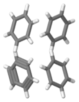
PubChem

COMPOUND SUMMARY

Benzene

PubChem CID	241
Structure	 2D  3D  Crystal Find Similar Structures
Chemical Safety	Flammable Irritant Health Hazard Laboratory Chemical Safety Summary (LCSS) Datasheet
Molecular Formula	C_6H_6
Synonyms	benzene benzol Cyclohexatriene 71-43-2 benzole More...
Molecular Weight	78.11
Dates	Modify 2021-07-03 Create 2004-09-16

Benzene is a clear, colorless, highly flammable and volatile, liquid aromatic hydrocarbon with a gasoline-like odor. Benzene is found in crude oils and as a by-product of oil-refining processes. In industry benzene is used as a solvent, as a chemical intermediate, and is used in the synthesis of numerous chemicals. Exposure to this substance causes neurological symptoms and affects the bone marrow causing aplastic anemia, excessive bleeding and damage to the immune system. Benzene is a known human carcinogen and is linked to an increased risk of developing lymphatic and hematopoietic cancers, acute myelogenous leukemia, as well as chronic lymphocytic leukemia. (NCI05)

▸ NCI Thesaurus (NCIt)

Benzene is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities. Benzene is widely used in the United States; it ranks in the top 20 chemicals for production volume. Some industries use benzene to make other chemicals which are used to make plastics, resins, and nylon and synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides. Natural sources of benzene include volcanoes and forest fires. Benzene is also a natural part of crude oil, gasoline, and cigarette smoke.

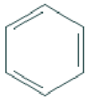
▸ CDC-ATSDR Toxic Substances Portal

Benzene appears as a clear colorless liquid with a petroleum-like odor. Flash point less than 0°F. Less dense than water and slightly soluble in water. Hence floats on water. Vapors are heavier than air.

▸ CAMEO Chemicals

1 Structures

1.1 2D Structure

Chemical Structure Depiction	

PubChem

1.2 3D Conformer

PubChem

1.3 Crystal Structures

Showing 1 of 7 View More

CCDC Number	298305
Crystal Structure Data	DOI:10.5517/ccb0drg
Crystal Structure Depiction	
Associated Article	DOI:10.1107/S010876810503747X

The Cambridge Structural Database

2 Names and Identifiers

2.1 Computed Descriptors

2.1.1 IUPAC Name

benzene

Computed by LexiChem 2.6.6 (PubChem release 2019.06.18)

▸ PubChem

2.1.2 InChI

InChI=1S/C6H6/c1-2-4-6-5-3-1/h1-6H

Computed by InChI 1.0.5 (PubChem release 2019.06.18)

▸ PubChem

2.1.3 InChI Key

UHOVQNZJYSORNB-UHFFFAOYSA-N

Computed by InChI 1.0.5 (PubChem release 2019.06.18)

▸ PubChem

2.1.4 Canonical SMILES

C1=CC=CC=C1

Computed by OEChem 2.1.5 (PubChem release 2019.06.18)

▸ PubChem

2.2 Molecular Formula

C_6H_6

▸ CAMEO Chemicals; ILO International Chemical Safety Cards (ICSC); Wikipedia; PubChem

2.3 Other Identifiers

2.3.1 CAS

71-43-2

▸ CAMEO Chemicals; CAS Common Chemistry; ChemIDplus; DTP/NCI; EPA Acute Exposure Guideline Levels (AEGLs); EPA Chemicals under the TSCA; EPA DSSTox; European Chemicals Agency (ECHA); Hazardous Substances Data Bank (HSDB); Human Metabolome Database (HMDB); ILO International Cl

26181-88-4

▸ ChemIDplus

2.3.2 Related CAS

25053-22-9

Compound: Benzene, homopolymer

▸ CAS Common Chemistry

6842-25-7

Compound: Benzene, dimer

- CAS Common Chemistry

79086-19-4

Compound: Benzene, trimer

- CAS Common Chemistry

2.3.3 Deprecated CAS

174973-66-1, 54682-86-9, 1053658-43-7, 1173023-23-8

- ChemIDplus

2.3.4 European Community (EC) Number

200-753-7

- European Chemicals Agency (ECHA)

2.3.5 ICSC Number

0015

- ILO International Chemical Safety Cards (ICSC)

2.3.6 NSC Number

67315

- DTP/NCI

2.3.7 RTECS Number

CY1400000

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

DE3030000

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

2.3.8 UN Number

1114

- 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)

2.3.9 UNII

J64922108F

- FDA/SPL Indexing Data

2.3.10 DSSTox Substance ID

DTXSID3039242

- EPA DSSTox

2.3.11 Wikipedia

Benzene

- Wikipedia

2.4 Synonyms

2.4.1 MeSH Entry Terms

Benzene
Benzol
Benzole
Cyclohexatriene

- Medical Subject Headings (MeSH)

2.4.2 Depositor-Supplied Synonyms

- benzene
- benzol
- Cyclohexatriene
- 71-43-2
- benzole
- Pyrobenzole
- Benzine
- Benzen
- Phenyl hydride
- Pyrobenzol
- Phene
- Mineral naphtha
- Coal naphtha
- Bicarburet of hydrogen
- Benzolene
- Benzin
- [6]Annulene
- Motor benzol
- Carbon oil
- Benzeen
- Benzolo
- Fenzen
- Nitration benzene
- (6)Annulene
- Benzol 90
- Rcra waste number U019
- NCI-C55276
- NSC 67315
- UN 1114
- CHEBI:16716
- UNII-J64922108F
- CHEMBL277500
- MFCD00003009
- J64922108F
- Benzeen [Dutch]
- Benzen [Polish]
- Fenzen [Czech]
- Benzolo [Italian]
- BNZ
- Benzine (Obs.)
- Benzin (Obs.)
- 2,5-cyclohexadien-1,4-ylene
- BENZENE (13C6)
- Benzene-1,2,4,5-d4
- Caswell No. 077
- Benzol diluent
- Benzene 100 microg/mL in Methanol
- Benzene, ACS reagent, >=99.0%
- Benzene, pure
- CCRIS 70
- 54682-86-9
- HSDB 35
- 1,3,5-cyclohexatriene
- EINECS 200-753-7
- UN1114
- EPA Pesticide Chemical Code 008801
- Benzinum
- Benzolum
- Aromatic alkane
- Benzene (including benzene from gasoline)
- p-benzene
- benzene solution
- benzene-
- AI3-00808
- 1hyz
- 1swi
- [6]-annulene
- Benzene ACS Grade
- Benzene, for HPLC
- {[6]Annulene}
- 14941-52-7
- Benzene-1,4-d2
- Ph-H
- Phenyl; Phenyl Radical
- 2z9g
- 4i7j
- ACMC-209snd
- Benzene + aniline combo
- DSSTox_CID_135
- Benzene, labeled with carbon-14 and tritium
- WLN: RH
- Epitope ID:116867
- Benzene, purification grade
- EC 200-753-7
- Benzene, analytical standard
- DSSTox_RID_79433
- Benzene, LR, >=99%
- DSSTox_GSID_39242
- BENZENE-1,2-D2
- BENZENE-1,3-D2
- ghl.PD_Mitscher_leg0.503
- 26181-88-4
- Benzene, anhydrous, 99.8%
- Benzene, AR, >=99.5%
- BENZENE-1,2,3-D3
- DTXSID3039242
- 3,4-DNH
- 1I83
- 220I
- 223I
- Benzene 10 microg/mL in Meth
- ZINC967532
- trans-N-Methylphenylcyclopro
- ACT02832
- BCP26158
- Benzene, for HPLC, >=99.8%
- Benzene, for HPLC, >=99.9%
- NSC67315

- PubChem

3 Chemical and Physical Properties

3.1 Computed Properties

Property Name	Property Value	Reference
Molecular Weight	78.11	Computed by PubChem 2.1 (PubChem release 2021.05.07)
XLogP3	2.1	Computed by XLogP3 3.0 (PubChem release 2019.06.18)
Hydrogen Bond Donor Count	0	Computed by Cactvs 3.4.6.11 (PubChem release 2019.06.18)
Hydrogen Bond Acceptor Count	0	Computed by Cactvs 3.4.6.11 (PubChem release 2019.06.18)
Rotatable Bond Count	0	Computed by Cactvs 3.4.6.11 (PubChem release 2019.06.18)
Exact Mass	78.0469501914	Computed by PubChem 2.1 (PubChem release 2021.05.07)
Monoisotopic Mass	78.0469501914	Computed by PubChem 2.1 (PubChem release 2021.05.07)
Topological Polar Surface Area	0 Å^2	Computed by Cactvs 3.4.6.11 (PubChem release 2019.06.18)
Heavy Atom Count	6	Computed by PubChem
Formal Charge	0	Computed by PubChem
Complexity	15.5	Computed by Cactvs 3.4.6.11 (PubChem release 2019.06.18)
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 2019.01.04)

▸ PubChem

3.2 Experimental Properties

3.2.1 Physical Description

Benzene appears as a clear colorless liquid with a petroleum-like odor. Flash point less than 0°F. Less dense than water and slightly soluble in water. Hence floats on water. Vapors are heavier than air.

▸ CAMEO Chemicals

Liquid; OtherSolid

▸ EPA Chemicals under the TSCA

Liquid

▸ Human Metabolome Database (HMDB)

COLOURLESS LIQUID WITH CHARACTERISTIC ODOUR.

▸ ILO International Chemical Safety Cards (ICSC)

Highly flammable colorless to light-yellow liquid with a petroleum-like odor.

▸ Occupational Safety and Health Administration (OSHA)

Colorless to light-yellow liquid with an aromatic odor. [Note: A solid below 42°F.]

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

Clear, colorless to light yellow liquid at room temperature. Benzene is a solid below 42°F (5.6°C).

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

3.2.2 Color/Form

Clear, colorless liquid

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 188

- Hazardous Substances Data Bank (HSDB)

Orthorhombic prisms or liquid

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 3-34

- Hazardous Substances Data Bank (HSDB)

Colorless to light-yellow liquid [Note: A solid below 42 degrees F]

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)

3.2.3 Odor

Aromatic 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)

Gasoline-like odor; rather pleasant aromatic odor. Odor threshold = 4.68 ppm.

Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984., p. 152

- Hazardous Substances Data Bank (HSDB)

3.2.4 Taste

Taste threshold in water is 0.5-4.5 mg/l.

USEPA; Supplement to Development Doc: Haz Subset Regs Sect 311, FWPCA, (1975) EPA 440/9-75-009

- Hazardous Substances Data Bank (HSDB)

3.2.5 Boiling Point

176.2 °F at 760 mm Hg (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

- CAMEO Chemicals

80.0 °C

- EPA DSSTox

80.08 °C

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 3-34

- Hazardous Substances Data Bank (HSDB)

80 °C

- ILO International Chemical Safety Cards (ICSC)

176.2°F

- Occupational Safety and Health Administration (OSHA)

176°F

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

3.2.6 Melting Point

41.9 °F (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

- CAMEO Chemicals

5.5 °C

- EPA DSSTox

5.558 °C

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 3-34

- Hazardous Substances Data Bank (HSDB)

5.5°C

- Human Metabolome Database (HMDB)

6 °C

- ILO International Chemical Safety Cards (ICSC)

41.9°F

- Occupational Safety and Health Administration (OSHA)

42°F

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

3.2.7 Flash Point

12 °F (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

- CAMEO Chemicals

12 °F (-11 °C) Closed Cup

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 188

- Hazardous Substances Data Bank (HSDB)

-11.0 °C (12.2 °F) (Closed cup)

Sigma-Aldrich; Material Safety Data Sheet for Benzene. Product Number: 12540, Version 5.2 (Revision Date 06/23/2014). Available from, as of October 9, 2014: ***https://www.sigmaaldrich.com/safety-center.html***

- Hazardous Substances Data Bank (HSDB)

-11 °C c.c.

- ILO International Chemical Safety Cards (ICSC)

12°F

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

3.2.8 Solubility

1 to 5 mg/mL at 64° F (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

▸ CAMEO Chemicals

0.02 M

MAY,WE ET AL. (1983)

▸ EPA DSSTox

In water, 1.79X10+3 mg/L at 25 °C

May WE et al; J Chem Ref Data 28: 197-0200 (1983)

▸ Hazardous Substances Data Bank (HSDB)

Miscible with alcohol, chloroform, ether, carbon disulfide, acetone, oils, carbon tetrachloride, and glacial acetic acid

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 188

▸ Hazardous Substances Data Bank (HSDB)

Miscible with ethanol, ethyl ether, acetone, chloroform; coluble in carbon tetrachloride

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 3-34

▸ Hazardous Substances Data Bank (HSDB)

1.79 mg/mL

▸ Human Metabolome Database (HMDB)

Solubility in water, g/100ml at 25 °C: 0.18

▸ ILO International Chemical Safety Cards (ICSC)

0.07%

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

3.2.9 Density

0.879 at 68 °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

0.8756 g/cu cm at 20 °C

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 3-34

▸ Hazardous Substances Data Bank (HSDB)

SPECIFIC DISPERSION 189.6; DENSITY OF SATURATED VAPOR-AIR MIXT AT 760 MM HG (AIR= 1) IS 1.22 AT 26 °C; PERCENT IN SATURATED IN AIR AT 760 MM HG IS 13.15 AT 26 °C

Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963., p. 1222

▸ Hazardous Substances Data Bank (HSDB)

Relative density (water = 1): 0.88

▸ ILO International Chemical Safety Cards (ICSC)

0.88

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

3.2.10 Vapor Density

2.77 (NTP, 1992) (Relative to Air)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

- CAMEO Chemicals

2.8 (Air = 1)

Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997., p. 325-16

- Hazardous Substances Data Bank (HSDB)

Relative vapor density (air = 1): 2.7

- ILO International Chemical Safety Cards (ICSC)

2.77

- Occupational Safety and Health Administration (OSHA)

3.2.11 Vapor Pressure

60 mm Hg at 59 °F ; 76 mm Hg at 68° F (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

- CAMEO Chemicals

94.80 mmHg

- EPA DSSTox

94.8 mm Hg at 25 °C

Daubert, T.E., R.P. Danner. Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, D.C.: Taylor and Francis, 1989., p. 361

- Hazardous Substances Data Bank (HSDB)

Vapor pressure, kPa at 20 °C: 10

- ILO International Chemical Safety Cards (ICSC)

75 mmHg

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

3.2.12 LogP

2.13 (LogP)

HANSCH,C ET AL. (1995)

- EPA DSSTox

log Kow = 2.13

Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995., p. 18

- Hazardous Substances Data Bank (HSDB)

2.13

HANSCH,C ET AL. (1995)

- Human Metabolome Database (HMDB); ILO International Chemical Safety Cards (ICSC)

3.2.13 LogKoa

2.78 (Octanol-Air partition coefficient)

- EPA DSSTox

3.2.14 Henrys Law Constant

0.01 atm-m3/mole

- EPA DSSTox

Henry's Law constant= 5.56X10-3 atm-cu m/mol at 25 °C

Mackay D et al; Environ Sci Technol 13: 333-36 (1979)

- Hazardous Substances Data Bank (HSDB)

3.2.15 Atmospheric OH Rate Constant

1.23e-12 cm3/molecule*sec

ATKINSON,R (1989)

- EPA DSSTox

3.2.16 Stability/Shelf Life

Stable under recommended storage conditions.

*Sigma-Aldrich; Material Safety Data Sheet for Benzene. Product Number: 12540, Version 5.2 (Revision Date 06/23/2014). Available from, as of October 9, 2014: **https://www.sigmaaldrich.com/safety-center.html***

- Hazardous Substances Data Bank (HSDB)

3.2.17 Autoignition Temperature

1097 °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

928 °F (498 °C)

National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 325-18

- Hazardous Substances Data Bank (HSDB)

498 °C

- ILO International Chemical Safety Cards (ICSC)

3.2.18 Viscosity

0.604 mPa.s at 25 °C

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 6-238

- Hazardous Substances Data Bank (HSDB)

3.2.19 Heat of Combustion

-3267.6 kJ/mol (liquid)

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 5-68

▸ Hazardous Substances Data Bank (HSDB)

3.2.20 Heat of Vaporization

33.83 kJ/mol at 25 °C

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 6-132

▸ Hazardous Substances Data Bank (HSDB)

3.2.21 Surface Tension

28.22 mN/m at 25 °C

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 6-184

▸ Hazardous Substances Data Bank (HSDB)

3.2.22 Ionization Potential

9.24 eV

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

3.2.23 Odor Threshold

4.68 PPM

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)

In air: 4.9 mg/cu m (characteristic odor), in water: 2.0 mg/l.

USEPA; Health Advisories for 25 Organics: Benzene p.19 (1987) PB 87-235578

▸ Hazardous Substances Data Bank (HSDB)

distinct odor: 310 mg/cu m= 90 ppm

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. 256

▸ Hazardous Substances Data Bank (HSDB)

human odor perception: 3.0 mg/cu m=1 ppm

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. 256

▸ Hazardous Substances Data Bank (HSDB)

3.2.24 Refractive Index

Index of refraction: 1.5011 at 20 °C/D

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 3-34

▸ Hazardous Substances Data Bank (HSDB)

3.2.25 Relative Evaporation Rate

2.8 (Ether = 1)

AAI, Alliance of American Insurers, Handbook of Organic Industrial Solvents (1980) as cited in DHHS/ATSDR; Toxicological Profile for Benzene (Draft) p.34 (Dec/1987)

▸ Hazardous Substances Data Bank (HSDB)

