, 2010.*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Specific gravity: 0.690 at -40 °C; 0.639 at 0 °C; 0.580 at 40 °C

Eggeman T; *Ammonia. Kirk-Othmer Encyclopedia of Chemical Technology. (1999-2016). New York, NY: John Wiley & Sons. Online Posting Date: April 16, 2010.*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Dipole moment, gas: 4.9x10-30 C m; 1.47 D

Braker W, Mossman A; *Matheson Gas Data Book 6th ED p.23 (1980)*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Other Experimental Properties (Complete) data for Ammonia (12 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

3.3 SpringerMaterials Properties



15N nuclear magnetic resonance spectrum	Composition	Dielectricity	Enthalpy	Gross formula	Isotope mass-effect
Gibbs energy	Compressibility	Diffusion	Entropy	Heat capacity	Kinetic properties
Schoenflies notation	Compression	Diffusion of impurities	Excess enthalpy	Heat flow rate	Lattice stiffness
Absorbance	Core level transition	Diffusive flux	Excitation energy	Heat of solution	Magnetic permeability
Acentric factor	Corrosion	Dispersion	Fluorescence	Heat of sublimation	Melting temperature
Activation energy	Creep	Elasticity	Formation energy	Heat transfer coefficient	Migration energy

Band structure	Critical point	Elasto-optic coefficient	Formation enthalpy	High frequency properties	Mixing enthalpy
Boiling point	Crystal structure	Electron conductivity	Formation entropy	Hydrogen bonding potential	Molar mass
Chemical bond	Crystallographic point group	Electronic structure	Fusion entropy	Impurity concentration	Molecular structure
Chemical diffusion	Density	Electro-optical constant	Fusion temperature	Infrared spectroscopy	Nuclear magnetic resonance
Chemical shift	Dielectric constant	Emissivity	Grain size	Internuclear distance	Nuclear quadrupole resonance spectroscopy

► SpringerMaterials

4 Spectral Information



4.1 1D NMR Spectra



1D NMR Spectra [NMRShiftDB Link](#)

[▶ NMRShiftDB](#)

4.2 Mass Spectrometry



4.2.1 GC-MS



Showing 2 of 3 [View More](#)

NIST Number	6
Library	Main library
Total Peaks	5
m/z Top Peak	17
m/z 2nd Highest	16
m/z 3rd Highest	15
Thumbnail	

[▶ NIST Mass Spectrometry Data Center](#)

Source of Spectrum	AA-0-1-5
Copyright	Copyright © 2020-2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

[▶ SpectraBase](#)

4.3 IR Spectra



4.3.1 Vapor Phase IR Spectra



Instrument Name	DIGILAB FTS-14
Technique	Vapor Phase
Copyright	Copyright © 1980, 1981-2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	



▶ SpectraBase

5 Related Records



5.1 Related Compounds with Annotation



▶ PubChem

5.2 Related Compounds



Same Connectivity	20 Records
Mixtures, Components, and Neutralized Forms	72,936 Records
Similar Compounds	43 Records
Similar Conformers	22 Records

▶ PubChem

5.3 Substances



5.3.1 Related Substances



All	121,852 Records
Same	468 Records
Mixture	121,384 Records

▶ PubChem

5.3.2 Substances by Category



▶ PubChem

5.4 Entrez Crosslinks



PubMed	68 Records
Protein Structures	273 Records
Protein	2 Records
Taxonomy	10 Records
Gene	211 Records

▶ PubChem

▶ NCBI

▶ PubChem

7 Drug and Medication Information



7.1 FDA National Drug Code Directory



▶ [National Drug Code \(NDC\) Directory](#)

AMMONIA is an active ingredient in 11 products including: 'AMMONIA INHALANT', 'AMMONIA INHALANTS', and 'AMMONIA INHALENT'.

▶ [National Drug Code \(NDC\) Directory](#)

AMMONIAC is an active ingredient in the products 'CANDIDA PLUS' and CANDIDA.

▶ [National Drug Code \(NDC\) Directory](#)

7.2 Clinical Trials



7.2.1 ClinicalTrials.gov



▶ [ClinicalTrials.gov](#)

7.2.2 EU Clinical Trials Register



▶ [EU Clinical Trials Register](#)

7.2.3 NIPH Clinical Trials Search of Japan



▶ [NIPH Clinical Trials Search of Japan](#)

7.3 Therapeutic Uses



Reflex respiratory stimulant. /Ammonia [water-10%](#)/

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 84

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

7.4 Drug Warnings



Caution: Irritating to skin and mucous membranes. /Ammonia [water-10%](#)/

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 84

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

8 Food Additives and Ingredients



8.1 Food Additive Classes



Flavoring Agents

- ▶ [EU Food Improvement Agents](#)

8.2 FDA Indirect Additives used in Food Contact Substances



Indirect Additives	AMMONIA
Title 21 of the U.S. Code of Federal Regulations (21 CFR)	175.105
	176.170
	176.210

- ▶ [FDA Center for Food Safety and Applied Nutrition \(CFSAN\)](#)

9 Agrochemical Information



9.1 Agrochemical Category



Microbiocide

▶ [EPA Pesticide Ecotoxicity Database](#)

10.1 Absorption, Distribution and Excretion



Studies suggest that ammonia can be absorbed by the inhalation and oral routes of exposure, but there is less certainty regarding absorption through the skin. Absorption through the eye has been documented. Most of the inhaled ammonia is retained in the upper respiratory tract and is subsequently eliminated in expired air. Almost all of the ammonia produced endogenously in the intestinal tract is absorbed. Exogenous ammonia is also readily absorbed in the intestinal tract. Ammonia that reaches the circulation is widely distributed to all body compartments although substantial first pass metabolism occurs in the liver where it is transformed into **urea** and **glutamine**. Ammonia or **ammonium ion** reaching the tissues is taken up by **glutamic acid**, which participates in transamination and other reactions. The principal means of excretion of ammonia that reaches the circulation in mammals is as urinary **urea**; minimal amounts are excreted in the feces and in expired air.

HHS/ATSDR; Toxicological Profile for Ammonia p.78 (September 2004) TP126. Available from, as of May 24, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Experiments with volunteers show that ammonia, regardless of its tested concentration in air (range, 57-500 ppm), is almost completely retained in the nasal mucosa (83-92%) during short-term exposure, i.e., up to 120 sec. However, longer-term exposure (10-27 min) to a concentration of 500 ppm resulted in lower retention (4-30%), with 350-400 ppm eliminated in expired air by the end of the exposure period, suggesting an adaptive capability or saturation of the absorptive process. Nasal and pharyngeal irritation, but not tracheal irritation, suggests that ammonia is retained in the upper respiratory tract. Unchanged levels of blood-**urea-nitrogen** (BUN), non-protein **nitrogen**, urinary-**urea**, and urinary-ammonia are evidence of low absorption into the blood. Exposure to common occupational limits of ammonia in air (25 ppm) with 30% retention (and assuming this quantity is absorbed into the blood stream) would yield an increase in blood **ammonium** concentration of 0.09 mg/L. This calculated rise is only 10% above fasting levels.

HHS/ATSDR; Toxicological Profile for Ammonia p.79 (September 2004) TP126. Available from, as of May 24, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Animal data provide supporting evidence for high-percentage nasal retention, thus protecting the lower respiratory tract from exposure (rabbit, dog). Continuous exposure of rats for 24 hr to concentrations up to 32 ppm resulted in significant increase in blood ammonia levels. Exposures to 310-1,157 ppm led to significantly increased blood concentrations of ammonia within 8 hr of exposure initiation, but blood ammonia returned to pre-exposure values within 12 hr of continuous exposure and remained so over the remaining of the 24 hr exposure period. This suggests an adaptive response mechanism may be activated with longer-term exposure.

HHS/ATSDR; Toxicological Profile for Ammonia p.79 (September 2004) TP126. Available from, as of May 24, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Absorption data from human inhalation exposure suggest that only small amounts of ammonia are absorbed into the systemic circulation. Initial retention of inhaled ammonia in the mucus of the upper respiratory tract may be 80% or more, but after equilibrium is established (within 30 min) 70-80% of inspired ammonia is expired in exhaled air. The lack of change in blood **nitrogen** compounds and urinary-ammonia compounds lends further support to a limited absorption into the systemic circulation. Toxic effects reported from inhalation exposure suggest local damage, or changes resulting from necrotic tissue degradation, rather than the presence of elevated levels of NH_4^+ , per se, in tissues other than the respiratory/pharyngeal tissues. Information on the distribution of endogenously-produced ammonia suggests that any NH_4^+ absorbed through inhalation would be distributed to all body compartments via the blood, where it would be used in protein synthesis or as a buffer, and that excess levels would be reduced to normal by urinary excretion, or converted by the liver to **glutamine** and **urea**. If present in quantities that overtax these organs, NH_4^+ is distributed to other tissues and is known to be detoxified in the brain. NH_4^+

HHS/ATSDR; Toxicological Profile for Ammonia p.81 (September 2004) TP126. Available from, as of May 24, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Absorption, Distribution and Excretion (Complete) data for Ammonia (16 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

10.2 Metabolism/Metabolites



Human adults produce around 1000 mmol of ammonia daily. Some is reutilized in biosynthesis. The remainder is waste and neurotoxic. Eventually most is excreted in urine as **urea**, together with ammonia used as a buffer. In extrahepatic tissues, ammonia is incorporated into nontoxic **glutamine** and released into blood. Large amounts are metabolized by the kidneys and small intestine. In the intestine, this yields ammonia, which is sequestered in portal blood and transported to the liver for ureagenesis, and **citruiline**, which is converted to **arginine** by the kidneys. The amazing developments in NMR imaging and spectroscopy and molecular biology have confirmed concepts derived from early studies in animals and cell cultures. The processes involved are exquisitely tuned. When they are faulty, ammonia accumulates. Severe acute hyperammonemia causes a rapidly progressive, often fatal, encephalopathy with brain edema. Chronic milder hyperammonemia causes a neuropsychiatric illness. Survivors of severe neonatal hyperammonemia have structural brain damage. Proposed explanations for brain edema are an increase in astrocyte osmolality, generally attributed to **glutamine** accumulation, and cytotoxic oxidative/nitrosative damage. However, ammonia neurotoxicity is multifactorial, with disturbances also in neurotransmitters, energy production, anaplerosis, cerebral blood flow, **potassium**, and **sodium**. Around 90% of hyperammonemic patients have liver disease. Inherited defects are rare. They are being recognized increasingly in adults. Deficiencies of **urea** cycle enzymes, citrin, and **pyruvate** carboxylase demonstrate the roles of isolated pathways in ammonia metabolism. **Phenylbutyrate** is used routinely to treat inherited **urea** cycle disorders, and its use for hepatic encephalopathy is under investigation.

/Hyperammonemia/

PMID:25735860

Walker V; Adv Clin Chem 67: 73-150 (2014)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

The inhibitory effects of ammonia on two different degradation pathways of methanogenic **acetate** were evaluated using a pure culture (Methanosaeta thermophila strain PT) and defined co-culture (Methanothermobacter thermoautotrophicus strain TM and Thermacetogenium phaeum strain PB), which represented acetoclastic and syntrophic methanogenesis, respectively. Growth experiments with high concentrations of ammonia clearly demonstrated that sensitivity to ammonia stress was markedly higher in M. thermophila PT than in the syntrophic co-culture. M. thermophila PT also exhibited higher sensitivity to high pH stress, which indicated that an inability to maintain pH homeostasis is an underlying cause of ammonia inhibition. Methanogenesis was inhibited in the resting cells of M. thermophila PT with moderate concentrations of ammonia, suggesting that the inhibition of enzymes involved in methanogenesis may be one of the major factors responsible for ammonia toxicity. Transcriptomic analysis revealed a broad range of disturbances in M. thermophila PT cells under ammonia stress conditions, including protein denaturation, oxidative stress, and intracellular cation imbalances. The results of the present study clearly demonstrated that syntrophic **acetate** degradation dominated over acetoclastic methanogenesis under ammonia stress conditions, which is consistent with the findings of previous studies on complex microbial community systems. Our results also imply that the co-existence of multiple metabolic pathways and their different sensitivities to stress factors confer resiliency on methanogenic processes.

PMID:24920170

Full text: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4103522>

Kato S et al; Microbes Environ 29 (2): 162-7 (2014)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Recently, spatial-temporal/metabolic mathematical models have been established that allow the simulation of metabolic processes in tissues. We applied these models to decipher ammonia detoxification mechanisms in the liver. An integrated metabolic-spatial-temporal model was used to generate hypotheses of ammonia metabolism. Predicted mechanisms were validated using time-resolved analyses of **nitrogen** metabolism, activity analyses, immunostaining and gene expression after induction of liver damage in mice. Moreover, blood from the portal vein, liver vein and mixed venous blood was analyzed in a time dependent manner. Modeling revealed an underestimation of ammonia consumption after liver damage when only the currently established mechanisms of ammonia detoxification were simulated. By iterative cycles of modeling and experiments, the reductive amidation of **alpha-ketoglutarate** (alpha-KG) via **glutamate** dehydrogenase (GDH) was identified as the lacking component. GDH is released from damaged hepatocytes into the blood where it consumes ammonia to generate **glutamate**, thereby providing systemic protection against hyperammonemia. This mechanism was exploited therapeutically in a mouse model of hyperammonemia by injecting GDH together with optimized doses of cofactors. Intravenous injection of GDH (720 U/kg), alpha-KG (280 mg/kg) and **NADPH** (180 mg/kg) reduced the elevated blood ammonia concentrations (>200 uM) to levels close to normal within only 15 min. If successfully translated to patients the GDH-based therapy might provide a less aggressive therapeutic alternative for patients with severe hyperammonemia. /Hyperammonemia/

PMID:26639393

Ghallab A et al; J Hepatol 64 (4): 860-71 (2016)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

The rodent liver eliminates toxic ammonia. In mammals, three enzymes (or enzyme systems) are involved in this process: glutaminase, **glutamine** synthetase and the **urea** cycle enzymes, represented by **carbamoyl phosphate** synthetase. The distribution of these enzymes for optimal ammonia detoxification was determined by numerical optimization. This in silico approach predicted that the enzymes have to be zoned in order to achieve maximal removal of toxic ammonia and minimal changes in **glutamine** concentration. Using 13 compartments, representing hepatocytes, the following predictions were generated: **glutamine** synthetase is active only within a narrow pericentral zone. Glutaminase and **carbamoyl phosphate** synthetase are located in the periportal zone in a non-homogeneous distribution. This correlates well with the paradoxical observation that in a first step **glutamine**-bound ammonia is released (by glutaminase) although one of the functions of the liver is detoxification by ammonia fixation. The in silico approach correctly predicted the in vivo enzyme distributions also for non-physiological conditions (e.g. starvation) and during regeneration after **tetrachloromethane** (CCl4) intoxication. Metabolite concentrations of **glutamine**, ammonia and **urea** in each compartment, representing individual hepatocytes, were predicted. Finally, a sensitivity analysis showed a striking robustness of the results. These bioinformatics predictions were validated experimentally by immunohistochemistry and are supported by the literature. In summary, optimization approaches like the one applied can provide valuable explanations and high-quality predictions for in vivo enzyme and metabolite distributions in tissues and can reveal unknown metabolic functions.

PMID:26438405

Bartl M, Arch Toxicol 89 (11): 2069-78 (2015)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Metabolism/Metabolites (Complete) data for Ammonia (17 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

10.3 Biological Half-Life



... The rate of turnover of blood derived ammonia to **glutamine** in normal rat brain is extremely rapid (half-life < or = 3 s), but is slowed in the brains of chronically (12-14 wk portacaval shunted) or acutely (urease treated) hyperammonemic rats (half-life < or = 10 s). ...

PMID:2888066

Cooper AJ, Lai JC; Neurochem Pathol 6 (1-2): 67-95 (1987).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

10.4 Mechanism of Action



... Ammonia plays a key role in the pathogenesis of hepatic encephalopathy, which manifests as a neuropsychiatric syndrome accompanying acute and chronic liver failure. One consequence of ammonia action on the brain is astrocyte swelling, which triggers the generation of oxidative/nitrosative stress at the level of **NADPH** oxidase, **nitric oxide** synthases and the mitochondria. A self-amplifying signaling loop between oxidative stress and astrocyte swelling has been proposed. Consequences of the ammonia-induced oxidative/nitrosative stress response are protein modifications through nitration of **tyrosine** residues and oxidation of astrocytic and neuronal RNA. Nitrosative stress also mobilizes **zinc** from intracellular stores with impact on gene expression. These alterations may at least in part mediate cerebral ammonia toxicity through disturbances of intracellular and intercellular signaling and of synaptic plasticity. Oxidative/nitrosative stress and a low-grade cerebral edema as key events in the pathogenesis of ammonia toxicity and hepatic encephalopathy may offer potential new strategies for treatment. Ammonia-induced oxidation of RNA and proteins may impair postsynaptic protein synthesis, which is critically involved in learning and memory consolidation. RNA oxidation offers a novel explanation for multiple disturbances of neurotransmitter systems and gene expression and the cognitive deficits observed in hepatic encephalopathy.

PMID:19904201

Haussinger D, Gorg B; Curr Opin Clin Nutr Metab Care 13 (1): 87-92 (2010)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

SRP: Ammonia in an aqueous environment exists in equilibrium between ionized **ammonium cation** and the non-ionized ammonia. This equilibrium can be affected by buffers, pH, temperature, and salinity. Thus in many cases it is not possible to assign the associated toxicity to the ionized or non-ionized form of the ammonia-**nitrogen**. /Aqueous ammonia/

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Mechanisms involved in hepatic encephalopathy (HE) still remain poorly understood. It is generally accepted that ammonia plays a major role in this disorder, and that astrocytes represent the principal target of ammonia neurotoxicity. In recent years, studies from several laboratories have uncovered a number of factors and pathways that appear to be critically involved in the pathogenesis of this disorder. Foremost is oxidative and nitrosative stress (ONS), which is largely initiated by an ammonia-induced increase in intracellular Ca(2+). Such increase in Ca(2+) activates a number of enzymes that promote the synthesis of reactive **oxygen-nitrogen** species, including constitutive **nitric oxide** synthase, **NADPH** oxidase and phospholipase A2. ONS subsequently induces the mitochondrial permeability transition, and activates mitogen-activated protein kinases and the transcription factor, nuclear factor-kappaB (NF-kappaB). These factors act to generate additional reactive **oxygen-nitrogen** species, to phosphorylate various proteins and transcription factors, and to cause mitochondrial dysfunction. This article reviews the role of these factors in the mechanism of HE and ammonia toxicity with a focus on astrocyte swelling and **glutamate** uptake, which are important consequences of ammonia neurotoxicity...

PMID:19104923

Norenberg MD et al; Metab Brain Dis 24 (1): 103-17 (2009)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

A new model for ammonia excretion in freshwater fish and its variable linkage to Na(+) uptake and acid excretion /is proposed/. In this model, /the Rhesus protein/ Rhag facilitates NH(3) flux out of the erythrocyte, Rhbg moves it across the basolateral membrane of the branchial ionocyte, and an apical Na(+)/NH (+)(4) exchange complex consisting of several membrane transporters (Rhcg, V-type H(+)-ATPase, Na(+)/H(+) exchanger NHE-2 and/or NHE-3, Na(+) channel) working together as a metabolon provides an acid trapping mechanism for apical excretion. Intracellular carbonic anhydrase (CA-2) and basolateral Na(+)/HCO (-)(3) cotransporter (NBC-1) and Na(+)/K(+)-ATPase play indirect roles. These mechanisms are normally superimposed on a substantial outward movement of NH(3) by simple diffusion, which is probably dependent on acid trapping in boundary layer **water** by H(+) ions created by the catalyzed or non-catalyzed hydration of expired metabolic CO2 ...

PMID:19617422

Wright P, Wood C; J Exper Biol 212 (Pt 15): 2303-12 (2009)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Mechanism of Action (Complete) data for Ammonia (9 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

10.5 Human Metabolite Information



10.5.1 Tissue Locations



All Tissues

▶ [Human Metabolome Database \(HMDB\)](#)

10.5.2 Cellular Locations



Cytoplasm

▶ [Human Metabolome Database \(HMDB\)](#)

10.5.3 Metabolite Pathways



[2-Hydroxyglutric Aciduria \(D And L Form\)](#)
[3-Phosphoglycerate dehydrogenase deficiency](#)
[4-Hydroxybutyric Aciduria/Succinic Semialdehyde Dehydrogenase Deficiency](#)
[Acute Intermittent Porphyria](#)
[Adenine phosphoribosyltransferase deficiency \(APRT\)](#)
[Adenosine Deaminase Deficiency](#)
[Adenylosuccinate Lyase Deficiency](#)
[AICA-Ribosiduria](#)
[Alkaptonuria](#)
[Amino Sugar Metabolism](#)
Total 119 pathways, visit the [HMDB page](#) for details

▶ [Human Metabolome Database \(HMDB\)](#)

10.6 Biochemical Reactions



▶ [PubChem](#)

10.7 Transformations



11 Use and Manufacturing



11.1 Uses



EPA CPDat Chemical and Product Categories

The Chemical and Products Database, a resource for exposure-relevant data on chemicals in consumer products, Scientific Data, volume 5, Article number: 180125 (2018), DOI:10.1038/sdata.2018.125

▶ [EPA Chemical and Products Database \(CPDat\)](#)

For ammonia (USEPA/OPP Pesticide Code: 005302) ACTIVE products with label matches. /SRP: Registered for use in the U.S. but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./

National Pesticide Information Retrieval System's Database on Ammonia (7664-41-7). Available from, as of June 28, 2016: <https://npirpublic.ceris.purdue.edu/ppis/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

[Ammonia] is used in the production of [ammonium sulfate](#) and [ammonium nitrate](#) for fertilizers; and in the manufacture of [nitric acid](#), soda, synthetic [urea](#), synthetic fibers, dyes, and plastics.

Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 6th Edition Volume 1: A-K, Volume 2: L-Z. William Andrew, Waltham, MA 2012, p. 160

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Fertilizer, corrosion inhibitor, purification of [water](#) supplies, component of household [cleaners](#), as refrigerant. Manufacture of [nitric acid](#), explosives, synthetic fibers. In pulp and paper, metallurgy, rubber, food and beverage, textile and leather industries.

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013, p. 88

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Preharvest cotton defoliant /Former/

Farm Chemicals Handbook 1997. Willoughby, OH: Meister Publishing Co., 1997, p. C-22

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Uses (Complete) data for Ammonia (13 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

11.1.1 Use Classification



Food additives -> Flavoring Agents

▶ [EU Food Improvement Agents](#)

Health Hazards -> Corrosives

▶ [NJDOH RTK Hazardous Substance List](#)

Cosmetics -> Buffering

S13 | EU COSMETICS | Combined Inventory of Ingredients Employed in Cosmetic Products (2000) and Revised Inventory (2006) | DOI:10.5281/zenodo.2624118

▶ [NORMAN Suspect List Exchange](#)

Lung Damaging Agents -> NIOSH Emergency Response Categories

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

11.1.2 Industry Uses



A reactant in a Selective Catalytic Reduction system to lower NOx emissions from utility boilers.

Adsorbents and absorbents

Agricultural chemicals (non-pesticidal)

Agricultural use: pesticides

Ammonia Market

Ammonia used in production of [nitric acid](#) and [ammonium nitrate](#) solution for sale to wholesalers. Wholesalers distribute for miscellaneous industry uses.

Aqueous ammonia is converted to anhydrous ammonia in the vaporizer for the selective cathodic reduction system to control [nitrous oxide](#) emissions.

Functional fluids (closed systems)

Intermediates

Ion exchange agents

Oxidizing/reducing agents

Paint Manufacturing

Process regulators

Processing aids, not otherwise listed

Distribution by independent wholesalers. Final product use unknown to Agrium.

Dyes
Emission Control Equipment
Fuels and fuel additives

Production of Aqua ammonia for sale to wholesale
Reactant for NOx control.
Sales to power utilities for use in plant air pollution
Selective Noncatalytic Reduction/Urea Injection Sy

<https://www.epa.gov/chemical-data-reporting>

▶ [EPA Chemicals under the TSCA](#)

11.1.3 Consumer Uses



Agricultural products (non-pesticidal)

Air Pollution Control

Air pollution control

Air pollution control equipment - NAICS 221122

Anhydrous and aqua ammonia sold directly to wholesalers for distribution to multiple industrial clients and multiple industrial uses.

Catalyst

Chemical Production / Remarketing

Direct application: agriculture. Less than 2%

Distribution to independent wholesalers and industrial customers.