3.2.26 Kovats Retention Index

Standard non-polar	647.5, 638.32, 638.98, 645, 630, 640.2, 639, 638.6, 640.7, 645, 645, 646, 643.1, 640.5, 641.77, 641.83, 630, 644, 654, 641.72, 642, 642, 654, 654, 648, 648.9, 651.4, 640.61, 643.07, 644.46, 654, 642.7, 645.26, 646, 647.11, 642, 650, 648, 647, 645, 646.8, 648.9, 650.2, 651.1, 652.6, 657.6, 638, 649.89, 651.77, 653.93, 656.09, 658.35, 660.36, 663.6, 664.4, 666.96, 670.44, 672.02, 674.86, 672, 684.6, 629, 670.45, 654.52, 662, 663, 663, 668, 654, 649.7, 644, 677, 654.7, 660.2, 663.2, 667.4, 649.4, 656.3, 643, 678.1, 688, 653.5, 653.8, 654.2, 654.2, 654.4, 649, 647.2, 669.9, 666, 655, 655, 664, 664, 663.1, 670.7, 663, 651.3, 651.4, 655.4, 655.8, 654, 655, 661.6, 649, 653, 658, 661, 662, 664, 672, 652.1, 654.1, 656, 658.3, 681, 655, 681, 668, 675, 669, 662, 662, 664, 664, 647, 649, 651, 653, 656, 658, 653.8, 654.4, 657.1, 664, 652, 659, 670, 664, 671, 678, 642, 650, 651, 653, 654, 645.7, 648, 648.4, 650.3, 650.5, 652.6, 652.7, 654.9, 655.2, 657.2, 658.2, 659.7, 663.6, 670.7, 677.8, 646, 659.1, 647, 648, 674, 650, 654.7, 654.7, 654.8, 654.8, 654.8, 654.8, 652, 654, 654, 656, 656, 692, 660, 648, 643, 653, 657, 660, 663, 667, 668, 668, 637, 658, 662, 668, 668, 668, 668, 672, 678, 670, 657, 651, 654.1, 656, 644.9, 647.7, 647.5, 643.1, 656.1, 644.1, 639.25, 645.5, 654, 664, 652, 651.5, 638.83, 649, 640, 651.1, 649, 654, 657, 655, 648, 654, 657, 664, 657, 643, 640, 653, 651, 640, 658, 657, 663, 664, 670, 670, 649, 638, 640, 640, 660, 665, 654, 655, 655, 656, 657, 658, 659, 653, 644, 647, 648.6, 658, 663.5, 664.6, 642, 644, 643, 644, 638, 634, 644, 640.5, 665, 644, 641, 653, 669, 673, 651, 655, 660, 642, 641, 644, 670, 648, 652, 653, 665, 665, 654
Semi-standard non-polar	663, 654, 662, 663, 648, 653.8, 654.8, 654.2, 654.8, 656.1, 660.6, 648, 659, 658, 664, 654.1, 660.1, 653.8, 654.2, 654.8, 654.8, 656.1, 654, 655.57, 658.13, 659.63, 672.74, 674.03, 685, 694.74, 664, 667, 686, 678.8, 683.3, 641.45, 641.51, 641.96, 666.03, 667.42, 669.56, 671.74, 673.5, 675.7, 677.75, 680.27, 681.27, 683.59, 685.29, 687.79, 682.5, 676, 686.4, 662, 636.6, 639.1, 641.7, 644.5, 646.6, 650, 652.5, 677.2, 675, 649.9, 681.3, 649, 675, 637.2, 641.8, 666.5, 667.4, 650, 645, 637, 641.4, 630, 650, 687, 646, 642, 651, 687, 647, 652, 653, 670, 675, 671.1, 673, 675.1, 677.2, 679.5, 681.9, 647, 650, 685.2, 685.6, 686.8, 687.4, 667, 680, 648, 650.22, 638, 638, 642.9, 683, 650, 637.4, 642.2, 637.2, 642.5, 651, 652, 648, 642.5, 642.9, 647.8, 648, 648.7, 649, 641.1, 641.4, 648, 650.2, 636.8, 684, 650, 645.5, 646, 659.2, 678.8, 639, 642, 644.42, 652, 650, 636, 644, 637, 642, 650.4, 638, 660.7, 644, 649, 652, 655, 657, 660, 662, 640, 639.7, 665, 648, 637, 685, 648.5, 646.6, 653.6, 681, 634, 640, 645, 649, 645, 650, 655, 660, 680, 681, 686, 694, 631, 632, 634, 643, 645, 691, 653, 657, 642, 642, 657, 655, 661, 661, 665.5, 646, 643.7, 659.9, 655.6, 663, 686, 653, 662, 663, 671, 661, 645.3, 667, 655.1, 643, 668, 661, 674, 671.3, 654.4, 625, 640, 650.4, 663, 666, 652, 663, 638, 650, 682, 610, 622, 645, 645, 654, 635, 658, 655
Standard polar	936, 938, 938, 938, 936, 940, 954, 942, 943, 947, 930, 939, 938, 940, 947, 938, 926, 965, 947, 979, 979.4, 988.6, 999.5, 1007.64, 947.77, 953.66, 963.67, 971.57, 980.53, 989.54, 998.62, 953, 970, 971, 925, 955.5, 945.2, 958.2, 959.5, 964, 967.7, 992, 952, 924, 971, 957.21, 960.69, 964.88, 968.66, 972.8, 976.91, 979, 954.5, 965.7, 973.3, 979.3, 982.6, 969.7, 974.2, 978.8, 983.4, 992.6, 959, 955, 967, 972.6, 973.4, 985.7, 947.2, 933.4, 1000, 1005, 978, 987, 991, 970, 985, 967, 974, 981, 987, 957, 936, 938, 951, 937, 936, 938, 924, 956, 965, 975, 982, 994, 964.3, 955, 956, 957, 979, 983, 934, 951.4, 943.9, 947, 952, 959, 960, 965, 938, 932, 933, 959.5, 947, 954, 938, 930, 947, 950, 937, 937, 937, 938, 937, 937, 935, 959, 965, 948, 947.6, 946.6, 956.4

▸ NIST Mass Spectrometry Data Center

3.2.27 Other Experimental Properties

Conversion factors: 1 mg/cu m = 0.31 ppm; 1 ppm = 3.26 mg/cu m

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. 255

▸ Hazardous Substances Data Bank (HSDB)

Blood/air partition coefficient is 7.8

Sato A, Nakajima T; Toxicol Appl Pharmacol 48 p.49 (1979)

▸ Hazardous Substances Data Bank (HSDB)

Sublimes -30 to 5 °C

Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988., p. C-664

▸ Hazardous Substances Data Bank (HSDB)

Heat of fusion = 9.87 KJ/mol

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 6-151

▸ Hazardous Substances Data Bank (HSDB)

For more Other Experimental Properties (Complete) data for BENZENE (6 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

3.3 SpringerMaterials Properties

13C nuclear magnetic resonance spectrum
Coriolis coupling
Dunham energy parameter
Gibbs energy
Schoenflies notation
Absorbance
Acentric factor
Activation energy
Activity
Adsorbate coverage
Angular frequency
Azeotropes
Band gap energy
Band structure
Boiling point
Centrifugal distortion
Charge carrier mobility
Chemical bond
Chemical diffusion
Chemical shift
Composition
Compressibility
Core level transition
Corrosion
Creep
Critical point
Crystal structure
Crystallographic point group
Defect energy
Density
Density functional theory
Diamagnetic susceptibility
Diamagnetic susceptibility exaltation
Dielectric constant
Dielectricity
Diffusion
Diffusion of impurities
Diffusive flux
Dispersion
Effective mass
Elastic coefficients
Elasticity
Elastooptic coefficient
Electron conductivity
Electron diffraction
Electronic structure
Electrooptical constant
Enthalpy
Entropy
Equilibrium structure
Exaltation data
Excess enthalpy
Excess volume
Exciton fine structure
External quantum efficiency
Fluorescence
Formation energy
Formation enthalpy
Formation entropy
Formula unit
Formula weight
Fusion entropy
Fusion temperature
Grain size
Gross formula
Heat capacity
Heat flow rate
Heat of solution
Heat of sublimation
Heat transfer coefficient
High frequency properties
Hydrogen bonding potential
Impurity concentration
Internuclear distance
Ionic conductivity
Isentropic compressibility
Isotope mass-effect
Kinetic properties
Laser-induced fluorescence
Latent heat
Lattice stiffness
Liquid-liquid equilibrium
Luminescence
Luminescence emission linewidth
Magnetic anisotropy
Magnetic susceptibility
Magnetic susceptibility exaltation
Mass loss rate
Melting curve
Melting temperature
Migration energy
Mixing enthalpy
Mobility
Molar heat capacity
Molar mass
Molecular structure
Neutron scattering
Nuclear magnetic r
Nuclear quadrupole
Nuclear quadrupole
Optical coefficient
Partial pressure
Phase diagram
Phase equilibrium
Phase transition
Phonon wavenumb
Photoemission
Photoemission spe

▸ SpringerMaterials

4 Spectral Information

4.1 1D NMR Spectra

Showing 2 of 3 View More

1D NMR Spectra	NMR: 3429 (Sadtler Research Laboratories Spectral Collection)

Hazardous Substances Data Bank (HSDB)

1D NMR Spectra	1D NMR Spectrum 2592 - Benzene (HMDB0001505) 1D NMR Spectrum 3288 - Benzene (HMDB0001505)

Human Metabolome Database (HMDB)

4.1.1 1H NMR Spectra

Instrument Name	Varian A-60
Source of Sample	James Hinton, Valparaiso, Florida
Copyright	Copyright © 2009-2020 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

SpectraBase

4.1.2 13C NMR Spectra

Showing 2 of 315 View More

13C NMR Spectra	13C NMR: 49 (Stothers, Carbon-13 NMR Spectroscopy, Academic Press, New York)

Hazardous Substances Data Bank (HSDB)

Source of Sample	MCB Manufacturing Chemists, Norwood, Ohio
Copyright	Copyright © 1980, 1981-2020 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

▸ SpectraBase

4.2 2D NMR Spectra

2D NMR Spectra	2D NMR Spectrum 1659 - Benzene (HMDB0001505)

▸ Human Metabolome Database (HMDB)

4.3 Mass Spectrometry

Showing 2 of 27 View More

Source of Spectrum	Chemical Concepts, A Wiley Division, Weinheim, Germany
Copyright	Copyright © 2002-2020 Wiley-VCH Verlag GmbH & Co. KGaA. All Rights Reserved.
Thumbnail	

▸ SpectraBase

Source of Spectrum	Chemical Concepts, A Wiley Division, Weinheim, Germany
Copyright	Copyright © 2002-2020 Wiley-VCH Verlag GmbH & Co. KGaA. All Rights Reserved.
Thumbnail	

▸ SpectraBase

4.3.1 GC-MS

Showing 2 of 10 View More

GC-MS	GC-MS Spectrum 27186 - Benzene (HMDB0001505) GC-MS Spectrum 27237 - Benzene (HMDB0001505) GC-MS Spectrum 29300 - Benzene (HMDB0001505) GC-MS Spectrum 29985 - Benzene (HMDB0001505) GC-MS Spectrum 99692 - Benzene (HMDB0001505) GC-MS Spectrum 99693 - Benzene (HMDB0001505) GC-MS Spectrum 99694 - Benzene (HMDB0001505) GC-MS Spectrum 99695 - Benzene (HMDB0001505)

▸ Human Metabolome Database (HMDB)

MoNA ID	JP002103
MS Category	Experimental
MS Type	GC-MS
MS Level	MS1
Instrument	HITACHI RMU-7M
Instrument Type	EI-B
Ionization Mode	positive
Top 5 Peaks	78 100 77 21.2 52 18.8 51 14.8 50 11.5
SPLASH	splash10-004i-9000000000-70967112fec69784847c
Thumbnail	
Submitter	University of Tokyo Team, Faculty of Engineering, University of Tokyo

▸ MassBank of North America (MoNA)

4.3.2 MS-MS

MS-MS	MS-MS Spectrum 6501 - Benzene (HMDB0001505) MS-MS Spectrum 6502 - Benzene (HMDB0001505) MS-MS Spectrum 6503 - Benzene (HMDB0001505) MS-MS Spectrum 6504 - Benzene (HMDB0001505)

Human Metabolome Database (HMDB)

4.3.3 EI-MS

EI-MS	EI-MS Spectrum 1270 - Benzene (HMDB0001505)

Human Metabolome Database (HMDB)

4.3.4 Other MS

Other MS	MASS: 61115 (NIST/EPA/MSDC Mass SPectral Database, 1990 version); 1790 (Atlas of Mass Spectral Data, John Wiley & Sons, New York)

Hazardous Substances Data Bank (HSDB)

MoNA ID	MSJ00090
MS Category	Experimental
MS Level	MS1
Instrument	PTR-QMS 500 (IONICON Analytik GmbH, Innsbruck, Austria)
Instrument Type	CI-Q
Ionization	CI
Ionization Mode	positive
Top 5 Peaks	78 5.2 108 1.7
SPLASH	splash10-004i-9200000000-d4888ed94a6a4e783628
Thumbnail	
Submitter	Mass Spectrometry Society of Japan Team, Mass Spectrometry Society of Japan

MassBank of North America (MoNA)

4.4 UV Spectra

MAX ABSORPTION (ALCOHOL): 243 NM (LOG E= 2.2), 249 NM (LOG E= 2.3), 256 NM (LOG E= 2.4), 261 NM (LOG E= 2.2); SADTLER REF NUMBER: 6402 (IR, PRISM), 1765 (UV)

Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988., p. C-146

Hazardous Substances Data Bank (HSDB)

UV: 198 (Sadtler Research Laboratories Spectral Collection)

Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. V1: 575

▸ Hazardous Substances Data Bank (HSDB)

4.5 IR Spectra

IR Spectra	IR: 136 (Sadtler Research Laboratories IR Grating Collection)

▸ Hazardous Substances Data Bank (HSDB)

4.5.1 FTIR Spectra

Showing 2 of 6 View More

Technique	NEAT
Source of Sample	J. T. Baker Chemical Company
Copyright	Copyright © 1980, 1981-2020 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

▸ SpectraBase

Technique	LIQUID, 15 MICROMETERS
Source of Spectrum	SCHOLL
Copyright	Copyright © 1980, 1981-2020 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

▸ SpectraBase

4.5.2 ATR-IR Spectra

Technique	ATR-Neat
Copyright	Copyright © 1980, 1981-2020 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

▸ SpectraBase

Source of Sample	Sigma-Aldrich
Catalog Number	319953
Copyright	Copyright © 2018-2020 Sigma-Aldrich Co. LLC. - Database Compilation Copyright © 2018-2020 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

▸ SpectraBase

4.5.3 Near IR Spectra

Technique	NIR Path Length= 2/50 Spectrometer= INSTRUMENT PARAMETERS=INST=BRUKER,RSN=21162,REO=2,CNM=HEI,ZFF=2 Spectrometer= BRUKER IFS 88
Source of Spectrum	Prof. Buback, University of Goettingen, Germany
Copyright	Copyright © 1989, 1990-2020 Wiley-VCH Verlag GmbH & Co. KGaA. All Rights Reserved.
Thumbnail	

SpectraBase

Technique	NIR Path Length= 2/50 Spectrometer= INSTRUMENT PARAMETERS=INST=BRUKER,RSN=21162,REO=2,CNM=HEI,ZFF=2 Spectrometer= BRUKER IFS 88
Source of Spectrum	Prof. Buback, University of Goettingen, Germany
Copyright	Copyright © 1989, 1990-2020 Wiley-VCH Verlag GmbH & Co. KGaA. All Rights Reserved.
Thumbnail	

SpectraBase

4.5.4 Vapor Phase IR Spectra

Instrument Name	DIGILAB FTS-14
Technique	Vapor Phase
Copyright	Copyright © 1980, 1981-2020 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

SpectraBase

Technique	Vapor Phase
Source of Spectrum	Sigma-Aldrich Co. LLC.
Source of Sample	Sigma-Aldrich
Catalog Number	154628
Copyright	Copyright © 2018-2020 Sigma-Aldrich Co. LLC. - Database Compilation Copyright © 2020-2020 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

SpectraBase

4.6 Raman Spectra

Showing 2 of 3 View More

Raman Spectra	Raman: 66 (Dollish et al; Characteristic Raman Frequencies of Organic Compounds, John Wiley & Sons, New York)

Hazardous Substances Data Bank (HSDB)

Technique	FT-Raman
Source of Spectrum	Forensic Spectral Research
Source of Sample	Chemsavers, Inc.
Copyright	Copyright © 2015-2020 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

▸ SpectraBase

4.7 Other Spectra

Intense mass spectral peaks: 78 m/z

Pfleger, K., H. Maurer and A. Weber. Mass Spectral and GC Data of Drugs, Poisons and their Metabolites. Parts I and II. Mass Spectra Indexes. Weinheim, Federal Republic of Germany. 1985., p. 73

▸ Hazardous Substances Data Bank (HSDB)

5 Related Records

5.1 Related Compounds with Annotation

▸ PubChem

5.2 Related Compounds

Same Connectivity	27 Records
Same Parent, Connectivity	745 Records
Same Parent, Exact	705 Records
Mixtures, Components, and Neutralized Forms	19,208 Records
Similar Compounds	737 Records
Similar Conformers	11,874 Records

▸ PubChem

5.3 Substances

5.3.1 Related Substances

All	23,371 Records
Same	581 Records
Mixture	22,790 Records

▸ PubChem

5.3.2 Substances by Category

▸ PubChem

5.4 Entrez Crosslinks

PubMed	29,126 Records
Protein Structures	22 Records
Taxonomy	9 Records
OMIM	24 Records
Gene	1,129 Records

▸ PubChem

5.5 NCBI LinkOut

▸ NCBI

6 Chemical Vendors

▸ PubChem

7 Drug and Medication Information

7.1 Therapeutic Uses

MEDICATION (VET): Has been used as a disinfectant. /Former Use/

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 188

▸ Hazardous Substances Data Bank (HSDB)

7.2 Drug Warnings

Protected intercourse may be prudent following high exposure to benzene. As well, nursing mothers may be advised to discontinue nursing for 5 days following high exposure.

Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994, p. 712

▸ Hazardous Substances Data Bank (HSDB)

7.3 Reported Fatal Dose

Immediately dangerous to life and health = 500 ppm

Sullivan, J.B., Krieger G.R. (eds). Clinical Environmental Health and Toxic Exposures. Second edition. Lippincott Williams and Wilkins, Philadelphia, Pennsylvania 1999., p. 754

▸ Hazardous Substances Data Bank (HSDB)

... It has been estimated that 5-10 minutes of exposure to 20,000 ppm benzene in air is usually fatal.

U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Benzene p.30 PB2008-100004 (2007). Available from, as of August 12, 2014: ***https://www.atsdr.cdc.gov/toxprofiles/index.asp***

▸ Hazardous Substances Data Bank (HSDB)

Estimated oral doses from 9-30 g have proved fatal.

WHO; Environmental Health Criteria 150: Benzene p.46 (1993)

▸ Hazardous Substances Data Bank (HSDB)

Single exposures to concentrations of 66,000 mg/cu m (20,000 ppm) commercial benzene have been reported to be fatal in man within 5-10 minutes. At lower levels, loss of consciousness, irregular heart-beat, dizziness, headache and nausea are observed.

IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: ***https://monographs.iarc.fr/ENG/Classification/index.php****, p. V29 116 (1982)*

▸ Hazardous Substances Data Bank (HSDB)

8 Food Additives and Ingredients

8.1 Food Additive Classes

JECFA Functional Classes

Food Additives -> EXTRACTION_SOLVENT

▸ Joint FAO/WHO Expert Committee on Food Additives (JECFA)

8.2 FDA Substances Added to Food

Substance	BENZENE
Document Number (21 CFR)	172.560 175.105

▸ FDA Center for Food Safety and Applied Nutrition (CFSAN)

8.3 Evaluations of the Joint FAO/WHO Expert Committee on Food Additives - JECFA

Chemical Name	BENZENE
Evaluation Year	1979
ADI	NOT TO BE USED
Report	TRS 648-JECFA 23/18

▸ Joint FAO/WHO Expert Committee on Food Additives (JECFA)

9 Pharmacology and Biochemistry

9.1 Pharmacology

Benzene is a clear, colorless, highly flammable and volatile, liquid aromatic hydrocarbon with a gasoline-like odor. Benzene is found in crude oils and as a by-product of oil-refining processes. In industry benzene is used as a solvent, as a chemical intermediate, and is used in the synthesis of numerous chemicals. Exposure to this substance causes neurological symptoms and affects the bone marrow causing aplastic anemia, excessive bleeding and damage to the immune system. Benzene is a known human carcinogen and is linked to an increased risk of developing lymphatic and hematopoietic cancers, acute myelogenous leukemia, as well as chronic lymphocytic leukemia. (NCI05)

▸ NCI Thesaurus (NCIt)

9.2 Absorption, Distribution and Excretion

Benzene is readily absorbed via lung, & about 40-50% is retained. ... It is taken up preferentially by fatty & nervous tissues, & about 30-50% ... is excreted unchanged via lung; a 3-phase excretion pattern is seen at ... /approx/ 0.7-1.7 hr, 3-4 hr, & 20-30 hr.

IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: ***https://monographs.iarc.fr/ENG/Classification/index.php****, p. V7 211 (1974)*

▸ Hazardous Substances Data Bank (HSDB)

When benzene was placed on skin under closed cup it was absorbed at rate of 0.4 mg/sq cm/hr (Hanke et al 1961) ...

IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: ***https://monographs.iarc.fr/ENG/Classification/index.php****, p. V29 117 (1982)*

▸ Hazardous Substances Data Bank (HSDB)

Mice treated SC with 2 mL (3)H-labeled benzene/kg contained irreversibly bound radioactivity with decreasing binding magnitude in the following organs: liver, brain, kidney, spleen, fat. Mice treated with 2 daily SC doses of 0.5 mL (3)H-benzene/kg for 1-10 days showed a radioactivity binding with liver & bone marrow residues which increased with treatment duration, except in the case of binding to bone marrow which decreased after day 6.

PMID:663402
Snyder R et al; Res Commun Chem Pathol Pharmacol 20 (1): 191-4 (1978)

▸ Hazardous Substances Data Bank (HSDB)

When administered to mice subcutaneously, 72% of dose is recovered in expired air.

PMID:849319
Andrews LS et al; Biochem Pharmacol 26: 293 (1977)

▸ Hazardous Substances Data Bank (HSDB)

For more Absorption, Distribution and Excretion (Complete) data for BENZENE (14 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

9.3 Metabolism/Metabolites

The major metabolitesof benzene metabolism are phenol, hydroquinone, and catechol. These metabolites are interactive and can affect the rate of each other's metabolism because they are substrates for the P-450 enzyme system. The route of exposure has little effect on the subsequent metabolism of benzene to hemotoxic metabolites.

Sullivan, J.B., Krieger G.R. (eds). Clinical Environmental Health and Toxic Exposures. Second edition. Lippincott Williams and Wilkins, Philadelphia, Pennsylvania 1999., p. 754

▸ Hazardous Substances Data Bank (HSDB)

Metabolic products in rat ... are phenol, hydroquinone, catechol, hydroxyhydroquinone, & phenylmercapturic acid. Conjugated phenols have been reported ... except for a small amt of free phenol, all the phenolic metabolites were excreted in conjugated form. When (3)H-benzene was admin to mice, (3)H2O was also recovered from urine.

National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977., p. 688

▸ Hazardous Substances Data Bank (HSDB)

Yields N-acetyl-S-phenyl-cysteine in rat. Yields benzyl alcohol in guinea pigs. ... Yields cis-1,2-dihydro-1,2-dihydroxybenzene in pseudomonas. Phenol in pseudomonas & achromobacter. Yields cis,cis-muconic acid in rabbit. /From table/

Goodwin, B.L. Handbook of Intermediary Metabolism of Aromatic Compounds. New York: Wiley, 1976., p. B-4

▸ Hazardous Substances Data Bank (HSDB)

In the rabbit, the major hydroxylation product of benzene was phenol, which along with some catechol and hydroquinone, was found in the urine conjugated with ethereal sulfate or glucuronic acid.

USEPA; Ambient Water Quality Criteria: Benzene p.C-11 (1980) EPA 440/5-80-018

▸ Hazardous Substances Data Bank (HSDB)

For more Metabolism/Metabolites (Complete) data for BENZENE (26 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

Benzene has known human metabolites that include phenol.

S73 | METXBIODB | Metabolite Reaction Database from BioTransformer | DOI:10.5281/zenodo.4056560

▸ NORMAN Suspect List Exchange

9.4 Biological Half-Life

Biodegradation Half-Life

6.00 Days

▸ EPA DSSTox

The excretion of unchanged benzene from the lung of rats was reported to be biphasic, suggesting a two-compartment model for distribution and a half-life of 0.7 hr. This agreed with experimental half-life values for various tissues that ranged from 0.4 to 1.6 hr.

Rickert DE et al; Toxicol Appl Pharmacol 49: 417 (1979) as cited in USEPA; Ambient Water Quality Criteria: Benzene p.C-11 (1980) EPA 440/5-80-018

▸ Hazardous Substances Data Bank (HSDB)

... The half-time of benzene in /high lipid content/ tissues is approximately 24 hours.

Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994, p. 146

▸ Hazardous Substances Data Bank (HSDB)

9.5 Mechanism of Action

Covalent interaction of a benzene metabolite with dna was shown in vivo, but no information was given about the chem nature of this metabolite. A likely intermediate in benzene metabolism is benzene oxide. In neutral aq media it rearranges only slowly to the phenol so that its lifetime could be long enough for diffusion from the site of activation to the dna. Alternatively, the metabolic appearance of polyhydroxy derivatives suggests the formation of a phenol epoxide, so that the reactive molecule could be a secondary metabolite.

PMID:890848

Lutz WK, Schlatter C; Chem Biol Interact 18 (2): 241-6 (1977)

▸ Hazardous Substances Data Bank (HSDB)

The available evidence supports the concept that benzene toxicity is caused by one or more metabolites of benzene. ... Benzene metabolites containing 2 or 3 hydroxyl groups inhibited mitosis. Toluene, which inhibits benzene metabolism, protected animals against benzene-induced myelotoxicity. Benzene toxicity could be correlated with the appearance of benzene metabolites in bone marrow. Although it is clear that benzene can be metabolized in bone marrow, the observation that partial hepatectomy protects against benzene toxicity suggests that a metabolite formed in liver is essential for benzene toxicity.

IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: https://monographs.iarc.fr/ENG/Classification/index.php, p. V29 113 (1982)

▸ Hazardous Substances Data Bank (HSDB)

... Importance of polyhydroxylated derivatives of benzene & their semiquinones. ... /It has been/ shown that hydroquinone inhibits rat brain microtubule polymerization; that hydroquinone & para-benzoquinone are the most potent inhibitors of T- & B-lymphocyte function, as measured in mouse spleen cells in culture; that hydroquinone inhibits lectin-stimulated lymphocyte agglutination in rat spleen prepn in vitro; & that para-benzoquinone is the metabolite most likely to be responsible for suppression of lymphocyte transformation & microtubule assembly in rat spleen cells in culture. However, admin of these cmpd to animals does not produce the typical picture of benzene toxicity ... admin /of/ major metabolites of benzene to mice ... failed to ... decr ... red blood cell production, using the (59)Fe uptake technique ... /it's been/ suggested that ring-opening products may play a role in benzene toxicity. ... In mice benzene treatment suppressed subsequent colony forming unit-C formation from bone-marrow cells in vitro. Treating the animals with phenol, hydroquinone or benzene dihydrodiol failed to suppress colony forming unit-C. Thus, the toxic metabolites of benzene have yet to be identified.

IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: https://monographs.iarc.fr/ENG/Classification/index.php, p. V29 113 (1982)

▸ Hazardous Substances Data Bank (HSDB)

... Radioactivity /has been demonstrated/ in a nucleic acid fraction from rat liver following admin of either (3)h- or (14)C-labelled benzene. It has been shown that benzene binds covalently to protein in liver, bone marrow, kidney, lung, spleen, blood, & muscle. Less covalent binding was observed to the protein of bone marrow, blood, & spleen of C57Bl/6 mice, which are more resistant to the benzene-induced effects on red cell production, than to that of sensitive DBA/2 mice. ... Covalent binding of benzene to protein in perfused bone-marrow prepn /has been demonstrated/. ... A metabolite of phenol binds to liver protein more efficiently than does benzene oxide, & they have electrophoretically separated hepatic proteins to which benzene preferentially binds. ... Covalent binding to mitochondria is a prominent feature of benzene metabolism. ... There is relatively more radioactivity in a nucleic acid-rich fraction of a benzene metabolite isolated from mouse bone-marrow cells than in a similar fraction from liver.

IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: https://monographs.iarc.fr/ENG/Classification/index.php, p. V29 113 (1982)

▸ Hazardous Substances Data Bank (HSDB)

For more Mechanism of Action (Complete) data for BENZENE (12 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

9.6 Human Metabolite Information

9.6.1 Tissue Locations

Bone Marrow
Epidermis
Leukocyte
Liver

▸ Human Metabolome Database (HMDB)

9.7 Biochemical Reactions

▸ Rhea - Annotated Reactions Database

▸ PubChem

9.8 Transformations

▸ NORMAN Suspect List Exchange

10 Use and Manufacturing

10.1 Use Classification

Chemical Classes -> Hydrocarbons (contain hydrogen and carbon atoms), Volatile organic compounds

▸ CDC-ATSDR Toxic Substances Portal

Hazardous Air Pollutants (HAPs)

▸ EPA Air Toxics

Food Additives -> EXTRACTION_SOLVENT -> JECFA Functional Classes

▸ Joint FAO/WHO Expert Committee on Food Additives (JECFA)

Fire Hazards -> Carcinogens, Mutagens, Flammable - 3rd degree

▸ NJDOH RTK Hazardous Substance List

Systemic Agents -> NIOSH Emergency Response Categories

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

SOLVENTS

▸ USGS Columbia Environmental Research Center

10.2 Household Products

Household & Commercial/Institutional Products

Information on 72 consumer products that contain Benzene in the following categories is provided:

- Auto Products
- Commercial / Institutional
- Home Maintenance
- Inside the Home
- Pet Care

▸ Consumer Product Information Database (CPID)

10.3 Uses

Benzene is used as a constituent in motor fuels; as a solvent for fats, waxes, resins, oils, inks, paints, plastics, and rubber; in the extraction of oils from seeds and nuts; and in photogravure printing. It is also used as a chemical intermediate. Benzene is also used in the manufacture of detergents, explosives, pharmaceuticals, and dyestuffs.

▸ EPA Air Toxics

EPA CPDat Chemical and Product Categories

- EPA Chemical and Products Database (CPDat)

For benzene (USEPA/OPP Pesticide Code: 008801) there are 0 labels match. /SRP: Not registered for current 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 Benzene (71-43-2). Available from, as of January 29, 2014: ***https://npirspublic.ceris.purdue.edu/ppis/***

- Hazardous Substances Data Bank (HSDB)

Manufacture of industrial chemicals such as polymers, detergents, pesticides pharmaceuticals, dyes, plastics, resins. Organic solvent for waxes, resins, oils, natural rubber, etc. Reference for quantitating compounds. Gasoline additive.

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 188

- Hazardous Substances Data Bank (HSDB)

Used for printing and lithography, paint, rubber, dry cleaning, adhesives and coatings, detergents

NIOSH; Criteria Document: Benzene. DHEW Pub No 74-137 p. 20 (1974)

- Hazardous Substances Data Bank (HSDB)

Extraction and rectification; preparation and use of inks in the graphic arts industries; as a thinner for paints; as a degreasing agent

Fishbein L; Potential Indust Carcins & Mutagens p.96 (1977) USEPA 560/ 5-77-005

- Hazardous Substances Data Bank (HSDB)

For more Uses (Complete) data for BENZENE (10 total), please visit the HSDB record page.

- Hazardous Substances Data Bank (HSDB)

Benzene is used to make chemicals used in the manufacture of industrial products such as dyes, detergents, explosives, pesticides, synthetic rubber, plastics, and pharmaceuticals. Benzene is found in gasoline and trace amounts are found in cigarette smoke. Benzene has been banned as an ingredient in products intended for use in the home, including toys. Benzene has a sweet, aromatic, gasoline-like odor. Most individuals can begin to smell benzene in air at 1.5 to 4.7 ppm. The odor threshold generally provides adequate warning for acutely hazardous exposure concentrations but is inadequate for more chronic exposures.

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

10.3.1 Industry Uses

Adhesives and sealant chemicals
Fuels and fuel additives
Intermediates
Laboratory chemicals
Plasticizers
Processing aids, not otherwise listed
Processing aids, specific to petroleum production
Rubber Vehicle Tires
Sold to re-sellers for petroleum fuel and petrochemical industry
Solvents (for cleaning and degreasing)
Solvents (which become part of product formulation or mixture)

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

- EPA Chemicals under the TSCA

10.3.2 Consumer Uses

Adhesives and sealants
Automotive care products
Chemical Feed Stock
Sold to re-sellers for petroleum fuel and petrochemical industry
petrochemicals

Cleaning and furnishing care products
Food packaging
Fuels and related products
Intermediate
Intermediates
Lubricants and greases
Metal products not covered elsewhere
Paper products
Plastic and rubber products not covered elsewhere

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

▸ EPA Chemicals under the TSCA

10.4 Methods of Manufacturing

Worldwide, ~30% of commercial benzene is produced by catalytic reforming, a process in which aromatic molecules are produced from the dehydrogenation of cycloparaffins, dehydroisomerization of alkyl cyclopentanes, and the cyclization and subsequent dehydrogenation of paraffins. The feed to the catalytic reformer may be a straight-run, hydrocracked, or thermally cracked naphtha fraction in the C6 to 200 °C range. If benzene is the main product desired, a narrow naphtha cut of 71-104 °C is fed to the reformer. The reforming catalyst most frequently consists of platinum-rhenium on a high surface area alumina support. The reformer operating conditions and type of feedstock largely determine the amount of benzene that can be produced. The benzene product is most often recovered from the reformate by solvent extraction techniques.

Fruscella W; Benzene. Kirk-Othmer Encyclopedia of Chemical Technology (1999-2014). John Wiley & Sons, Inc. Online Posting Date: June 10, 2002

▸ Hazardous Substances Data Bank (HSDB)

Benzene is produced from the hydrodemethylation of toluene under catalytic or thermal conditions. The main catalytic hydrodealkylation processes are Hydeal and DETOL. Two widely used thermal processes are HDA and THD. These processes contribute 25-30% of the world's total benzene supply. In catalytic toluene hydrodealkylation, toluene is mixed with a hydrogen stream and passed through a vessel packed with a catalyst, usually supported chromium or molybdenum oxides, platinum or platinum oxides, on silica or alumina. The operating temperatures range from 500 to 595 °C and pressures are usually 4-6 MPa (40-60 atm). The reaction is highly exothermic and the temperature is controlled by injection of quench hydrogen at several places along the reaction. Conversions per pass typically reach 90% and selectivity to benzene is often >95%. The catalytic process occurs at lower temperatures and offers higher selectivities but requires frequent regeneration of the catalyst. Products leaving the reactor pass through a separator where unreacted hydrogen is removed and recycled to the feed. Further fractionation separates methane from the benzene product.

Fruscella W; Benzene. Kirk-Othmer Encyclopedia of Chemical Technology (1999-2014). John Wiley & Sons, Inc. Online Posting Date: June 10, 2002

▸ Hazardous Substances Data Bank (HSDB)

The steam cracking of heavy naphthas or light hydrocarbons such as propane or butane to produce ethylene yields a liquid by-product rich in aromatic content called pyrolysis gasoline, dripolene, or drip oil. A typical pyrolysis gasoline contains up to 65% aromatics, 50% of which is benzene. Approximately 30-35% of benzene produced worldwide is derived from pyrolysis gasoline. The remainder of the product is composed of mono- and diolefins. These olefinic substances are removed by a mild hydrogenation step. Following hydrogenation, the resulting pyrolysis gasoline is used in motor gasoline. Alternatively, pure benzene could be recovered from the pyrolysis gasoline by solvent extraction and subsequent distillation.

Fruscella W; Benzene. Kirk-Othmer Encyclopedia of Chemical Technology (1999-2014). John Wiley & Sons, Inc. Online Posting Date: June 10, 2002

▸ Hazardous Substances Data Bank (HSDB)

Two molecules of toluene are converted into one molecule of benzene and one molecule of mixed-xylene isomers in a sequence called transalkylation or disproportionation. Economic feasibility of the process strongly depends on the relative prices of benzene, toluene, and xylene. Operation of a transalkylation unit is practical only when there is an excess of toluene and a strong demand for benzene. In recent years, xylene and benzene prices have generally been higher than toluene prices so transalkylation is presently an attractive alternative to hydrodealkylation.

Fruscella W; Benzene. Kirk-Othmer Encyclopedia of Chemical Technology (1999-2014). John Wiley & Sons, Inc. Online Posting Date: June 10, 2002

▸ Hazardous Substances Data Bank (HSDB)

Benzene has been recovered from coal tar. The lowest boiling fraction is extracted with caustic soda to remove tar acids. The base washed oil is then distilled and further purified by hydrodealkylation.

Fruscella W; Benzene. Kirk-Othmer Encyclopedia of Chemical Technology (1999-2014). John Wiley & Sons, Inc. Online Posting Date: June 10, 2002

▸ Hazardous Substances Data Bank (HSDB)

10.5 Impurities

Major impurities are toluene and xylene, others: phenol, thiophene, carbon disulfide, acetylnitrile, and pyridine.

NIOSH; Criteria Document: Benzene p.20 (1974) DHEW Pub No 74-137

▸ Hazardous Substances Data Bank (HSDB)

10.6 Formulations/Preparations

Nitration grade > 99% purity.

Environment Canada; Tech Info for Problem Spills: Benzene (Draft) p.20 (1981)

▸ Hazardous Substances Data Bank (HSDB)

"Benzol 90" contains 80-85% benzene, 13-15% toluene, 2-3% xylene.

NIOSH; Criteria Document: Benzene p.20 (1974) DHEW Pub No 74-137

▸ Hazardous Substances Data Bank (HSDB)

Grade: crude, straw color; motor; industrial pure (2C); nitration (1C); thiophene-free; 99 mole%; 99.94 mole%; nanograde.

Lewis, R.J. Sr.; Hawley's Condensed Chemical Dictionary 15th Edition. John Wiley & Sons, Inc. New York, NY 2007., p. 134

▸ Hazardous Substances Data Bank (HSDB)

10.7 Consumption Patterns

Consumption by chemical industry in USA, 1977: 1.4 billion gallons annually.

Fishbein L; Pot Ind Carcin & Muta p.296 (1977) EPA 560/5-77-005

▸ Hazardous Substances Data Bank (HSDB)

Chem int for ethylbenzene, 49.1%; chem int for cumene, 18.4%; chem int for cyclohexane, 15.1%; chem int for nitrobenzene, 4.5%; chem int for maleic anhydride, 2.8%; chem int for chlorobenzenes, 2.5%; chem int for detergent alkylate, 2.4%; exports, 2.7%; other uses, 2.5% (1981 non-gasoline uses)

SRI Consulting. 2011 Directory of Chemical Producers United States. SRI Consulting, Menlo Park, CA 2011

▸ Hazardous Substances Data Bank (HSDB)

Demand: (1980) 1,586 Million Gal; /Projected demand for/ (1984): 1,708 Million Gal

Kavaler. Chem Market Reporter (1981)

▸ Hazardous Substances Data Bank (HSDB)

BENZENE RANKED 17TH IN 1981 & 1982 IN THE TOP 50 CHEMICAL PRODUCTION: BILLIONS OF LB: 7.87 (1982), 9.61 (1981).

CHEMICAL & ENGINEERING NEWS; MAY 2: 11 (1983)

▸ Hazardous Substances Data Bank (HSDB)

For more Consumption Patterns (Complete) data for BENZENE (10 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

10.8 U.S. Production

Aggregated Product Volume (EPA CDR 2016)

10,000,000,000 - 20,000,000,000 lb

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

▸ EPA Chemicals under the TSCA

(1967) 9.6X10+8 gal (data reported by tar distillers are not included)

United States International Trade Commission. Synthetic Organic Chemicals-- United States Production and Sales, 1981. USITC Publications 1291 Washington, DC: United States International Trade Commission, 1981., p. 10

▸ Hazardous Substances Data Bank (HSDB)

(1977) 4.80X10+12 G

SRI

▸ Hazardous Substances Data Bank (HSDB)

(1980) 1.5X10+9 gal (data reported by tar distillers are not included)

United States International Trade Commission. Synthetic Organic Chemicals-- United States Production and Sales, 1981. USITC Publications 1291 Washington, DC: United States International Trade Commission, 1981., p. 10

▸ Hazardous Substances Data Bank (HSDB)

(1981) 4.3X10+11 GRAMS

United States International Trade Commission. Synthetic Organic Chemicals-- United States Production and Sales, 1981. USITC Publications 1291 Washington, DC: United States International Trade Commission, 1981.

▸ Hazardous Substances Data Bank (HSDB)

For more U.S. Production (Complete) data for BENZENE (24 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

10.9 U.S. Imports

(1978) 2.26X10+11 G

SRI

▸ Hazardous Substances Data Bank (HSDB)

(1979) 1.6 billion kg

DHHS/NTP; Third Annual Report On Carcinogens p.28 (1983) NTP 82-330

▸ Hazardous Substances Data Bank (HSDB)

(1983) 4.93X10+11 G

SRI

▸ Hazardous Substances Data Bank (HSDB)

(1985) 4.96X10+11 g

BUREAU OF THE CENSUS. U.S. IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1985 p. 1-546

▸ Hazardous Substances Data Bank (HSDB)

For more U.S. Imports (Complete) data for BENZENE (6 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

10.10 U.S. Exports

(1978) 1.52X10+11 G

SRI

▸ Hazardous Substances Data Bank (HSDB)

(1983) 3.66X10+10 G

SRI

▸ Hazardous Substances Data Bank (HSDB)

(1979) 1.3 million lb

DHHS/NTP; Third Annual Report On Carcinogens p.28 (1983) NTP 82-330

▸ Hazardous Substances Data Bank (HSDB)

(1985) 3.77X10+10 g

BUREAU OF THE CENSUS. U.S. EXPORTS, SCHEDULE E, 1985 p.2-69

▸ Hazardous Substances Data Bank (HSDB)

Exports were thought to be less than 10 million gallons.