Emission control product

Explosive materials

Fabric, textile, and leather products not covered elsewhere

Flue gas treatment in power generation plants

Food packaging

Fuels and related products

Lawn and garden care products

METALS HEAT-TREATING AID; REFRIGERANT; or STACK EMISSIONS CON

Metal products not covered elsewhere

Paper products

Plastic and rubber products not covered elsewhere

Repackaging/chemical distribution

Selective Noncatalytic Reduction/Urea Injection System

<https://www.epa.gov/chemical-data-reporting>

▶ [EPA Chemicals under the TSCA](#)

11.1.4 Household Products



Household & Commercial/Institutional Products

Information on 123 consumer products that contain Ammonia in the following categories is provided:

- Auto Products
- Commercial / Institutional
- Hobby/Craft
- Home Maintenance
- Inside the Home
- Landscaping/Yard

▶ [Consumer Product Information Database \(CPID\)](#)

11.2 Methods of Manufacturing



Ammonia is produced as a by-product in coal distillation and by the action of steam on calcium cyanamide, and from the decomposition of nitrogenous materials.

Pohanish, R.P. (ed.). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 6th Edition Volume 1: A-K, Volume 2: L-Z. William Andrew, Waltham, MA 2012, p. 160

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Ammonia is manufactured primarily by a modified Haber reduction process using atmospheric [nitrogen](#) and a [hydrogen](#) source, for example, [methane](#), [ethylene](#) or naphtha, at high temperatures (400 to 6500 °C) and pressures (100 to 900 atm) in the presence of an [iron](#) catalyst.

Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994., p. 756

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

From synthesis gas, a mixture of [carbon monoxide](#), [hydrogen](#), [carbon dioxide](#), and [nitrogen](#) (from air) obtained by steam reforming or by partial combustion of natural gas (U.S.). or from the action of steam on hot coke (Haber-Bosch process).

Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 65

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Manufactured from [water](#) gas (obtained by blowing steam through incandescent coke) as source of [hydrogen](#), and from producer gas (obtained from steam and air through incandescent coke), as source of [nitrogen](#) by the Haber-Bosch process.

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

11.3 Formulations/Preparations



Grades: Commercial 99.5%; refrigerant 99.97%.

Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 65

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Aqueous soln of ammonia ... is often referred to & labeled as a soln of [ammonium hydroxide](#) /although there is little [ammonium hydroxide](#) present/. In commerce, ammonia is avail ... in form of aqueous soln of varying concn, or as anhydrous ammonia furnished in liquefied form Ammonia in household use contains 10% ammonia & is ... known as 16 deg ammonia (referring to density in degrees Baume, a concn term).

Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980., p. 350

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Shipping grades or purity: Commercial, industrial, refrigeration, electronic, and metallurgical grades all have purity greater than 99.5%.

U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Ammonia solution, more than 10% and not more than 35% ammonia.

IATA. Dangerous Goods Regulations. 28th ed. Montreal, Canada: International Air Transport Association. Dangerous Goods Board, January 1, 1987, p. 82

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Formulations/Preparations (Complete) data for Ammonia (8 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

11.4 Consumption Patterns



Fertilizer, 80%; Polymers, 7%; Exports, 6%; Explosives, 3%; Animal feeds, 2%; Other, 2% (1985)

Chemical Profile: Ammonia, 1985

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Chemical Profile: Ammonia. Direct application fertilizer, 27%; urea, 21%; ammonium phosphates, 14%; nitric acid, 11%; ammonium nitrate, 8%; exports, 6%; ammonium sulfate, 3%; other, 10%.

Kavaler AR; Chemical Marketing Reporter 234 (14): 52 (1988)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Chemical Profile: Ammonia. Demand: July 1987-June 1988: 16.4 million tons; 1988-1989: 17.7 million tons; 1992-1993 /projected/: 18.4 million tons. (Includes exports, but not imports, which totaled 3.2 million tons in 1987-1988.)

Kavaler AR; Chemical Marketing Reporter 234 (14): 52 (1988)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Chemical Profile: Ammonia. Direct application fertilizer, 25%; urea, 25%; ammonium phosphates, 17%; nitric acid, 12%; ammonium nitrate, 8%; acrylonitrile, 3%; ammonium sulfate, 4%; other, 6%.

Kavaler AR; Chemical Marketing Reporter 240: 52 (1994)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Chemical Profile: Ammonia. Demand: (1993) 17.2 million tons; (1994) 17.9 million tons; (1998) /projected/: 20.9 million tons. (Includes exports of 507,000 tons in 1993, but not imports, which totaled 2.84 million tons.)

Kavaler AR; Chemical Marketing Reporter 240: 52 (1994)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

11.5 U.S. Production



Aggregated Product Volume (EPA CDR 2016)

30,000,000,000 - 40,000,000,000 lb

<https://www.epa.gov/chemical-data-reporting>

▶ [EPA Chemicals under the TSCA](#)

(1972) 1.42 X 10⁺¹³ g (Anhydrous)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

(1975) 1.49 X 10⁺¹³ g (Anhydrous)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

(1985) 1.47 X 10⁺¹³ g

Chem Eng News 64 (23): 35 (1986)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

(1986) 1.70 X 10⁺⁴ metric ton

SRI. Directory Of Chemical Producers--USA 1987, p.459

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more U.S. Production (Complete) data for Ammonia (17 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

11.6 U.S. Imports



(1972) 3.50 X 10⁺¹¹ g (Anhydrous)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

(1975) 7.33 X 10+11 g (Anhydrous)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

(1985) 2.27 X 10+12 g

Chem Eng News 64 (7): 17 (1986)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

(2000) 3.9 million metric tons

U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Ammonia p.121 (2004) TP126. Available from, as of May 6, 2010: <https://www.atsdr.cdc.gov/toxpro2.html#>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more U.S. Imports (Complete) data for Ammonia (7 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

11.7 U.S. Exports



(1972) 6.46 X 10+11 g (anhydrous and aqueous)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

(1975) 2.95 X 10+11 g (anhydrous)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

(1985) 4.54 X 10+11 g

Chem Eng News 64 (7): 17 (1986)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

(1987) 1.80 X 10+3 content ton (aq)

Bureau Of The Census. U.S. Exports, Schedule E, October 1987, p.2-91

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more U.S. Exports (Complete) data for Ammonia (7 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

11.8 General Manufacturing Information



Industry Processing Sectors

Agriculture, forestry, fishing and hunting
All other basic inorganic chemical manufacturing
All other basic organic chemical manufacturing
All other chemical product and preparation manufacturing
Computer and electronic product manufacturing
Explosives manufacturing
Fabricated metal product manufacturing
Food, beverage, and tobacco product manufacturing
Industrial gas manufacturing
Miscellaneous manufacturing
Paint and coating manufacturing
Paper manufacturing
Pesticide, fertilizer, and other agricultural chemical manufacturing

Petrochemical manufacturing
Petroleum lubricating oil and grease manufacturing
Petroleum refineries
Pharmaceutical and medicine manufacturing
Plastic material and resin manufacturing
Plastics product manufacturing
Primary metal manufacturing
Rubber product manufacturing
Services
Textiles, apparel, and leather manufacturing
Utilities
Wholesale and retail trade

▶ [EPA Chemicals under the TSCA](#)

EPA TSCA Commercial Activity Status

Ammonia: ACTIVE

<https://www.epa.gov/tsca-inventory>

▶ [EPA Chemicals under the TSCA](#)

Ammonia in solution ... in varying concentration is used in variety of products such as **cleaning** agents, liniments, and aromatic spirits. Ammonia solution are sometimes used as fertilizers ... Fresh household ammonia ranges in concentration from 5 to 10% NH₃, but a 54% solution is also available commercially. [[Ammonium hydroxide/](#)

Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984., p. III-21

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

... Usually marketed in liquefied form in steel cylinders or as ammonia **water** (aqua ammonia, [ammonium hydroxide](#)) in drums and bottles.

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

In air: Detector tubes Model 1055A are used for high concentrations (1-25%) and Model 105SC for low (5-260 ppm) concentration ranges of ammonia. A color stain is produced in the detector tube which varies in length with the concentration of the sample being measured.

Braker W, Mossman A; Matheson Gas Data Book 6th ED p.26 (1980)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/Air/ Sampler: gas washing bottle: medium 200 ml [water](#); sampling rate: 0.12 cu ft/min; test concn: 162 ppm; absorption efficiency: 84%.

Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983., p. 263

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

The concentration of ammonia in air can be ... determined by titration. A known volume of the air is passed through two bubblers in series containing a known volume of standardized 0.02 N [sulfuric acid](#), the solution in each bubbles combined quantitatively, and the excess acid titrated with standardized 0.02 N [sodium hydroxide](#), using [methyl red](#) indicator.

Braker W, Mossman A; Matheson Gas Data Book 6th ED p.26 (1980)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

12 Identification



12.1 Analytic Laboratory Methods



Method: NIOSH 3800, Issue 2; Procedure: extractive fourier transform infrared (FTIR) spectrometry; Analyte: ammonia; Matrix: air; Detection Limit: 0.77 ppm (10 m absorption path length).

CDC; NIOSH Manual of Analytical Methods, 5th ed. Ammonia (7664-41-7). Available from, as of June 29, 2016: <https://www.cdc.gov/niosh/nmam/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Method: NIOSH 6016, Issue 2; Procedure: ion chromatography, conductivity detection; Analyte: ammonia; Matrix: air; Detection Limit: 2 ug/sample.

CDC; NIOSH Manual of Analytical Methods, 5th ed. Ammonia (7664-41-7). Available from, as of June 29, 2016: <https://www.cdc.gov/niosh/nmam/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Method: OSHA ID-188; Procedure: ion chromatography; Analyte: ammonia; Matrix: air; Detection Limit: qualitative 0.60 ppm (24-L air sample), 1.9 ppm (7.5-L air sample); quantitative 1.5 ppm (24-L air sample) 4.8 ppm (7.5-L air sample).

U.S. Department of Labor/Occupational Safety and Health Administration's Index of Sampling and Analytical Methods. Ammonia (7664-41-7). Available from, as of June 29, 2016: <https://www.osha.gov/dts/sltc/methods/toc.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Method: OSHA ID-164; Procedure: ion specific electrode; Analyte: ammonia; Matrix: air; Detection Limit: 2.0 ug NH3 in solution.

U.S. Department of Labor/Occupational Safety and Health Administration's Index of Sampling and Analytical Methods. Ammonia (7664-41-7). Available from, as of June 29, 2016: <https://www.osha.gov/dts/sltc/methods/toc.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Analytic Laboratory Methods (Complete) data for Ammonia (20 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

12.2 OSHA Chemical Sampling



IC - OSHA ID-188 (fully validated)

ISE - OSHA ID-164 (partially validated)

▶ [Occupational Safety and Health Administration \(OSHA\)](#)

12.3 NIOSH Analytical Methods



ORGANIC AND INORGANIC GASES BY EXTRACTIVE FTIR SPECTROMETRY 3800

▶ [NIOSH Manual of Analytical Methods](#)

AMMONIA 6015

▶ [NIOSH Manual of Analytical Methods](#)

AMMONIA by IC 6016

▶ [NIOSH Manual of Analytical Methods](#)

13 Safety and Hazards




13.1 Hazards Identification



13.1.1 GHS Classification



Showing 1 of 7 [View More](#)

Pictogram(s)	 Corrosive Acute Toxic Environmental Hazard
Signal	Danger
GHS Hazard Statements	H221: Flammable gas [Danger Flammable gases] H314: Causes severe skin burns and eye damage [Danger Skin corrosion/irritation] H331: Toxic if inhaled [Danger Acute toxicity, inhalation] H400: Very toxic to aquatic life [Warning Hazardous to the aquatic environment, acute hazard]
Precautionary Statement Codes	P210, P260, P261, P264, P271, P273, P280, P301+P330+P331, P302+P361+P354, P304+P340, P305+P354+P338, P316, P321, P363, P377, P381, P391, P403, P403+P233, P405, and P501 (The corresponding statement to each P-code can be found at the GHS Classification page.)

[EU REGULATION \(EC\) No 1272/2008](#)

13.1.2 Hazard Classes and Categories



Showing 2 of 5 [View More](#)

Flam. Gas 2
Press. Gas
Acute Tox. 3 *
Skin Corr. 1B
Aquatic Acute 1

[EU REGULATION \(EC\) No 1272/2008](#)


Acute toxicity (inhalation) - category 3
Acute toxicity (ingestion) - category 4
Skin corrosion - category 1
Flammable gas - category 2
Hazardous to the aquatic environment (acute) - category 1
Gases under pressure

[Hazardous Chemical Information System \(HCIS\), Safe Work Australia](#)

13.1.3 NFPA Hazard Classification



Showing 1 of 2 [View More](#)

NFPA 704 Diamond	 3-1-0
NFPA Health Rating	3 - Materials that, under emergency conditions, can cause serious or permanent injury.
NFPA Fire Rating	1 - Materials that must be preheated before ignition can occur. Materials require considerable preheating, under all ambient temperature conditions, before ignition and combustion can occur.
NFPA Instability Rating	0 - Materials that in themselves are normally stable, even under fire conditions.

[Hazardous Substances Data Bank \(HSDB\)](#)

13.1.4 Substance of Very High Concern (SVHC)



OSHA Highly Hazardous Chemicals, Toxics and Reactives

Chemical: Ammonia, Anhydrous Threshold: 10000 [lb] Note: Ammonia, Anhydrous in quantities at or above 10000lb presents a potential for a catastrophic event as a toxic or reactive highly hazardous chemical.

[Occupational Safety and Health Administration \(OSHA\)](#)

13.1.5 Health Hazards



Excerpt from ERG Guide 125 [Gases - Corrosive]: TOXIC; may be fatal if inhaled, ingested or absorbed through skin. Vapors are extremely irritating and corrosive. Contact with gas or liquefied gas may cause burns, severe injury and/or frostbite. Fire will produce irritating, corrosive and/or toxic gases. Runoff from fire control may cause pollution. (ERG, 2016)

▶ CAMEO Chemicals

Vapors cause irritation of eyes and respiratory tract. Liquid will burn skin and eyes. Poisonous; may be fatal if inhaled. Contact may cause burns to skin and eyes. Contact with liquid may cause frostbite. (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides*. Washington, D.C.: U.S. Government Printing Office.

▶ CAMEO Chemicals

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]: TOXIC; inhalation, ingestion or skin contact with material may cause severe injury or death. Contact with molten substance may cause severe burns to skin and eyes. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution [water](#) may be corrosive and/or toxic and cause pollution. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ CAMEO Chemicals

Corrosives

▶ NJDOH RTK Hazardous Substance List

13.1.6 Fire Hazards



Excerpt from ERG Guide 125 [Gases - Corrosive]: Some may burn but none ignite readily. Vapors from liquefied gas are initially heavier than air and spread along ground. Some of these materials may react violently with [water](#). Cylinders exposed to fire may vent and release toxic and/or corrosive gas through pressure relief devices. Containers may explode when heated. Ruptured cylinders may rocket. For UN1005: Anhydrous ammonia, at high concentrations in confined spaces, presents a flammability risk if a source of ignition is introduced. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ CAMEO Chemicals

Mixing of ammonia with several chemicals can cause severe fire hazards and/or explosions. Ammonia in container may explode in heat of fire. Incompatible with many materials including [silver](#) and [gold](#) salts, halogens, alkali metals, [nitrogen trichloride](#), [potassium chlorate](#), [chromyl chloride](#), oxygen halides, acid vapors, azides, [ethylene oxide](#), [picric acid](#) and many other chemicals. Mixing with other chemicals and [water](#). Hazardous polymerization may not occur. (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides*. Washington, D.C.: U.S. Government Printing Office.

▶ CAMEO Chemicals

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]: Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. Some are oxidizers and may ignite combustibles (wood, paper, oil, clothing, etc.). Contact with metals may evolve flammable [hydrogen](#) gas. Containers may explode when heated. For electric vehicles or equipment, ERG Guide 147 ([lithium ion](#) batteries) or ERG Guide 138 ([sodium](#) batteries) should also be consulted. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ CAMEO Chemicals

Flammable. Cylinder may explode in heat of fire. Gas/air mixtures are explosive.

▶ ILO International Chemical Safety Cards (ICSC)

13.1.7 Explosion Hazards



When ammonia mixes with gas and/or air it forms an explosive mixture.

Lower explosive (flammable) limit in air (LEL), 15%; upper explosive (flammable) limit in air (UEL), 28%.

Containers may explode when heated.

Ruptured cylinders may rocket.

▶ The National Institute for Occupational Safety and Health (NIOSH)

13.1.8 Hazards Summary



Ammonia occurs naturally and is produced by human activity. It is an important source of [nitrogen](#) which is needed by plants and animals. Bacteria found in the intestines can produce ammonia. Ammonia is a colorless gas with a very distinct odor. This odor is familiar to many people because ammonia is used in smelling salts, many household and industrial [cleaners](#), and window-cleaning products. Ammonia gas can be dissolved in [water](#). This kind of ammonia is called liquid ammonia or aqueous ammonia. Once exposed to open air, liquid ammonia quickly turns into a gas. Ammonia is applied directly into soil on farm fields, and is used to make fertilizers for farm crops, lawns, and plants. Many household and industrial [cleaners](#) contain ammonia.

▶ CDC-ATSDR Toxic Substances Portal

The major hazards encountered in the use and handling of ammonia stem from its toxicologic properties and reactivity. Exposure to this colorless gas (liquid, if compressed or in aqueous solution) may occur from its use as a fertilizer, chemical intermediate, alkalizer, metal treating/extraction agent, and common household [cleaner](#). Ammonia is hazardous by all routes (ie, dermal, ingestion, inhalation), with the liquid capable of burning the skin, causing permanent eye damage, or corroding the digestive tract upon contact; and the gas capable of causing severe eye damage, pulmonary edema, and even death from spasm, inflammation, and edema of the larynx. OSHA has established an ammonia Permissible Exposure Level (PEL) of 50 ppm as an 8-hr time-weighted average (TWA). The ACGIH recommends an 8-hr TLV-TWA of 25 ppm. Ammonia levels should be controlled through process enclosure and the use of local exhaust and dilution ventilation, as necessary. While its offensive odor may serve as a warning, to assure against ammonia exposure, workers should wear chemical protective clothing composed of [butyl rubber](#), natural rubber, [neoprene](#), nitrile rubber, or [polyvinyl chloride](#) (not [Viton](#)), gloves, face protection, and, in emergency situations, a self-contained breathing apparatus. Facilities for quick-drenching the body, as well as eye-wash fountains, should be immediately at hand for the worker. Clothing that becomes wet with liquid ammonia should be placed in closed containers until it can be discarded. While this substance does not burn or ignite readily (autoignition temp: 1204 °F), containers of ammonia may explode in the heat of a fire. For small fires involving ammonia, extinguish with dry chemical or CO₂, and for large fires, use [water](#) spray, fog, or foam, taking care to prevent fire control or dilution [water](#) from causing pollution. More hazardous than its fire potential is ammonia's reactivity with halogens, interhalogens, and oxidizers. These reactions may be violent and/or may form explosive

products. Ammonia should be stored in a cool, well-ventilated location, away from sources of ignition, and separate from other chemicals, particularly oxidizing gases (chlorine, bromine, and iodine) and acids. Aqueous ammonia is commonly containerized in steel drums. Anhydrous ammonia is stored and shipped (prohibited in passenger planes) in pressurized containers, fitted with pressure-relief safety devices, and bearing the label, "Nonflammable Compressed Gas". For small spills of ammonia, isolate 80 feet in all directions from the spill, ventilate the area, and allow vapor or gas to disperse. For large spills, evacuate the area for 160 feet in all directions, and dike to contain the spill for later recovery or disposal and to prevent runoff from causing pollution. Stay upwind and wear positive-pressure breathing apparatus and full protective clothing, as necessary.

[▶ Hazardous Substances Data Bank \(HSDB\)](#)

13.1.9 Fire Potential



Not flammable.

CDC; NIOSH Emergency Response Safety and Health Database, Emergency Response Card for Ammonia (CAS #7664-41-7). Available from, as of May 11, 2010: <https://www.cdc.gov/niosh/ershdb/>

[▶ Hazardous Substances Data Bank \(HSDB\)](#)

13.1.10 Skin, Eye, and Respiratory Irritations



The vapor even in low concn is extremely irritating to skin, eyes and respiratory passages.

Gosselin, R.E., R.P. Smith, H.C. Hodge. *Clinical Toxicology of Commercial Products*. 5th ed. Baltimore: Williams and Wilkins, 1984., p. III-22

[▶ Hazardous Substances Data Bank \(HSDB\)](#)

... Eye, nose and throat irritation ...

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Whitehouse Station, NJ: Merck and Co., Inc., 2006., p. 83

[▶ Hazardous Substances Data Bank \(HSDB\)](#)

Strong irritant to eyes, skin, respiratory tract...

Prager, J.C. *Environmental Contaminant Reference Databook Volume 1*. New York, NY: Van Nostrand Reinhold, 1995., p. 137

[▶ Hazardous Substances Data Bank \(HSDB\)](#)

13.2 Safety and Hazard Properties



13.2.1 Acute Exposure Guideline Levels (AEGLs)



13.2.1 AEGLs Table



AEGLs	10 min	30 min	60 min	4 hr	8 hr
AEGL 1: Notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure (Unit: ppm)	30	30	30	30	30
AEGL 2: Irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape (Unit: ppm)	220	220	160	110	110
AEGL 3: Life-threatening health effects or death (Unit: ppm)	2,700	1,600	1,100	550	390

[▶ EPA Acute Exposure Guideline Levels \(AEGLs\)](#)

13.2.2 AEGLs Notes



AEGLs Status: Final

[▶ EPA Acute Exposure Guideline Levels \(AEGLs\)](#)

13.2.2 Flammable Limits



Lower flammable limit: 15% by volume; Upper flammable limit: 28% by volume

National Fire Protection Association; *Fire Protection Guide to Hazardous Materials*. 14TH Edition, Quincy, MA 2010, p. 49-18

[▶ Hazardous Substances Data Bank \(HSDB\)](#)

Flammability

[Note: Although NH₃ does not meet the DOT definition of a Flammable Gas (for labeling purposes), it should be treated as one.]

[▶ The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.2.3 Lower Explosive Limit (LEL)



16 % (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides*. Washington, D.C.: U.S. Government Printing Office.

[▶ CAMEO Chemicals](#)

15%

[▶ Occupational Safety and Health Administration \(OSHA\); The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.2.4 Upper Explosive Limit (UEL)



25 % (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides*. Washington, D.C.: U.S. Government Printing Office.

▶ [CAMEO Chemicals](#)

28%

▶ [Occupational Safety and Health Administration \(OSHA\)](#)

13.2.5 Critical Temperature & Pressure



Critical temperature: 132.4 °C; critical pressure: 111.5 atm

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 88

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.2.6 Physical Dangers



The gas is lighter than air.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

Ammonia gas is lighter than air. However, under certain conditions, when compressed liquified ammonia gas initially escapes a cylinder and comes into contact with moisture in the air it will form an ammonia fog. This fog is likely to remain low to the ground, and could prevent ammonia gas from rising in the air.

Dangerous concentrations of ammonia gas will occur quickly in enclosed or poorly ventilated spaces.

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.2.7 Explosive Limits and Potential



Lower explosive limit: 13% by volume; Upper explosive limit: 28% by volume

Pohanish, R.P. (ed). *Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 6th Edition Volume 1: A-K, Volume 2: L-Z*. William Andrew, Waltham, MA 2012, p. 160

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Explosion hazard when exposed to flame or in a fire. Ammonia + air in a fire can detonate ... Forms sensitive explosive mixtures with air + hydrocarbons, [1-chloro-2,4-dinitrobenzene](#), 2- or 4- chloronitrobenzene (above 160 °C/30 bar), [ethanol](#) + [silver nitrate](#), [germanium](#) derivatives, [stibine](#), and [chlorine](#). Reactions with [silver chloride](#), [silver nitrate](#), [silver azide](#), and silver oxide form the explosive silver nitride. Reactions with [chlorine azide](#), [bromine](#), [iodine](#), [iodine](#) + [potassium](#), heavy metals and their compounds (e.g., [gold\(III\) chloride](#), [mercury](#), and potassium thallium amide ammoniate), tellurium halides (e.g., [tellurium tetrabromide](#) and [tellurium tetrachloride](#)) and penta-borane(9) give explosive products.

Lewis, R.J. Sr. (ed) *Sax's Dangerous Properties of Industrial Materials*. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 228-9

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

May be an explosion hazard in a confined space ... Reacts with [hypochlorite](#) or other halogen sources to form explosive compounds that are sensitive to pressure or increases in temperature.