Chemical & Engineering News p.11 (2/9/87)

▸ Hazardous Substances Data Bank (HSDB)

10.11 General Manufacturing Information

Industry Processing Sectors

Adhesive manufacturing
All other basic organic chemical manufacturing
All other chemical product and preparation manufacturing
All other petroleum and coal products manufacturing
Cyclic crude and intermediate manufacturing
Electrical equipment, appliance, and component manufacturing
Petrochemical manufacturing
Petroleum lubricating oil and grease manufacturing
Petroleum refineries
Plastic material and resin manufacturing
Plastics product manufacturing
Rubber product manufacturing
Soap, cleaning compound, and toilet preparation manufacturing
Synthetic rubber manufacturing
Wholesale and retail trade
fuels blending

▸ EPA Chemicals under the TSCA

EPA TSCA Commercial Activity Status

Benzene: ACTIVE

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

▸ EPA Chemicals under the TSCA

The term benzene denotes the pure compound; benzol is still used to a small degree in some countries to represent the compound or a material having benzene as its main component. Benzine, on the other hand, is a low-boiling hydrocarbon mixture or naphtha, often nonaromatic in composition.

Folkins HO; Ullmann's Encyclopedia of Industrial Chemistry 7th ed. (1999-2014). NY, NY: John Wiley & Sons; Benzene. Online Posting Date: June 15, 2000

▸ Hazardous Substances Data Bank (HSDB)

Benzene is a component of gasoline; European concn 5-16%, USA concn 0.3-2.0% averaging 0.8%.

NIOSH; Criteria Document: Benzene p.21 (1974) DHEW Pub No 74-137

▸ Hazardous Substances Data Bank (HSDB)

Benzene was first isolated by Michael Faraday in 1825 from the liquid condensed by compressing oil gas. He proposed the name bicarburet of hydrogen for the new compound. In 1833, Eilhard Mischerlich synthesized bicarburet of hydrogen by distilling benzoic acid, obtained from gum benzoin, with lime and suggested the name benzin for the compound. In 1845, A.W. Hoffman and C. Mansfield found benzene in light oil derived from coal tar. The first practical industrial process for recovery of benzene from coal tar was reported by Mansfield in 1849. Coal tar soon became the largest source of benzene. Soon afterward, benzene was discovered in coal gas and this initiated the recovery of coal gas light oil as a source of benzene. Until the 1940's, light oil obtained from the destructive distillation of coal was the principal source of benzene.

Fruscella W; Benzene. Kirk-Othmer Encyclopedia of Chemical Technology (1999-2014). John Wiley & Sons, Inc. Online Posting Date: June 10, 2002

▸ Hazardous Substances Data Bank (HSDB)

The Comission of European Communities ... prohibit the use of benzene in products intended for use as toys (eg, children's balloons).

*IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: **https://monographs.iarc.fr/ENG/Classification/index.php**, p. V29 98 (1982)*

▸ Hazardous Substances Data Bank (HSDB)

For more General Manufacturing Information (Complete) data for BENZENE (8 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

10.12 Sampling Procedures

Analyte: Benzene by portable GC; Matrix: air; Sampler: air bag (Tedlar); Flow rate: 0.02 to 0.05 l/min or higher; Stability: approx 4 hr

U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984., p. V1 3700-1

▸ Hazardous Substances Data Bank (HSDB)

Analyte: Benzene; Matrix: air; Sampler: Solid sorbent tube (coconut shell charcoal, 100 mg/50 mg); Flow rate: approx 0.20 L/min; Vol: max: 30 L; Stability: at least 2 wk; Bulk sample: 1 to 10 mL, ship in separate containers from samples.

U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984., p. V2 1500-1

▸ Hazardous Substances Data Bank (HSDB)

11 Identification

11.1 Analytic Laboratory Methods

Method: NIOSH 1501, Issue 3; Procedure: gas chromatography with flame ionization detector; Analyte: benzene; Matrix: air; Detection Limit: 0.5 ug/sample.

CDC; NIOSH Manual of Analytical Methods, 4th ed. Benzene (71-43-2). Available from, as of January 31, 2014: https://www.cdc.gov/niosh/docs/2003-154/

▸ Hazardous Substances Data Bank (HSDB)

Method: NIOSH 2549, Issue 1; Procedure: thermal desorption, gas chromatography, mass spectrometry; Analyte: benzene; Matrix: air; Detection Limit: 100 ng per tube or less.

CDC; NIOSH Manual of Analytical Methods, 4th ed. Benzene (71-43-2). Available from, as of January 31, 2014: https://www.cdc.gov/niosh/docs/2003-154/

▸ Hazardous Substances Data Bank (HSDB)

Method: NIOSH 3700, Issue 2; Procedure: gas chromatography (portable), photoionization detector; Analyte: benzene; Matrix: air; Detection Limit: 0.01 ppm for a 1-mL injection.

CDC; NIOSH Manual of Analytical Methods, 4th ed. Benzene (71-43-2). Available from, as of January 31, 2014: https://www.cdc.gov/niosh/docs/2003-154/

▸ Hazardous Substances Data Bank (HSDB)

Method: NIOSH 3800, Issue 1; Procedure: extractive fourier transform infrared (FTIR) spectrometry; Analyte: benzene; Matrix: air; Detection Limit: 0.32 ppm for a 10 meter absorption pathlength.

CDC; NIOSH Manual of Analytical Methods, 4th ed. Benzene (71-43-2). Available from, as of January 31, 2014: https://www.cdc.gov/niosh/docs/2003-154/

▸ Hazardous Substances Data Bank (HSDB)

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

▸ Hazardous Substances Data Bank (HSDB)

11.2 Clinical Laboratory Methods

Volatile cmpd such as benzene are separated from blood or tissue homogenate directly on gas-chromatographic column & detected using a flame ionization detector. High volatility permits gas chromatograph to be operated at relatively low temp. The nonvolatile & high boiling components of the biological matrix are left behind in the injection port. This insures long column life & requires only occasional cleaning of the injection chamber: Baker RN et al; Toxic volatiles in alcoholic coma; Bull Los Angles County Neurol Soc 33: 140 (1968); Wallace JE, Dahl EV; Rapid vapor phase method for determining ethanol in blood & urine by gas chromatography; Am J Clin Pathol 46: 152 (1966).

Sunshine, Irving (ed.) Methodology for Analytical Toxicology. Cleveland: CRC Press, Inc., 1975., p. 378

▸ Hazardous Substances Data Bank (HSDB)

GLC & colorimetric (phenol metabolite) methods are used to determine benzene in serum, urine, & breath. Conventional reference range: >1.0 mg/L (toxic concn) for serum; <10.0 mg/L as phenol, >75.0 mg/L (toxic concn) as phenol for urine. Internationally recommended conc reference range is: >13 umol/L (toxic concn) for serum; <106 umol/L as phenol, >795 umol/L (toxic concn) as phenol for urine. Substances producing phenol as a metabolite can interfere with color assay.

Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B. Saunders Co., 1983., p. 76

▸ Hazardous Substances Data Bank (HSDB)

GC/MS method to determine benzene in adipose tissue, brain, kidney, liver, lung, muscle, pancreas, & spleen; treat sample with chlorobenzene, ethanol & water at 60 °C; inject vapor phase into gas chromatograph: Nagata T et al; Koenshu-Iyo Masu Kenkyukai 3: 77-82 (1978), (Chem Abstr 92: 192082X).

IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: https://monographs.iarc.fr/ENG/Classification/index.php, p. V29 107 (1982)

▸ Hazardous Substances Data Bank (HSDB)

The urinary metabolites isolated by DEAE Sephadex A-24 anion-exchange chromatography from mice treated with radiolabeled benzene included phenol as the major component, as well as catechol, hydroquinone, and phenylmercapturic acid.

Longacre SL et al; Adv Exp Med Biol 136A: 307-17 (1982)

▸ Hazardous Substances Data Bank (HSDB)

For more Clinical Laboratory Methods (Complete) data for BENZENE (6 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

11.3 OSHA Chemical Sampling

GC-FID - OSHA 1005 (fully validated)

GC-FID - OSHA 5000 (fully validated)

- Occupational Safety and Health Administration (OSHA)

11.4 NIOSH Analytical Methods

HYDROCARBONS, AROMATIC 1501

- NIOSH Manual of Analytical Methods

VOLATILE ORGANIC COMPOUNDS (SCREENING) 2549

- NIOSH Manual of Analytical Methods

BENZENE by portable GC 3700

- NIOSH Manual of Analytical Methods

ORGANIC AND INORGANIC GASES BY EXTRACTIVE FTIR SPECTROMETRY 3800

- NIOSH Manual of Analytical Methods

12 Safety and Hazards

12.1 Hazards Identification

12.1.1 GHS Classification

Showing 1 of 7 View More

Pictogram(s)	 Flammable  Irritant  Health Hazard
Signal	Danger
GHS Hazard Statements	H225: Highly Flammable liquid and vapor [Danger Flammable liquids] H304: May be fatal if swallowed and enters airways [Danger Aspiration hazard] H315: Causes skin irritation [Warning Skin corrosion/irritation] H319: Causes serious eye irritation [Warning Serious eye damage/eye irritation] H340: May cause genetic defects [Danger Germ cell mutagenicity] H350: May cause cancer [Danger Carcinogenicity] H372 **: Causes damage to organs through prolonged or repeated exposure [Danger Specific target organ toxicity, repeated exposure]
Precautionary Statement Codes	P201, P202, P210, P233, P240, P241, P242, P243, P260, P264, P270, P280, P281, P301+P310, P302+P352, P303+P361+P353, P305+P351+P338, P308+P313, P314, P321, P331, P332+P313, P337+P313, P362, P370+P378, P403+P235, P405, and P501 (The corresponding statement to each P-code can be found at the GHS Classification page.)

▸ EU REGULATION (EC) No 1272/2008

12.1.2 Hazard Classes and Categories

Showing 2 of 6 View More

Flam. Liq. 2

Carc. 1A

Muta. 1B

Asp. Tox. 1

STOT RE 1

Skin Irrit. 2

Eye Irrit. 2

▸ EU REGULATION (EC) No 1272/2008

Flam. Liq. 2 (99.85%)

Asp. Tox. 1 (99.44%)

Skin Irrit. 2 (99.95%)

Eye Irrit. 2 (99.95%)

Muta. 1B (99.9%)

Carc. 1A (99.9%)

STOT RE 1 (100%)

Aquatic Chronic 3 (11.76%)

▸ European Chemicals Agency (ECHA)

12.1.3 NFPA Hazard Classification

Showing 1 of 2 View More

NFPA 704 Diamond	 1-3-0
NFPA Health Rating	1 - Materials that, under emergency conditions, can cause significant irritation.
NFPA Fire Rating	3 - Liquids and solids that can be ignited under almost all ambient temperature conditions. Materials produce hazardous atmospheres with air under almost all ambient temperatures or, though unaffected by ambient temperatures, are readily ignited under almost all conditions.
NFPA Instability Rating	0 - Materials that in themselves are normally stable, even under fire conditions.

▸ Hazardous Substances Data Bank (HSDB)

12.1.4 Substance of Very High Concern (SVHC)

REACH Restricted Substance

Restricted substance: Benzene
Restriction condition document: PDF link

▸ European Chemicals Agency (ECHA)

12.1.5 Health Hazards

Dizziness, excitation, pallor, followed by flushing, weakness, headache, breathlessness, chest constriction, nausea, and vomiting. Coma and possible death. (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

12.1.6 Fire Hazards

Behavior in Fire: Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. (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

Highly flammable. Vapour/air mixtures are explosive. Risk of fire and explosion. See Chemical Dangers.

▸ ILO International Chemical Safety Cards (ICSC)

Carcinogens, Mutagens, Flammable - 3rd degree

▸ NJDOH RTK Hazardous Substance List

12.1.7 Explosion Hazards

Benzene reacts violently with oxidants and halogens, causing an explosion hazard.

Benzene poses a vapor explosion hazard indoors, outdoors, or in sewers.

Vapors may form explosive mixtures with air.

Run-off to sewers may create an explosion hazard.

Containers may explode when heated.

Lower explosive (flammable) limit in air (LEL), 1.2%; upper explosive (flammable) limit in air (UEL), 7.8%.

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

12.1.8 Hazards Summary

Benzene is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities. Benzene is widely used in the United States; it ranks in the top 20 chemicals for production volume. Some industries use benzene to make other chemicals which are used to make plastics, resins, and nylon and synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides. Natural sources of benzene include volcanoes and forest fires. Benzene is also a natural part of crude oil, gasoline, and cigarette smoke.

▸ CDC-ATSDR Toxic Substances Portal

Benzene is found in the air from emissions from burning coal and oil, gasoline service stations, and motor vehicle exhaust. Acute (short-term) inhalation exposure of humans to benzene may cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation, and, at high levels, unconsciousness. Chronic (long-term) inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anemia, in occupational settings. Reproductive effects have been reported for women exposed by inhalation to high levels, and adverse effects on the developing fetus have been observed in animal tests. Increased incidence of leukemia (cancer of the tissues that form white blood cells) have been observed in humans occupationally exposed to benzene. EPA has classified benzene as known human carcinogen for all routes of exposure.

▸ EPA Air Toxics

12.1.9 Fire Potential

A dangerous fire hazard when exosed to heat or flame. ... Ignites on contact with sodium peroxide + water, dioxygenyl tetrafluoroborate, iodine heptafluoride, and dioxygen difluoride.

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 360

▸ Hazardous Substances Data Bank (HSDB)

12.1.10 Skin, Eye, and Respiratory Irritations

A severe eye and moderate skin irritant.

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 360

▸ Hazardous Substances Data Bank (HSDB)

Skin irritation has been noted at occupational exposures of greater than 60 ppm for up to three weeks.

U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Benzene p.83 PB2008-100004 (2007). Available from, as of August 12, 2014: ***https://www.atsdr.cdc.gov/toxprofiles/index.asp***

▸ Hazardous Substances Data Bank (HSDB)

Direct exposure of the eyes, skin, or lungs to benzene can cause tissue injury and irritation.

CDC; Emergency Preparedness and Response: Facts about Benzene; Available from, as of February 21, 2014: ***https://www.bt.cdc.gov/agent/benzene/basics/facts.asp***

▸ Hazardous Substances Data Bank (HSDB)

12.1.11 EPA Hazardous Waste Number

U019; A toxic waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate.

▸ Hazardous Substances Data Bank (HSDB)

F005; A hazardous waste from nonspecific sources when a spent solvent.

▸ Hazardous Substances Data Bank (HSDB)

D018; A waste containing benzene may or may not be characterized as a hazardous waste following testing by the Toxicity Characteristic Leaching Procedure as prescribed by the Resource Conservation and Recovery Act (RCRA) regulations.

▸ Hazardous Substances Data Bank (HSDB)

12.2 Safety and Hazard Properties

12.2.1 Acute Exposure Guideline Levels (AEGLs)

12.2.1 AEGLs Table

AEGLs	10 min	30 min	60 min	4 hr	8 hr

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)	130	73	52	18	9.0
AEGL 2: Irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape (Unit: ppm)	2,000*	1,100	800	400	200
AEGL 3: Life-threatening health effects or death (Unit: ppm)	**	5,600*	4,000*	2,000*	990

▸ EPA Acute Exposure Guideline Levels (AEGLs)

12.2.2 AEGLs Notes

Lower Explosive Limit (LEL) = 14,000 ppm

* = >10% LEL; ** = >50% LEL

AEGL 3 - 10 mins = ** 9,700 ppm

For values denoted as * safety considerations against the hazard(s) of explosion(s) must be taken into account.

For values denoted as ** extreme safety considerations against the hazard(s) of explosion(s) must be taken into account.

AEGLs Status: Interim

▸ EPA Acute Exposure Guideline Levels (AEGLs)

12.2.2 Flammable Limits

Lower flammable limit: 1.2% by volume; Upper flammable limit: 7.8% by volume

National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 325-18

▸ Hazardous Substances Data Bank (HSDB)

Flammability

Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F.

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

12.2.3 Lower Explosive Limit (LEL)

1.4 % (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

▸ CAMEO Chemicals

1.2%

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

12.2.4 Upper Explosive Limit (UEL)

8 % (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

▸ CAMEO Chemicals

8%

▸ Occupational Safety and Health Administration (OSHA)

12.2.5 Critical Temperature & Pressure

Critical temperature: 562.0 K; critical pressure: 5.90 MPa; critical volume: 257 cu cm/mol

Haynes, W.M. (ed.). CRC Handbook of Chemistry and Physics. 94th Edition. CRC Press LLC, Boca Raton: FL 2013-2014, p. 6-59

▸ Hazardous Substances Data Bank (HSDB)

12.2.6 Physical Dangers

The vapour is heavier than air and may travel along the ground; distant ignition possible. As a result of flow, agitation, etc., electrostatic charges can be generated.

▸ ILO International Chemical Safety Cards (ICSC)

Benzene vapors are heavier than air. They will spread along the ground and collect and stay in poorly-ventilated, low-lying, or confined areas (e.g., sewers, basements, and tanks).

Hazardous concentrations may develop quickly in enclosed, poorly-ventilated, or low-lying areas. Keep out of these areas. Stay upwind.

Benzene liquid is less dense than water and will float on the surface of water.

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

12.2.7 Explosive Limits and Potential

Lower 1.4%, upper 8.0%

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 360

▸ Hazardous Substances Data Bank (HSDB)

Explosive limits , vol% in air: 1.2-8.0

▸ ILO International Chemical Safety Cards (ICSC)

12.2.8 OSHA Standards

Permissible exposure limits (PELs) - (1) Time-weighted average limit (TWA). The employer shall assure that no employee is exposed to an airborne concentration of benzene in excess of one part of benzene per million parts of air (1 ppm) as an 8 hr TWA. (2) Short-term exposure limit (STEL). The employer shall assure that no employee is exposed to an airborne concentration of benzene in excess of 5 ppm as averaged over any 15 min period.

29 CFR 1910.1028(c) (USDOL); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: ***https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

Permissible Exposure Limit: Table Z-2 8-hr Time Weighted Avg: 10 ppm. (This standard applies to the industry segments exempt from the 1 ppm 8-hour TWA and 5 ppm STEL of the benzene standard at 1910.1028.)

29 CFR 1910.1000 (USDOL); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: ***https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

Permissible Exposure Limit: Table Z-2 Acceptable Ceiling Concentration: 25 ppm. (This standard applies to the industry segments exempt from the 1 ppm 8-hour TWA and 5 ppm STEL of the benzene standard at 1910.1028.)

29 CFR 1910.1000 (USDOL); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: ***https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

Permissible Exposure Limit: Table Z-2 Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift. Concentration: 50 ppm. Maximum Duration: 10 minutes. (This standard applies to the industry segments exempt from the 1 ppm 8-hour TWA and 5 ppm STEL of the benzene standard at 1910.1028.)

29 CFR 1910.1000 (USDOL); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: ***https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

12.2.9 NIOSH Recommendations

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration.

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: 10 Hour Time-Weighted Average: 0.1 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)

Recommended Exposure Limit: 15 Minute Short-Term Exposure Limit: 1 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)

12.3 First Aid Measures

12.3.1 First Aid

EYES: First check the victim for contact lenses and remove if present. Flush victim's eyes with water or normal saline solution for 20 to 30 minutes while simultaneously calling a hospital or poison control center. Do not put any ointments, oils, or medication in the victim's eyes without specific instructions from a physician. IMMEDIATELY transport the victim after flushing eyes to a hospital even if no symptoms (such as redness or irritation) develop. SKIN: IMMEDIATELY flood affected skin with water while removing and isolating all contaminated clothing. Gently wash all affected skin areas thoroughly with soap and water. IMMEDIATELY call a hospital or poison control center even if no symptoms (such as redness or irritation) develop. IMMEDIATELY transport the victim to a hospital for treatment after washing the affected areas. INHALATION: IMMEDIATELY leave the contaminated area; take deep breaths of fresh air. IMMEDIATELY call a physician and be prepared to transport the victim to a hospital even if no symptoms (such as wheezing, coughing, shortness of breath, or burning in the mouth, throat, or chest) develop. Provide proper respiratory protection to rescuers entering an unknown atmosphere. Whenever possible, Self-Contained Breathing Apparatus (SCBA) should be used; if not available, use a level of protection greater than or equal to that advised under Protective Clothing. INGESTION: DO NOT INDUCE VOMITING. Volatile chemicals have a high risk of being aspirated into the victim's lungs during vomiting which increases the medical problems. If the victim is conscious and not convulsing, give 1 or 2 glasses of water to dilute the chemical and IMMEDIATELY call a hospital or poison control center. IMMEDIATELY transport the victim to a hospital. If the victim is convulsing or unconscious, do not give anything by mouth, ensure that the victim's airway is open and lay the victim on his/her side with the head lower than the body. DO NOT INDUCE VOMITING. IMMEDIATELY transport the victim to a hospital. OTHER: Since this chemical is a known or suspected carcinogen you should contact a physician for advice regarding the possible long term health effects and potential recommendation for medical monitoring. Recommendations from the physician will depend upon the specific compound, its chemical, physical and toxicity properties, the exposure level, length of exposure, and the route of exposure. (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

▶ CAMEO Chemicals

(See procedures)

Eye:Irrigate immediately - If this chemical contacts the eyes, immediately wash (irrigate) the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately.

Skin:Soap wash immediately - If this chemical contacts the skin, immediately wash the contaminated skin with soap and water. If this chemical penetrates the clothing, immediately remove the clothing, wash the skin with soap and water, and get medical attention promptly.

Breathing:Respiratory support

Swallow:Medical attention immediately - If this chemical has been swallowed, get medical attention immediately.

▶ 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 benzene 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).

Take measures to avoid stomach contents being taken into the lungs (pulmonary aspiration); i.e., place the patient/victim on their side.

Activated charcoal has limited ability to decrease gastrointestinal absorption of benzene.

Once the airway is secured, consider using a soft flexible nasogastric tube to aspirate the stomach contents.

See the Inhalation section for first aid recommendations.

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.

If cough, difficulty breathing, or shortness of breath (dyspnea) develop, evaluate for respiratory tract irritation, inflammation of the large airways (bronchitis), and inflammatory lung disease (pneumonia).

Monitor for low blood pressure (hypotension), abnormal heart rhythms (dysrhythmias), and reduced respiratory function (respiratory depression).

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

If evidence of shock or low blood pressure (hypotension) is observed, begin intravenous (IV) fluid administration.

Avoid use of epinephrine for alteration of heart rhythm (cardiac arrhythmias) due to possible sensitization of the heart muscle.

If seizures develop administer benzodiazepines.

Seek medical attention immediately.

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

See the Decontamination section for patient/victim decontamination procedures.

Seek medical attention immediately.

See ATSDR Medical Management Guidelines for Acute Chemical Exposures, Benzene, https://www.atsdr.cdc.gov/MHMI/mmg3.pdf, for detailed recommendations.

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

12.3.2 Inhalation First Aid

Fresh air, rest. Refer for medical attention.

▸ ILO International Chemical Safety Cards (ICSC)

12.3.3 Skin First Aid

Remove contaminated clothes. Rinse skin with plenty of water or shower. Refer for medical attention .

▸ ILO International Chemical Safety Cards (ICSC)

12.3.4 Eye First Aid

First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then refer for medical attention.

▸ ILO International Chemical Safety Cards (ICSC)

12.3.5 Ingestion First Aid

Rinse mouth. Do NOT induce vomiting. Refer for medical attention .

▸ ILO International Chemical Safety Cards (ICSC)

12.4 Fire Fighting

Excerpt from ERG Guide 130 [Flammable Liquids (Water-Immiscible / Noxious)]: CAUTION: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient. SMALL FIRE: Dry chemical, CO2, water spray or regular foam. LARGE FIRE: Water spray, fog or regular foam. Do not use straight streams. Move containers from fire area if you can do it without risk. FIRE INVOLVING TANKS OR CAR/TRAILER LOADS: 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. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn. (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

Use foam, water spray, carbon dioxide, powder. In case of fire: keep drums, etc., cool by spraying with water.

▸ ILO International Chemical Safety Cards (ICSC)

Benzene is highly flammable.

The agent will be easily ignited by heat, sparks, or flames.

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

Benzene reacts violently with oxidants and halogens, causing a fire hazard.

Vapors may travel to the source of ignition and flash back.

Run-off to sewers may create a fire hazard.

Caution: The agent has a very low flash point. Use of water spray when fighting fires may be inefficient.

For small fires, use dry chemical, carbon dioxide, water spray, or regular foam.

For large fires, use water spray, fog, or regular foam. Do not use straight streams. Move containers from the fire area if it is possible to do so without risk to personnel.

For fire involving tanks or car/trailer loads, fight the fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after the fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tanks. Always stay away from tanks engulfed in fire.

For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from the area and let the fire burn.

Run-off from fire control or dilution water may cause pollution.

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

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

12.4.1 Fire Fighting Procedures

Approach fire from upwind to avoid hazardous vapors. Use water spray, dry chemical, foam, or carbon dioxide. Use water spray to keep fire-exposed containers cool.

National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-27

▸ Hazardous Substances Data Bank (HSDB)

If material on fire or involved in fire: Do not extinguish fire unless flow can be stopped. Use water in flooding quantities as fog. Solid streams of water may spread fire. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Use foam, dry chemical, or carbon dioxide.

Association of American Railroads; Bureau of Explosives. Emergency Handling of Hazardous Materials in Surface Transportation. Association of American Railroads, Pueblo, CO. 2005, p. 111

▸ Hazardous Substances Data Bank (HSDB)

Suitable extinguishing media: Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Sigma-Aldrich; Material Safety Data Sheet for Benzene. Product Number: 12540, Version 5.2 (Revision Date 06/23/2014). Available from, as of October 9, 2014: ***https://www.sigmaaldrich.com/safety-center.html***

▸ Hazardous Substances Data Bank (HSDB)

Advice for firefighters: Wear self contained breathing apparatus for fire fighting if necessary.

Sigma-Aldrich; Material Safety Data Sheet for Benzene. Product Number: 12540, Version 5.2 (Revision Date 06/23/2014). Available from, as of October 9, 2014: ***https://www.sigmaaldrich.com/safety-center.html***

▸ Hazardous Substances Data Bank (HSDB)

Use water spray to cool unopened containers.

Sigma-Aldrich; Material Safety Data Sheet for Benzene. Product Number: 12540, Version 5.2 (Revision Date 06/23/2014). Available from, as of October 9, 2014: ***https://www.sigmaaldrich.com/safety-center.html***

▸ Hazardous Substances Data Bank (HSDB)

12.4.2 Firefighting Hazards

Vapors are heavier than air and may travel to a source of ignition & flash back. Liquid floats on water and may travel to a source of ignition and spread fire.

National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-27

▸ Hazardous Substances Data Bank (HSDB)

Special hazards arising from the substance or mixture: Carbon oxides Flash back possible over considerable distance. Container explosion may occur under fire conditions.

Sigma-Aldrich; Material Safety Data Sheet for Benzene. Product Number: 12540, Version 5.2 (Revision Date 06/23/2014). Available from, as of October 9, 2014: ***https://www.sigmaaldrich.com/safety-center.html***

▸ Hazardous Substances Data Bank (HSDB)

12.5 Accidental Release Measures

12.5.1 Isolation and Evacuation

Excerpt from ERG Guide 130 [Flammable Liquids (Water-Immiscible / Noxious)]: As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions. LARGE SPILL: Consider initial downwind evacuation for at least 300 meters (1000 feet). 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

12.5.2 Spillage Disposal

Remove all ignition sources. Evacuate danger area! Consult an expert! Personal protection: complete protective clothing including self-contained breathing apparatus. Do NOT wash away into sewer. Do NOT let this chemical enter the environment. Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent. Then store and dispose of according to local regulations.

▸ ILO International Chemical Safety Cards (ICSC)

12.5.3 Cleanup Methods

For spills on water, contain with booms or barriers, use surface acting agents to thicken spilled materials. Remove trapped materials with suction hoses.

USEPA; Methods to Treat, Control and Monitor Spilled Hazardous Materials, EPA-670/2-75-042 (1975) EPA 670/2-75-042

▸ Hazardous Substances Data Bank (HSDB)

Small spills of benzene can be taken up by sorption on carbon or synthetic sorbent resins. Flush area with water. For large quantities, if response is rapid, benzene can be skimmed off the surface. Straw may be used to mop slicks.

USEPA; Intermedia Priority Pollutant Guidance Documents p.8-1 (July, 1982)

▸ Hazardous Substances Data Bank (HSDB)

PRECAUTIONS FOR "CARCINOGENS": A high-efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air ventilated safety cabinets, lab hoods, glove boxes or animal rooms. ... Filter housing that is designed so that used filters can be transferred into plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal. ... The plastic bag should be sealed immediately. ... The sealed bag should be labelled properly. ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated. ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/

Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 15

▸ Hazardous Substances Data Bank (HSDB)

Eliminate all ignition sources. Stop or control the leak, if this can be done without undue risk. Use water spray to cool and disperse vapors, protect personnel, and dilute spills to form nonflammable mixtures. Absorb in noncombustible material for proper disposal. Control runoff and isolate discharged material for proper disposal.

National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-27

▸ Hazardous Substances Data Bank (HSDB)

For more Cleanup Methods (Complete) data for BENZENE (9 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

12.5.4 Disposal Methods

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number F005, U019, D018, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.

40 CFR 240-280, 300-306, 702-799 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of November April 6, 2014: ***https://www.ecfr.gov***

▸ 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)

Biodegradation, incineration: Benzene is biodegradable. Diluted aqueous soln, therefore, are drained into sewage treatment plants and decomposed there by anaerobic bacteria. Solvent mixtures and sludges of higher concn are burnt in special waste incinerators if a recovery process is uneconomical.

United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985., p. 100

Hazardous Substances Data Bank (HSDB)

This flammable liquid burns with a very smoky flame. Dilution with alcohol or acetone is suggested to minimize smoke. Recommendable methods: Use as boiler fuel, incineration. Not recommendable: Landfill, discharge to sewer.

United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985., p. 100

Hazardous Substances Data Bank (HSDB)

For more Disposal Methods (Complete) data for BENZENE (31 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

12.5.5 Preventive Measures

SRP: The scientific literature for the use of contact lenses by industrial workers is inconsistent. The benefits or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.

Hazardous Substances Data Bank (HSDB)

SRP: Local exhaust ventilation should be applied wherever there is an incidence of point source emmissions or dispersion of regulated contaminants in the work area. Ventilation control of the contaminant as close to its point of generation is both the most economical and safest method to minimize personnel exposure to airborne contaminants.

Hazardous Substances Data Bank (HSDB)

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory. All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/

Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 8

Hazardous Substances Data Bank (HSDB)

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... Clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/

Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 8

Hazardous Substances Data Bank (HSDB)

For more Preventive Measures (Complete) data for BENZENE (19 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

12.6 Handling and Storage

12.6.1 Nonfire Spill Response

Excerpt from ERG Guide 130 [Flammable Liquids (Water-Immiscible / Noxious)]: ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor-suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Use clean, non-sparking tools to collect absorbed material. LARGE SPILL: Dike far ahead of liquid spill for later disposal. Water spray may reduce vapor, but may not prevent ignition in closed spaces. (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

12.6.2 Safe Storage

Fireproof. Separated from food and feedstuffs, oxidants and halogens. Store in an area without drain or sewer access.

ILO International Chemical Safety Cards (ICSC)

12.6.3 Storage Conditions

Keep in well closed containers in a cool place and away from fire.

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 188

- Hazardous Substances Data Bank (HSDB)

PRECAUTIONS FOR "CARCINOGENS": Storage site should be as close as practicable to lab in which carcinogens are to be used, so that only small quantities required for ... expt need to be carried. Carcinogens should be kept in only one section of cupboard, an explosion-proof refrigerator or freezer (depending on chemicophysical properties ...) that bears appropriate label. An inventory ... should be kept, showing quantity of carcinogen & date it was acquired ... Facilities for dispensing ... should be contiguous to storage area. /Chemical Carcinogens/

Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 13

- Hazardous Substances Data Bank (HSDB)

Conditions for safe storage, including any incompatibilities: Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

Sigma-Aldrich; Material Safety Data Sheet for Benzene. Product Number: 12540, Version 5.2 (Revision Date 06/23/2014). Available from, as of October 9, 2014: https://www.sigmaaldrich.com/safety-center.html

- Hazardous Substances Data Bank (HSDB)

12.7 Exposure Control and Personal Protection

12.7.1 Recommended Exposure Limit (REL)

REL-TWA (Time Weighted Average)

0.1 ppm

- Occupational Safety and Health Administration (OSHA)

REL-STEL (Short Term Exposure Limit)

1 ppm

- Occupational Safety and Health Administration (OSHA)

Ca TWA 0.1 ppm ST 1 ppm See Appendix A

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

12.7.2 Permissible Exposure Limit (PEL)

PEL-TWA (8-Hour Time Weighted Average)

1 ppm

- Occupational Safety and Health Administration (OSHA)

PEL-STEL (Short Term Exposure Limit)

5 ppm

- Occupational Safety and Health Administration (OSHA)

[1910.1028] TWA 1 ppm ST 5 ppm See Appendix F

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

12.7.3 Immediately Dangerous to Life or Health (IDLH)

500 ppm ; A potential occupational carcinogen. (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

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration.

*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)

500 ppm

▸ Occupational Safety and Health Administration (OSHA)

Ca [500 ppm]

See: 71432

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

12.7.4 Threshold Limit Values (TLV)

8 hr Time Weighted Avg (TWA): 0.5 ppm, skin; 15 min Short Term Exposure Limit (STEL): 2.5 ppm, skin.

American Conference of Governmental Industrial Hygienists. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH, Cincinnati, OH 2014, p. 13

▸ Hazardous Substances Data Bank (HSDB)

A1; Confirmed human carcinogen.

American Conference of Governmental Industrial Hygienists. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH, Cincinnati, OH 2014, p. 13

▸ Hazardous Substances Data Bank (HSDB)

Biological Exposure Index (BEI): Determinant: t,t-muconic acid in urine; Sampling Time: end of shift; BEI: 500 ug/g creatinine; Notation: The determinant may be present in biological specimens collected from subjects who have not been occupationally exposed, at a concentration which could affect interpretation of the result. Such background concentrations are incorporated in the BEI value.

American Conference of Governmental Industrial Hygienists. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH, Cincinnati, OH 2014, p. 112

▸ Hazardous Substances Data Bank (HSDB)

Biological Exposure Index (BEI): Determinant: S-phenylmercapturic acid in urine; Sampling Time: end of shift; BEI: 25 ug/g creatinine. The determinant may be present in biological specimens collected from subjects who have not been occupationally exposed, at a concentration which could affect interpretation of the result. Such background concentrations are incorporated in the BEI value.

American Conference of Governmental Industrial Hygienists. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH, Cincinnati, OH 2014, p. 112

▸ Hazardous Substances Data Bank (HSDB)

0.5 ppm as TWA; 2.5 ppm as STEL; (skin); A1 (confirmed human carcinogen); BEI issued.

▸ ILO International Chemical Safety Cards (ICSC)

carcinogen category: 1; germ cell mutagen group: 3A; skin absorption (H)

▸ ILO International Chemical Safety Cards (ICSC)

TLV-TWA (Time Weighted Average)

0.5 ppm [1996]

▸ Occupational Safety and Health Administration (OSHA)

TLV-STEL (Short Term Exposure Limit)

2.5 ppm [1996]

▸ Occupational Safety and Health Administration (OSHA)

12.7.5 Other Standards Regulations and Guidelines

Belgium: TWA (skin) 30 mg/cu m, 10 ppm (1978); Czechoslovakia: TWA 50 mg/cu m, Ceiling 80 mg/cu m/10 min (1976); Finland: TWA (skin) 32 mg/cu m, 10 ppm (1975); Hungary: TWA 20 mg/cu m, may be exceeded 5 times/shift as long as avg does not exceed value (1974); Poland: Ceiling (skin) 30 mg/cu m (1976); Romania: Maximum (skin) 50 mg/cu m (1975); Switzerland: TWA (skin) 6.5 mg/cu m, 2 ppm (1978); USSR: Ceiling (skin) 5 mg/cu m (1980); Yugoslavia: Ceiling (skin) 50 mg/cu m, 15 ppm (1971).

*IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: **https://monographs.iarc.fr/ENG/Classification/index.php**, p. V29 97 (1982)*

▶ Hazardous Substances Data Bank (HSDB)

Emergency Response Planning Guidelines (ERPG): ERPG(1) 50 ppm (no more than mild, transient effects) for up to 1 hr exposure; ERPG(2) 150 ppm (without serious, adverse effects) for up to 1 hr exposure; ERPG(3) 1000 ppm (not life threatening) up to 1 hr exposure.

American Industrial Hygiene Association. The AIHA 1999 Emergency Response Planning Guidelines and Workplace Environmental Exposure Level Guides Handbook. American Industrial Hygiene Association. Fairfax, VA 1999., p. 25

▶ Hazardous Substances Data Bank (HSDB)

Australia: 5 ppm, Category 1, established human carcinogen (1990); Commission of the European Communities: 0.5 ppm (corresponding to estimated lifetime risk of 0.25-3.3 excess leukemia cases per 1000 workers); Federal Republic of Germany: no MAK, Group A1 carcinogen, capable of inducing malignant tumors in humans, skin, Technical Guiding Concentration (TRK), 1 ppm (1996); Sweden: 0.5 ppm, short-term value, 3 ppm, 15 min, skin, carcinogenic (1991); United Kingdom: 5 ppm (1997).

American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991., p. BENZENE-1

▶ Hazardous Substances Data Bank (HSDB)

12.7.6 Inhalation Risk

A harmful contamination of the air can be reached very quickly on evaporation of this substance at 20 °C.

▶ ILO International Chemical Safety Cards (ICSC)

12.7.7 Effects of Short Term Exposure

The substance is irritating to the eyes, skin and respiratory tract. If this liquid is swallowed, aspiration into the lungs may result in chemical pneumonitis. The substance may cause effects on the central nervous system. This may result in lowering of consciousness. Exposure far above the OEL could cause unconsciousness and death. If swallowed the substance easily enters the airways and could result in aspiration pneumonitis.

▶ ILO International Chemical Safety Cards (ICSC)

Benzene is carcinogenic to humans. It has been associated with cancer of the blood (leukemia), which may occur with chronic exposures to benzene of 10 ppm. Information is inconclusive but suggestive of developmental toxicity and reproductive toxicity risk with chronic or repeated exposure to benzene. Adverse health effects due to long-term benzene exposure are non-specific. Effects include fatigue, headache, dizziness, nausea, loss of appetite, loss of weight, and weakness. Repeated or prolonged skin contact with liquid benzene can remove the natural oils from the skin, causing it to crack and peel. Repeated exposure to levels of benzene below 200 ppm may cause chronic CNS effects (headache, drowsiness, and nervousness). Chronic benzene exposure in the workplace has been associated with blood (hematologic) disorders, such as low platelet counts (thrombocytopenia), absence of red blood cells (aplastic anemia), and loss of all types of blood cells due to bone marrow damage.

On-Site Fatalities

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

12.7.8 Effects of Long Term Exposure

The substance defats the skin, which may cause dryness or cracking. The substance may have effects on the central nervous system and immune system. The substance may have effects on the bone marrow. This may result in anaemia. This substance is carcinogenic to humans. May cause heritable genetic damage to human germ cells.

▶ ILO International Chemical Safety Cards (ICSC)

12.7.9 Acceptable Daily Intakes

Insufficient data are available to calculate a one-day Health Advisory for benzene. The Ten-day Health Advisory (0.235 mg/l) is considered to be adequately protective for a one-day exposure as well. ... Longer-term Health Advisories have not been calculated because of the carcinogenic potency of benzene.