National Fire Protection Association; *Fire Protection Guide to Hazardous Materials*. 14TH Edition, Quincy, MA 2010, p. 49-18

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Critical temp of 133 °C is easily exceeded in fires so that containers of liquefied ammonia may explode unless their rupture strength is safely in excess of 112 atm.

Clayton, G.D., F.E. Clayton (eds.) *Patty's Industrial Hygiene and Toxicology*. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994., p. 757

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Explosive limits , vol% in air: 15-33.6

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.2.8 OSHA Standards



Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 50 ppm (35 mg/cu m).

29 CFR 1910.1000 (USDOL); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of June 27, 2016: <https://www.ecfr.gov>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Vacated 1989 OSHA PEL STEL 35 ppm (27 mg/cu m) is still enforced in some states.

NIOSH. *NIOSH Pocket Guide to Chemical Hazards*. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997., p. 359

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.2.9 NIOSH Recommendations



Recommended Exposure Limit: 10-hour Time-Weighted Average: 25 ppm (18 mg/cu m).

NIOSH. *NIOSH Pocket Guide to Chemical Hazards*. Department of Health & Human Services, Centers for Disease Control & Prevention. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2010-168 (2010). Available from: <https://www.cdc.gov/niosh/npg>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Recommended Exposure Limit: 15-minute Short-Term Exposure Limit: 35 ppm (27 mg/cu m).

NIOSH. *NIOSH Pocket Guide to Chemical Hazards*. Department of Health & Human Services, Centers for Disease Control & Prevention. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2010-168 (2010). Available from: <https://www.cdc.gov/niosh/npg>

13.3 First Aid Measures



13.3.1 First Aid



Excerpt from ERG Guide 125 [Gases - Corrosive]: Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves. Move victim to fresh air. Call 911 or emergency medical service. Give artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer **oxygen** if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with liquefied gas, thaw frosted parts with lukewarm **water**. In case of contact with substance, immediately flush skin or eyes with running **water** for at least 20 minutes. In case of contact with **Hydrogen fluoride**, anhydrous (UN1052), flush with large amounts of **water**. For skin contact, if **calcium gluconate** gel is available, rinse 5 minutes, then apply gel. Otherwise, continue rinsing until medical treatment is available. For eyes, flush with **water** or a saline solution for 15 minutes. Keep victim calm and warm. Keep victim under observation. Effects of contact or inhalation may be delayed. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

► CAMEO Chemicals

Warning: Ammonia is extremely corrosive to the skin, eyes, and mucous membranes. Contact with the liquified gas may cause frostbite. Caution is advised. Signs and Symptoms of Acute Ammonia Exposure: Inhalation of ammonia may cause irritation and burns of the respiratory tract, laryngitis, dyspnea (shortness of breath), stridor (high-pitched respirations), and chest pain. Pulmonary edema and pneumonia may also result from inhalation. A pink frothy sputum, convulsions, and coma are often seen following exposure to high concentrations. When ammonia is ingested, nausea and vomiting may result; oral, esophageal, and stomach burns are common. If ammonia has contacted the eyes, irritation, pain, conjunctivitis (red, inflamed eyes), lacrimation (tearing), and corneal erosion may occur. Loss of vision is possible. Dermal exposure may result in severe burns and pain. Emergency Life-Support Procedures: Acute exposure to ammonia may require decontamination and life support for the victims. Emergency personnel should wear protective clothing appropriate to the type and degree of contamination. Air-purifying or supplied-air respiratory equipment should also be worn, as necessary. Inhalation Exposure: 1. Move victims to fresh air. Emergency personnel should avoid self-exposure to ammonia. 2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer **oxygen** or other respiratory support. 3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures. 4. Transport to a health care facility. Dermal/Eye Exposure: 1. Remove victims from exposure. Emergency personnel should avoid self-exposure to ammonia. 2. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer **oxygen** or other respiratory support. Warning: Do not attempt to neutralize with an acid wash; excessive liberation of heat may result. 3. If eye exposure has occurred, eyes must IMMEDIATELY be flushed with lukewarm **water** for at least 15 minutes. 4. Remove contaminated clothing as soon as possible. 5. Wash exposed skin areas THOROUGHLY with soap and **water**. 6. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures. 7. Transport to a health care facility. Ingestion Exposure: 1. Evaluate vital signs including pulse and respiratory rate, and note any trauma. If no pulse is detected, provide CPR. If not breathing, provide artificial respiration. If breathing is labored, administer **oxygen** or other respiratory support. 2. DO NOT induce vomiting or attempt to neutralize! 3. Obtain authorization and/or further instructions from the local hospital for administration of an antidote or performance of other invasive procedures. 4. Activated **charcoal** does not strongly bind ammonia, and therefore is of little or no value. 5. Give the victims **water** or milk: children up to 1 year old, 125 mL (4 oz or 1/2 cup); children 1 to 12 years old, 200 mL (6 oz or 3/4 cup); adults, 250 mL (8 oz or 1 cup). **Water** or milk should be given only if victims are conscious and alert. 6. Transport to a health care facility. (EPA, 1998)

U.S. Environmental Protection Agency. 1998. Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides. Washington, D.C.: U.S. Government Printing Office.

► CAMEO Chemicals

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]: Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves. Move victim to fresh air. Call 911 or emergency medical service. Give artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer **oxygen** if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running **water** for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Keep victim calm and warm. Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

► CAMEO Chemicals

(See procedures)

Eye: Irrigate immediately (solution/liquid)

Skin: **Water** flush immediately (solution/liquid)

Breathing: Respiratory support

Swallow: Medical attention immediately (solution)

► The National Institute for Occupational Safety and Health (NIOSH)

GENERAL INFORMATION: Initial treatment is primarily supportive of respiratory and cardiovascular function.

ANTIDOTE: There is no antidote for ammonia toxicity.

EYE: Immediately remove the patient/victim from the source of exposure.

Immediately wash eyes with large amounts of tepid **water** for at least 15 minutes.

Seek medical attention immediately.

INGESTION: Immediately remove the patient/victim from the source of exposure.

Ensure that the patient/victim has an unobstructed airway.

Do not induce vomiting (emesis).

Administer nothing by mouth (NPO).

Administer supplemental **oxygen** and assist ventilation as needed.

Monitor fluid and electrolyte balance and restore if abnormal.

Seek medical attention immediately.

INHALATION: Immediately remove the patient/victim from the source of exposure.

Evaluate respiratory function and pulse.

Ensure that the patient/victim has an unobstructed airway.

If shortness of breath occurs or breathing is difficult (dyspnea), administer [oxygen](#).

Assist ventilation as required. Always use a barrier or bag-valve-mask device.

If breathing has ceased (apnea), provide artificial respiration.

In cases of respiratory compromise, secure airway and respiration by inserting a tube within the trachea (endotracheal intubation).

Use caution when administering intravenous (IV) fluids when fluid accumulation in the lungs (pulmonary edema) is present.

Seek medical attention immediately.

SKIN: Immediately remove the patient/victim from the source of exposure.

See the decontamination section for patient/victim decontamination procedures.

Treat any chemical burns with standard burn therapy.

Seek medical attention immediately.

See ATSDR Medical Management Guidelines for Acute Chemical Exposures, Ammonia, <https://www.atsdr.cdc.gov/MHMI/mmg126.pdf>, for detailed recommendations.

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.3.2 Inhalation First Aid



Fresh air, rest. Half-upright position. Administration of [oxygen](#) may be needed. Refer immediately for medical attention.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.3.3 Skin First Aid



Rinse skin with plenty of [water](#) or shower for at least 15 minutes. ON FROSTBITE: rinse with plenty of [water](#), do NOT remove clothes. Refer immediately for medical attention.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.3.4 Eye First Aid



Rinse with plenty of [water](#) for several minutes (remove contact lenses if easily possible). Refer immediately for medical attention.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.4 Fire Fighting



Excerpt from ERG Guide 125 [Gases - Corrosive]: SMALL FIRE: Dry chemical or CO₂. LARGE FIRE: [Water](#) spray, fog or regular foam. Move containers from fire area if you can do it without risk. Do not get [water](#) inside containers. Damaged cylinders should be handled only by specialists. FIRE INVOLVING TANKS: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of [water](#) until well after fire is out. Do not direct [water](#) at source of leak or safety devices; icing may occur. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ [CAMEO Chemicals](#)

Wear positive pressure breathing apparatus and full protective clothing. Small fires: dry chemical or [carbon dioxide](#). Large fires: [water](#) spray, fog or foam. Apply [water](#) gently to the surface. Do not get [water](#) inside container. Move container from fire area if you can do it without risk. Stay away from ends of tanks. Cool containers that are exposed to flames with [water](#) from the side until well after fire is out. Isolate area until gas has dispersed. (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides*. Washington, D.C.: U.S. Government Printing Office.

▶ [CAMEO Chemicals](#)

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]: SMALL FIRE: Dry chemical, CO₂ or [water](#) spray. LARGE FIRE: Dry chemical, CO₂, alcohol-resistant foam or [water](#) spray. Move containers from fire area if you can do it without risk. Dike fire-control [water](#) for later disposal; do not scatter the material. FIRE INVOLVING TANKS OR CAR/TRAILER LOADS: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Do not get [water](#) inside containers. Cool containers with flooding quantities of [water](#) until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ [CAMEO Chemicals](#)

In case of fire in the surroundings, use appropriate extinguishing media. In case of fire: keep cylinder cool by spraying with [water](#).

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

Ammonia is flammable.

Fire will produce irritating, corrosive, and/or toxic gases.

Never direct [water](#) jet straight at liquid ammonia.

For small fires use dry chemical or [carbon dioxide](#).

For large fires use [water](#) spray, fog, or regular foam. Move containers from the fire area if possible to do so without risk to personnel. Do not get [water](#) inside containers. Damaged cylinders should be handled by a specialist only.

For fire involving tanks, fight fire from a maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of [water](#) until well after fire is out. Do not direct [water](#) at source of leak or safety device; icing may occur. Withdraw immediately in case of rising sound from venting safety device or discoloration of tank. Always stay away from tanks engulfed in fire.

Run-off from fire control may cause pollution.

If the situation allows, control and properly dispose of run-off (effluent).

13.4.1 Fire Fighting Procedures



Suitable extinguishing media: Use [water](#) spray, alcohol-resistant foam, dry chemical or [carbon dioxide](#).

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Advice for firefighters: Wear self-contained breathing apparatus for firefighting if necessary.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Use [water](#) spray to cool unopened containers.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Firefighting gear (including SCBA) does not provide adequate protection ... If exposure occurs, remove and isolate gear immediately and thoroughly decontaminate personnel. Move container from fire area if you can do it without risk. Vapors are heavier than air and will collect in low areas. Vapors in confined areas may explode when exposed to fire. Vapors may travel long distances to ignition sources and flash back. Storage containers and parts of containers may rocket great distances, in many directions. If material or contaminated runoff enters waterways, notify downstream users of potentially contaminated waters. Notify local health and fire officials and pollution control agencies. Do not put [water](#) on liquid ammonia: will increase evaporation. Small fires: dry chemical or [carbon dioxide](#). Large fires: [water](#) spray, fog, or foam. Apply [water](#) gently to the surface. Do not get [water](#) inside container. From a secure explosion-proof location, use [water](#) spray to cool exposed containers. If cooling streams are ineffective (venting sound increased in volume and pitch, tank discolors or shows any signs of deforming), withdraw immediately to a secure position. Isolate until gas has dispersed.

Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 6th Edition Volume 1: A-K, Volume 2: L-Z. William Andrew, Waltham, MA 2012, p. 160

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Fire Fighting Procedures (Complete) data for Ammonia (7 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.4.2 Firefighting Hazards



Under prolonged exposure to fire or intense heat the containers may rupture violently and rocket.

Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 54

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Presence of oil or other combustible materials will increase the fire hazard.

Environment Canada; Tech Info for Problem Spills: Ammonia (Draft) p.4 (1981)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.5 Accidental Release Measures



13.5.1 Isolation and Evacuation



Excerpt from ERG Guide 125 [Gases - Corrosive]: As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions. SPILL: Increase, in the downwind direction, as necessary, the isolation distance shown above. FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ [CAMEO Chemicals](#)

Excerpt from ERG Guide 125 [Gases - Corrosive]: As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions. SPILL: See ERG Tables 1 and 3 - Initial Isolation and Protective Action Distances on the UN/NA 1005 datasheet. FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ [CAMEO Chemicals](#)

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]: As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids. SPILL: Increase, in the downwind direction, as necessary, the isolation distance shown above. FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ [CAMEO Chemicals](#)

13.5.2 Spillage Disposal



Evacuate danger area! Consult an expert! Personal protection: gas-tight chemical protection suit including self-contained breathing apparatus. Ventilation. Shut off cylinder if possible. Isolate the area until the gas has dispersed. Remove gas with fine [water](#) spray. NEVER direct [water](#) jet on liquid.

13.5.3 Cleanup Methods



ACCIDENTAL RELEASE MEASURES: Personal precautions, protective equipment and emergency procedures: Wear respiratory protection. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapors accumulating to form explosive concentrations. Vapors can accumulate in low areas. Environmental precautions: Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided. Methods and materials for containment and cleaning up: Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

SRP: Wastewater from contaminant suppression, cleaning of protective clothing/equipment, or contaminated sites should be contained and evaluated for subject chemical or decomposition product concentrations. Concentrations shall be lower than applicable environmental discharge or disposal criteria. Alternatively, pretreatment and/or discharge to a permitted wastewater treatment facility is acceptable only after review by the governing authority and assurance that "pass through" violations will not occur. Due consideration shall be given to remediation worker exposure (inhalation, dermal and ingestion) as well as fate during treatment, transfer and disposal. If it is not practicable to manage the chemical in this fashion, it must be evaluated in accordance with EPA 40 CFR Part 261, specifically Subpart B, in order to determine the appropriate local, state and federal requirements for disposal.

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Wear a self-contained breathing apparatus, eye protection, laboratory coat, and nitrile rubber gloves (and rubber boots or overshoes if spillage is large). Cover the spill with a 1:1:1 mixture by weight of sodium carbonate or calcium carbonate, clay cat litter (bentonite), and sand. Scoop the mixture into a plastic pail and, in the fume hood, add to a pail of cold water. Neutralize the mixture with 5% hydrochloric acid, let stand overnight, and then pour liquid into the drain. Dispose of any solid with normal refuse. Wash area of the spill with plenty of water.

Armour, MA. Hazardous Laboratory Chemicals Disposal Guide, 3 ed.; Lewis Publishers; New York, NY (2008).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Spill handling: evacuate and restrict persons not wearing protective equipment from area of spill or leak until cleanup is complete. Remove all ignition sources. Establish forced ventilation to keep levels below explosive limit. Ventilate area of spill or leak. Stop the flow of gas if it can be done safely. Stay upwind; keep out of low areas. Wear positive pressure breathing apparatus and full protective clothing. If the leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to a safe place in the open air and repair the leak or allow the cylinder to empty. For small liquid spills, neutralize with hydrochloric acid. Wipe or mop or use water aspirator. Drain into sewer with sufficient water. It may be necessary to contain and dispose of this chemical as a hazardous waste. If material or contaminated runoff enters waterways, notify downstream users of potentially contaminated waters. Contact your Department of Environmental Protection or your regional office of the federal EPA for specific recommendations. Initial isolation and protective action distances: distances shown are likely to be affected during the first 30 min after materials are spilled and could increase with time. If more than one tank car, cargo tank, portable tank, or large cylinder involved in the incident is leaking, the protective action distance may need to be increased ... Small spills (from a small package or a small leak from a large package): First isolate in all directions 100 ft. Then protect persons downwind 0.1 mile (day), 0.1 mile (night). Large spills (from a large package or from many small packages): First isolate in all directions 200 ft. Then protect persons downwind 0.4 miles (day), 1.4 miles (night).

Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 6th Edition Volume 1: A-K, Volume 2: L-Z. William Andrew, Waltham, MA 2012, p. 162

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Cleanup Methods (Complete) data for Ammonia (8 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.5.4 Disposal Methods



SRP: Recycle any unused portion of the material for its approved use or return it to the manufacturer or supplier. Ultimate disposal of the chemical must consider: the material's impact on air quality; potential migration in air, soil or water; effects on animal, aquatic and plant life; and conformance with environmental and public health regulations. If it is possible or reasonable use an alternative chemical product with less inherent propensity for occupational harm/injury/toxicity or environmental contamination.

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

SRP: Wastewater from contaminant suppression, cleaning of protective clothing/equipment, or contaminated sites should be contained and evaluated for subject chemical or decomposition product concentrations. Concentrations shall be lower than applicable environmental discharge or disposal criteria. Alternatively, pretreatment and/or discharge to a permitted wastewater treatment facility is acceptable only after review by the governing authority and assurance that "pass through" violations will not occur. Due consideration shall be given to remediation worker exposure (inhalation, dermal and ingestion) as well as fate during treatment, transfer and disposal. If it is not practicable to manage the chemical in this fashion, it must be evaluated in accordance with EPA 40 CFR Part 261, specifically Subpart B, in order to determine the appropriate local, state and federal requirements for disposal.

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Product: Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Contaminated packaging: Dispose of as unused product.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Solutions of ammonia can be highly diluted with water, or alternatively, diluted with water and neutralized with HCl and then routed to the sewer system. The amount released to the receiving stream should not exceed the established limits for ammonia. Limited amounts of gaseous ammonia may be discharged to the atmosphere. Federal, state, and local guidelines should be consulted before disposal. Disposal of liquefied ammonia or of large quantities of gaseous or aqueous ammonia directly into water is not desirable, because of the large amount of heat generated. This generation of heat could increase exposure to personnel involved in the process. Recovery of ammonia from aqueous waste solutions is a viable option for many industries.

U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Ammonia p.122 (2004) TP126. Available from, as of May 6, 2010: <https://www.atsdr.cdc.gov/toxpro2.html#>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Disposal Methods (Complete) data for Ammonia (6 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.5.5 Preventive Measures



Precautions for safe handling: Avoid contact with skin and eyes. Avoid inhalation of vapor or mist. Keep away from sources of ignition - No smoking. Take measures to prevent the build up of electrostatic charge.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Appropriate engineering controls: Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Process enclosure; local exhaust ventilation and general dilution ventilation ... Where there is any possibility of exposure of employee's body ... facilities for quick drenching of body should be provided within the immediate work area ... Clothing wet with liquid anhydrous ammonia ... should be placed in closed containers ...until it can be discarded ... An eye wash fountain should be provided within immediate work area ...

Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981, p. 3

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Preventive Measures (Complete) data for Ammonia (14 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.6 Handling and Storage



13.6.1 Nonfire Spill Response



Excerpt from ERG Guide 125 [Gases - Corrosive]: Fully encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire. Do not touch or walk through spilled material. Stop leak if you can do it without risk. If possible, turn leaking containers so that gas escapes rather than liquid. Prevent entry into waterways, sewers, basements or confined areas. Do not direct **water** at spill or source of leak. Use **water** spray to reduce vapors or divert vapor cloud drift. Avoid allowing **water** runoff to contact spilled material. Isolate area until gas has dispersed. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ [CAMEO Chemicals](#)

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]: ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. DO NOT GET **WATER** INSIDE CONTAINERS. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ [CAMEO Chemicals](#)

13.6.2 Safe Storage



Fireproof. Separated from oxidants, acids and halogens. Cool. Keep in a well-ventilated room.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.6.3 Storage Conditions



Keep container tightly closed in a dry and well-ventilated place. Contents under pressure. Storage class (TRGS 510): Gases

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Before entering confined space where this chemical may be present, check to make sure that an explosive concentration does not exist. Protect against physical damage. Outside or detached storage is preferred. Inside storage should be in a cool, well-ventilated, noncombustible location, preferably with automatic monitoring systems, away from all possible sources of ignition. Separate from other chemicals, particularly oxidizing gases, **chlorine**, **bromine**, **iodine**, and acids.

Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 6th Edition Volume 1: A-K, Volume 2: L-Z. William Andrew, Waltham, MA 2012, p. 162

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

SRP: Operations involving entry into tanks or closed vessels, and emergency situations, require consideration of potentially **oxygen** deficient, or "immediately dangerous to life and health" IDLH environments. This may necessitate use of a self-contained breathing apparatus (SCBA), or a positive pressure supplied air respirator.

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Separate from other chemicals, particularly oxidizing materials, acids, and halogens. Store in a cool, dry, well-ventilated location.

National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-18

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Storage Conditions (Complete) data for Ammonia (7 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.7 Exposure Control and Personal Protection



13.7.1 Recommended Exposure Limit (REL)



REL-TWA (Time Weighted Average)

25 ppm (18 mg/m³)

▶ [Occupational Safety and Health Administration \(OSHA\)](#)

REL-STEL (Short Term Exposure Limit)

35 ppm (27 mg/m³)

▶ [Occupational Safety and Health Administration \(OSHA\)](#)

TWA 25 ppm (18 mg/m³) ST 35 ppm (27 mg/m³)

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.7.2 Permissible Exposure Limit (PEL)



PEL-TWA (8-Hour Time Weighted Average)

50 ppm (35 mg/m³)

▶ [Occupational Safety and Health Administration \(OSHA\)](#)

CAPEL-TWA (California PEL - Time Weighted Average)

25 ppm (17 mg/m³)

▶ [Occupational Safety and Health Administration \(OSHA\)](#)

CAPEL-STEL (California PEL - Short Term Exposure Limit)

35 ppm (27 mg/m³)

▶ [Occupational Safety and Health Administration \(OSHA\)](#)

TWA 50 ppm (35 mg/m³) [See Appendix G](#)

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.7.3 Immediately Dangerous to Life or Health (IDLH)



300 ppm (NIOSH, 2016)

National Institute of Occupational Safety and Health. NIOSH Pocket Guide to Chemical Hazards (full website version). <https://www.cdc.gov/niosh/npg> (accessed August 2016).

▶ [CAMEO Chemicals](#)

300 ppm

NIOSH. NIOSH Pocket Guide to Chemical Hazards. Department of Health & Human Services, Centers for Disease Control & Prevention. National Institute for Occupational Safety & Health. DHHS (NIOSH) Publication No. 2010-168 (2010). Available from: <https://www.cdc.gov/niosh/npg>

▶ [Hazardous Substances Data Bank \(HSDB\)](#); [Occupational Safety and Health Administration \(OSHA\)](#)

300 ppm

See: [7664417](#)

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.7.4 Threshold Limit Values (TLV)



8 hr Time Weighted Avg (TWA): 25 ppm; 15 min Short Term Exposure Limit (STEL): 35 ppm.

American Conference of Governmental Industrial Hygienists TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH 2016, p. 12

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

25 ppm as TWA; 35 ppm as STEL.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

14 mg/m³, 20 ppm; peak limitation category: I(2); pregnancy risk group: C

- ▶ ILO International Chemical Safety Cards (ICSC)

TLV-TWA (Time Weighted Average)

25 ppm [1970]

- ▶ Occupational Safety and Health Administration (OSHA)

TLV-STEL (Short Term Exposure Limit)

35 ppm [1970]

- ▶ Occupational Safety and Health Administration (OSHA)

13.7.5 Other Standards Regulations and Guidelines



AEGLS

Table: AEGLs for AMMONIA (ppm)

Exposure Time	AEGL 1 (Discomfort)	AEGL 2 (Impaired Escape)	AEGL 3 (Life Threatening/Death)
10 minutes	30	220	2700
30 minutes	30	220	1600
1 hour	30	160	1100
4 hours	30	110	550
8 hours	30	110	390

U.S. EPA; Acute Exposure Guideline Levels (AEGLs) - Results for Ammonia. Available from, as of August 5, 2009: <https://www.epa.gov/oppt/aegl/pubs/chemlist.htm>

- ▶ Hazardous Substances Data Bank (HSDB)

Emergency Response Planning Guidelines (ERPGs) for ammonia:

ERPG / LEL	Airborne Concentration	Notations
ERPG-1: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.	25 ppm	Odor should be detectable near ERPG-1
ERPG-2: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.	150 ppm	
ERPG-3: The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.	1500 ppm	

2015 Emergency Response Planning Guidelines (ERPG) & Workplace Exposure Level (WEEL). American Industrial Hygiene Association, Falls Church, VA 2015, p. 22

- ▶ Hazardous Substances Data Bank (HSDB)

13.7.6 Inhalation Risk



A harmful concentration of this gas in the air will be reached very quickly on loss of containment.