USEPA; Health Advisories for 25 Organics: Benzene p.20 (1987) PB 87-235578

▶ Hazardous Substances Data Bank (HSDB)

12.7.10 Personal Protective Equipment (PPE)

Skin: Wear appropriate personal protective clothing to prevent skin contact. Eyes: Wear appropriate eye protection to prevent eye contact. Wash skin: The worker should immediately wash the skin when it becomes contaminated. Remove: Work clothing that becomes wet should be immediately removed due to its flammability hazard(i.e. for liquids with flash point Change: No recommendation is made specifying the need for the worker to change clothing after the work shift. Provide: Eyewash fountains should be provided in areas where there is any possibility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection. Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.] (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

Protective clothing consisting of coveralls or other full body clothing should be worn and changed at least twice weekly.

NIOSH; Criteria Document: Benzene p.12 (1974) DHEW Pub No 74-137

▸ Hazardous Substances Data Bank (HSDB)

Where there is a possibility of benzene contact to eyes or skin, safety showers, eye-wash fountains, and cleansing facilities shall be installed and maintained.

NIOSH; Criteria Document: Benzene p.13 (1974) DHEW Pub. No. 74-137

▸ Hazardous Substances Data Bank (HSDB)

Where high vapor concn are unavoidable, forced air masks should be used. Lifeline attended by ... person outside contaminated enclosure is mandatory. If skin contact is unavoidable, neoprene gloves must be worn.

Dreisbach, R.H. Handbook of Poisoning. 12th ed. Norwalk, CT: Appleton and Lange, 1987., p. 193

▸ Hazardous Substances Data Bank (HSDB)

Hydrocarbon vapor canister, supplied air or a hose mask; hydrocarbon insoluble rubber or plastic gloves; chemical goggles or face splash shield; hydrocarbon-insoluble apron such as neoprene.

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)

For more Personal Protective Equipment (PPE) (Complete) data for BENZENE (17 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

Remove:When wet (flammable)

Change:No recommendation

Provide:Eyewash, Quick drench

▸ 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)

12.7.11 Respirator Recommendations

(See Appendix E)

NIOSH

At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:

(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 organic vapor canister

Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection

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

12.7.12 Fire Prevention

NO open flames, NO sparks and NO smoking. Closed system, ventilation, explosion-proof electrical equipment and lighting. Do NOT use compressed air for filling, discharging, or handling. Use non-sparking handtools. Prevent build-up of electrostatic charges (e.g., by grounding).

▸ ILO International Chemical Safety Cards (ICSC)

12.7.13 Exposure Prevention

AVOID ALL CONTACT!

▸ ILO International Chemical Safety Cards (ICSC)

12.7.14 Inhalation Prevention

Use ventilation, local exhaust or breathing protection.

▸ ILO International Chemical Safety Cards (ICSC)

12.7.15 Skin Prevention

Protective gloves. Protective clothing.

▸ ILO International Chemical Safety Cards (ICSC)

12.7.16 Eye Prevention

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

▸ ILO International Chemical Safety Cards (ICSC)

12.7.17 Ingestion Prevention

Do not eat, drink, or smoke during work.

- ILO International Chemical Safety Cards (ICSC)

12.8 Stability and Reactivity

12.8.1 Air and Water Reactions

Highly flammable. Slightly soluble in water.

- CAMEO Chemicals

12.8.2 Reactive Group

Hydrocarbons, Aromatic

- CAMEO Chemicals

12.8.3 Reactivity Alerts

Highly Flammable

- CAMEO Chemicals

12.8.4 Reactivity Profile

BENZENE reacts vigorously with allyl chloride or other alkyl halides even at -70° C in the presence of ethyl aluminum dichloride or ethyl aluminum sesquichloride. Explosions have been reported [NFPA 491M 1991]. Ignites in contact with powdered chromic anhydride [Mellor 11:235 1946-47]. Incompatible with oxidizing agents such as nitric acid. Mixtures with bromine trifluoride, bromine pentafluoride, iodine pentafluoride, iodine heptafluoride and other interhalogens can ignite upon heating [Bretherick 5th ed. 1995]. Benzene and cyanogen halides yield HCl as a byproduct (Hagedorn, F. H. Gelbke, and Federal Republic of Germany. 2002. Nitriles. In Ullmann's Encyclopedia of Industrial Chemistry. Wiley-VCH Verlag GmbH & Co. KGaA.). The reaction of benzene and trichloroacetonitrile evolves toxic chloroform and HCl gases. (Hagedorn, F., H.-P. Gelbke, and Federal Republic of Germany. 2002. Nitriles. In Ullmann's Encyclopedia of Industrial Chemistry. Wiley-VCH Verlag GmbH & Co. KGaA.).

- CAMEO Chemicals

12.8.5 Hazardous Reactivities and Incompatibilities

Reacts violently with iodine pentafluoride.

Environment Canada; Tech Info for Problem Spills: Benzene (Draft) p.96 (1981)

- Hazardous Substances Data Bank (HSDB)

Hydrogenation of benzene to cyclohexane was effected in a fixed bed reactor at 210-230 °C, but a fall in conversion was apparent. Increasing the bed temp by 10 °C & the hydrogen flow led to a large increase in reaction rate which the interbed cooling coils could not handle, & an exotherm to 280 °C developed, with a hot spot around 600 °C which bulged the reactor wall.

Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 612

- Hazardous Substances Data Bank (HSDB)

Benzene ... ignites in contact with /iodine heptafluoride/ gas ...

Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 1127

- Hazardous Substances Data Bank (HSDB)

Dioxygenyl tetrafluoroborate is a very powerful oxidant, addition of a small particle to small samples of benzene ... at ambient temp ... /caused/ ignition.

Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990, p. 60

- Hazardous Substances Data Bank (HSDB)

For more Hazardous Reactivities and Incompatibilities (Complete) data for BENZENE (25 total), please visit the HSDB record page.

- Hazardous Substances Data Bank (HSDB)

12.9 Transport Information

12.9.1 DOT Emergency Guidelines

/GUIDE 130: FLAMMABLE LIQUIDS (Non-Polar/Water-Immiscible/Noxious)/ Fire or Explosion: HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks). Vapor explosion hazard indoors, outdoors or in sewers. Those substances designated with a (P) may polymerize explosively when heated or involved in a fire. Runoff to sewer may create fire or explosion hazard. Containers may explode when heated. Many liquids are lighter than water.

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

- Hazardous Substances Data Bank (HSDB)

/GUIDE 130: FLAMMABLE LIQUIDS (Non-Polar/Water-Immiscible/Noxious)/ Health: May cause toxic effects if inhaled or absorbed through skin. Inhalation or contact with material may irritate or burn skin and eyes. Fire will produce irritating, corrosive and/or toxic gases. Vapors may cause dizziness or suffocation. Runoff from fire control or dilution water may cause pollution.

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

- Hazardous Substances Data Bank (HSDB)

/GUIDE 130: FLAMMABLE LIQUIDS (Non-Polar/Water-Immiscible/Noxious)/ Public Safety: CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover. As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. Ventilate closed spaces before entering.

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

- Hazardous Substances Data Bank (HSDB)

/GUIDE 130: FLAMMABLE LIQUIDS (Non-Polar/Water-Immiscible/Noxious)/ Protective Clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Structural firefighters' protective clothing will only provide limited protection.

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 BENZENE (8 total), please visit the HSDB record page.

- Hazardous Substances Data Bank (HSDB)

12.9.2 DOT ID and Guide

1114 130

- DOT Emergency Response Guidebook; The National Institute for Occupational Safety and Health (NIOSH)

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

UN 1114; Benzene

- Hazardous Substances Data Bank (HSDB)

IMO 3.2; Benzene

- Hazardous Substances Data Bank (HSDB)

12.9.4 Standard Transportation Number

49 081 10; Benzene

- Hazardous Substances Data Bank (HSDB)

12.9.5 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 February 5, 2014: 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.

International Air Transport Association. Dangerous Goods Regulations. 47th Edition. Montreal, Quebec Canada. 2006., p. 148

▸ 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.

International Maritime Organization. IMDG Code. International Maritime Dangerous Goods Code Volume 2 2006, p. 46

▸ Hazardous Substances Data Bank (HSDB)

PRECAUTIONS FOR "CARCINOGENS": Procurement ... of unduly large amt ... should be avoided. To avoid spilling, carcinogens should be transported in securely sealed glass bottles or ampoules, which should themselves be placed inside strong screw-cap or snap-top container that will not open when dropped & will resist attack from the carcinogen. Both bottle & the outside container should be appropriately labelled. ... National post offices, railway companies, road haulage companies & airlines have regulations governing transport of hazardous materials. These authorities should be consulted before ... material is shipped. /Chemical Carcinogens/

Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 13

▸ Hazardous Substances Data Bank (HSDB)

PRECAUTIONS FOR "CARCINOGENS": When no regulations exist, the following procedure must be adopted. The carcinogen should be enclosed in a securely sealed, watertight container (primary container), which should be enclosed in a second, unbreakable, leakproof container that will withstand chem attack from the carcinogen (secondary container). The space between primary & secondary container should be filled with absorbent material, which would withstand chem attack from the carcinogen & is sufficient to absorb the entire contents of the primary container in the event of breakage or leakage. Each secondary container should then be enclosed in a strong outer box. The space between the secondary container & the outer box should be filled with an appropriate quantity of shock-absorbent material. Sender should use fastest & most secure form of transport & notify recipient of its departure. If parcel is not received when expected, carrier should be informed so that immediate effort can be made to find it. Traffic schedules should be consulted to avoid ... arrival on weekend or holiday. ... /Chemical Carcinogens/

Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 13

▸ Hazardous Substances Data Bank (HSDB)

12.9.6 DOT Label

Flammable Liquid

▸ CAMEO Chemicals

12.9.7 Packaging and Labelling

Do not transport with food and feedstuffs.

▸ ILO International Chemical Safety Cards (ICSC)

12.9.8 EC Classification

Symbol: F, T; R: 45-46-11-36/38-48/23/24/25-65; S: 53-45; Note: E

▸ ILO International Chemical Safety Cards (ICSC)

12.9.9 UN Classification

UN Hazard Class: 3; UN Pack Group: II

▸ ILO International Chemical Safety Cards (ICSC)

12.10 Regulatory Information

12.10.1 Atmospheric Standards

National emission standard for equipment leaks (fugitive emission sources) of benzene prohibit detectable benzene emissions from processing equipment (eg, pumps, valves) that contains materials which have a benzene concn of 10% or more by wt.

40 CFR 61.110 (7/1/99)

- Hazardous Substances Data Bank (HSDB)

This action promulgates standards of performance for equipment leaks of Volatile Organic Compounds (VOC) in the Synthetic Organic Chemical Manufacturing Industry (SOCMI). The intended effect of these standards is to require all newly constructed, modified, and reconstructed SOCMI process units to use the best demonstrated system of continuous emission reduction for equipment leaks of VOC, considering costs, non air quality health and environmental impact and energy requirements. Benzene is produced, as an intermediate or a final product, by process units covered under this subpart.

40 CFR 60.489 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: https://www.ecfr.gov/cgi-bin/ECFR?page=browse

- Hazardous Substances Data Bank (HSDB)

Benzene has been designated as a hazardous air pollutant under section 112 of the Clean Air Act.

40 CFR 61.01 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: https://www.ecfr.gov/cgi-bin/ECFR?page=browse

- Hazardous Substances Data Bank (HSDB)

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. Benzene is included on this list.

Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990

- Hazardous Substances Data Bank (HSDB)

12.10.2 Federal Drinking Water Standards

Maximum contaminant levels (MCL) for organic contaminants apply to community and non-transient, non-community water systems: Benzene, MCL 0.005 mg/L.

40 CFR 141.61(a) (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: https://www.ecfr.gov/cgi-bin/ECFR?page=browse

- Hazardous Substances Data Bank (HSDB)

EPA 5 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

- Hazardous Substances Data Bank (HSDB)

12.10.3 State Drinking Water Standards

(CA) CALIFORNIA 1 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

- Hazardous Substances Data Bank (HSDB)

(FL) FLORIDA 1 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

- Hazardous Substances Data Bank (HSDB)

(NJ) NEW JERSEY 1 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

- Hazardous Substances Data Bank (HSDB)

12.10.4 State Drinking Water Guidelines

(AZ) ARIZONA 1.3 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

- Hazardous Substances Data Bank (HSDB)

(CT) CONNECTICUT 1 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

▸ Hazardous Substances Data Bank (HSDB)

(ME) MAINE 6 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

▸ Hazardous Substances Data Bank (HSDB)

(MN) MINNESOTA 3 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

▸ Hazardous Substances Data Bank (HSDB)

12.10.5 Clean Water Act Requirements

Toxic pollutant designated pursuant to section 307(a)(1) of the Federal Water Pollution Control Act and is subject to effluent limitations.

*40 CFR 401.15 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: **https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

Benzene 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 January 28, 2014: **https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

12.10.6 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 10 lb or 4.54 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 January 28, 2014: **https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

12.10.7 RCRA Requirements

D018; A solid waste containing benzene may or may not become characterized as a hazardous waste when subjected to the Toxicity Characteristic Leaching Procedure listed in 40 CFR 261.24, and if so characterized, must be managed as a hazardous waste.

*40 CFR 261.24 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: **https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

F005; When benzene is a spent solvent, it is classified as a hazardous waste from a nonspecific source (F005), as stated in 40 CFR 261.31, and must be managed according to State and/or Federal hazardous waste regulations.

*40 CFR 261.31 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: **https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

U019; As stipulated in 40 CFR 261.33, when benzene, as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to Federal and/or State hazardous waste regulations. Also defined as a hazardous waste is any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5).

*40 CFR 261.33 (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of January 28, 2014: **https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

12.10.8 FDA Requirements

Benzene 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 January 28, 2014: **https://www.ecfr.gov/cgi-bin/ECFR?page=browse***

▸ Hazardous Substances Data Bank (HSDB)

12.11 Other Safety Information

Methods of Dissemination

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

Water: Benzene can be used to contaminate water.

Food: Benzene can be used to contaminate food.

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

Agricultural: If benzene is released into the air as a mist, it has the potential to contaminate agricultural products.

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

12.11.1 Other Hazardous Reactions

May accumulate static electricity

National Fire Protection Association; Fire Protection Guide to Hazardous Materials. 14TH Edition, Quincy, MA 2010, p. 49-27

▸ Hazardous Substances Data Bank (HSDB)

12.11.2 History and Incidents

/On June 30, 1992/ a derailed tank car fell 135 feet from a trestle cracking open and spilling most of its 26,200 gallons of benzene solution into the Nemadji River in Wisconsin. /This accident/ resulted in a 10 hr evacuation of more than 50,000 people. About 25 persons went to hospitals in Superior, WI and Duluth, MN complaining of dizziness, headaches, and burning eyes and skin, after a noxious gas cloud enveloped low-lying areas. The vapor was dispersed later that day by wind and rain.

C&E News 70 (27): 5 (1992)

▸ Hazardous Substances Data Bank (HSDB)

12.11.3 Special Reports

DHHS/NTP; Toxicology & Carcinogenesis Studies of Benzene in F344/N Rats and B6C3F1 Mice (Gavage Studies) Technical Report Series No. 289 (1986) NIH Publication No. 86-2545

▸ Hazardous Substances Data Bank (HSDB)

DHHS/ATSDR; Toxicological Profile for Benzene (August 2007)

▸ Hazardous Substances Data Bank (HSDB)

WHO; Environmental Health Criteria 150: Benzene (1993)

▸ Hazardous Substances Data Bank (HSDB)

U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) for Benzene (71-43-2) Toxicological Review in Adobe PDF.[Available from, as of December 15, 2009: http://www.epa.gov/iris/]

▸ Hazardous Substances Data Bank (HSDB)

U.S. Department of Health & Human Services/National Toxicology Program; Twelfth Report on Carcinogens (2011). The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. Benzene (71-43-2) is listed as known to be a human carcinogen. First listed in the First Annual Report on Carcinogens (1980).[Available from, as of February 5, 2014: http://ntp.niehs.nih.gov/]

▸ Hazardous Substances Data Bank (HSDB)

13 Toxicity

13.1 Toxicological Information

CDC-ATSDR Toxicological Profile

CDC-ATSDR Toxic Substances Portal

13.1.1 Toxicity Summary

IDENTIFICATION AND USE: Benzene is a clear, colorless liquid with a sweet aromatic odor. It is used mainly as a starting material in manufacturing other chemicals, including detergents, pesticides, plastics and resins, synthetic rubber, aviation fuel, pharmaceuticals, dye, explosives, PCB gasoline, flavors and perfumes, paints and coatings, nylon intermediates, photographic chemicals. HUMAN EXPOSURE AND TOXICITY: Immediate signs and symptoms of exposure to benzene: People who breathe in high levels of benzene may develop drowsiness, dizziness, rapid or irregular heartbeat, headaches, tremors, confusion unconsciousness, death. Eating foods or drinking beverages containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid or irregular heartbeat, death. Long-term (a year or more) exposure to benzene causes harmful effects on the bone marrow, resulting in anemia and excessive bleeding. It can also affect the immune system, increasing the chance for infection. Some women who breathed high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries. Acute deaths from benzene exposure at high concentrations have been due to ventricular fibrillation caused by exertion and release of epinephrine. Benzene causes cancer in humans. A retrospective cohort study was conducted in 233 benzene factories and 83 control factories in 12 cities in China. The benzene cohort and the control cohort consisted of 28,460 benzene exposed workers and 28,257 control workers. The leukemia mortality rate was 14/100,000 person-years in the benzene cohort and 2/100,000 person-years in the control cohort. Most (76.6%) cases of benzene leukemia were of the acute type. The mortality due to benzene leukemia was high in organic synthesis plants followed by painting and rubber synthesis industries. The concentration of benzene to which patients with a leukemia were exposed ranged from 10 to 1000 mg/cu m (mostly from 50 to 500 mg/cu m). Benzene is genotoxic in humans: a significantly increased frequency of chromatid and isochromatid breaks in the cultured lymphocytes of exposed workers has been reported, as well as a significant increase of peripheral blood lymphocyte chromosomal aberrations. Metabolic activation of benzene by rat liver microsomes induced sister chromatid exchanges and cell division delays in cultured human lymphocytes. Occupational exposure to benzene may occur through inhalation and dermal contact. The general population may be exposed to benzene via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with consumer products containing benzene. ANIMAL TOXICITY STUDIES: Experimental animal studies, both inhalation and oral, also support the evidence that exposure to benzene increases the risk of cancer in multiple organ systems, including the hematopoietic system, oral and nasal cavities, liver, forestomach, preputial gland, lung, ovary, and mammary gland. Rats exposed to 3,526-8,224 ppm of benzene in a closed chamber for 15 minutes exhibited an increased number of ectopic ventricular beats. In developmental study, rats exposed to 10, 50, or 500 ppm (32, 160 & 1600 mg/cu m) of benzene for 7 hr/day had low incidence of brain and skeletal defects. Rats exposed continuously to 209.7 ppm for 10 days prior to breeding showed a complete absence of pregnancy. 1/10 rats exposed to 19.8 ppm had resorbed embryos. Genotoxicity studies have demonstrated the induction of chromosomal aberrations in bone-marrow cells from mice, rats, and rabbits treated with single or multiple daily doses of benzene ranging from about 0.2 to 2.0 mL/kg per day given either sc or ip. The major metabolites of benzene are phenol, hydroquinone, and catechol. The route of exposure has little effect on the subsequent metabolism of benzene to hemotoxic metabolites. ECOTOXICITY STUDIES: Young Coho salmon mortality was 12/20 at 50 ppm after 24 hr up to 96 hr and 30/30 at 100 ppm after 24 hr in artificial seawater at 8 °C. Herring and anchovy larvae studies showed that 35-45 ppm caused delay in development of eggs and produced abnormal larvae; 10-35 ppm caused delay in development of larvae, decrease in feeding and growth, and increase in respiration. Blue crab juveniles when exposed to sublethal concentrations of benzene (0.1 or 5.0 ppm) in a static system showed an increase in the time needed to complete a molt cycle (50 days in case of benzene-exposed crab, as compared to 33 days for controls), a slower rate of growth of regenerating limb buds, and a depressed activity of ATPase in mitochrondria. Oxygen consumption by the crab decreased from exposure to 1.0 ppm benzene.