- ▶ ILO International Chemical Safety Cards (ICSC)

13.7.7 Effects of Short Term Exposure



Rapid evaporation of the liquid may cause frostbite. The substance is corrosive to the eyes, skin and respiratory tract. Exposure could cause asphyxiation due to swelling in the throat. Inhalation may cause lung oedema, but only after initial corrosive effects on eyes and/or airways have become manifest.

- ▶ ILO International Chemical Safety Cards (ICSC)

Information regarding ammonia's potential as a carcinogen, developmental toxin or reproductive toxin from chronic or repeated exposure is inconclusive. Chronic or repeated exposure to ammonia may cause chronic respiratory tract irritation, chronic cough, asthma, lung fibrosis, headaches, somnolence, chronic eye membrane irritation, and dermatitis.

On-Site Fatalities

- ▶ The National Institute for Occupational Safety and Health (NIOSH)

13.7.8 Effects of Long Term Exposure



Repeated or chronic inhalation of the vapour may cause chronic inflammation of the upper respiratory tract. Lungs may be affected by repeated or prolonged exposure. This may result in chronic obstructive pulmonary disorders (COPD).

- ▶ ILO International Chemical Safety Cards (ICSC)

13.7.9 Personal Protective Equipment (PPE)



Excerpt from ERG Guide 125 [Gases - Corrosive]: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

- ▶ CAMEO Chemicals

For emergency situations, wear a positive pressure, pressure-demand, full facepiece self-contained breathing apparatus (SCBA) or pressure-demand supplied air respirator with escape SCBA and a fully-encapsulating, chemical resistant suit. (EPA, 1998)

U.S. Environmental Protection Agency. 1998. *Extremely Hazardous Substances (EHS) Chemical Profiles and Emergency First Aid Guides*. Washington, D.C.: U.S. Government Printing Office.

▶ [CAMEO Chemicals](#)

Excerpt from ERG Guide 154 [Substances - Toxic and/or Corrosive (Non-Combustible)]: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 *Emergency Response Guidebook*. <https://www.phmsa.dot.gov/hazmat/outreach-training/erg> (accessed April 26, 2016).

▶ [CAMEO Chemicals](#)

Eye/face protection: Tightly fitting safety goggles. Faceshield (8-inch minimum). Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Skin protection: Handle with gloves.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Body Protection: Complete suit protecting against chemicals. Flame retardant antistatic protective clothing. The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Respiratory protection: Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multipurpose combination (US) or type AXBEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Personal Protective Equipment (PPE) (Complete) data for Ammonia (15 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

[\(See protection codes\)](#)

Skin: Prevent skin contact – Wear appropriate personal protective clothing to prevent skin contact.

Eyes: Prevent eye contact – Wear appropriate eye protection to prevent eye contact.

Wash skin: When contaminated (solution)

Remove: When wet or contaminated (solution)

Change: No recommendation

Provide: Eyewash (>10%), Quick drench (>10%)

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

GENERAL INFORMATION: First Responders should use a NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA) with a Level A protective suit when entering an area with an unknown contaminant or when entering an area where the concentration of the contaminant is unknown. Level A protection should be used until monitoring results confirm the contaminant and the concentration of the contaminant. NOTE: Safe use of protective clothing and equipment requires specific skills developed through training and experience.

LEVEL A: (RED ZONE): Select when the greatest level of skin, respiratory, and eye protection is required. This is the maximum protection for workers in danger of exposure to unknown chemical hazards or levels above the IDLH or greater than the AEGL-2. A NIOSH-certified CBRN full-face-piece SCBA operated in a pressure-demand mode or a pressure-demand supplied air hose respirator with an auxiliary escape bottle.

A Totally-Encapsulating Chemical Protective (TECP) suit that provides protection against CBRN agents.

Chemical-resistant gloves (outer).

Chemical-resistant gloves (inner).

Chemical-resistant boots with a steel toe and shank.

Coveralls, long underwear, and a hard hat worn under the TECP suit are optional items.

LEVEL B: (RED ZONE): Select when the highest level of respiratory protection is necessary but a lesser level of skin protection is required. This is the minimum protection for workers in danger of exposure to unknown chemical hazards or levels above the IDLH or greater than AEGL-2. It differs from Level A in that it incorporates a non-encapsulating, splash-protective, chemical-resistant splash suit that provides Level A protection against liquids but is not airtight. A NIOSH-certified CBRN full-face-piece SCBA operated in a pressure-demand mode or a pressure-demand supplied air hose respirator with an auxiliary escape bottle.

A hooded chemical-resistant suit that provides protection against CBRN agents.

Chemical-resistant gloves (outer).

Chemical-resistant gloves (inner).

Chemical-resistant boots with a steel toe and shank.

Coveralls, long underwear, a hard hat worn under the chemical-resistant suit, and chemical-resistant disposable boot-covers worn over the chemical-resistant suit are optional items.

LEVEL C: (YELLOW ZONE): Select when the contaminant and concentration of the contaminant are known and the respiratory protection criteria factors for using Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR) are met. This level is appropriate when decontaminating patient/victims. A NIOSH-certified CBRN tight-fitting APR with a canister-type gas mask or CBRN PAPR for air levels greater than AEGL-2.

A NIOSH-certified CBRN PAPR with a loose-fitting face-piece, hood, or helmet and a filter or a combination organic vapor, acid gas, and particulate cartridge/filter combination or a continuous flow respirator for air levels greater than AEGL-1.

A hooded chemical-resistant suit that provides protection against CBRN agents.

Chemical-resistant gloves (outer).

Chemical-resistant gloves (inner).

Chemical-resistant boots with a steel toe and shank.

Escape mask, face shield, coveralls, long underwear, a hard hat worn under the chemical-resistant suit, and chemical-resistant disposable boot-covers worn over the chemical-resistant suit are optional items.

LEVEL D: (GREEN ZONE): Select when the contaminant and concentration of the contaminant are known and the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. Limited to coveralls or other work clothes, boots, and gloves.

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.7.10 Respirator Recommendations



NIOSH

Up to 250 ppm:

(APF = 10) Any chemical cartridge respirator with cartridge(s) providing protection against the compound of concern*

(APF = 10) Any supplied-air respirator*

Up to 300 ppm:

(APF = 25) Any supplied-air respirator operated in a continuous-flow mode*

(APF = 25) Any powered, air-purifying respirator with cartridge(s) providing protection against the compound of concern*

(APF = 50) Any chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against the compound of concern

(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern

(APF = 50) Any self-contained breathing apparatus with a full facepiece

(APF = 50) Any supplied-air respirator with a full facepiece

Emergency or planned entry into unknown concentrations or IDLH conditions:

(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

Escape:

(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the compound of concern

Any appropriate escape-type, self-contained breathing apparatus

[Important additional information about respirator selection](#)

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.7.11 Fire Prevention



NO open flames, NO sparks and NO smoking. Closed system, ventilation, explosion-proof electrical equipment and lighting.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.7.12 Exposure Prevention



AVOID ALL CONTACT! IN ALL CASES CONSULT A DOCTOR!

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.7.13 Inhalation Prevention



Use ventilation, local exhaust or breathing protection.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.7.14 Skin Prevention



Cold-insulating gloves. Protective clothing.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.7.15 Eye Prevention



Wear face shield or eye protection in combination with breathing protection.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.8 Stability and Reactivity



13.8.1 Air and Water Reactions



Soluble in [water](#) with evolution of heat. The amount of heat generated may be large.

▶ [CAMEO Chemicals](#)

Water soluble.

▶ [CAMEO Chemicals](#)

13.8.2 Reactive Group



Bases, Weak

[Water](#) and Aqueous Solutions

▶ [CAMEO Chemicals](#)

Bases, Weak

▶ [CAMEO Chemicals](#)

13.8.3 Reactivity Alerts



Water-Reactive

▶ [CAMEO Chemicals](#)

13.8.1 CSL Reaction Information



CSL No	CSL00056
Reactants/Reagents	CHLORINE; AMMONIA
GHS Category	Explosive
Warning Message	Potentially explosive in the presence of chlorine , bromine or iodine
Source Reference	User-Reported
CSL Status	Approved
Modified Date	8/7/2018

▶ [Pistoia Alliance Chemical Safety Library](#)

CSL No	CSL00070
Reactants/Reagents	ETHANOL ; AMMONIA; SILVER OXIDE
GHS Category	Explosive
Warning Message	Potentially explosive
Source Reference	User-Reported
CSL Status	Approved
Modified Date	8/7/2018

▶ [Pistoia Alliance Chemical Safety Library](#)

13.8.4 Reactivity Profile



Ammonia solutions react exothermically with acids to produce [water](#) and ammonium salts, Heating or treating with strong bases also causes evolution of gaseous ammonia. Ammonia can burn or explode if exposed to an intense source of ignition but can generally be treated as nonflammable. Readily combines with silver oxide, [silver chloride](#), [silver nitrate](#), [silver azide](#) or [mercury](#) to form explosive compounds. Forms explosive [ammonium chlorate](#) on contact with chlorates [Kirk-Othmer, 3rd ed., Vol. 2, 1978, p. 470]. Reacts violently or produces explosive products with [fluorine](#), [chlorine](#), [bromine](#) and [iodine](#) and [bromine pentafluoride](#) and [chlorine trifluoride](#). Mixing of bleaching powder ([hypochlorite](#) solution) with ammonia solutions produces toxic/explosive ammonia trichloride vapors. May react violently with boron halides, [ethylene oxide](#) (polymerization), perchlorates and strong oxidizing agents ([chromyl chloride](#), [chromium trioxide](#), [chromic acid](#), [nitric acid](#), [hydrogen peroxide](#), chlorates, [fluorine](#), [nitrogen oxide](#), liquid [oxygen](#)).

▶ [CAMEO Chemicals](#)

AMMONIA is a base. Reacts exothermically with all acids. Violent reactions are possible. Readily combines with silver oxide or [mercury](#) to form compounds that explode on contact with halogens. When in contact with chlorates it forms explosive [ammonium chlorate](#) [Kirk-Othmer, 3rd ed., Vol. 2, 1978, p. 470]. Reacts violently or produces explosive products with [fluorine](#), [chlorine](#), [bromine](#) and [iodine](#) and some of the interhalogen compounds ([bromine pentafluoride](#), [chlorine trifluoride](#)). Mixing of bleaching powder ([hypochlorite](#) solution) with ammonia solutions produces toxic/explosive ammonia trichloride vapors. Undergoes potentially violent or explosive reactions on contact with [1,2-dichloroethane](#) (with liquid ammonia), boron halides, [ethylene oxide](#) (polymerization), perchlorates or strong oxidants ([chromyl chloride](#), [chromium trioxide](#), [chromic acid](#), [nitric acid](#), [hydrogen peroxide](#), chlorates, [fluorine](#), [nitrogen oxide](#), liquid [oxygen](#)). Reacts with [silver chloride](#), silver oxide, [silver nitrate](#) or [silver azide](#) to form the explosive silver nitride. May react with some heavy metal compounds ([mercury](#), [gold\(III\) chloride](#)) to produce materials that may explode when dry. [Bretherick, 5th ed., 1995, p. 1553].

▶ [CAMEO Chemicals](#)

AMMONIA SOLUTION is basic. Reacts exothermically with acids to produce [water](#) and ammonium salts, which, being generally [water](#)-soluble, stay in the solution. The heat can cause evolution of quantities of unreacted ammonia as a corrosive, irritating gas. Heating ammonia solutions or treating them with strong bases also causes evolution of gaseous ammonia. Salts with oxidizing acids (such as [ammonium chlorate](#)) may explode if obtained in dry or nearly dry form [Kirk-Othmer, 3rd ed., Vol. 2, 1978, p. 470]. Intense sources of ignition can

cause air/ammonia mixtures to burn or explode, but the conditions are so specialized that ammonia is generally regarded as nonflammable. Mixing of bleaching powder (hypochlorite solution) with ammonia solutions produces toxic/explosive ammonia trichloride vapors.

▶ [CAMEO Chemicals](#)

13.8.5 Hazardous Reactivities and Incompatibilities



Incompatible materials: Oxidizing agents, [iron](#), [zinc](#), [copper](#), [silver](#)/silver oxides, [cadmium](#)/cadmium oxides, alcohols, acids, halogens, aldehydes.

Sigma-Aldrich; Safety Data Sheet for Ammonia (7664-41-7). Product Number: 294993, Version 3.10 (Revision Date 02/23/2016). Available from, as of May 2, 2016: <https://www.sigmaaldrich.com/safety-center.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Shock-sensitive compounds may be formed with [gold](#), halogens, [mercury](#), mercury oxide, and silver oxide.

Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 6th Edition Volume 1: A-K, Volume 2: L-Z. William Andrew, Waltham, MA 2012, p. 160

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Attacks some coatings, plastics, rubber, [copper](#), brass, bronze, [aluminum](#), steel, [tin](#), [zinc](#), and their alloys.

Pohanish, R.P. (ed). Sittig's Handbook of Toxic and Hazardous Chemical Carcinogens 6th Edition Volume 1: A-K, Volume 2: L-Z. William Andrew, Waltham, MA 2012, p. 160

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Potentially violent or explosive reactions on contact with interhalogens (e.g., [bromine pentafluoride](#), [chlorine trifluoride](#)), [1,2-dichloroethane](#) (with liquid ammonia), boron halides, chloroformamideium [nitrate](#), [ethylene oxide](#) (polymerization reaction), [magnesium perchlorate](#), [nitrogen trichloride](#), [oxygen](#) + [platinum](#), or strong oxidants (e.g., [potassium chlorate](#), [nitryl chloride](#), [chromyl chloride](#), [dichlorine oxide](#), [chromium trioxide](#), trioxxygen difluoride, [nitric acid](#), [hydrogen peroxide](#), [tetramethylammonium](#) amide, [thiocarbonyl azide thiocyanate](#), [sulfanyl chloride](#), [thiotriazolyl chloride](#), [ammonium peroxodisulfate](#), [fluorine](#), [nitrogen oxide](#), [dinitrogen tetraoxide](#), and liquid [oxygen](#)).

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 228

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Hazardous Reactivities and Incompatibilities (Complete) data for Ammonia (9 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.9 Transport Information



13.9.1 DOT Emergency Guidelines



If ... THERE IS NO FIRE, go directly to the Table of Initial Isolation and Protective Action Distances (see table below) ... to obtain initial isolation and protective action distances. IF THERE IS A FIRE, or IF A FIRE IS INVOLVED, go directly to the appropriate guide (see guide(s) below) and use the evacuation information shown under PUBLIC SAFETY. /Ammonia, anhydrous; Anhydrous ammonia/

Table: Table of Initial Isolation and Protective Action Distances for Ammonia, anhydrous; Anhydrous ammonia ID: 1005

Small Spills (from a small package or small leak from a large package)	Small Spills (from a small package or small leak from a large package)	Small Spills (from a small package or small leak from a large package)	Large Spills (from a large package or small leak from a large package)	Large Spills (from a large package or small leak from a large package)	Large Spills (from a large package or small leak from a large package)
First ISOLATE in all Directions	Then PROTECT persons Downwind during DAY:	Then PROTECT persons Downwind during NIGHT:	First ISOLATE in all Directions	Then PROTECT persons Downwind during DAY:	Then PROTECT persons Downwind during NIGHT:
30 m (100 ft)	0.1 km (0.1 mi)	0.2 km (0.1 mi)	150 m (500 ft)	0.8 km (0.5 mi)	2.0 km (1.3 mi)

U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

If ... THERE IS NO FIRE, go directly to the Table of Initial Isolation and Protective Action Distances (see table below) ... to obtain initial isolation and protective action distances. IF THERE IS A FIRE, or IF A FIRE IS INVOLVED, go directly to the appropriate guide (see guide(s) below) and use the evacuation information shown under PUBLIC SAFETY. /Ammonia, anhydrous: Large Spills/

Table: Table of Initial Isolation and Protective Action Distances For Different Quantities in Ammonia, anhydrous: Large Spills ID:1005

TRANSPORT CONTAINER	First ISOLATE in all Directions	Then PROTECT persons downwind during	Then PROTECT persons downwind during	Then PROTECT persons downwind during	Then PROTECT persons downwind during	Then PROTECT persons downwind during	Then PROTECT persons downwind during
TRANSPORT CONTAINER	First ISOLATE in all Directions	DAY	DAY	DAY	NIGHT	NIGHT	NIGHT
TRANSPORT CONTAINER	First ISOLATE in all Directions	Low Wind (<6 mph= <10 km/h)	Moderate wind (6-12 mph = 10-20 km/hr)	High wind (>12 mph = >20 km/hr)	Low Wind (<6 mph= <10 km/h)	Moderate wind (6-12 mph = 10-20 km/hr)	High wind (>12 mph = >20 km/hr)
Rail tank car	300 m (1000 ft)	2.3 km (1.4 mi)	1.3 km (0.8 mi)	1 km (0.6 mi)	6.3 km (3.9 mi)	2.6 km (1.6 mi)	1.3 km (0.8 mi)
Highway tank truck or trailer	125 m (400 ft)	1 km (0.6 mi)	0.5 km (0.3 mi)	0.3 km (0.2 mi)	2.6 km (1.6 mi)	0.8 km (0.5 mi)	0.5 km (0.3 mi)
Agricultural nurse tank	60 m (200 ft)	0.6 km (0.4 mi)	0.3 km (0.2 mi)	0.3 km (0.2 mi)	1.5 km (0.9 mi)	0.5 km (0.3 mi)	0.3 km (0.2 mi)
Multiple small cylinders	30 m (100 ft)	0.3 km (0.2 mi)	0.2 km (0.1 mi)	0.2 km (0.1 mi)	0.8 km (0.5 mi)	0.3 km (0.2 mi)	0.2 km (0.1 mi)

U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

If ... THERE IS NO FIRE, go directly to the Table of Initial Isolation and Protective Action Distances (see table below) ... to obtain initial isolation and protective action distances. IF THERE IS A FIRE, or IF A FIRE IS INVOLVED, go directly to the appropriate guide (see guide(s) below) and use the evacuation information shown under PUBLIC SAFETY. /Ammonia solution, with more than 50% Ammonia/

Table: Table of Initial Isolation and Protective Action Distances for Ammonia solution, with more than 50% Ammonia ID: 3318

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Small Spills (from a small package or small leak from a large package)	Small Spills (from a small package or small leak from a large package)	Small Spills (from a small package or small leak from a large package)	Large Spills (from a large package or small leak from a large package)	Large Spills (from a large package or small leak from a large package)	Large Spills (from a large package or small leak from a large package)
First ISOLATE in all Directions	Then PROTECT persons Downwind during DAY:	Then PROTECT persons Downwind during NIGHT:	First ISOLATE in all Directions	Then PROTECT persons Downwind during DAY:	Then PROTECT persons Downwind during NIGHT:
30 m (100 ft)	0.1 km (0.1 mi)	0.2 km (0.1 mi)	150 m (500 ft)	0.8 km (0.5 mi)	2.0 km (1.3 mi)

U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/GUIDE 125 GASES - CORROSIVE/ Fire or Explosion: Some may burn but none ignite readily. Vapors from liquefied gas are initially heavier than air and spread along ground. Some of these materials may react violently with [water](#). Cylinders exposed to fire may vent and release toxic and/or corrosive gas through pressure relief devices. Containers may explode when heated. Ruptured cylinders may rocket. /Ammonia, anhydrous; Anhydrous ammonia; Ammonia, solution, with more than 35% but not more than 50% Ammonia; Ammonia solution, with more than 50% Ammonia/

U.S. Department of Transportation. 2012 Emergency Response Guidebook. Washington, D.C. 2012

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more DOT Emergency Guidelines (Complete) data for Ammonia (19 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.9.2 DOT ID and Guide



1005 125

▶ [DOT Emergency Response Guidebook](#)

1005 125 (anhydrous)

2672 154 (10-35% solution)

2073 125 (>35-50% solution)

1005 125 (>50% solution)

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.9.3 Shipping Name/ Number DOT/UN/NA/IMO



UN 1005; Ammonia, anhydrous

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

UN 2073; Ammonia solutions, relative density less than 0.880 at 15 °C in [water](#), with more than 35% but not more than 50% ammonia

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

UN 2672; Ammonia solutions, relative density between 0.880 and 0.957 at 15 °C in [water](#), with more than 10% but not more than 35% ammonia

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

UN 3318; Ammonia solution, relative density less than 0.880 at 15 °C in [water](#), with more than 50% ammonia

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Shipping Name/ Number DOT/UN/NA/IMO (Complete) data for Ammonia (7 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.9.4 Standard Transportation Number



49 042 10; Anhydrous ammonia

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.9.5 Shipment Methods and Regulations



No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./

49 CFR 171.2 (USDOT); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of June 28, 2016: <https://www.ecfr.gov>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials. Ammonia solution relative density (specific gravity) less than 0.880 at 15 °C in [water](#), with more than 35% but not more than 50% ammonia; Ammonia, anhydrous; Ammonia solution relative density (specific gravity) less than 0.880 at 15 °C in [water](#), with more than 50% ammonia; and Ammonia solution relative density (specific gravity) between 0.880 and 0.957 at 15 °C in [water](#), with more than 10% but not more than 35% ammonia are included on the dangerous goods list. /Ammonia solution relative density (specific gravity) less than 0.880 at 15 °C in [water](#), with more than 35% but not more than 50% ammonia; Ammonia, anhydrous; Ammonia solution relative density (specific gravity) less than 0.880 at 15 °C in [water](#), with more than 50% ammonia; and Ammonia solution relative density (specific gravity) between 0.880 and 0.957 at 15 °C in [water](#), with more than 10% but not more than 35% ammonia/

International Air Transport Association. Dangerous Goods Regulations. 57th Edition. Montreal, Quebec Canada. 2016., p. 197

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article. Ammonia solution relative density less than 0.880 at 15 °C in [water](#), with more than 35% but not more than 50% ammonia; Ammonia, anhydrous; Ammonia solution relative density less than 0.880 at 15 °C in [water](#), with more than 50% ammonia; and Ammonia solution relative density between 0.880 and 0.957 at 15 °C in [water](#), with more than 10% but not more than 35% ammonia are included on the dangerous goods list. /Ammonia solution relative density less than 0.880 at 15 °C in [water](#), with more than 35% but not more than 50% ammonia; Ammonia, anhydrous; Ammonia solution relative density less than 0.880 at 15 °C in [water](#), with more than 50% ammonia; and Ammonia solution relative density between 0.880 and 0.957 at 15 °C in [water](#), with more than 10% but not more than 35% ammonia/

International Maritime Organization. IMDG Code. International Maritime Dangerous Goods Code Volume 2 2014, p. 43, 101, 128, 173

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.9.6 DOT Label



Non-Flammable Gas

▶ [CAMEO Chemicals](#)

Non-Flammable Gas (domestic) Inhalation Hazard (Special Provision 13) (domestic) Poison Gas (international) Corrosive (international)

▶ [CAMEO Chemicals](#)

Corrosive

▶ [CAMEO Chemicals](#)

13.9.7 EC Classification



Symbol: T, N; R: 10-23-34-50; S: (1/2)-9-16-26-36/37/39-45-61; Note: U

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.9.8 UN Classification



UN Hazard Class: 2.3; UN Subsidiary Risks: 8

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

13.10 Regulatory Information



13.10.1 Clean Water Act Requirements



Ammonia is designated as a hazardous substance under section 311(b)(2)(A) of the Federal [Water](#) Pollution Control Act and further regulated by the [Clean Water](#) Act Amendments of 1977 and 1978. These regulations apply to discharges of this substance. This designation includes any isomers and hydrates, as well as any solutions and mixtures containing this substance.

40 CFR 116.4 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of June 27, 2016: <https://www.ecfr.gov>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.10.2 CERCLA Reportable Quantities



Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 100 lb or 45.4 kg. The toll free number of the NRC is (800) 424-8802. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).

40 CFR 302.4 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of June 27, 2016: <https://www.ecfr.gov>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Releases of CERCLA hazardous substances are subject to the release reporting requirement of CERCLA section 103, codified at 40 CFR part 302, in addition to the requirements of 40 CFR part 355. Ammonia is an extremely hazardous substance (EHS) subject to reporting requirements when stored in amounts in excess of its threshold planning quantity (TPQ) of 500 lbs.

40 CFR 355 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of June 27, 2016: <https://www.ecfr.gov>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.10.3 FIFRA Requirements



New Active Ingredients ... includes chemicals not previously registered as pesticides, as well as pesticide active ingredients initially registered after November 1, 1984 and that currently have active product registrations. By law, these pesticides must meet new safety standards, such as those described in the Food Quality Protection Act of 1996 and, if new safety standards are met, will be reviewed again on a 15-year cycle. Ammonia is designated by EPA as a New Pesticide Active Ingredient. Active Ingredient Number: 005302; Type of Pesticide: insecticide; Use Site: non-food use; Year: 1994.