Hazardous Substances Data Bank (HSDB)

13.1.2 NIOSH Toxicity Data

The National Institute for Occupational Safety and Health (NIOSH)

13.1.3 Evidence for Carcinogenicity

Classification of carcinogenicity: 1) evidence in humans: sufficient; 2) evidence in animals: sufficient; Overall summary evaluation of carcinogenic risk to humans is group 1: The chemical is carcinogenic to humans. /From table/

IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: ***https://monographs.iarc.fr/ENG/Classification/index.php****, p. S7 120 (1987)*

- Hazardous Substances Data Bank (HSDB)

A1; Confirmed human carcinogen.

American Conference of Governmental Industrial Hygienists. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH, Cincinnati, OH 2014, p. 13

- Hazardous Substances Data Bank (HSDB)

Cancer Classification: Carcinogenic to Humans

USEPA Office of Pesticide Programs, Health Effects Division, Science Information Management Branch: "Chemicals Evaluated for Carcinogenic Potential" (April 2006)

- Hazardous Substances Data Bank (HSDB)

WEIGHT-OF-EVIDENCE CHARACTERIZATION: Benzene is classified as a "known" human carcinogen (Category A) under the Risk Assessment Guidelines of 1986. Under the proposed revised Carcinogen Risk Asessment Guidelines (USEPA, 1996), benzene is characterized as a known human carcinogen for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies. Epidemiologic studies and case studies provide clear evidence of a causal association between exposure to benzene and acute nonlymphocytic leukemia and also suggest evidence for chronic nonlymphocytic leukemia and chronic lymphocytic leukemia. Other neoplastic conditions that are associated with an increased risk in humans are hematologic neoplasms, blood disorders such as preleukemia and aplastic anemia, Hodgkin's lymphoma, and myelodysplastic syndrome. These human data are supported by animal studies. The experimental animal data add to the argument that exposure to benzene increases the risk of cancer in multiple species at multiple organ sites (hematopoietic, oral and nasal, liver, forestomach, preputial gland, lung, ovary, and mammary gland). It is likely that these responses are due to interactions of the metabolites of benzene with DNA ... Recent evidence supports the viewpoint that there are likely multiple mechanistic pathways leading to cancer and, in particular, to leukemogenesis from exposure to benzene. HUMAN CARCINOGENICITY DATA: Benzene is a known human carcinogen based upon evidence presented in numerous occupational epidemiological studies. Significantly increased risks of leukemia, chiefly acute myelogenous leukemia, have been reported in benzene-exposed workers in the chemical industry, shoemaking and oil refineries. ANIMAL CARCINOGENICITY DATA:... many experimental animal studies, both inhalation and oral, also support the evidence that exposure to benzene increases the risk of cancer in multiple organ systems, including the hematopoietic system, oral and nasal cavities, liver, forestomach, preputial gland, lung, ovary, and mammary gland ....

U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS). Summary on Benzene (71-43-2). Available from, as of February 21, 2014: ***https://www.epa.gov/IRIS/subst/0276.htm***

- Hazardous Substances Data Bank (HSDB)

Benzene: known to be a human carcinogen. Carcinogenicity: Benzene is known to be a human carcinogen based on sufficient evidence of carcinogenicity from studies in humans.

DHHS/National Toxicology Program; Twelfth Report on Carcinogens: Benzene (71-43-2) (2011). Available from, as of February 21, 2014: ***https://ntp.niehs.nih.gov/ntp/roc/twelfth/profiles/Benzene.pdf***

- Hazardous Substances Data Bank (HSDB)

EPA-A; K, IARC-1, NIOSH-Ca, NTP-K, OSHA-Ca, TLV-A1

- Occupational Safety and Health Administration (OSHA)

13.1.4 Carcinogen Classification

IARC Carcinogenic Agent	Benzene
IARC Carcinogenic Classes	Group 1: Carcinogenic to humans
IARC Monographs	Volume 29: (1982) Some Industrial Chemicals and Dyestuffs Volume Sup 7. 100F (in preparation) Volume 120: (2018) Benzene

- International Agency for Research on Cancer (IARC)

13.1.5 Health Effects

Health Effect Code(s)

HE1 - Cancer---Currently regulated by OSHA as carcinogen

HE7 - Nervous System Disturbances---Nervous system effects other than narcosis

HE8 - Nervous System Disturbances---Narcosis

HE12 - Hematologic (Blood) Disturbances---Anemias

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

- Occupational Safety and Health Administration (OSHA)

13.1.6 Exposure Routes

The substance can be absorbed into the body by inhalation, through the skin and by ingestion.

- ILO International Chemical Safety Cards (ICSC)

inhalation, skin absorption, ingestion, skin and/or eye contact

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

Benzene can be absorbed into the body by inhalation, ingestion, or skin contact. Inhalation is an important route of exposure.

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

13.1.7 Symptoms

irritation eyes, skin, nose, respiratory system; dizziness; headache, nausea, staggered gait; anorexia, lassitude (weakness, exhaustion); dermatitis; bone marrow depression; [potential occupational carcinogen]

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

13.1.8 Inhalation Symptoms

Dizziness. Drowsiness. Headache. Nausea. Shortness of breath. Convulsions. Unconsciousness.

- ILO International Chemical Safety Cards (ICSC)

700 to 3,000 ppm: Drowsiness, dizziness, headaches, tremors, confusion, unconsciousness, abnormally rapid heart rate (tachycardia), and irritation of the moist linings (mucous membranes of the respiratory tract).

3,000 ppm and above: Slow and shallow breathing; a deeper level of unconsciousness, due to narcotic-like action on the CNS; and with prolonged exposures, seizures, paralysis, abnormal (potentially fatal) heart rhythms (cardiac arrhythmia), and cessation of breathing (apnea).

20,000 ppm for 5 minutes: Cessation of breathing (apnea) due to accumulation of fluid in the lungs (pulmonary edema).

If benzene is ingested and vomited, inhalation of benzene-containing vomitus into the lungs (aspiration) may cause potentially fatal lung damage.

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

13.1.9 Skin Symptoms

MAY BE ABSORBED! Dry skin. Redness. Pain. Further see Inhalation.

- ILO International Chemical Safety Cards (ICSC)

Mild to moderate: Irritation, redness (erythema), and burning sensation.

Severe: Fluid accumulation (edema), blistering (vesication), and inflammation (dermatitis).

Absorption through the skin is slow, but it may contribute to whole-body (systemic) toxicity.

See Inhalation Exposure

Decontamination

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

13.1.10 Eye Symptoms

Redness. Pain.

- ILO International Chemical Safety Cards (ICSC)

High concentrations of vapor: Irritation and blurred vision.

Liquid: Burning pain and possibly reversible loss (sloughing) and injury to the surface of the cornea.

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

13.1.11 Ingestion Symptoms

Abdominal pain. Sore throat. Vomiting. Further see Inhalation.

- ILO International Chemical Safety Cards (ICSC)

Nine to 12 g: Irritation of the stomach causing nausea, vomiting (emesis), and diarrhea; burning sensation to the mouth, esophagus, and stomach; abnormally rapid heart rate (tachycardia); staggering gait, drowsiness (somnolence), loss of consciousness, or altered mental status; and inflammation of the lungs and respiratory failure.

Slightly higher ingested doses: Dizziness and excitation followed by a flushed appearance, difficulty breathing or shortness of breath (dyspnea), feeling of chest tightness, headache, and generalized weakness.

At the highest ingested doses: In addition to the above adverse health effects, symptoms include euphoria and excitation followed by fatigue, coma, and death.

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

13.1.12 Target Organs

Hematological (Blood Forming), Immunological (Immune System), Neurological (Nervous System)

- CDC-ATSDR Toxic Substances Portal

Eyes, skin, respiratory system, blood, central nervous system, bone marrow

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

13.1.13 Cancer Sites

[leukemia]

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

13.1.14 Acute Toxicity Link

Chemical: BENZENE

- USGS Columbia Environmental Research Center

13.1.15 Acute Effects

- ChemIDplus

13.1.16 Interactions

Dimethyl sulfoxide (DMSO) enhanced the hypertaurinuria produced by benzene, chlorobenzene, and toluene in rats. Undiluted DMSO was more effective than DMSO diluted with water in potentiating the toxicity of benzene in both rats and mice. Supernatants (9000g) prepared from livers of rats treated with DMSO 24 hours earlier metabolized more benzene than those from control rats.

PMID:5644044

Kocsis JJ et al; Science 160: 427 (1968)

▸ Hazardous Substances Data Bank (HSDB)

Benzene & ethanol induced a common cytochrome P450 species in rabbit liver specifically effective in hydroxyl radical-mediated oxygenation of ethanol. Benzene oxidation by the benzene-inducible form of cytochrome P450 was almost completely inhibited by catalase, superoxide dismutase, DMSO, & mannitol.

Ingelman-Sundberg M et al; Dev Biiochem 23 (Iss Cytochrome P450, Biochem Biophys Environ Implic): 19-26 (1982)

▸ Hazardous Substances Data Bank (HSDB)

Simultaneous treatments with both benzene and toluene, or benzene and piperonyl butoxide, increased the excretion of unchanged benzene in the expired air. These compounds apparently act by inhibiting benzene metabolism.

USEPA; ECAO Atlas Document: Benzene IV-12 (1980)

▸ Hazardous Substances Data Bank (HSDB)

Toluene, Aroclor 1254, phenobarbital, acetone, and ethanol are known to alter the metabolism and toxicity of benzene.

*U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Benzene p.212 PB2008-100004 (2007). Available from, as of August 12, 2014: **https://www.atsdr.cdc.gov/toxprofiles/index.asp***

▸ Hazardous Substances Data Bank (HSDB)

For more Interactions (Complete) data for BENZENE (13 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

13.1.17 Antidote and Emergency Treatment

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. /Benzene and Related Compounds/

Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 213-4

▸ Hazardous Substances Data Bank (HSDB)

Basic treatment: Establish a patent airway (oropharyngeal or nasopharyngeal airway, if needed). Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Monitor for shock and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with 0.9% saline (NS) during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 mL/kg up to 200 mL of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . /Benzene and Related Compounds/

Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 213-4

▸ Hazardous Substances Data Bank (HSDB)

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious, has severe pulmonary edema, or is in severe respiratory distress. Positive-pressure ventilation techniques with a bag valve mask device may be beneficial. Consider drug therapy for pulmonary edema ... . Consider administering a beta agonist such as albuterol for severe bronchospasm ... . Monitor cardiac rhythm and treat arrhythmias as necessary ... . Start IV administration of D5W /SRP: "To keep open", minimal flow rate/. Use 0.9% saline (NS) or lactated Ringer's (LR) if signs of hypovolemia are present. For hypotension with signs of hypovolemia, administer fluid cautiously. Watch for signs of fluid overload ... . Treat seizures with diazepam or lorazepam ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Benzene and related Compounds/

Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3Rd edition, Elsevier Mosby, St. Louis, MO 2005, p. 214

▸ Hazardous Substances Data Bank (HSDB)

Emergency and supportive measures. 1. Maintain an open airway and assist ventilation if necessary. 2. Treat coma, seizures, arrhythmias, and other complications is they occur. 3. Be cautious with the use of any beta-adrenergic agents (eg, epinephrine, albuterol) because of the possibility of dyshythmias due to myocardial sensitization. 4. Monitor vital signs and ECG for 12-24 hours after significant exposure.

OLSON, K.R. (Ed). Poisoning and Drug Overdose, Sixth Edition. McGraw-Hill, New York, NY 2012, p. 140

▸ Hazardous Substances Data Bank (HSDB)

For more Antidote and Emergency Treatment (Complete) data for BENZENE (6 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

13.1.18 Medical Surveillance

...trans, trans-muconic acid appeared to be the most reliable of benzene metabolites to employ for low-level benzene exposure monitoring between 0.25 and 3.5 ppm.

Sullivan, J.B., Krieger G.R. (eds). Clinical Environmental Health and Toxic Exposures. Second edition. Lippincott Williams and Wilkins, Philadelphia, Pennsylvania 1999., p. 755

▸ Hazardous Substances Data Bank (HSDB)

PRECAUTIONS FOR "CARCINOGENS": ... In relation specifically to cancer hazards, there are at present no health monitoring methods that may ensure the early detection of preneoplastic lesions or lesions which may preclude them. Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning additional tests that might become useful or mandatory. /Chemical Carcinogens/

Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979., p. 23

▸ Hazardous Substances Data Bank (HSDB)

13.1.19 Human Toxicity Excerpts

/SIGNS AND SYMPTOMS/ Direct exposure of the eyes, skin, or lungs to benzene can cause tissue injury and irritation.

*CDC; Emergency Preparedness and Response: Facts about Benzene; Available from, as of February 21, 2014: **https://www.bt.cdc.gov/agent/benzene/basics/facts.asp***

▸ Hazardous Substances Data Bank (HSDB)

/SIGNS AND SYMPTOMS/ Immediate signs and symptoms of exposure to benzene: People who breathe in high levels of benzene may develop the following signs and symptoms within minutes to several hours:Drowsiness,Dizziness,Rapid or irregular heartbeat, Headaches,Tremors,Confusion Unconsciousness,Death (at very high levels). Eating foods or drinking beverages containing high levels of benzene can cause the following symptoms within minutes to several hours: Vomiting, Irritation of the stomach,Dizziness,Sleepiness,Convulsions,Rapid or irregular heartbeat,Death (at very high levels).

*CDC; Emergency Preparedness and Response: Facts about Benzene; Available from, as of February 21, 2014: **https://www.bt.cdc.gov/agent/benzene/basics/facts.asp***

▸ Hazardous Substances Data Bank (HSDB)

/SIGNS AND SYMPTOMS/ Long-term health effects of exposure to benzene: The major effect of benzene from long-term exposure is on the blood. (Long-term exposure means exposure of a year or more.) Benzene causes harmful effects on the bone marrow and can cause a decrease in red blood cells, leading to anemia. It can also cause excessive bleeding and can affect the immune system, increasing the chance for infection. Some women who breathed high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries. It is not known whether benzene exposure affects the developing fetus in pregnant women or fertility in men. Animal studies have shown low birth weights, delayed bone formation, and bone marrow damage when pregnant animals breathed benzene. The Department of Health and Human Services (DHHS) has determined that benzene causes cancer in humans. Long-term exposure to high levels of benzene in the air can cause leukemia, cancer of the blood-forming organs.

*CDC; Emergency Preparedness and Response: Facts about Benzene; Available from, as of February 21, 2014: **https://www.bt.cdc.gov/agent/benzene/basics/facts.asp***

▸ Hazardous Substances Data Bank (HSDB)

/SIGNS AND SYMPTOMS/ Benzene (benzol) ... has specific toxic effect on blood formation, causing aplastic anemia & tendency to hemorrhage. Occasionally hemorrhages in retina & in conjunctiva are found in systemic poisoning by benzene. In rare instances neuroretinal edema & papilledema have been described accompanying retinal hemorrhages. It has not been established that benzene can induce retrobulbar neuritis or optic neuritis ...

Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986., p. 140

▸ Hazardous Substances Data Bank (HSDB)

For more Human Toxicity Excerpts (Complete) data for BENZENE (61 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

13.1.20 Non-Human Toxicity Excerpts

/LABORATORY ANIMALS: Acute Exposure/ The effect of a single dose of benzene (0.5 mL/kg body wt ip) on the heme saturation of tryptophan pyrrolase activity in liver was examined /in female albino rats/. There was a significant decrease in the heme saturation of hepatic tryptophan pyrrolase, suggesting depletion of regulatory heme. After benzene administration there was significant increase in delta-aminolevulinate synthetase activity while delta-aminolevulinate dehydratase activity was significantly decreased, however, ferrochelatase and heme oxygenase activities were unaltered. Administration of tryptophan to benzene pretreated rats showed a reversal of benzene effects on heme synthesizing enzymes: there is an increase in the heme saturation of tryptophan pyrrolase and decrease in delta-aminolevulinate synthetase. However, there was no significant alteration in the activity of delta-aminolevulinate dehydratase.

Siddiqui SM et al; Toxicol 48 (3): 245-51 (1988)

▸ Hazardous Substances Data Bank (HSDB)

/LABORATORY ANIMALS: Acute Exposure/ Rats exposed to 3,526-8,224 ppm of benzene in a closed chamber for 15 min exhibited an increased number of ectopic ventricular beats.

Magos GA et al; Neurotoxicol Teratol 12 (2): 119-24 (1990)

▸ Hazardous Substances Data Bank (HSDB)

/LABORATORY ANIMALS: Acute Exposure/ Sprague-Dawley rats received a single dose of 950 mg/kg benzene by gavage and were sacrificed 2 hr after treatment. The control group received nothing. Brains were dissected ... Results showed that benzene decreased acetylcholine content of rat hippocampus. 3,4-Dihydroxyphenylalanine and norepinephrine content decreased in the rat midbrain. Dopamine, serotonin and 5-hydroxyindoleacetic acid content increased in the rat midbrain. Dopamine, 3,4-dihydroxyphenylacetic acid, norepinephrine, and 5-hydroxyindoleacetic acid content increased and serotonin content decreased in the rat hypothalamus after oral administration of benzene. Increased dopamine, homovanillic acid, 3-methoxy-4-hydroxyphenylglycol, and serotonin content of rat medulla oblongata was observed. Decreased norepinephrine and 5-hydroxyindoleacetic acid content of rat medulla oblongata by benzene treatment was observed.

Kanada M et al; Ind Health 32: 145-64 (1994)

▸ Hazardous Substances Data Bank (HSDB)

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ In series of chronic studies, bilateral cataracts were found in 50% of rats exposed /to/ ... 50 ppm for 600 hr ...

National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977., p. 689

▸ Hazardous Substances Data Bank (HSDB)

For more Non-Human Toxicity Excerpts (Complete) data for BENZENE (43 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

13.1.21 Human Toxicity Values

Estimated oral doses from 9-30 g have proved fatal.

WHO; Environmental Health Criteria 150: Benzene p.46 (1993)

▸ Hazardous Substances Data Bank (HSDB)

...concentrations of 66,000 mg/cu m (20,000 ppm) commercial benzene have been reported to be fatal in man within 5-10 minutes.

*IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: **https://monographs.iarc.fr/ENG/Classification/index.php**, p. V29 116 (1982)*

▸ Hazardous Substances Data Bank (HSDB)

Immediately dangerous to life and health = 500 ppm

Sullivan, J.B., Krieger G.R. (eds). Clinical Environmental Health and Toxic Exposures. Second edition. Lippincott Williams and Wilkins, Philadelphia, Pennsylvania 1999., p. 754

▸ Hazardous Substances Data Bank (HSDB)

13.1.22 Non-Human Toxicity Values

LD50 Mice ip 0.34 mL/kg

PMID:5644044
Kocsis JJ et al; Science 160 (3826): 427-8 (1968)

▸ Hazardous Substances Data Bank (HSDB)

LD50 Rat oral 3306 mg/kg

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 360

▸ Hazardous Substances Data Bank (HSDB)

LC50 Rat ihl 10,000 ppm/7 hr

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 360

▸ Hazardous Substances Data Bank (HSDB)

LD50 Rat ip 2890 ug/kg

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 360

▸ Hazardous Substances Data Bank (HSDB)

For more Non-Human Toxicity Values (Complete) data for BENZENE (10 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

13.1.23 Ecotoxicity Values

LC100; Species: Tetrahymena pyriformis /protozoa/; Concentration: 1000 mg/L for 24 hr /Conditions of bioassay not specified/

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. 262

▸ Hazardous Substances Data Bank (HSDB)

LC50; Species: Palaemonetes pugio (grass shrimp); Concentration: 27 ppm for 96 hr /Conditions of bioassay not specified/

Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994., p. 263

▸ Hazardous Substances Data Bank (HSDB)

LC50; Species: Cancer magister (crab larvae) stage 1; Concentration: 108 ppm for 96 hr /Conditions of bioassay not specified/

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. 263

▸ Hazardous Substances Data Bank (HSDB)

LC50; Species: Crangon franciscorum (shrimp); Concentration: 20 ppm for 96 hr /Conditions of bioassay not specified/

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. 263

▸ Hazardous Substances Data Bank (HSDB)

For more Ecotoxicity Values (Complete) data for BENZENE (74 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

13.1.24 Ecotoxicity Excerpts

/AQUATIC SPECIES/ Toxicity threshold (cell multiplication inhibition test): bacteria (Pseudomonas putida) 92 mg/L; algae (Microcystis aeruginosa) >1400 mg/L; green algae (Scenedesmus quadricauda) >1400 mg/L; protozoa (Entosiphon sulcatum) >700 mg/L, & (Uronema parduczi Chatton-Lwoff) 486 mg/L. Algae (Chlorella vulgaris) /showed/ 50% reduction of cell numbers versus controls after 1 day incubation at 20 °C at 525 ppm. Inhibition of photosynthesis (of a freshwater, nonaxenic unialgal culture of Selenastrum capricornutum) at 10 mg/L, 95% carbon-14 fixation (versus controls); at 100 mg/L, 84% carbon-14 fixation (versus controls); at 1000 mg/L, 5% carbon-14 fixation (versus controls).