United States Environmental Protection Agency/ Prevention, Pesticides and Toxic Substances; Status of Pesticides in Registration, Reregistration, and Special Review. (1998) EPA 738-R-98-002, p. 352

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.10.4 FDA Requirements



Ammonia is an indirect food additive for use only as a component of adhesives.

21 CFR 175.105 (USFDA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of June 27, 2016: <https://www.ecfr.gov>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.11 Other Safety Information



Methods of Dissemination

Indoor Air: Ammonia can be released into indoor air as a liquid spray (aerosol) or as a vapor.

Water: Ammonia can be used to contaminate [water](#).

Food: Ammonia is unlikely to contaminate food due to unpalatable qualities rendered to food.

Outdoor Air: Ammonia can be released into outdoor air as a liquid spray (aerosol) or as a vapor.

Agricultural: If ammonia is released into the air as a liquid spray (aerosol), it has the potential to contaminate agricultural products. If ammonia is released as a vapor, it is highly unlikely to contaminate agricultural products.

▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

13.11.1 Toxic Combustion Products



Fire will produce irritating, corrosive, and/or toxic gases.

CDC; NIOSH Emergency Response Safety and Health Database, Emergency Response Card for Ammonia (CAS #7664-41-7). Available from, as of May 11, 2010: <https://www.cdc.gov/niosh/ershdb/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.11.2 Other Hazardous Reactions



Poisonous, visible vapor cloud is produced from contact with [water](#).

U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.11.3 History and Incidents



An April 11, 2003, vessel explosion at the D. D. Williamson & Co., Inc. (DDW), plant in Louisville, Kentucky, killed one operator. The explosion damaged the western end of the facility and released 26,000 pounds of aqua ammonia (29.4 percent ammonia solution in [water](#)), forcing the evacuation of as many as 26 residents and requiring 1,500 people to shelter-in-place. DDW used the vessel in the manufacture of food-grade caramel coloring. It functioned as a feed tank for a spray dryer that produced powdered colorants. The feed tank, which was heated with steam and pressurized with air, was operated manually. To ensure that the filling, heating, and material transfer processes stayed within operating limits, operators relied on their experience and on readouts from local temperature and pressure indicators. The feed tank most likely failed as a result of overheating the caramel color liquid, which generated excessive pressure.

U.S. Chemical Safety and Hazard Investigation Board; Investigation Report: Catastrophic Vessel Failure p. 9 (March 2004). Available from, as of September 16, 2016: <https://www.csb.gov/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

On June 10, 2008, Goodyear operators closed an isolation valve between the heat exchanger shell (ammonia cooling side) and a relief valve to replace a burst rupture disk under the relief valve that provided overpressure protection. Maintenance workers replaced the rupture disk on that day; however, the closed isolation valve was not reopened. On the morning of June 11, an operator closed a block valve isolating the ammonia pressure control valve from the heat exchanger. The operator then connected a steam line to the process line to **clean** the piping. The steam flowed through the heat exchanger tubes, heated the liquid ammonia in the exchanger shell, and increased the pressure in the shell. The closed isolation and block valves prevented the increasing ammonia pressure from safely venting through either the ammonia pressure control valve or the rupture disk and relief valve. The pressure in the heat exchanger shell continued climbing until it violently ruptured at about 7:30 a.m. The catastrophic rupture threw debris that struck and killed a Goodyear employee walking through the area. The rupture also released ammonia, exposing five nearby workers to the chemical. One additional worker was injured while exiting the area. Immediately after the rupture and resulting ammonia release, Goodyear evacuated the plant. Medical responders transported the six injured workers. The employee tracking system failed to properly account for all workers and as a result, Goodyear management believed all workers had safely evacuated the affected area. Management declared the incident over the morning of June 11, although debris blocked access to the area immediately surrounding the heat exchanger. Plant responders managed the **cleanup** while other areas of the facility resumed operations.

U.S. Chemical Safety and Hazard Investigation Board; Case Study: Heat exchanger rupture and ammonia release in Houston, Texas p. 2 (January 2011). Available from, as of September 16, 2016: <https://www.csb.gov/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

On June 9, 2009, a major natural gas explosion heavily damaged the ConAgra Slim Jim meat processing factory in Garner, North Carolina, just south of Raleigh. Three workers were crushed to death when a large section of the building collapsed. The explosion critically burned four others and sent a total of 71 people to the hospital including three firefighters who were exposed to toxic anhydrous ammonia from the plant's refrigeration system. Approximately 18,000 pounds of ammonia were released to the environment and 100,000 square feet of the plant were damaged. ... Following the June 9 explosion, ConAgra established new procedures for gas purging. These procedures require direct venting of purged gases via a hose or piping to a safe location outdoors, exclusion of personnel and ignition sources from the vicinity of the vent, continuous air monitoring using combustible gas detectors, and evacuation of nonessential personnel from the facility.

U.S. Chemical Safety and Hazard Investigation Board; Safety Bulletin: Dangers of Purging Gas Piping into Buildings p. 3-4 (September 2009). Available from, as of September 16, 2016: <https://www.csb.gov/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

On August 23, 2010, at the Millard Refrigerated Services facility in Theodore, Alabama, hydraulic shock caused a roof-mounted 12-inch suction pipe to catastrophically fail leading to the release of more than 32,000 pounds of anhydrous ammonia. The hydraulic shock was enabled during the restart of the plant's ammonia refrigeration system following a 7-hour power outage. In addition to the catastrophic failure of roof-mounted piping, the pressure developed by the hydraulic shock event also caused an evaporator coil inside the facility to rupture. The ammonia cloud released from the roof-mounted pipe and traveled 0.25 miles across the river adjacent to the plant. Downwind of the ammonia release were crew members on the ships docked at Millard and over 800 contractors working outdoors at a **clean-up** site for the Deepwater Horizon oil spill. One Millard employee sustained injuries after briefly losing consciousness from ammonia inhalation. Nine ship crew members and 143 of the offsite contractors downwind reported exposure. Of the exposed victims, 32 required hospitalization, and 4 were placed in intensive care. ... Approximately 15 minutes after being notified of the release, the Millard Plant Manager called 9-1-1, triggering a response from the Mobile Fire Department (MFD), which arrived on scene 16 minutes later with hazardous materials technicians to assess and mitigate the release. The Theodore Volunteer Fire Department also responded on the south side of the canal. The MFD called the Mobile County Emergency Management Agency and advised shelter-in-place for the surrounding community and the U.S. Coast Guard halted [water](#) traffic on the industrial canal. Shortly after the release occurred, contract employees working at the Deepwater Horizon (DWH) vessel and boom

decontamination site,⁷ approximately 0.25 miles south of Millard, became engulfed in the ammonia cloud and immediately started experiencing symptoms of ammonia exposure. The workers were advised to go to their personal cars and evacuate the facility. The Mobile County Fire and Rescue set up an impromptu triage site at a gas station about 2 miles from the DWH clean-up site where exposed workers gathered upon evacuation. Most of the offsite contractors went to the triage site for medical evaluation, and some were transported to the hospital.

U.S. Chemical Safety and Hazard Investigation Board; Safety Bulletin: Key Lessons for Preventing Hydraulic Shock in Industrial Refrigeration Systems p. 2,4 (January 2015). Available from, as of September 16, 2016: <https://www.csb.gov/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

An explosion at the Dixie Cold Storage Company in Shreveport, LA occurred as two firemen attempted to isolate an anhydrous ammonia leak in a cold storage warehouse. The men were badly burned when their protective clothing ignited in the ensuing fire, and one died within 36 hr. ... Several days prior to the accident, employees noted a smell of ammonia and located a leak in the refrigeration system. Steps were taken to isolate the system and repair a leaky valve at the evaporator unit. As they were working, ammonia continued to accumulate in the room. The crew tried to absorb the gas using a 50 lb cylinder of [carbon dioxide](#). This has been effective for small amounts of ammonia but was not recommended for large leaks. The [carbon dioxide](#) contacted moist room air and condensed. Ammonia also condensed, greatly reducing visibility. The room became untenable for anyone not wearing full protective equipment and workers were using only industrial type filter masks or chemical respirators. They left the room and called the fire department to borrow full protective gear. When firemen arrived, they were told that the leak had been isolated, that it had not been prolonged, and that only residual gas remained. [Water](#) was sprayed in the room to absorb the ammonia, and a fan was set up. After considering various alternatives, the firefighters decided to use an electric fork lift truck to replace the valve located 17 ft above the floor. The floor was very slippery, and the truck slid into an interior wall and the concrete curb at its base. Explosion occurred immediately. One firefighter was unable to escape or remove his burning suit. /The situation indicated that/ the warehouse workers' failure to reduce the possibility of hazardous anhydrous ammonia levels, the firefighters' lack of awareness of hazardous gas levels, and ignition of the gas are major factors in loss of life in this accident.

Klem TJ; Amer Inst Chem Eng 26: 145-49 (1986)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

13.11.4 Special Reports



NIOSH; Criteria Document: Ammonia (1974) DHEW Pub. NIOSH 74-136.

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

DHHS/ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (September 2004)[Available from, as of May 24, 2016: <http://www.atsdr.cdc.gov/toxprofiles/index.asp>]

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

European Commission, ESIS; IUCLID Dataset, Ammonia, anhydrous (CAS #7664-41-7) (2000 CD-ROM edition).[Available from, as of May 7, 2010: <http://esis.jrc.ec.europa.eu/>]

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14 Toxicity



14.1 Toxicological Information



CDC-ATSDR [Toxicological Profile](#)

▶ [CDC-ATSDR Toxic Substances Portal](#)

14.1.1 Toxicity Summary



IDENTIFICATION AND USE: Ammonia is a colorless gas or liquid. Ammonia is used in the production of [ammonium sulfate](#) and [ammonium nitrate](#) for fertilizers; and in the manufacture of [nitric acid](#), soda, synthetic [urea](#), synthetic fibers, dyes, and plastics. Ammonia, or dissociated ammonia, is used in such metal treating operations as nitriding, carbo-nitriding, bright annealing, furnace brazing, sintering, [sodium hydride](#) descaling, atomic [hydrogen](#) welding, and other applications where protective atmospheres are required. The petroleum industry utilizes anhydrous ammonia in neutralizing the acid constituents of crude oil and in protecting equipment such as bubble plate towers, heat exchangers, condensers, and storage tanks from corrosion. It is also used as medication. Ammonia in an aqueous environment exists in equilibrium between ionized [ammonium cation](#) and the non-ionized ammonia. This equilibrium can be affected by buffers, pH, temperature, and salinity. Thus, in many cases it is not possible to assign the associated toxicity to the ionized or non-ionized form of the ammonia-nitrogen. HUMAN EXPOSURE AND TOXICITY: Studies using low levels of ammonia show that inhaled ammonia is temporarily dissolved in the mucus of the upper respiratory tract, and then a high percentage of it is released back into the expired air. Following exposure to 500 ppm ammonia for 10-27 min, healthy male subjects eliminated 70-80% of the inspired ammonia by this route. Short term exposure: eye or skin contact with ammonia can cause irritation, burns, frostbite (anhydrous), and permanent damage. Irritates the respiratory tract causing coughing, wheezing, and shortness of breath. Higher exposure can cause pulmonary edema, a medical emergency, that can be delayed for several hours and is life-threatening. Exposure can cause headache, loss of sense of smell, nausea, and vomiting. Inhalation: nose and throat irritation have been reported at 72 ppm after 5 min exposure. Exposures of 500 ppm for 30 min have caused upper respiratory irritation, tearing, increased pulse rate, and blood pressure. Death has been reported after an exposure to 10,000 ppm for an unknown duration. Skin: Solutions of 2% ammonia can cause burns and blisters after 15 min of exposure. These burns may be slow to heal. Anhydrous ammonia may cause skin to freeze. Eyes: Levels of 70 ppm (gas) have caused eye irritation. If not flushed with [water](#) immediately, contact with eye may cause partial or complete blindness. Ingestion: ammonia will cause pain if swallowed and burning of the throat and stomach. May cause vomiting. One teaspoon of 28% aqua ammonia may cause death. Long term exposure: repeated exposure can cause chronic eye, nose, and throat irritation. Repeated lung irritation can result in bronchitis with coughing, shortness of breath, and phlegm. Analysis of blood samples from 22 workers exposed to ammonia in a fertilizer factory and 42 control workers not exposed to ammonia showed increased frequency of chromosomal aberrations (CAs) and sister chromatid exchanges (SCEs), increased mitotic index (MI), and increased frequency of CAs and SCEs with increasing length of exposure. ANIMAL STUDIES: Analysis of endogenous ammonia levels in the expired air of rats showed concentrations ranging from 10-353 ppb (mean = 78 ppb) in nose-breathing animals. The quantitative difference between inspired and expired ammonia suggests that small amounts are absorbed across the nasopharyngeal membranes into the systemic circulation. Absorbed ammonia is excreted by the kidneys as [urea](#) and urinary [ammonium](#) compounds, as [urea](#) in feces, and as components of sweat. Toxic levels do not develop as a result of chronic inhalation exposure because the body has multiple effective mechanisms for detoxifying and excreting it. Cardiovascular changes that may be analogous to those observed in humans have been observed in rabbits exposed to high concentrations of ammonia. Bradycardia was seen at 2,500 ppm, and hypertension and cardiac arrhythmias leading to cardiovascular collapse followed acute exposures to concentrations exceeding 5,000 ppm. Pathological correlates for these effects have not been demonstrated. Atrophy of pericardial fat has been observed in mice exposed to 4,000 ppm ammonia. Hepatic effects are usually not seen in animals exposed to ammonia gas. Liver necrosis has been observed following acute lethal exposure of mice to 3,440 ppm ammonia for 1 hour. Levels of 170 ppm of ammonia vapor caused mild changes in the spleens, kidneys, and livers of guinea pigs. Static exposures of cats and rabbits for 1 hr at 7000 mg/cu m resulted in the death of approx 50%. Postmortem exam showed severe effects on the upper respiratory tract. Less severe effects in the lower respiratory tract included damage to bronchioles and alveolar congestion, edema, atelectasis, hemorrhage, emphysema, and fluid. The search for the peripheral toxins responsible for the CNS impairment present in hepatic encephalopathy has shown that the administration of ammonia in normal rats reproduced behavioral and electrophysiological changes similar to those seen in [galactosamine](#) induced encephalopathy. No statistically significant differences were noted in ovarian or uterine weights of pigs exposed to about 7 or 35 ppm ammonia for 6 weeks. Female pigs that were continuously exposed to about 35 ppm ammonia from 6 weeks before breeding until day 30 of gestation had no statistically significant differences in age at puberty, number of live fetuses, or fetus-to-corpus luteum ratio compared to pigs exposed to only about 7 ppm. No unexposed controls were included in that study. No statistically significant difference in fetal length was evident at 30 days of gestation in offspring of pig dams that were continuously exposed to about 7 or 35 ppm ammonia from 6 weeks before breeding until day 30 of gestation. The mutagenicity of anhydrous ammonia was investigated in a Ames test in *S. typhimurium* TA98, TA100, TA1535, TA1537 and TA1538, and in *E. coli* WP2uvrA. The test method was modified appropriately to investigate a volatile test substance. Studies were performed in duplicate in the presence and absence of an exogenous metabolic activation system. No evidence of mutagenicity was seen under the conditions of this assay. ECOTOXICITY STUDIES: Ammonia is an environmental pollutant that is toxic to all aquatic animals. The major sources for atmospheric NH₃ are agricultural activities and animal feedlot operations, followed by biomass burning (including forest fires) and to a lesser extent fossil fuel combustion. Close to its sources, acute exposures to NH₃ can result in visible foliar injury on vegetation.

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.1.2 NIOSH Toxicity Data



▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

14.1.3 Evidence for Carcinogenicity



Not listed

▶ [Occupational Safety and Health Administration \(OSHA\)](#)

14.1.4 Health Effects



Health Effect Code(s)

HE4 - Acute Toxicity---Short-term high risk effects

HE11 - Respiratory Effects---Acute lung damage/edema or other

HE14 - Irritation--Eyes, Nose, Throat, Skin---Marked

- ▶ Occupational Safety and Health Administration (OSHA)

14.1.5 Exposure Routes



The substance can be absorbed into the body by inhalation.

- ▶ ILO International Chemical Safety Cards (ICSC)

inhalation, ingestion (solution), skin and/or eye contact (solution/liquid)

- ▶ The National Institute for Occupational Safety and Health (NIOSH)

Ammonia can be absorbed into the body by inhalation, ingestion, eye contact, and skin contact. Ingestion is an uncommon route of exposure. Absorption by eye contact may be limited by severe corrosive injury and/or by significant spasmodic blinking (blepharospasm), even with mild exposures.

- ▶ The National Institute for Occupational Safety and Health (NIOSH)

14.1.6 Symptoms



irritation eyes, nose, throat; dyspnea (breathing difficulty), wheezing, chest pain; pulmonary edema; pink frothy sputum; skin burns, vesiculation; liquid: frostbite

- ▶ The National Institute for Occupational Safety and Health (NIOSH)

14.1.7 Inhalation Symptoms



Burning sensation. Cough. Laboured breathing. Shortness of breath. Sore throat.

- ▶ ILO International Chemical Safety Cards (ICSC)

Mild to moderate: Nausea, vomiting (emesis), abdominal pain, and burns of the mouth, throat, esophagus, and stomach.

Severe: Swelling of the lips, mouth, and voice box (larynx) and severe corrosive damage or burns to the mouth, throat, and stomach.

Ingestion does not normally result in whole-body (systemic) toxicity.

- ▶ The National Institute for Occupational Safety and Health (NIOSH)

14.1.8 Skin Symptoms



Redness. Pain. Blisters. Skin burns. ON CONTACT WITH LIQUID: FROSTBITE.

- ▶ ILO International Chemical Safety Cards (ICSC)

Mild to moderate: Irritation, swelling, and mild or stinging pain.

Severe: Pain, inflammation, blistering (vesication), tissue death (necrosis), and deep penetrating burns, especially on moist skin areas.

Exposure to liquefied ammonia gas may cause frostbite injury and possibly severe burns with more localized deep tissue damage (ulcerations).

Decontamination

- ▶ The National Institute for Occupational Safety and Health (NIOSH)

14.1.9 Eye Symptoms



Redness. Pain. Severe burns. ON CONTACT WITH LIQUID: FROSTBITE.

- ▶ ILO International Chemical Safety Cards (ICSC)

Mild to moderate: Rapid eye irritation and burning sensation.

Severe: Severe corrosive eye injury, inflammation of the membranes of the eye (conjunctivitis), tear production (lacrimation), swelling and sloughing of the surface cells of the eye, and temporary or permanent blindness.

- ▶ The National Institute for Occupational Safety and Health (NIOSH)

14.1.10 Ingestion Symptoms



Mild to moderate: Nausea, vomiting (emesis), abdominal pain, burns of mouth, throat, esophagus, and stomach.

Severe: Swelling of lips, mouth, and voice box (larynx), severe corrosive damage or burns of mouth, throat and stomach.

Ingestion does not normally result in whole-body (systemic) toxicity.

- ▶ The National Institute for Occupational Safety and Health (NIOSH)

Respiratory (From the Nose to the Lungs)

- ▶ [CDC-ATSDR Toxic Substances Portal](#)

Eyes, skin, respiratory system

- ▶ [The National Institute for Occupational Safety and Health \(NIOSH\)](#)

- ▶ [ChemIDplus](#)

The present study investigated the simultaneous influence of particulate matter (PM10) and ammonia (NH3) on performance, lung lesions and the presence of Mycoplasma hyopneumoniae (M. hyopneumoniae) in finishing pigs. A pig herd experiencing clinical problems of M. hyopneumoniae infections was selected. In total, 1095 finishing pigs of two replicates in eight compartments each were investigated during the entire finishing period (FP). Indoor PM10 and NH3 were measured at regular intervals during the FP with two Grimm spectrometers and two Graywolf Particle Counters (PM10) and an [Innova](#) photoacoustic gas monitor (NH3). Average daily weight gain (ADG) and mortality were calculated and associated with PM10 and NH3 during the FP. Nasal swabs (10 pigs/compartment) were collected one week prior to slaughter to detect DNA of M. hyopneumoniae with nested PCR (nPCR). The prevalence and extent of pneumonia lesions, and prevalence of fissures and pleurisy were examined at slaughter (29 weeks). The results from the nasal swabs and lung lesions were associated with PM10 and NH3 during the FP and the second half of the FP. In the univariable model, increasing PM10 concentrations resulted in a higher odds of pneumonia lesions (second half of the FP: OR=8.72; P=0.015), more severe pneumonia lesions (FP: P=0.04, second half of the FP: P=0.009), a higher odds of pleurisy lesions (FP: OR=20.91; P<0.001 and second half of the FP: OR=40.85; P<0.001) and a higher number of nPCR positive nasal samples (FP: OR=328.00; P=0.01 and second half of the FP: OR=185.49; P=0.02). Increasing NH3 concentrations in the univariable model resulted in a higher odds of pleurisy lesions (FP: OR=21.54; P=0.003) and a higher number of nPCR positive nasal samples (FP: OR=70.39; P=0.049; second half of the FP: OR=8275.05; P=0.01). In the multivariable model, an increasing PM10 concentration resulted in a higher odds of pleurisy lesions (FP: OR=8.85; P=0.049). These findings indicate that the respiratory health of finishing pigs was significantly affected by PM10.

[PMID:26148844](#)

Michiels A et al; Prev Vet Med 121 (1-2): 99-107 (2015)

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Ammonia is metabolized by the liver and has established neurological effects. The current study examined the possibility that ammonia contributes to the neurotoxic effects of [methamphetamine](#) (METH). The results show that a binge dosing regimen of METH to the rat increased plasma and brain ammonia concentrations that were paralleled by evidence of hepatotoxicity. The role of peripheral ammonia in the neurotoxic effects of METH was further substantiated by the demonstration that the enhancement of peripheral ammonia excretion blocked the increases in brain and plasma ammonia and attenuated the long-term depletions of [dopamine](#) and [serotonin](#) typically produced by METH. Conversely, the localized perfusion of ammonia in combination with METH, but not [METH alone](#) or ammonia alone, into the striatum recapitulated the neuronal damage produced by the systemic administration of METH. Furthermore, this damage produced by the local administration of ammonia and METH was blocked by the [GYKI 52466](#) [4-(8-methyl-9H-1,3-dioxolo[4,5-h][2,3]benzodiazepin-5-yl)-benzamine hydrochloride], an [AMPA](#) receptor antagonist. These findings highlight the importance of ammonia derived from the periphery as a small-molecule mediator of METH neurotoxicity and more broadly emphasize the importance of peripheral organ damage as a possible mechanism that mediates the neuropathology produced by drugs of abuse and other neuroactive molecules.

[PMID:22993432](#)

Full text: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3464918>
Halpin LE, Yamamoto BK; J Neurosci 32 (38): 13155-63 (2012)

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Ammonia is a bi-product of protein metabolism in the body. It is able to cross the blood-brain barrier and elevated ammonia levels are toxic to the brain. Rats with hyperammonemia showed impaired learning ability and impaired function of the [glutamate-nitric oxide](#)-cyclic guanosine monophosphate ([glutamate-NO-cGMP](#)) pathway in the brain. Chronic treatment with [sildenafil](#) restored learning ability. We therefore tested the hypothesis that [sildenafil](#) has a protective effect on the brains of hyperammonemic rats. Hyperammonemia was induced in male rats by daily intraperitoneal (i.p.) injection of [ammonium chloride](#) (100 mg/kg body weight) for 8 weeks. [Sildenafil citrate](#) was administered intraperitoneally (10 mg/kg body weight/3 days) for 8 weeks. Treatment with [sildenafil](#) resulted in a significant reduction in plasma liver enzymes, lipid profile as well as brain lipid peroxidation and caspase-3 mRNA. Meanwhile, plasma NO as well as [cGMP](#), antioxidants and endothelial [nitric oxide](#) synthase (eNOS) gene expression were significantly elevated in the brains of hyperammonemic rats. Our results showed that [sildenafil](#) exerts a protective effect on the brain by reversing oxidative stress during hyperammonemia and this could be due to (i) cytoprotective, antioxidant and anti-apoptotic effects (ii) increasing [cGMP](#) and enhancing the proper metabolism of fats which could suppress [oxygen](#) radical generation and thus preventing oxidative damage in the brain. The exact protective mechanism of [sildenafil](#) has to be still investigated ... Consequently, therapeutic modulation of the NO/cGMP pathway might have important clinical applications to improve brain functions in patients with hyperammonemia or clinical hepatic encephalopathy. /Hyperammonemia/

[PMID:23343352](#)

Arafa MH, Atteia HH; Toxicol Mech Methods 23 (6): 402-11 (2013)

- ▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Ammonia is a key toxin in the precipitation of hepatic encephalopathy (HE), a neuropsychiatric disorder associated with liver failure. In response to ammonia, various toxic events are triggered in astroglial cells, and alterations in brain **glutamate** communication are common. **Resveratrol** is a polyphenolic compound that has been extensively studied in pathological events because it presents several beneficial effects, including some in the central nervous system (CNS). We previously described that **resveratrol** is able to significantly modulate glial functioning and has a protective effect during ammonia challenge in vitro. In this study, we addressed the mechanisms by which **resveratrol** can protect C6 astroglial cells from glutamatergic alterations induced by ammonia. **Resveratrol** was able to prevent all the effects triggered by ammonia: (i) decrease in **glutamate** uptake activity and expression of the EAAC1 **glutamate** transporter, the main **glutamate** transporter present in C6 cells; (ii) increase of **glutamate** release, which was also dependent on the activation of the Na(+)-K(+)-Cl(-) co-transporter NKCC1; (iii) reduction in GS activity and intracellular **GSH** content; and (iv) impairment of Na(+)-K(+)-ATPase activity. Interestingly, **resveratrol**, per se, also positively modulated the astroglial functions evaluated. Moreover, we demonstrated that heme oxygenase 1 (HO1), an enzyme that is part of the cellular defense system, mediated some of the effects of **resveratrol**. In conclusion, the mechanisms of the putative protective role of **resveratrol** against ammonia toxicity involve the modulation of pathways and molecules related to **glutamate** communication in astroglial cells.

PMID:26318273

Bobermin LD et al; *Toxicol In Vitro* 29 (8): 2022-9 (2015)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Interactions (Complete) data for Ammonia (13 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.1.14 Antidote and Emergency Treatment



Inhalation of ammonia gas: Observe carefully for signs of progressive upper airway obstruction, and intubate early if necessary. Administer humidified supplemental **oxygen** and bronchodilators for wheezing. Treat noncardiogenic pulmonary edema if it occurs. Asymptomatic or mildly symptomatic patients may be discharged after a brief observation period. Ingestion of aqueous solution: If a solution of 10% or greater has been ingested or if there are any symptoms of corrosive injury (dysphagia, drooling, or pain), perform flexible endoscopy to evaluate for serious esophageal or gastric injury. Obtain chest and abdominal radiograph to look for mediastinal or abdominal free air, which suggests esophageal or gastrointestinal perforation. Eye exposure: After eye irrigation, perform **fluorescein** examination and refer the patient to an ophthalmologist if there is evidence of corneal injury.

OLSON, K.R. (Ed). *Poisoning and Drug Overdose, Sixth Edition*. McGraw-Hill, New York, NY 2012, p. 76

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Decontamination. Inhalation: Remove immediately from exposure, and give supplemental **oxygen** if available. Ingestion: Immediately give **water** by mouth to dilute the ammonia. Do NOT induce vomiting because this may aggravate corrosive effects. Do NOT attempt to neutralize the ammonia (eg, with an acidic solution). Gastric lavage may be useful to remove liquid caustic in the stomach (in cases of deliberate ingestion of large quantities) and to prepare for endoscopy; use a small, flexible tube and pass it gently to avoid injury to damaged mucosa. Do NOT use activated **charcoal**; it does not absorb ammonia, and it may obscure the endoscopist's view. Skin and eyes: Remove contaminated clothing and wash exposed skin with **water**. Irrigate exposed eyes with copious amounts of tepid **water** or saline.

OLSON, K.R. (Ed). *Poisoning and Drug Overdose, Sixth Edition*. McGraw-Hill, New York, NY 2012, p. 76

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Enhanced elimination: There is no role for dialysis or other enhanced elimination procedures.

OLSON, K.R. (Ed). *Poisoning and Drug Overdose, Sixth Edition*. McGraw-Hill, New York, NY 2012, p. 77

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Immediate first aid: Ensure that adequate decontamination has been carried out. If patient is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask, as trained. Perform CPR as necessary. Immediately flush contaminated eyes with gently flowing **water**. Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration. Keep patient quiet and maintain normal body temperature. Obtain medical attention. /Choking Agents (Pulmonary/Lung-Damaging Agents)/

Currance, P.L., Clements, B., Bronstein, A.C. (Eds.); *Emergency Care For Hazardous Materials Exposure, 3rd revised edition, Elsevier Mosby, St. Louis, MO 2007, p. 590*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Antidote and Emergency Treatment (Complete) data for Ammonia (9 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.1.15 Medical Surveillance



The following medical procedures should be made available to each employee who is exposed to ammonia at potentially hazardous levels: (1) A complete medical history and physical examination: the purpose is to detect existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the eyes and respiratory tract should be stressed. The skin should be examined for evidence of chronic disorders; (2) 14" x 17" chest roentgenogram: Ammonia causes human lung damage. Surveillance of the lungs is indicated; (3) FVC and FEV (1 sec): Ammonia is a respiratory irritant. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated. Medical examinations should be repeated on an annual basis, except that an X-ray is necessary only when indicated by the results of pulmonary function testing, or by signs and symptoms of respiratory disease.

Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). *NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS)*. Washington, DC: U.S. Government Printing Office, Jan. 1981, p. 1

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.1.16 Human Toxicity Excerpts



/HUMAN EXPOSURE STUDIES/ A group of 6 healthy volunteers, not previously accustomed to working in an ammonia environment, were exposed 5 days/week to 25 ppm (2 hr/day), 50 ppm (4 hr/day), or 100 ppm (6 hr/day) of ammonia, or to 50 ppm of ammonia 6 hr/day for 6 weeks. End points monitored included subjective and objective measures of eye and throat irritation as well as pulse rate, respiration rate, pulmonary function (FVC, FEV), assessment of neurological function (reflex, balance, and coordination), and body weight. The exposure protocol consisted of a pre-exposure evaluation by a physician, 3 hr of exposure (this conflicts with exposure data on table 2 of the study and mentioned above), a mid-point physician's observation, lunch break, 3 additional hr of exposure, and a third physician's observation 30 min after exposure ceased. The conjunctiva and mucosa of the nose and throat were examined by a physician before and after each daily exposure and the degree of irritation noted was described as mild, moderate, or marked. Exposure to ammonia had no significant effect on the measures of respiratory function or in the neurological tests conducted. The results of the evaluations of irritation conducted by the physician showed no significant differences between the exposure groups, including the 0 ppm exposure group (preexposure). All subjects experienced some watering of the eyes and a sensation of dryness in the nose and throat, and there was one observation of definite redness in the mucosa of the nose after a 6-hour exposure to 100 ppm during which time, there was an excursion to 200 ppm ammonia. No redness was observed in this subject the following morning. Throughout the study, the physician observed 6 cases of eye irritation, 20 of nose irritation, and 9 of throat

irritation, and most cases appeared to have occurred the first week of the study during exposure to 50 ppm. It is difficult to determine in this study a no-observed adverse- effect level (NOAEL) or LOAEL for irritation due to the different exposure durations experienced by the subjects.

HHS/ATSDR; *Toxicological Profile for Ammonia pp.18-19 (September 2004) TP126*. Available from, as of May 24, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/HUMAN EXPOSURE STUDIES/ Groups of four healthy human volunteers were exposed weekly (5 days/week) to 25 (2 hr/day), 50 (4 hr/day) or 100 (6 hr/day) ppm ammonia (1.0, 4.1, or 12.1 mg/cu m) for 6 weeks; or to 50 ppm (6.2 mg/cu m) 6 hr/day for 6 weeks. Subjective and objective indications of eye and respiratory tract irritation, pulse rate, respiration rate, FVC [Forced Expiratory Vital Capacity], FEV [Forced Expiratory] and difficulty in performing simple cognitive tasks were used to assess toxicity. No abnormalities of the chest, heart, vital organs, neurological response, apparent motor function, or significant weight changes were observed during weekly medical examinations. Transient irritation of the nose and throat was observed at 50 ppm (duration-adjusted to 4.1 mg/cu m) or greater

U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Ammonia (CAS #7664-41-7). Available from, as of May 11, 2010: <https://www.epa.gov/iris/subst/index.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/HUMAN EXPOSURE STUDIES/ Eight human volunteers were exposed to 50, 80, 110, and 140 ppm ammonia (35, 56, 76, and 97 mg/cu m, respectively) for 2 hr, with a 1 week interval between exposures. The subjects tolerated a concentration of 76 mg/cu m, although they rated the throat irritation as a nuisance. An ammonia concentration of 97 mg/cu m was intolerable, and all of the subjects left the exposure chamber prematurely.

U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Ammonia (CAS #7664-41-7). Available from, as of May 11, 2010: <https://www.epa.gov/iris/subst/index.html>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/HUMAN EXPOSURE STUDIES/ ... Forty-three healthy male volunteers were exposed to ammonia vapors in concentrations of 0, 10, 20, 20/40, and 50 ppm on five consecutive days. To explore a possible influence of habituation on the perception of symptoms, the study group was divided into 30 men who were not familiar with the smell of ammonia, and ten participants regularly exposed to ammonia at the workplace. The perceived acute health symptoms and self-reported changes of well-being were assessed by the German version of a questionnaire of the Swedish Performance Evaluation System (SPES). Personal traits were ascertained with the positive and negative affectivity schedule (PANAS) and the Freiburger Persönlichkeits Inventar (FPI). There are significant associations between personal traits and the amount of complaints. Subjects with high positive affectivity report less respiratory and irritative complaints, whereas persons with negative affectivity report significantly more olfactory and respiratory symptoms. In general, the strength of these correlations decreases with higher exposure levels. At ammonia concentration above 20 ppm, these associations were no more statistically significant. During the daily exposures, the score of symptoms did not vary significantly. The perceived intensity of health symptoms and annoyance increased with the concentration of ammonia, while the self-reported dimensions of well-being decreased. Workers familiar with the smell of ammonia vapors reported less symptoms compared to naive subjects ...

PMID:16365751

Ihrig A et al; *Int Arch Occup Environ Health* 79 (4): 332-8 (2006)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Human Toxicity Excerpts (Complete) data for Ammonia (78 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.1.17 Non-Human Toxicity Excerpts



/LABORATORY ANIMALS: Acute Exposure/ This study examined the acute median lethal concentration (LC50) and the non-lethal threshold concentration (LC01) of ammonia in male and female Wistar rats nose-only exposed at exposure durations of either 1 or 4 hr. Additional attributes characterizing the acute toxicity of inhaled ammonia were determined during a post-exposure period of 2 weeks. The objective of this study is to further refine the methodology applied to derive Emergency Response Planning Guideline (ERPG) values on potent sensory irritants in a controlled rat bioassay. In the more susceptible male rats the 1- and 4-hr LC50 (LC01) were 12,303 (10,067) and 4923 (4028) mg/cu m, respectively. At sublethal exposure levels the ventilation of rats was about one third of normal breathing. This change in ventilation and inhalation dosimetry was adjusted for Cxt-dependent lethal endpoints whereas sensory irritation-related phenomena were C-dependently adjusted. In summary, the outcome of this study shows that C- and C x t-dependent causes of toxicity need to be appreciated when extrapolating across species with species-specific inhalation dosimetry. It also appears to be indispensable that each exposure metric must be disentangled when translating C x t-dependent lethality and reflexively-induced, sensation-based C-dependent point of departures. For one hour exposure periods, these PODs were derived to be 1500 and 500 ppm, respectively.

PMID:23707397

Pauluhn J; *Regul Toxicol Pharmacol* 66 (3): 315-25 (213)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/LABORATORY ANIMALS: Acute Exposure/ This study examined acute toxicity and lung injury following inhalation exposure to ammonia. Male Sprague-Dawley rats (300-350 g) were exposed to 9000, 20,000, 23,000, 26,000, 30,000 or 35,000 ppm of ammonia for 20 min in a custom head-out exposure system. The exposure atmosphere, which attained steady state within 3 min for all ammonia concentrations, was monitored and verified using a Fourier transform infrared spectroscopy (FTIR) gas analyzer. Animals exposed to ammonia resulted in dose-dependent increases in observed signs of intoxication, including increased chewing and licking, ocular irritation, salivation, lacrimation, oronasal secretion and labored breathing. The LCt50 of ammonia within this head-out inhalation exposure model was determined by probit analysis to be 23,672 ppm (16,489 mg/cu m) for the 20 min exposure in male rats. Exposure to 20,000 or 23,000 ppm of ammonia resulted in significant body weight loss 24-hr post-exposure. Lung edema increased in all ammonia-exposed animal groups and was significant following exposure to 9000 ppm. Bronchoalveolar fluid (BALF) protein concentrations significantly increased following exposure to 20,000 or 23,000 ppm of ammonia in comparison to controls. BAL cell (BALC) death and total cell counts increased in animals exposed to 20,000 or 23,000 ppm of ammonia in comparison to controls. Differential cell counts of white blood cells, neutrophils and platelets from blood and BALF were significantly increased following exposure to 23,000 ppm of ammonia ...

PMID:26821737

Perkins MW et al; *Inhal Toxicol* 28 (2): 71-9 (2016)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/LABORATORY ANIMALS: Acute Exposure/ Anesthetized, mechanically ventilated rabbits exposed to high levels of nebulized ammonia (2 mL of 23-27% ammonia solution; estimated by the study authors as peak ammonia concentrations of 35,000-39,000 ppm) for 4 min had a decrease in blood oxygen saturation and an increase in airway pressure (a measure of changes in airway resistance). Arterial oxygen tension decreased from 23.3 (+/- 3.6) to 11.0 (+/- 3.6) kPa and peak airway pressure increased from 13 (+/- 2) to 17 (+/- 2) cm H2O. At baseline and 5 and 15 min after ammonia administration, measurements were taken via a catheter in the left auricular artery, which monitored pressure and sampled for arterial blood gases, and via transducers in the ventilator. Thirty and 150 min after ammonia exposure, rabbits received inhalation therapy of either 0.5 mg budesonide (a steroid) or a placebo, and airway pressure, hemodynamics, and gas exchange were measured every 30 min for 6 hr. Slight, gradual improvement of blood gas parameters was noted over the 6 hr observation period in all rabbits, with or without steroid treatment; however, no parameters approached normal during that time period.

HHS/ATSDR; *Toxicological Profile for Ammonia pp.49-50 (September 2004) TP126*. Available from, as of May 24, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/LABORATORY ANIMALS: Acute Exposure/ Cardiovascular changes that may be analogous to those observed in humans have been observed in rabbits exposed to high concentrations of ammonia. Bradycardia was seen at 2,500 ppm, and hypertension and cardiac arrhythmias leading to cardiovascular collapse followed acute exposures to concentrations exceeding 5,000

ppm. Pathological correlates for these effects have not been demonstrated. Atrophy of pericardial fat has been observed in mice exposed to 4,000 ppm ammonia.

HHS/ATSDR; *Toxicological Profile for Ammonia* p.52 (September 2004) TP126. Available from, as of May 24, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Non-Human Toxicity Excerpts (Complete) data for Ammonia (72 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.1.18 Non-Human Toxicity Values



LC50 Rabbit inhalation 7,050 mg/cu m/1 hr

Environment Canada; Tech Info for Problem Spills: Ammonia (Draft) p.101 (1981)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

LC50 Cat inhalation 746 mg/cu m (1064 ppm)/1 hr (Dynamic air flow)

Environment Canada; Tech Info for Problem Spills: Ammonia (Draft) p.102 (1981)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

LC50 Cat inhalation 7,050 mg/cu m (10,070 ppm)/1 hr (Static conditions)

Environment Canada; Tech Info for Problem Spills: Ammonia (Draft) p.102 (1981)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

LC50 Rat inhalation 112 mg/L (16,000 ppm) for 15 min

HHS/ATSDR; *Toxicological Profile for Ammonia* p.71 (September 2004) TP126. Available from, as of May 24, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Non-Human Toxicity Values (Complete) data for Ammonia (13 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.1.19 Ecotoxicity Values



LC50; Species: *Campostoma anomalum* (stoneroller); Concentration: 1.72 mg/L for 96 hr /Conditions of bioassay not specified/

European Commission, ESIS; IUCLID Dataset, Ammonia, anhydrous (CAS #7664-41-7) p.53 (2000 CD-ROM edition).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

LC50; Species: *Carassius auratus* (goldfish); Concentration: 2-2.5 mg/L for 24-96 hr /Conditions of bioassay not specified/

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996., p. 186

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

LC50; Species: *Carassius auratus* (goldfish); Concentration: 7.2 mg/L for 24 hr /Conditions of bioassay not specified/

European Commission, ESIS; IUCLID Dataset, Ammonia, anhydrous (CAS #7664-41-7) p.40 (2000 CD-ROM edition).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

LC50; Species: *Catostomus commersoni* (White sucker); Concentration: 0.79 mg/L for 96 hr /Conditions of bioassay not specified/

European Commission, ESIS; IUCLID Dataset, Ammonia, anhydrous (CAS #7664-41-7) p.41 (2000 CD-ROM edition).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Ecotoxicity Values (Complete) data for Ammonia (126 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.1.20 Ecotoxicity Excerpts



/AQUATIC SPECIES/ Nitric oxide (NO) is a highly versatile and unique ubiquitous signaling molecule, and is known to play diverse physiological functions in mammals including those of adaptation to various stresses. The present study reports on the influence of exposure to high external ammonia (HEA) on the production of nitric oxide (NO) and the expression of inducible nitric oxide synthase (iNOS), that produces NO from L-arginine in the freshwater air-breathing catfish (*Heteropneustes fossilis*), which is reported to tolerate a very HEA. Some levels of NO were found to be present in all the tissues and also in plasma of control fish, which further enhanced significantly in fishes treated with high concentrations of environmental ammonia (25 and 50 mM ammonium chloride) for 7 days, accompanied by more efflux of NO from the perfused liver. This was accomplished by the induction of iNOS activity in different tissues of fish exposed to HEA, which otherwise was not detectable in control fish. Exposure to 25 mM ammonium chloride also led to a significant expression of iNOS protein in different tissues, followed by further increase at 50 mM ammonium chloride. Further, there was an increase in the expression of iNOS mRNA in ammonia-treated fish, thus suggesting that the expression of iNOS gene under hyper-ammonia stress was probably regulated at the transcriptional level. Immunocytochemical analysis indicated that the expression of iNOS in different tissues was zonal specific and not expressed uniformly throughout the organ. Hyper-ammonia stress also led to activation and nuclear translocation of nuclear factor kappaB (NFkB) in hepatic cells. These results suggest that the activation of iNOS gene under hyper-ammonia stress was probably mediated through the activation of one of the major transcription factors, the NFkB ... /Ammonium chloride/

PMID:22466354

Choudhury MG, Saha N; *Aquat Toxicol* 116-117: 43-53 (2012)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/AQUATIC SPECIES/ The objective of this study was to determine the underlying physiological and molecular responses to long-term sublethal ammonia exposure in Atlantic salmon (*Salmo salar*) parr. Previous studies have predominately focused on mechanisms during acute, short-term exposure. For that purpose Atlantic salmon parr were exposed to four ammonia concentrations between 4 and 1800 umol/L total ammonia nitrogen (TAN), and subjected to two feeding regimes for 15 weeks. Elevated environmental ammonia and full feeding strength

caused an initial increase in plasma ammonia levels ([T(amm)]) after 22 days of exposure, which thereafter declined and remained similar to the control animals towards the end of the study ... In conclusion, Atlantic salmon parr adapts to the long-term sublethal ammonia concentrations with increased branchial transcription levels of ammonia and urea transporting proteins and ammonia detoxification in the brain.

PMID:22898234

Kolarevic J et al; *Aquat Toxicol* 124-125: 48-57 (2012)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/AQUATIC SPECIES/ Ammonia and nitrite are the most common toxic nitrogenous compounds in aquaculture ponds. ...The effects of a combined treatment with these two compounds on the hemolymph acid-base balance, electrolytes and oxyhemocyanin content in kuruma shrimp, (*Marsupenaeus japonicus*) /was evaluated/. The shrimp (6.37 +/- 1.29 g) were individually exposed to 9 different ammonia and nitrite regimes (ammonia at 0 (control), 0.39, and 1.49 mM combined with nitrite at 0 (control), 0.38, and 1.49 mM) in a 30 ppt saline solution at 22 °C. Hemolymph oxyhemocyanin (OxyHc), protein content, acid-base balance, osmolality, and electrolyte levels were measured in treated shrimp after 48 hr of treatment. Hemolymph OxyHc, protein content, the OxyHc/protein ratio, pH, pCO₂, HCO₃⁻, TCO₂, OH⁻/H⁺, osmolality, and Cl⁻, Na⁺, K⁺, Ca²⁺, and Mg²⁺ levels were inversely related to the dose of ammonia and nitrite. However, hemolymph pO₂ levels directly increased with the ammonia and nitrite concentrations. Following exposure to 1.49 mM ammonia +1.49 mM nitrite, the hemolymph pO₂ increased by 89.5%, whereas the hemolymph OxyHc, protein content, OxyHc/protein ratio, pH, pCO₂, HCO₃⁻, TCO₂, OH⁻/H⁺, osmolality, Cl⁻, and Na⁺ decreased by 51.2, 28.2, 34.9, 2.9, 51.1, 71.5, 70.8, 42.8, 4.9, 32.1, and 38.6%, respectively, compared with control shrimp. Combined ammonia and nitrite stress may therefore exert a synergistic effect on shrimp relative to the stress induced by ammonia or nitrite alone.

PMID:23399445

Cheng SY et al; *Aquat Toxicol* 130-131: 132-8 (2013)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

/AQUATIC SPECIES/ The degradation of cyanobacterial blooms often causes hypoxia and elevated concentrations of ammonia, which can aggravate the adverse effects of blooms on aquatic organisms. However, it is not clear how one stressor would work in the presence of other coexistent stressors. ...The toxic effects of elevated ammonia /were studied/ under hypoxia using a common yet important cladoceran species *Daphnia similis* isolated from heavily eutrophicated Lake Taihu. A 3 x 2 factorial experimental design was conducted with animals exposed to three un-ionized ammonia levels under two dissolved oxygen levels. Experiments lasted for 14 days and ...the life-history traits such as survival, molt, maturation, and fecundity /were recorded/. Results showed that hypoxia significantly decreased survival time and the number of molts of *D. similis*, whereas ammonia had no effect on them. Elevated ammonia significantly delayed development to maturity in tested animals and decreased their body sizes at maturity. Both ammonia and hypoxia were significantly detrimental to the number of broods, the number of offspring per female, and the number of total offspring per female, and significantly synergistic interactions were detected. Our data clearly demonstrate that elevated ammonia and hypoxia derived from cyanobacterial blooms synergistically affect the cladoceran *D. similis*.

PMID:23417362

Lyu K et al; *Environ Sci Pollut Res Int* 20 (8): 5379-87 (2013)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

For more Ecotoxicity Excerpts (Complete) data for Ammonia (74 total), please visit the [HSDB record page](#).

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.1.21 Populations at Special Risk



Since ammonia is a respiratory tract irritant, persons who are hyperreactive to other respiratory irritants, or who are asthmatic, would be expected to be more susceptible to ammonia inhalation effects. The results of an epidemiological study of a group of workers chronically exposed to airborne ammonia indicate that ammonia inhalation can exacerbate existing symptoms including cough, wheeze, nasal complaints, eye irritation, throat discomfort, and skin irritation.

HHS/ATSDR; *Toxicological Profile for Ammonia* p.99 (September 2004) TP126. Available from, as of May 24, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Persons with corneal disease, and glaucoma, or chronic respiratory diseases may suffer increased risk /from ammonia exposure/.

Sittig, M. *Handbook of Toxic and Hazardous Chemicals and Carcinogens*, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985., p. 46

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2 Ecological Information



14.2.1 EPA Ecotoxicity



Pesticide Ecotoxicity Data from EPA

▶ [EPA Pesticide Ecotoxicity Database](#)

14.2.2 US EPA Regional Screening Levels for Chemical Contaminants



Resident Air (ug/m3)	5.20e+01
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Industrial Air (ug/m3)	2.20e+02
Chronic Inhalation Reference Concentration (mg/m3)	5.00e-01
Volatile	Volatile
Fraction of Contaminant Absorbed in Gastrointestinal Tract	1

▶ [EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites](#)

14.2.3 US EPA Regional Removal Management Levels for Chemical Contaminants



Resident Air (ug/m3)	1.60e+03
Industrial Air (ug/m3)	6.60e+03
Chronic Inhalation Reference Concentration (mg/m3)	5.00e-01
Volatile	Volatile
Fraction of Contaminant Absorbed in Gastrointestinal Tract	1

▶ [EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites](#)

14.2.4 ICSC Environmental Data



The substance is very toxic to aquatic organisms. It is strongly advised not to let the chemical enter into the environment.

▶ [ILO International Chemical Safety Cards \(ICSC\)](#)

14.2.5 Environmental Fate/Exposure Summary



Ammonia's production and use in fertilizers, as a component of household **cleaners**, as a refrigerant, in the manufacture of a various compounds and as a microbiocide for controlling algal, bacterial and fungal deposits in influent **water** systems may result in its release to the environment through various waste streams. The application of fertilizer to soil, as ammonia, **ammonium** compounds, or ammonia precursors (such as **urea**), is a major source of ammonia release to the atmosphere. Ammonia is released in exhaust emissions from automobiles and in tobacco smoke. Large amounts of ammonia are released to the atmosphere worldwide by domesticated farm animals. Natural sources of ammonia emissions to the atmosphere are volcanic eruptions, forest fires, and the decomposition of nitrogenous compounds arising from microbially-fixed **nitrogen**. If released to the atmosphere, a vapor pressure of 7500 mm Hg at 25 °C indicates ammonia will exist solely as a gas in the atmosphere. Gas-phase ammonia will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals and **nitrate** radicals; the half-lives for these reactions in air are estimated to be 100 and 54 days respectively. Ammonia reacts rapidly in the atmosphere with both sulfuric and nitric acids to form fine particles. The formation of **ammonium** ions in air can result in incorporation into an aerosol or as part of the ionic mix found in cloud and raindrops. Ammonia itself can dissolve in the **water** in the atmosphere and form clouds or fog. The half-life for ammonia in the atmosphere has been estimated to be a few days. The reaction with acidic substances in the air results in the formation of **ammonium** aerosols that can be removed by wet or dry deposition. If released to soil, ammonia may either volatilize to the atmosphere, adsorb to particulate matter, or undergo microbial transformation to **nitrate** or **nitrite** anions. Uptake by plants can also be an important fate process. Ammonia at natural concentrations in soil is not believed to have a very long half-life. If ammonia is distributed to soil in large concentrations (such as following an ammonia-containing fertilizer application), the natural biological transformation processes can be overwhelmed, and the environmental fate of ammonia will become dependent upon the physical and chemical properties of ammonia, until the ammonia concentration returns to background levels. If released to **water**, ammonia may adsorb to sediments or suspended organic material. Transformation of ammonia in **water** occurs primarily by the microbial processes of nitrification (yielding **nitrate** and **nitrite** anions) and denitrification. Volatilization from **water** surfaces is expected to be an important fate process based upon this compound's Henry's Law constant of 1.61X10⁻⁵ atm-cu m/mole. In **water**, ammonia is in equilibrium with the **ammonium ion** (NH₄⁺), and the ammonia-**ammonium ion** equilibrium is dependent on the pH. Occupational exposure to ammonia may occur through inhalation and dermal contact with this compound at workplaces where ammonia is produced or used. Farmers may be exposed during the application of ammonia-containing fertilizers, or manures high in ammonia content. The general population may be exposed to ammonia via inhalation of ambient air, ingestion of food and drinking **water**, and dermal contact with consumer products containing ammonia. Low levels of ammonia can occur naturally in food and **water**. Exposure to the general population can especially occur during use of ammonia-containing household **cleaners**. People living near farms, cattle feedlots, poultry confinement buildings, or other areas where animal populations are concentrated may also be exposed to ammonia. (SRC)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.6 Natural Pollution Sources



Ammonia occurs naturally throughout the universe(1); for example, ammonia is a minor component of the atmospheres of Jupiter and Saturn(1). Ammonia is formed as an end product of animal metabolism by decomposition of **uric acid**(2).

(1) Eggeman T; Ammonia. Kirk-Othmer Encyclopedia of Chemical Technology. (1999-2016). New York, NY: John Wiley & Sons. Online Posting Date: April 16, 2010. (2) Larranaga MD et al; Hawley's Condensed Chemical Dictionary 16th ed. Hoboken, NJ: John Wiley & Sons, Inc., p. 76 (2016)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Large amounts of ammonia are released to the atmosphere worldwide by domesticated farm animals(1). Over 50% of the total US ammonia emissions between 1970-1997 resulted from livestock(2); animal-rearing operations (cattle, hogs, and poultry) are among those with the highest ammonia emission densities(2). Natural sources of ammonia emissions to the atmosphere are volcanic eruptions, forest fires, and the decomposition of nitrogenous compounds arising from microbially-fixed nitrogen(1).

(1) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp> (2) NOAA; Atmospheric Ammonia: Sources and Fate. A Review of Ongoing Federal Research and Future Needs (June 2000). Natl Ocean Atmos Admin, Aeronomy Laboratory, Boulder, CO; Available from, as of July 6, 2016: <https://www.esrl.noaa.gov/csd/AQRS/reports/ammonia.pdf>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Toxic concn ... can be liberated from decomposing manure that is confined to a slurry pit or chicken house.

Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982., p. 938

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.7 Artificial Pollution Sources



Ammonia's production and use in fertilizers, as a component of household cleaners, as a refrigerant, in the manufacture of a various compounds(1) and as a microbiocide for controlling algal, bacterial and fungal deposits in influent water systems(2) may result in its release to the environment through various waste streams(SRC). The application of fertilizer to soil, as ammonia, ammonium compounds, or ammonia precursors (such as urea), is a major source of ammonia release to the atmosphere(3,4). Ammonia is released in exhaust emissions from automobiles(4) and in tobacco smoke(5).

(1) O'Neil MJ, ed; *The Merck Index*. 15th ed., Cambridge, UK: Royal Society of Chemistry, p. 88 (2013) (2) USEPA; Label Amendment – Revise Directions for Use, BUSAN 1215, EPA Reg No: 1448-433, June 20, 2016. Available from, as of Sept 30, 2016: https://www3.epa.gov/pesticides/chem_search/ppls/001448-00433-20160719.pdf (3) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp> (4) NOAA; Atmospheric Ammonia: Sources and Fate. A Review of Ongoing Federal Research and Future Needs (June 2000). Natl Ocean Atmos Admin, Aeronomy Laboratory, Boulder, CO. Available from, as of July 6, 2016: <https://www.esrl.noaa.gov/csd/AQRS/reports/ammonia.pdf> (5) Rodgman A, Perfetti TA; *The Chemical Components of Tobacco and Tobacco Smoke*, 2nd ed., Boca Raton, FL: CRC Press (Taylor & Francis Group), p. 1340 (2013)

▶ Hazardous Substances Data Bank (HSDB)

Human production of fixed nitrogen (ammonia) is estimated to be 140 Tg of nitrogen (1 teragram is equivalent to one million metric tons) per year. ... Both natural and anthropogenic sources produce a total of approximately 230-270 million metric tons of ammonia per year(1).

(1) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ Hazardous Substances Data Bank (HSDB)

14.2.8 Environmental Fate



TERRESTRIAL FATE: In soil, ammonia may either volatilize to the atmosphere, adsorb to particulate matter, or undergo microbial transformation to nitrate or nitrite anions(1). Volatilization of ammonia from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 1.61×10^{-5} atm-cu m/mole(2). Ammonia is a gas with a vapor pressure of 7500 mm Hg at 25 °C and atmospheric pressure(3), and therefore, is expected to volatilize from dry soil surfaces(SRC). In soil, ammonia can serve as a nutrient source for plants, which can be taken up by plants and microorganisms and converted to organic-nitrogen compounds(1). Ammonia in soil can be rapidly transformed to nitrate by the microbial population through nitrification(1). The nitrate formed will either leach through the soil or be taken up by plants or other microorganisms(1). Ammonia at natural concentrations in soil is not believed to have a very long half-life. If ammonia is distributed to soil in large concentrations (such as following an ammonia-containing fertilizer application), the natural biological transformation processes can be overwhelmed, and the environmental fate of ammonia will become dependent upon the physical and chemical properties of ammonia, until the ammonia concentration returns to background levels(1).

(1) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: (2) Betterton EA; pp. 1-50 in *Gaseous Pollutants: Characterization and Cycling*, Nriagu JO, Ed. John Wiley & Sons, Inc. (1992) <https://www.atsdr.cdc.gov/toxprofiles/index.asp> (3) Daubert TE, Danner RP; *Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation*. Design Institute for Physical Property Data, American Institute of Chemical Engineers. New York, NY: Hemisphere Pub Corp (1999)

▶ Hazardous Substances Data Bank (HSDB)

AQUATIC FATE: Ammonia is lost from water by volatilization(1) and volatilization is expected(2) based upon a Henry's Law constant of 1.61×10^{-5} atm-cu m/mole(3). Using this Henry's Law constant and an estimation method(2), volatilization half-lives for a model river and model lake are 1.4 and 12 days, respectively(SRC). In water, ammonia is in equilibrium with the ammonium ion (NH₄⁺), and the ammonia-ammonium ion equilibrium is dependent on the pH(4). The pKa of ammonia is 9.25(5). The proportion of un-ionized ammonia in water increases with increasing temperature and pH, but decreases with increasing salinity(1). At pH 8.5, the proportion of un-ionized ammonia is approximately 10 times that at pH 7.5 and, for every 9 °C increase in temperature, the proportion of un-ionized ammonia approximately doubles(1). In surface water, groundwater, or sediment, ammonia can undergo sequential transformation by two processes in the nitrogen cycle, nitrification and denitrification, which would produce ionic nitrogen compounds, and from these, elemental nitrogen(4). The ionic nitrogen compounds formed from the aerobic process of nitrification (nitrate and nitrite anions) can leach through the sediment or be taken up by aquatic plants or other organisms(4). Removal of ammonium from water can also occur by adsorption to sediments or suspended organic material(4).

(1) Environment Agent UK; Proposed EQS for Water Framework Directive Annex VIII substances: ammonia (un-ionised). Science Report: SC040038/SR2 (Feb 2007). Bristol, England; Available from, as of July 5, 2016: <https://www.wfdok.org/sites/default/files/Media/ammonia.pdf> (2) Lyman WJ et al; *Handbook of Chemical Property Estimation Methods*. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Betterton EA; pp. 1-50 in *Gaseous Pollutants: Characterization and Cycling*, Nriagu JO, Ed. John Wiley & Sons, Inc. (1992) (4) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp> (5) Haynes WM, ed; *CRC Handbook of Chemistry and Physics*. 95th ed., Boca Raton, FL: CRC Press, p. 5-92 (2014)

▶ Hazardous Substances Data Bank (HSDB)

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), ammonia, which has a vapor pressure of 7500 mm Hg at 25 °C(2), is expected to exist solely as a gas in the ambient atmosphere. Gas-phase ammonia is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 100 days(SRC), calculated from its rate constant of 1.60×10^{-13} cu cm/molecule-sec at 25 °C(3). Gas-phase ammonia is also degraded in the atmosphere by reaction with nitrate radicals(SRC); the half-life for this reaction in air is estimated to be 54 days(SRC), calculated from its rate constant of 5.99×10^{-16} cu cm/molecule-sec at 25 °C(3). Ammonia reacts rapidly in the atmosphere with both sulfuric and nitric acids to form fine particles(4). In most of the US the majority of aerosol ammonium is associated with sulfate ion(4). Once released into the atmosphere, ammonia is returned to the surface as either gaseous ammonia or as an ammonium ion(4). The ammonium ion can be associated with nitrate, sulfate, or some other anion and incorporated into an aerosol or as part of the ionic mix found in cloud and raindrops(4). Ammonia can dissolve in the water in the atmosphere and form clouds or fog(5). The half-life for ammonia in the atmosphere has been estimated to be a few days; the reaction with acidic substances in the air results in the formation of ammonium aerosols that can be removed by wet or dry deposition(5). Vapor deposition of ammonia from air to surface (to vegetation, soil, etc) also occurs(4). Ammonia does not absorb at wavelengths >290 nm(6) and, therefore, is not expected to be susceptible to direct photolysis by sunlight(SRC).

(1) Bidleman TF; *Environ Sci Technol* 22: 361-367 (1988) (2) Daubert TE, Danner RP; *Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation*. Design Institute for Physical Property Data, American Institute of Chemical Engineers. New York, NY: Hemisphere Pub Corp (1999) (3) NIST; NIST Chemistry WebBook. Ammonia(7664-41-7). NIST Gas Phase Kinetics Database No. 69, Sept 2013 Release. Washington, DC: US Sec Commerce. Available from, as of July 5, 2016: <https://webbook.nist.gov> (4) NOAA; Atmospheric Ammonia: Sources and Fate. A Review of Ongoing Federal Research and Future Needs (June 2000). Natl Ocean Atmos Admin, Aeronomy Laboratory, Boulder, CO; Available from, as of July 6, 2016: <https://www.esrl.noaa.gov/csd/AQRS/reports/ammonia.pdf> (5) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp> (6) Walsh AD, Warsop PA; *Trans Faraday Soc* 57: 345-358 (1961)

▶ Hazardous Substances Data Bank (HSDB)

14.2.9 Environmental Biodegradation



AEROBIC: When ammonia appears in water under the normal conditions (aerobic), it is rapidly converted to nitrate by nitrification; the principal water contaminant normally being nitrate. The pH in water is increased by the presence of ammonia ion, in the form of hydroxide ions. ... Bacteria convert the ammonia to nitrate creating an oxygen demand (BOD) several days after the introduction of ammonia. The bacteria that oxidize ammonia to nitrate are largely of the genus Nitrosomonas; conversion of nitrite to nitrate is carried out primarily by the genus Nitrobacter. Temperature, oxygen supply, and pH of the water are factors in determining the rate of oxidation.

Environment Canada; *Tech Info for Problem Spills: Ammonia (Draft)* p.92 (1981)

▶ Hazardous Substances Data Bank (HSDB)

14.2.10 Environmental Abiotic Degradation



The rate constant for the vapor-phase reaction of ammonia with photochemically-produced hydroxyl radicals has been measured as 1.60×10^{-13} cu cm/molecule-sec at 25 °C(1). This corresponds to an atmospheric half-life of about 100 days at an atmospheric concentration of 5×10^5 hydroxyl radicals per cu cm(1). The rate constant for the vapor-phase reaction of ammonia with night-time nitrate radicals is 5.99×10^{-16} cu cm/molecule-sec at 25 °C(1). This corresponds to an atmospheric half-life of about 54 days at an atmospheric concentration of

2.5X10⁸ nitrate radicals per cu cm(3). Ammonia does not absorb at wavelengths >290 nm(4) and, therefore, is not expected to be susceptible to direct photolysis by sunlight(SRC). Ammonia reacts rapidly in the atmosphere with both sulfuric and nitric acids to form fine particles(5). Reaction of ammonia with sulfuric acid or ammonium bisulfate is favored over reaction with nitric acid. In most of the US the majority of aerosol ammonium is associated with sulfate ion(5). Some of the ammonium ions in the atmosphere are oxidized to oxides of nitrogen and nitrate ion, which represents a contribution to the total acidity of rainfall(6).

(1) NIST; NIST Chemistry WebBook. Ammonia(7664-41-7). NIST Gas Phase Kinetics Database No. 69, Sept 2013 Release. Washington, DC: US Sec Commerce. Available from, as of July 5, 2016: <https://webbook.nist.gov> (2) US EPA; Estimation Program Interface (EPI) Suite. Ver. 4.1. Nov. 2012. Available from, as of July 5, 2016: <https://www2.epa.gov/tsc-screening-tools/> (3) Atkinson R; Atmos Environ 34: 2063-2101 (2000) (4) Walsh AD, Warsop PA; Trans Faraday Soc 57: 345-358 (1961) (5) NOAA; Atmospheric Ammonia: Sources and Fate. A Review of Ongoing Federal Research and Future Needs (June 2000). Natl Ocean Atmos Admin, Aeronomy Laboratory, Boulder, CO. Available from, as of July 6, 2016: <https://www.esrl.noaa.gov/csd/AQRS/reports/ammonia.pdf> (6) Environment Canada; Tech Info for Problem Spills: Ammonia (Draft) p.93 (1981)

▶ Hazardous Substances Data Bank (HSDB)

When dissolved in water, ammonia (NH₃) reacts to form ammonium (NH₄⁺) and hydroxyl (OH⁻) ions(1). When the pH is above 7.2, some free NH₃ remains and this increases with increasing pH(1). The equilibrium for these chemical species can be expressed by the following: NH₃ + H₂O <=> NH₄⁺ + OH⁻(1). The reaction between ammonia and water is reversible (ammonium hydroxide reverting to ammonia and water)(2). The existence of undissociated ammonium hydroxide (NH₄OH) in aqueous solution is doubtful although there are indications that ammonia can exist in water in the form of the hydrates(2). Ammonia has a reported pKa of 9.25(3). The proportion of un-ionized ammonia in water increases with increasing temperature and pH, but decreases with increasing salinity(4). At pH 8.5, the proportion of un-ionized ammonia is approximately 10 times that at pH 7.5 and, for every 9 °C increase in temperature, the proportion of un-ionized ammonia approximately doubles(4).

(1) WQA; Ammonia Fact Sheet (2013). Water Quality Association; Available from, as of July 5, 2016: <https://www.wqa.org/> (2) Eggeman T; Ammonia. Kirk-Othmer Encyclopedia of Chemical Technology. (1999-2016). New York, NY: John Wiley & Sons. Online Posting Date: April 16, 2010. (3) Haynes WM, ed; CRC Handbook of Chemistry and Physics. 95th ed., Boca Raton, FL: CRC Press, p. 5-92 (2014) (4) Environment Agent UK; Proposed EQS for Water Framework Directive Annex VIII substances: ammonia (un-ionised). Science Report: SC040038/SR2 (Feb 2007). Bristol, England. Available from, as of July 5, 2016: <https://www.wfdok.org/sites/default/files/Media/ammonia.pdf>

▶ Hazardous Substances Data Bank (HSDB)

The proportion of ammonia (NH₃) and ammonium ion found in water used for production is considered an important indicator of quality in agriculture. In highly populated fish breeding plants, where feed left overs, excrement and metabolic waste cause growth disturbances and deficiencies, even though there is an adequate supply of oxygen, nitrogen compounds are the decisive factor. A significant role is played by the undissociated NH₃ molecule. ... Experiments were carried out both with and without ventilation and using varying amounts of fish feed. The concentration of NH₃, which depends on pH and temperature, was investigated to determine the extent of the oxidative change of NH₃ through NO₃⁻ during the mineralization process of the feed leftovers. Under the conditions used in the 2 sets of experiments there was hardly any tendency for the pH values in the unventilated experiments to alter and become more alkaline from an ammonification of left over feed. In the experiments using ventilation, the proteins underwent an especially intensive process of decomposition, i.e., they became completely mineralized, and considerable amounts of NH₄-N and NH₃ N were released. Due to the lack of organic acids, these could not be neutralized and, as a result, the pH value increased.

Eissa M G; Arch Hydrobiol 98 (3): 327-343 (1983)

▶ Hazardous Substances Data Bank (HSDB)

14.2.11 Environmental Bioconcentration



Plants have a high affinity for gaseous ammonia when leaf stomata are open in daylight.

Environment Canada; Tech Info for Problem Spills: Ammonia (Draft) p.91 (1981)

▶ Hazardous Substances Data Bank (HSDB)

14.2.12 Soil Adsorption/Mobility



Ammonia is strongly adsorbed on soil, and on sediment particles and colloids in water. This adsorption results in high concentrations of sorbed ammonia in oxidized sediments. Under anoxic conditions, the adsorptive capacity of sediments is less, resulting in the release of ammonia to either the water column or an oxidized sediment layer above.

Environment Canada; Tech Info for Problem Spills: Ammonia (Draft) p.94 (1981)

▶ Hazardous Substances Data Bank (HSDB)

In clay, the ammonia ion tends to be adsorbed on the negative adsorption sites of clay colloids. It may substitute for potassium in the lattice structure of a clay mineral.

Environment Canada; Tech Info for Problem Spills: Ammonia (Draft) p.94 (1981)

▶ Hazardous Substances Data Bank (HSDB)

14.2.13 Volatilization from Water/Soil



Ammonia is lost from water by volatilization(1). The Henry's Law constant for ammonia has been measured as 1.61X10⁻⁵ atm-cu m/mole(2). This Henry's Law constant indicates that ammonia is expected to volatilize from water surfaces(3). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(3) is estimated as 1.4 days(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(3) is estimated as 12 days(SRC). Ammonia's Henry's Law constant indicates that volatilization from moist soil surfaces may occur(SRC). Ammonia is a gas with a vapor pressure of 7500 mm Hg at 25 °C and atmospheric pressure(4), and therefore, is expected to volatilize from dry soil surfaces(SRC).

(1) Environment Agent UK; Proposed EQS for Water Framework Directive Annex VIII substances: ammonia (un-ionised). Science Report: SC040038/SR2 (Feb 2007). Bristol, England. Available from, as of July 5, 2016: <https://www.wfdok.org/sites/default/files/Media/ammonia.pdf> (2) Betterton EA; pp. 1-50 in Gaseous Pollutants: Characterization and Cycling, Nriagu JO, ed. John Wiley & Sons, Inc. (1992) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (4) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation. Design Institute for Physical Property Data, American Institute of Chemical Engineers. New York, NY: Hemisphere Pub Corp (1999)

▶ Hazardous Substances Data Bank (HSDB)

14.2.14 Environmental Water Concentrations



GROUNDWATER: Groundwater levels of ammonia were measured in Idaho in the late 1990's, with concentrations varying from 2.5 ppb in a municipal drinking water well, to 3.25 ppm in a deep, private well(1). Groundwater samples collected from wells near the Savannah River contained ammonia levels of 0.01-0.02 in two wells(2). Groundwater samples collected between 1992-1995 at an old municipal landfill site in Grindsted, Denmark contained ammonia levels ranging from <20 to >1000 mg/L(3). Groundwater sampled near sediment cores from Little Sioux River, IA had ammonia concentrations of <0.01 to 0.39 mg/L(4).

(1) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp> (2) Kirtland BC et al; Environ Sci Technol 37: 4205-4212 (2003) (3) Kjeldsen P et al; Waste Manage Research 16: 14-22 (1998) (4) Rogers SW et al; Chemosphere 69: 1563-1573 (2007)

▶ Hazardous Substances Data Bank (HSDB)

SURFACE WATER: The concentration of ammonia measured in Hamilton Harbour, a **water** body used for **water** transportation, as a source for industrial cooling, and as a receptor for waste **water** disposal, in Ontario, Canada in the early 1980's was 0.1-3 mg/L; measurements made in 1987-1988 showed much lower concentrations (concentration not specified)(1). **Water** samples collected from Lake Valencia, Venezuela in August 1995 (at depths from 0-25 meters) contained a total ammonia concentrations ranging from 0.5-7.5 uM(2). Monitoring at five sites of the Wascana Creek in Saskatchewan, Canada between 2005-2007 detected ammonia concentrations of 0.01-32 mg/L(3). Maximum ammonia concentrations (as NH4+) of 3.0 umol/L were detected during 2013-2014 monitoring in the Gulf Papagayo at the northern Pacific coast of Costa Rica(4). [(1) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <http://www.atsdr.cdc.gov/toxprofiles/index.asp> (2) Jaffe R et al; Bull Environ Contam Toxicol 59: 99-105 (1997) (3) Waiser MJ et al; Environ Toxicol Chem 30: 496-507 (2011) (4) Stuhldreier I et al; PLoS One 10 11]. Available from, as of July 7, 2016: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4641702/>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

RAIN/SNOW: Ammonia was measured in rain and snow samples from three sites in northern Michigan in 1978-1979, with concentrations ranging from 23.8 to 3,500 ppb, and mean values for each site of 816, 572, and 632 ppb, respectively; concentrations were generally greatest in the spring and fall and were lowest during winter(1). Treated effluent samples collected from a sewage treatment plant in Sydney, Australia contained an average ammonia concentration of 26.6 mg/L(2).

(1) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp> (2) Braga O et al; Environ Sci Technol 39: 3351-3358 (2005)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.15 Effluent Concentrations



Ammonia was detected in the surface **water** collected from nine sampling points at the North Porto Alegre landfill in Brazil from 1991-1993 at minimum, maximum, and average concentrations of 0.62, 47.3 and 1.629 mg/L, respectively(1). Ammonia was detected in the odor emissions from a municipal solid waste treatment plant in China(2). Following fertilizer applications to surface plots, ammonia volatilization rates ranged from about 270 to 30-40 g/ha/hr over 60 hours(3). Measurements have been made with the instrumented automobiles in park (in a parking indicated ammonia emission concentrations ranging from 5 to 55 ppm in exhaust(4). Estimated ammonia emission factors from livestock for cows, hogs, chickens, turkeys and sheep were 22.9, 9.2, 0.18, 0.86 and 3.4 kg ammonia/animal(4). Monitoring of hen houses in Taiwan between 2008-2009 detected hen house and exhaust ammonia concentrations of 0.5-12.5 ppm which estimated ammonia emission rates of 0.15-0.42 kg/ammonia/hen/year(5). Ammonia losses in emissions from manure composting ranged from 0.2-15.1 g/kg total solids(6). Ammonia is emitted to air from field applications of animal manure, but emission rates were decreased by nearly 90% through immediate incorporation into the soil by plough(7).

(1) Kuajara O et al; Water Environ Res 69: 1170-7 (1997) (2) Fang J et al; J Air Waste Manage Assoc 63: 1287-1597 (2013) (3) Menendez S et al; J Environ Qual 35: 973-981 (2006) (4) NOAA; Atmospheric Ammonia: Sources and Fate. A Review of Ongoing Federal Research and Future Needs (June 2000). Natl Ocean Atmos Admin, Aeronomy Laboratory, Boulder, CO. Available from, as of July 6, 2016: <https://www.esrl.noaa.gov/csd/AQRS/reports/ammonia.pdf> (5) Cheng WH et al; Environ Eng Sci 28: 283-289 (2011) (6) Chowdhury MA et al; Chemosphere 97: 16-25 (2014) (7) Webb J et al; Atmos Environ 82: 280-287 (2014)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.16 Atmospheric Concentrations



In fall 1979, the concentration of gaseous ammonia in air samples taken at ground-level at urban Hampton and rural Langley, VA, ranged from 0.2-4.0 and from 1.5-4.0 ppb, respectively(1). Ammonia concentrations obtained in December 1979 on Long Island, NY, ranged from 80-200 nmol/cu m(1). A two year atmospheric monitoring study conducted near Edinburgh, Scotland between 1992-1994 detected an overall arithmetic mean ammonia concentration of 1.4 ug/cu m(2). Monitoring conducted between 2006 to 2011 at Boulder, Wyoming detected a 5-year average ammonia concentrations of 0.17 ug/cu m(3); ammonia levels were higher in summer than other seasons(3). A year-long monitoring study (started in Nov 2008) conducted at the Rocky Mountain National Park detected overall mean ammonia levels in the atmospheric particulates (as NH4 species) of 3.31 ug/cu m(4). Monitoring at four rural and two suburban sites in the North China Plain between 2006-2009 detected a mean ammonia concentration of 15.6 ug/cu m and a mean **ammonium** concentration (in particulates) of 12.4 ug/cu m(5).

(1) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp> (2) Burkhardt J et al; Atmos Environ 32: 325-331 (1998) (3) Li Y et al; Atmos Environ 83: 80-89 (2014) (4) Malm WC et al; J Air Waste Manga Assoc 63: 1245-1263 (2013) (5) Shen J et al; Atmos Environ 45: 5033-5041 (2011)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.17 Food Survey Values



The US FDA states that the levels of ammonia and **ammonium** compounds normally found in food do not pose a health risk(1). Maximum allowable ammonia levels in processed foods are as follows: 0.04-3.2% **ammonium bicarbonate** in baked goods, grain, snack foods, and reconstituted vegetables; 2.0% **ammonium carbonate** in baked goods, gelatins, and puddings; 0.001% **ammonium chloride** in baked goods and 0.8% in condiments and relishes; 0.6-0.8% **ammonium hydroxide** in baked goods, cheeses, gelatins, and puddings; 0.01% monobasic ammonium phosphate in baked goods; and 1.1% dibasic ammonium phosphate in baked goods, 0.003% in nonalcoholic beverages, and 0.012% in condiments and relishes(1).

(1) ATSDR; Toxicological Profile for Ammonia. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.18 Plant Concentrations



Plants containing ammonia(1).

Table: Top 10 Plants

Genus species	Family	Common name(s)	Part	Concn (ppm)
Apium graveolens	Apiaceae	Celery	Stem	19600.0
Spinacia oleracea	Chenopodiaceae	Spinach	Leaf	18280.0
Apium graveolens	Apiaceae	Celery	Pt	15480.0
Brassica oleracea var. capitata l.	Brassicaceae	Cabbage	Leaf	3800.0-11060.0
Humulus lupulus	Cannabaceae	Hops	Flower	10660.0
Zea mays	Poaceae	Corn	Seed	10030.0
Glycine max	Fabaceae	Soybean	Seed	8600.0
Hordeum vulgare	Poaceae	Barley, Barleygrass	Seed	8130.0
Linum usitatissimum	Linaceae	Flax, Linseed	Seed	3000.0
Oenothera biennis	Onagraceae	Evening-Primrose	Seed	2300.0-2455.0

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.19 Other Environmental Concentrations



Ammonia has been detected in tobacco smoke(1,2).

(1) Talhout R et al; *Int J Environ Res Public Health* 8: 613-628 (2011) (2) Rodgman A, Perfetti TA; *The Chemical Components of Tobacco and Tobacco Smoke*, 2nd ed., Boca Raton, FL: CRC Press (Taylor & Francis Group), p. 1340 (2013)

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.20 Probable Routes of Human Exposure



According to the 2012 TSCA Inventory Update Reporting data, 126 reporting facilities estimate the number of persons reasonably likely to be exposed during the manufacturing, processing, or use of ammonia in the United States may be as low as <10 workers and as high as 1000-9999 workers per plant; the data may be greatly underestimated due to confidential business information (CBI) or unknown values(1).

(1) US EPA; *Chemical Data Reporting (CDR). Non-confidential 2012 Chemical Data Reporting information on chemical production and use in the United States. Available from, as of July 5, 2016: https://java.epa.gov/oppt_chemical_search/*

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

NIOSH (NOES Survey 1981-1983) has statistically estimated that 805,962 workers (287,974 of these were female) were potentially exposed to ammonia in the US(1). Occupational exposure to ammonia may occur through inhalation and dermal contact with this compound at workplaces where ammonia is produced or used. Occupational exposure to ammonia occurs in industries involved in its synthesis, formulation, processing, transportation and use, and during the use of ammonia-containing cleaning products(2). Farmers may be exposed during the application of ammonia-containing fertilizers, or manures high in ammonia content(2). The general population may be exposed to ammonia via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with consumer products containing ammonia(2). Low levels of ammonia can occur naturally in food and water(2). Exposure to the general population can especially occur during use of ammonia-containing household cleaners(2). People living near farms, cattle feedlots, poultry confinement buildings, or other areas where animal populations are concentrated may also be exposed to ammonia(2).

(1) CDC; *International Chemical Safety Cards (ICSC) 2012*. Atlanta, GA: Centers for Disease Prevention & Control. National Institute for Occupational Safety & Health (NIOSH). Ed Info Div. Available from, as of July 5, 2016: <https://www.cdc.gov/niosh/ipcs/icstart.html> (2) ATSDR; *Toxicological Profile for Ammonia*. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

Analysis of data obtained in plant surveys found the limit of detection to be below 5 ppm and the complaint level to be 20-25 ppm.

American Conference of Governmental Industrial Hygienists. *Documentation of the Threshold Limit Values and Biological Exposure Indices*. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986, p. 27

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.21 Average Daily Intake



If untreated surface water is ingested, the average uptake would be 0.36 mg/day, assuming an ammonia concentration in untreated water of 0.18 mg/L and a consumption of 2 L/day(1).

(1) ATSDR; *Toxicological Profile for Ammonia*. Atlanta, GA: Agency for Toxic Substances and Disease Registry, US Public Health Service (2004). Available from, as of July 5, 2016: <https://www.atsdr.cdc.gov/toxprofiles/index.asp>

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

14.2.22 Body Burden



Therapeutic or normal blood level: 0.05-0.17 mg %; 0.5-1.7 ug/mL

Winek, C.L. *Drug and Chemical Blood-Level Data 1985*. Pittsburgh, PA: Allied Fischer Scientific, 1985.

▶ [Hazardous Substances Data Bank \(HSDB\)](#)

▶ Comparative Toxicogenomics Database (CTD)

Disease	References
Short bowel syndrome	PubMed: 12553956 , 15896428 , 15449570
3-Methyl-crotonyl-glycinuria	PubMed: 7474896 , 25732994 , 12872837 , 11893004 MetaGene: Metabolic & Genetic Information Center (MIC: http://www.metagene.de)
Argininosuccinic aciduria	PubMed: 5075233 , 19551947 , 12408190 MetaGene: Metabolic & Genetic Information Center (MIC: http://www.metagene.de)
Sulfite oxidase deficiency, ISOLATED	PubMed: 10682307 , 27289259 , 23452914 , 15558695 Clinical and Laboratory Barriers to the Timely Diagnosis of Sulphite Oxidase Deficiency. Proceedings of Singapore Healthcare, 19(2), 94-100.
3-Hydroxy-3-methylglutaryl-CoA lyase deficiency	PubMed: 6157502 , 11129331 , 28583327 , 15505778 , 25557019 , 23705938 , 1886403 , 12072887 , 19893767 MetaGene: Metabolic & Genetic Information Center (MIC: http://www.metagene.de)
Fumarase deficiency	PubMed: 26078636 , 20549362 , 24182348 , 6616883 , 16972175 MetaGene: Metabolic & Genetic Information Center (MIC: http://www.metagene.de)
N-acetylglutamate synthetase deficiency	PubMed: 2044610 , 7623444 , 9427158
Citrullinemia type I	PubMed: 28132756
Citrullinemia type II, adult-onset	PubMed: 7202267 , 18620775
3-Hydroxyacyl-CoA dehydrogenase deficiency	PubMed: 11241047 , 11489939 , 14693719 , 22579592 , 23430856
Mitochondrial complex I deficiency due to ACAD9 deficiency	PubMed: 17564966
Hyperidibasic aminoaciduria I	PubMed: 5727921
Pearson Syndrome	PubMed: 25691415
Cutis laxa, autosomal recessive, type IIIA	PubMed: 11092761
Metabolic encephalomyopathic crises, recurrent, with rhabdomyolysis, cardiac arrhythmias, and neurodegeneration	PubMed: 26805781
Mitochondrial trifunctional protein deficiency	PubMed: 11978597 , 12838198
Pyruvate carboxylase deficiency	PubMed: 28649521
Carnitine palmitoyltransferase I deficiency	PubMed: 11286380
Cerebral creatine deficiency syndrome 2	PubMed: 9386672 , 15651030
Infantile Liver Failure Syndrome 2	PubMed: 26541327
Long-chain Fatty Acids, Defect in Transport of	PubMed: 3185635
Myopathy, lactic acidosis, and sideroblastic anemia 1	PubMed: 14981724 , 9950309
Phosphoenolpyruvate Carboxykinase Deficiency 1, Cytosolic	PubMed: 28216384 , 26971250

▶ Human Metabolome Database (HMDB)

16 Literature



16.1 NLM Curated PubMed Citations



▶ PubChem

16.2 Springer Nature References



▶ Springer Nature

16.3 Wiley References



▶ Wiley

16.4 Depositor Provided PubMed Citations



▶ [PubChem](#)

16.5 Synthesis References



Mohr, Rudolf. Ammonia separation from offgas obtained from [melamine](#) synthesis. U.S. (1971), 5 pp. CODEN: USXXAM US 3555784 19710119 CAN 77:50902 AN 1972:450902

▶ [Human Metabolome Database \(HMDB\)](#)

16.6 Metabolite References



▶ [Human Metabolome Database \(HMDB\)](#)

16.7 General References



Marshall et al. Screening and characterization of a diverse panel of metagenomic imine reductases for biocatalytic reductive amination. *Nature Chemistry*, doi: 10.1038/s41557-020-00606-w, published online 30 December 2020

▶ [Nature Chemistry](#)

16.8 Chemical Co-Occurrences in Literature



▶ [PubChem](#)

16.9 Chemical-Gene Co-Occurrences in Literature



17 Patents



17.1 Depositor-Supplied Patent Identifiers



▶ PubChem

[Link to all deposited patent identifiers](#)

▶ PubChem

17.2 WIPO PATENTSCOPE



Patents are available for this chemical structure:

<https://patentscope.wipo.int/search/en/result.jsf?inchikey=QGZKDVFNNGYKY-UHFFFAOYSA-N>

▶ PATENTSCOPE (WIPO)

18 Biomolecular Interactions and Pathways



18.1 Protein Bound 3D Structures



▶ [RCSB Protein Data Bank \(RCSB PDB\)](#)

[View 273 proteins in NCBI Structure](#)

▶ [PubChem](#)

18.1.1 Ligands from Protein Bound 3D Structures



Showing 1 of 2 [View More](#)

PDBe Ligand Code	NH2
PDBe Structure Code	2FLY
PDBe Conformer	

▶ [Protein Data Bank in Europe \(PDBe\)](#)

18.2 Drug-Gene Interactions



▶ [Drug Gene Interaction database \(DGIdb\)](#)

18.3 Chemical-Gene Interactions



18.3.1 CTD Chemical-Gene Interactions



18.4 Pathways



19 Biological Test Results



19.1 BioAssay Results



▶ PubChem

Escherichia coli (strain K12, MG1655)

- ▶ [E. coli Metabolome Database \(ECMDB\)](#)

WormJam Metabolites Local CSV for MetFrag | [DOI:10.5281/zenodo.3403364](https://doi.org/10.5281/zenodo.3403364)

WormJam: A consensus C. elegans Metabolic Reconstruction and Metabolomics Community and Workshop Series, *Worm*, 6:2, e1373939, [DOI:10.1080/21624054.2017.1373939](https://doi.org/10.1080/21624054.2017.1373939)

- ▶ [ECI Group, LCSB, University of Luxembourg](#)

Zebrafish Pathway Metabolite MetFrag Local CSV (Beta) | [DOI:10.5281/zenodo.3457553](https://doi.org/10.5281/zenodo.3457553)

- ▶ [ECI Group, LCSB, University of Luxembourg](#)

The LOTUS Initiative for Open Natural Products Research: frozen dataset union wikidata (with metadata) | [DOI:10.5281/zenodo.5794106](https://doi.org/10.5281/zenodo.5794106)

- ▶ [LOTUS - the natural products occurrence database](#)

21 Classification



21.1 Ontologies



21.1.1 MeSH Tree



▶ Medical Subject Headings (MeSH)

21.1.2 NCI Thesaurus Tree



▶ NCI Thesaurus (NCIt)

21.1.3 ChEBI Ontology



▶ ChEBI

21.1.4 KEGG: Risk Category of Japanese OTC Drugs



▶ KEGG

21.1.5 ChemIDplus



▶ ChemIDplus

21.1.6 CAMEO Chemicals



▶ CAMEO Chemicals

21.1.7 ChEMBL Target Tree



▶ ChEMBL

21.1.8 UN GHS Classification



▶ UN Globally Harmonized System of Classification and Labelling of Chemicals (GHS)

21.1.9 EPA CPDat Classification



▶ EPA Chemical and Products Database (CPDat)

21.1.10 NORMAN Suspect List Exchange Classification



▶ NORMAN Suspect List Exchange

21.1.11 EPA DSSTox Classification



▶ EPA DSSTox

- ▶ Consumer Product Information Database (CPID)

- ▶ LOTUS - the natural products occurrence database

- ▶ National Drug Code (NDC) Directory

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<https://cameochemicals.noaa.gov/chemical/24008>

AMMONIA, ANHYDROUS

<https://cameochemicals.noaa.gov/chemical/4860>

AMMONIA, SOLUTION, WITH MORE THAN 10% BUT NOT MORE THAN 35% AMMONIA

<https://cameochemicals.noaa.gov/chemical/19288>

CAMEO Chemical Reactivity Classification

<https://cameochemicals.noaa.gov/browse/react>

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Ammonia

https://commonchemistry.cas.org/detail?cas_rn=7664-41-7

Ammonia, dimer, radical ion(1+)

https://commonchemistry.cas.org/detail?cas_rn=69718-51-0

Ammonia, tetramer

https://commonchemistry.cas.org/detail?cas_rn=71187-51-4

Ammonia, pentamer

https://commonchemistry.cas.org/detail?cas_rn=71187-52-5

Ammonia, dimer

https://commonchemistry.cas.org/detail?cas_rn=63016-67-1

Ammonia, trimer

https://commonchemistry.cas.org/detail?cas_rn=71187-50-3

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Ammonia

<https://chem.nlm.nih.gov/chemidplus/sid/0007664417>

ChemIDplus Chemical Information Classification

<https://chem.nlm.nih.gov/chemidplus/>

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Ammonia

<https://www.epa.gov/aegl/ammonia-results-aegl-program>

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Ammonia

<https://comptox.epa.gov/dashboard/DTXSID0023872>

CompTox Chemicals Dashboard Chemical Lists

<https://comptox.epa.gov/dashboard/chemical-lists/>

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<https://echa.europa.eu/web/guest/legal-notice>

Ammonia, anhydrous

<https://echa.europa.eu/substance-information/-/substanceinfo/100.028.760>

anhydrous ammonia

<https://echa.europa.eu/information-on-chemicals>

8. Hazardous Substances Data Bank (HSDB)

Ammonia

<https://pubchem.ncbi.nlm.nih.gov/source/hsdb/162>

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<http://www.hmdb.ca/citing>

Ammonia
<http://www.hmdb.ca/metabolites/HMDB0000051>

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AMMONIA (ANHYDROUS)

https://www.ilo.org/dyn/icsc/showcard.display?p_version=2&p_card_id=0414

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AMMONIA

<https://www.osha.gov/chemicaldata/623>

Ammonia, Anhydrous

<https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.119AppA>

12. Wikipedia

ammonia

<https://en.wikipedia.org/wiki/Ammonia>

13. DOT Emergency Response Guidebook

ammonia, anhydrous

<https://www.phmsa.dot.gov/hazmat/erg/emergency-response-guidebook-erg>

14. NJDOH RTK Hazardous Substance List

ammonia

<http://nj.gov/health/eoh/rtkweb/documents/fs/0084.pdf>

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Ammonia

<https://www.cdc.gov/niosh/npg/npgd0028.html>

AMMONIA SOLUTION (UN 3318); AMMONIA, ANHYDROUS (UN 1005)

https://www.cdc.gov/niosh/ershdb/emergencyresponsecard_29750013.html

Ammonia

<https://www.cdc.gov/niosh-rtecs/BOD59F8.html>

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Ammonia

<https://wwwn.cdc.gov/TSP/substances/ToxSubstance.aspx?toxid=2>

17. ChEBI

Ammonia

<http://www.ebi.ac.uk/chebi/searchId.do?chebiId=CHEBI:16134>

ChEBI Ontology

<http://www.ebi.ac.uk/chebi/userManualForward.do#ChEBI%20Ontology>

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<https://ecmdb.ca/compounds/M2MDB000017>

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<https://lotus.nprod.net/>

LOTUS Tree

<https://lotus.naturalproducts.net/>

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<https://www.whatsinproducts.com/contents/view/1/6>

Ammonia

<https://www.whatsinproducts.com/chemicals/view/1/569/007664-41-7>

Consumer Products Category Classification

<https://www.whatsinproducts.com/>

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EPA CPDat Classification

<https://www.epa.gov/chemical-research/chemical-and-products-database-cpdats>

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Ammonia

https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Ammonia

https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search?tool=rml

30. EU Clinical Trials Register

<https://www.clinicaltrialsregister.eu/>

31. EU Food Improvement Agents

Ammonia

<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R0872>

32. NORMAN Suspect List Exchange

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NORMAN Suspect List Exchange Classification

<https://www.norman-network.com/nds/SLE/>

33. EU REGULATION (EC) No 1272/2008

ammonia, anhydrous

<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008R1272-20211001>

34. Hazardous Chemical Information System (HCIS), Safe Work Australia

Ammonia gas

<http://hcis.safeworkaustralia.gov.au/HazardousChemical/Details?chemicalID=225>

35. NITE-CMC

Ammonia - FY2016

<https://www.nite.go.jp/chem/english/ghs/16-moe-0007e.html>

Ammonia - FY2014

<https://www.nite.go.jp/chem/english/ghs/14-mhlw-2011e.html>

Ammonia - FY2009

<https://www.nite.go.jp/chem/english/ghs/09-mhlw-2003e.html>

Ammonia - FY2006

<https://www.nite.go.jp/chem/english/ghs/06-imcg-0557e.html>

36. FDA Center for Food Safety and Applied Nutrition (CFSAN)

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<https://www.fda.gov/about-fda/about-website/website-policies#linking>

AMMONIA

<https://www.cfsanappsexternal.fda.gov/scripts/fdcc/index.cfm?set=IndirectAdditives&id=AMMONIA>

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<https://www.fda.gov/about-fda/about-website/website-policies#linking>

5138Q19F1X

<https://www.fda.gov/ForIndustry/DataStandards/SubstanceRegistrationSystem-UniqueIngredientIdentifierUNII/>

38. Flavor and Extract Manufacturers Association (FEMA)

AMMONIA (ALSO INCLUDES AMMONIUM CHLORIDE)

<https://www.femaflavor.org/flavor-library/ammonia-also-includes-ammonium-chloride>

39. National Drug Code (NDC) Directory

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<https://www.fda.gov/about-fda/about-website/website-policies#linking>

AMMONIA

<https://www.fda.gov/drugs/drug-approvals-and-databases/national-drug-code-directory>

40. Nature Chemistry

<https://pubchem.ncbi.nlm.nih.gov/substance/433982629>

41. NIOSH Manual of Analytical Methods

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<https://www.cdc.gov/Other/disclaimer.html>

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<https://www.cdc.gov/niosh/docs/2003-154/pdfs/3800.pdf>

7664-41-7

<https://www.cdc.gov/niosh/docs/2003-154/pdfs/6015.pdf>

7664-41-7

<https://www.cdc.gov/niosh/docs/2003-154/pdfs/6015REV.pdf>

7664-41-7

<https://www.cdc.gov/niosh/docs/2003-154/pdfs/6016.pdf>

42. NIPH Clinical Trials Search of Japan

<https://rctportal.niph.go.jp/en/>

43. NIST Mass Spectrometry Data Center

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<https://www.nist.gov/srd/public-law>

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<http://www.nist.gov/srd/nist1a.cfm>

44. SpectraBase

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<https://spectrabase.com/spectrum/FhGHFq2cPuS>

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<https://spectrabase.com/spectrum/BOvIIAJrd7g>

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<https://spectrabase.com/spectrum/77SJur7fazW>

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<https://www.nlm.nih.gov/research/umls/rxnorm/docs/termservice.html>

<https://rxnav.nlm.nih.gov/id/rxnorm/1299884>

46. NMRShiftDB

<https://pubchem.ncbi.nlm.nih.gov/substance/594654>

47. Pistoia Alliance Chemical Safety Library

CHLORINE; AMMONIA

<http://www.pistoiaalliance.org/projects/chemical-safety-library/>

48. Protein Data Bank in Europe (PDBe)

<http://www.ebi.ac.uk/pdbe-srv/pdbechem/chemicalCompound/show/NH2>

<http://www.ebi.ac.uk/pdbe-srv/pdbechem/chemicalCompound/show/NH3>

49. RCSB Protein Data Bank (RCSB PDB)

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<https://www.rcsb.org/pages/policies>

<https://www.rcsb.org/>

50. Springer Nature

<https://pubchem.ncbi.nlm.nih.gov/substance/341138792>

51. SpringerMaterials

ammonia

https://materials.springer.com/substanceprofile/docs/smsid_zfrecrumnfgbqpw

52. **Wikidata**

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<https://pubchem.ncbi.nlm.nih.gov/substance/?source=wiley&sourceid=128117>
<https://pubchem.ncbi.nlm.nih.gov/substance/?source=wiley&sourceid=137736>

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Ammonia
<https://www.ncbi.nlm.nih.gov/mesh/68000641>

MeSH Tree
<http://www.nlm.nih.gov/mesh/meshhome.html>

55. **PubChem**

<https://pubchem.ncbi.nlm.nih.gov>

56. **KEGG**

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<https://www.kegg.jp/kegg/legal.html>

Risk category of Japanese OTC drugs
http://www.genome.jp/kegg-bin/get_htext?br08312.keg

57. **UN Globally Harmonized System of Classification and Labelling of Chemicals (GHS)**

GHS Classification Tree
http://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html

58. **PATENTSCOPE (WIPO)**

SID 403029800
<https://pubchem.ncbi.nlm.nih.gov/substance/403029800>

59. **NCBI**

<https://www.ncbi.nlm.nih.gov/projects/linkout>