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. 262-3

▸ Hazardous Substances Data Bank (HSDB)

/AQUATIC SPECIES/ ... Young Coho salmon /showed/ no significant mortalities up to 10 ppm after 96 hr in artificial seawater at 8 °C ... Mortality /was/ 12/20 at 50 ppm after 24 hr up to 96 hr and 30/30 at 100 ppm after 24 hr in artificial seawater at 8 °C. Herring and anchovy larvae (Clupea pallasi and Engraulis mordex) /studies showed that/ 35-45 ppm caused delay in development of eggs and /produced/ abnormal larvae; 10-35 ppm caused delay in development of larvae, decrease in feeding and growth, and increase in respiration.

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. 262-3

▸ Hazardous Substances Data Bank (HSDB)

/AQUATIC SPECIES/ Blue crab juveniles when exposed to sublethal concentration of benzene (0.1 or 5.0 ppm) in a static system showed an increase in the time needed to complete a molt cycle (50 days in case of benzene-exposed crab, as compared to 33 days for controls), a slower rate of growth of regenerating limb buds, and a depressed activity of ATPase in mitochrondria. Oxygen consumption by the crab decreased from exposure to 1.0 ppm benzene.

Cantelmo A et al; Physiol Mech Mar Pollut Toxic (Proc Symp Pollut Mar Org): 349-89 (1982)

▸ Hazardous Substances Data Bank (HSDB)

/PLANTS/ In higher plants, benzene administered in aqueous solution or as vapor is translocated and metabolized. The proposed sequence of benzene metabolism in plants is benzene /to/ phenol /to/ pyrocatechol /to/ o-benzoquinone /to/ muconic acid.

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001, p. 264

▸ Hazardous Substances Data Bank (HSDB)

13.1.25 Ongoing Test Status

The following link will take the user to the National Toxicology Program (NTP) Test Agent Search Results page, which tabulates all of the "Standard Toxicology & Carcinogenesis Studies", "Developmental Studies", and "Genetic Toxicity Studies" performed with this chemical. Clicking on the "Testing Status" link will take the user to the status (i.e., in review, in progress, in preparation, on test, completed, etc.) and results of all the studies that the NTP has done on this chemical.[Available from, as of February 5, 2014: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchresults&searchterm=71-43-2]

▸ Hazardous Substances Data Bank (HSDB)

13.1.26 National Toxicology Program Studies

During the 17-week studies, groups of 10 or 15 male and female F344/N rats and B6C3F1 mice were gavaged 5 days per week with benzene in corn oil (5 mL/kg) at doses of 0 to 600 mg/kg. No benzene- related deaths occurred; in rats that received benzene, final mean body weights were 14%-22% lower compared with vehicle controls and in mice, slight dose-related reductions were observed (less than 10% differences).

Toxicology & Carcinogenesis Studies of Benzene in F344/N Rats and B6C3F1 Mice (Gavage Studies). Technical Report Series No. 289 (1986) NIH Publication No. 86-2545 U.S. Department of Health and Human Services, National Toxicology Program, National Institute of Environmental Health Sciences, Research Triangle Park, NC 27709; Available from, as of February 25, 2014: ***https://ntp.niehs.nih.gov/ntp/htdocs/LT_rpts/tr289.pdf***

▸ Hazardous Substances Data Bank (HSDB)

Two yr toxicology and carcinogenesis studies of benzene (greater than 99.7% pure) were conducted in groups of 50 F344/N rats and 50 B6C3F1 mice of each sex and for each dose. Doses of 0, 50, 100, or 200 mg/kg body weight benzene in corn oil (5 ml/kg) were administered by gavage to male rats, 5 days/wk for 103 wk. Doses of 0, 25, 50, or 100 mg/kg benzene in corn oil were administered by gavage to female rats and to male and female mice for 103 wk. ... Under the conditions of these 2 yr gavage studies, there was clear evidence of carcinogenicity of benzene for male F344/N rats, for female F344/N rats, for male B6C3F1 mice and for female B6C3F1 mice. For male rats, benzene caused increased incidences of Zymbal gland carcinomas, squamous cell papillomas and squamous cell carcinomas of the oral cavity, and squamous cell papillomas and squamous cell carcinomas of the skin. For female rats, benzene caused increased incidences of Zymbal gland carcinomas, squamous cell papillomas, and squamous cell carcinomas of the oral cavity. For male mice, benzene caused increased incidences of Zymbal gland squamous cell carcinomas, lymphomas, alveolar/bronchiolar carcinomas and alveolar/bronchiolar adenomas or carcinomas (combined), Harderian gland adenomas, and squamous cell carcinomas of the preputial gland. For female mice, benzene caused increased incidences of malignant lymphomas, ovarian granulosa cell tumors, ovarian benign mixed tumors, carcinomas and carcinosarcomas of the mammary gland, alveolar/bronchiolar adenomas, alveolar/bronchiolar carcinomas, and Zymbal gland squamous cell carcinomas. ...

Toxicology & Carcinogenesis Studies of Benzene in F344/N Rats and B6C3F1 Mice (Gavage Studies). Technical Report Series No. 289 (1986) NIH Publication No. 86-2545 U.S. Department of Health and Human Services, National Toxicology Program, National Institute of Environmental Health Sciences, Research Triangle Park, NC 27709; Available from, as of February 25, 2014: ***https://ntp.niehs.nih.gov/ntp/htdocs/LT_rpts/tr289.pdf***

▸ Hazardous Substances Data Bank (HSDB)

13.1.27 TSCA Test Submissions

An evaluation of fertility was made in female Charles River CD rats (26/group) exposed by inhalation to benzene at 0, 1, 10, 30 and 300 ppm for 6 hrs/day, 5 days/week during a 10 week pre-mating treatment period and ensuing mating period, and continued exposure for mated females daily for 6 hrs/day during gestation to day 20. Daily exposure was resumed on day 5 of lactation until weaning (day 21 of lactation). There were significant differences between treated and control animals in the following: decrease in pup survival index (for lactation day 4-21 at 10 ppm, no dose-response), decreased mean pup weights (days 14 and 21 of lactation for high-dose level), and decreased mean absolute liver weights (high-dose female pups). There were no significant differences between treated and control animals in the following: maternal mortality, body weights, in-life observations, pregnancy rates, mean number dead pups, mean liver weights (male pups at all levels), mean relative liver weights (female pups at all levels), mean relative and absolute kidney weights (all female pups), or gross postmortem examinations of adult females or pups.

Bio Dynamics Inc.; An Inhalation Female Fertility Study With Benzene in Rats, Final Report. (1980), EPA Document No. FYI-AX-0481-0110, Fiche No. 0110-0

▸ Hazardous Substances Data Bank (HSDB)

Teratogenic effects were evaluated in pregnant female Sprague Dawley rats (40/group) exposed via inhalation to benzene at 0 (two groups), 1, 10, 40 and 100 ppm for 6 hrs/day from days 6-15 of gestation. On day 20 of gestation, the dams were sacrificed and the fetuses removed by cesarean section. There were significant differences between treated and control groups only in the decreased mean fetal body weights of fetuses from dams exposed at the high-dose level. There were no significant differences between treated and control dams in the following: mortality, clinical observations, body weight data, maternal gross pathology, pregnancy rates, mean number of corpora and implantations, or implantation efficiencies. There were no significant differences between fetuses from treated and control dams in the following: mean incidence of fetal resorptions, mortality, mean percentage of male fetuses/litter, mean fetal body lengths, or fetal development.

Hazelton Laboratories America, Inc.; Inhalation Teratology Study in Rats, Benzene, Final Report. (1982), EPA Document No. FYI-AX-0482-0127, Fiche No. 0127-0

▸ Hazardous Substances Data Bank (HSDB)

The mutagenicity of benzene was evaluated in dominant lethal assay using four groups of 20 male Sprague-Dawley rats receiving whole body exposures to nominal concentrations of test material at 1, 10, 30 and 300ppm in a dynamic air flow chamber for 6hours/day, 5days/week for ten consecutive weeks. Following exposure, each male was mated with two untreated females per week for two consecutive weeks. There was no effect of treatment for all dosed male rats as indicated by: mortality, body weight data and in-life physical observations. Pregnancy rates and implantation efficiency ratios of females mated to treated males was not significant different from control group females. Slight increases in the mean number of dead implantations and mean mutagenic ratios (i.e. no. dead implants/total implants) were noted for each week of the post treatment mating period for females mated to high dose males, but these differences were not statistically significant compared to controls. Males were sacrificed after a 10-week post mating period and microscopic examination of testis/epididymides revealed two-high dose males with testicular lesions.

Bio/dynamics Inc.; A Dominant-Lethal Inhalation Study with Benzene in Rats, Final Report, (1980), EPA Document No. FYI-AX-0481-0110, Fiche No. OTS0000110-0

▸ Hazardous Substances Data Bank (HSDB)

As part of subchronic inhalation study, the ability of benzene to cause chromosome aberrations was evaluated in bone marrow cells of (50/sex) CD-1 mice receiving whole body exposures to nominal concentrations of 0, 1, 10, 30 and 300ppm in dynamic air flow chamber for 6hours/day, 5days/week for 13 weeks. Following the last day of exposure, animals received a single intraperitoneal injection of colchicine and were sacrificed. Bone marrow slides of mice at the highest concentration (300ppm) exhibited statistically significant increases chromosome aberrations relative to the control.

Hazleton Laboratories America Inc.; Subchronic Inhalation Study in Mice and Rats, Final Report, (1983), EPA Document No. FYI-AX-0783-0203, Fiche No. OTS0000203-1

▸ Hazardous Substances Data Bank (HSDB)

For more TSCA Test Submissions (Complete) data for BENZENE (12 total), please visit the **HSDB record page**.

▸ Hazardous Substances Data Bank (HSDB)

13.1.28 Populations at Special Risk

... /It has been observed/ that levels of leukocyte agglutins were elevated in selected individuals exposed to benzene. ... /This/ suggested that in some people benzene toxicity may be accounted for in part by an allergic blood dyscrasia.

IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work). Available at: ***https://monographs.iarc.fr/ENG/Classification/index.php****, p. V29 117 (1982)*

▸ Hazardous Substances Data Bank (HSDB)

... Workers with higher activities of /cytochrome P-450(2E1)/ are at more risk /of benzene hematoxicity/.

International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998., p. 1.2

▸ Hazardous Substances Data Bank (HSDB)

... It has been suggested that Thalassemia minor, and presumably other disorders in which there is increased bone marrow turnover, may predispose a person to benzene-induced aplastic anemia.

International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998., p. 1.2

▸ Hazardous Substances Data Bank (HSDB)

13.2 Ecological Information

13.2.1 US EPA Regional Screening Levels for Chemical Contaminants

Resident Soil (mg/kg)	1.20e+00
Industrial Soil (mg/kg)	5.10e+00
Resident Air (ug/m3)	3.60e-01
Industrial Air (ug/m3)	1.60e+00
Tapwater (ug/L)	4.60e-01
MCL (ug/L)	5.00e+00
Risk-based SSL (mg/kg)	2.30e-04
MCL-based SSL (mg/kg)	2.60e-03
Oral Slope Factor (mg/kg-day)-1	5.50e-02
Inhalation Unit Risk (ug/m3)-1	7.8e-06
Chronic Oral Reference Dose (mg/kg-day)	4.00e-03
Chronic Inhalation Reference Concentration (mg/m3)	3.00e-02
Volatile	Volatile
Fraction of Contaminant Absorbed in Gastrointestinal Tract	1
Soil Saturation Concentration (mg/kg)	1.82e+03

▸ US EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites

13.2.2 US EPA Regional Removal Management Levels for Chemical Contaminants

Resident Soil (mg/kg)	1.20e+02
Industrial Soil (mg/kg)	5.10e+02
Resident Air (ug/m3)	3.60e+01
Industrial Air (ug/m3)	1.60e+02
Tapwater (ug/L)	4.60e+01
MCL (ug/L)	5.00e+00
Oral Slope Factor (mg/kg-day)-1	5.50e-02
Inhalation Unit Risk (ug/m3)-1	7.8e-06
Chronic Oral Reference Dose (mg/kg-day)	4.00e-03
Chronic Inhalation Reference Concentration (mg/m3)	3.00e-02
Volatile	Volatile

Fraction of Contaminant Absorbed in Gastrointestinal Tract	1
Soil Saturation Concentration (mg/kg)	1.82e+03

- US EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites

13.2.3 ICSC Environmental Data

The substance is toxic to aquatic organisms. The substance may cause long-term effects in the aquatic environment.

- ILO International Chemical Safety Cards (ICSC)

13.2.4 Environmental Fate/Exposure Summary

Benzene's production, existence in gasoline, and use in the production of ethylbenzene and styrene as well as many other chemicals may result in its release to the environment through various waste streams. Benzene is found in volcanoes, as a constituent of crude oil, from forest fires, and as a plant volatile. If released to air, a vapor pressure of 94.8 mm Hg at 25 °C indicates benzene will exist solely as a vapor in the ambient atmosphere. Vapor-phase benzene will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 13 days. Vapor-phase benzene is also degraded by ozone radicals and nitrate found in the atmosphere but at such low rates as to not be important. A half-life of 16.9 days was reported for photolysis of benzene dissolved in deionized water saturated with air exposed to sunlight. Since benzene is very water soluble, it may be removed from the atmosphere by rain. If released to soil, benzene is expected to have high mobility based upon a Koc of 85. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 5.56X10-3 atm-cu m/mole. Benzene may volatilize from dry soil surfaces based upon its vapor pressure. Using a base-rich para-brownish soil incubated for 10 weeks, 20 ppm benzene was 24% degraded in 1 week, 44% in 5 weeks, and 47% in 10 weeks, indicating that biodegradation may be an important environmental fate process in soil. If released into water, benzene is not expected to adsorb to sediment and suspended solids in water based upon the Koc. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 2.7 hrs and 3.5 days, respectively. Utilizing the Japanese MITI test, 40% of the Theoretical BOD was reached in 2 weeks indicating that biodegradation is important environmental fate process in water. In aqueous solution, benzene will react with hydroxyl radical (OH radical average concentration = 1.0X10-17 molec/cu cm) at a reaction rate of 7.8X10+9 L/mol sec which results in an estimated half-life of 103 days. A BCF ranging from 1.1-20 suggests bioconcentration in aquatic organisms is low. Hydrolysis is not expected to occur due to the lack of hydrolyzable functional groups. Occupational exposure to benzene may occur through inhalation and dermal contact with this compound at workplaces where benzene is produced or used. Monitoring data indicate that the general population may be exposed to benzene via inhalation of ambient air, ingestion of food and drinking water, and dermal and inhalation contact with consumer products containing this compound. Benzene is a component of cigarette smoke and is widely detected in atmospheric samples due to its presence in gasoline. (SRC)

- Hazardous Substances Data Bank (HSDB)

13.2.5 Natural Pollution Sources

... Benzene has been reported to be a natural constituent of fruits, vegetables, meats, and dairy products with concentrations ranging from 2 ug/kg in canned beef to 2100 ug/kg for eggs.

Sullivan, J.B. Jr., G.R. Krieger (eds.). Hazardous Materials Toxicology-Clinical Principles of Environmental Health. Baltimore, MD: Williams and Wilkins, 1992., p. 724

- Hazardous Substances Data Bank (HSDB)

Benzene is found naturally in the environment from volcanoes, as a natural constituent of crude oil, from forest fires and as a plant volatile(1,2). Benzene concentrations range from 100-200 parts per trillion over the Pacific and Atlantic Oceans due to seepage and spillage of oil into the oceans(3).

(1) IARC; Monograph. Some Industrial Chemicals and Dyestuffs 29: 99-106 (1982) (2) Graedel TE; Chemical Cmpds in the Atmos. NY, NY: Academic Press (1978) (3) Singh HB, Zimmerman PB; Adv Environ Sci Technol 24: 177-235 (1992)

- Hazardous Substances Data Bank (HSDB)

13.2.6 Artificial Pollution Sources

Benzene's production and use in the manufacture of industrial chemicals such as polymers, detergents, pesticides, pharmaceuticals, dyes, plastics, resins, as an organic solvent for waxes, resins, oils, natural rubber, etc, a reference for quantitating compounds, and as a gasoline additive(1) may result in its release to the environment through various waste streams(SRC).

(1) O'Neil MJ, ed; The Merck Index. 15th ed., Cambridge, UK: Royal Society of Chemistry, p. 188 (2013)

- Hazardous Substances Data Bank (HSDB)

Benzene enters the environment from production, storage, transport, venting, and combustion of gasoline; and from production, storage, and transport of benzene itself. Other sources result from its use as an intermediate in the production of other chemicals, and as a solvent, from spills, including oil spills; from its indirect production in coke ovens; from nonferrous metal manufacture, ore mining, wood processing, coal mining and textile manufacture, and from cigarette smoke(1,2).

(1) IARC; Monograph. Some Industrial Chemicals and Dyestuffs 29: 99-106 (1982) (2) Graedel TE; Chemical Cmpds in the Atmos, New York, NY: Academic Press (1978)

- Hazardous Substances Data Bank (HSDB)

Benzene is the largest volume aromatic petrochemical; ethylbenzene is the largest chemical outlet for benzene, and nearly all is consumed for the production of styrene(1). Benzene has been detected in cigarette smoke ranging from 47-64 ppm(2). The world wide release of benzene into the environment is estimated to be 4-5 Tg/yr with 0.6 Tg/yr coming from the United States alone(3). Leachate from landfills is also a source of benzene in the environment(4).

*(1) ICIS Chemical Business; US Chemical Profile Benzene. 25 Feb- 3 Mar 2013. Available from, as of Feb 20, 2014: **https://www.icis.com** (2) Clayton GD, Clayton FE; Patty's Industrial Hygiene And Toxicology, 4th ed., New York, NY: John Wiley & Sons, Vol IIB p. 1302 (1994) (3) Singh HB, Zimmerman PB; Adv Environ Sci Technol 24: 177-235 (1992) (4) Johnston JJ et al; J Contam Hydrol 23: 263-283 (1996)*

▸ Hazardous Substances Data Bank (HSDB)

13.2.7 Environmental Fate

TERRESTRIAL FATE: Based on a classification scheme(1), a Koc value of 85(2), indicates that benzene is expected to have high mobility in soil(SRC). Volatilization of benzene from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 5.56X10-3 atm-cu m/mole(3). The potential for volatilization of benzene from dry soil surfaces may exist(SRC) based upon a vapor pressure of 94.8 mm Hg(4). Using a base-rich para-brownish soil incubated for 10 weeks, 20 ppm benzene was 24% degraded in 1 week, 44% in 5 weeks, and 47% in 10 weeks(5), indicating that biodegradation may be an important environmental fate process in soil(SRC). Anaerobic degradation of benzene in soil is not expected to be an important loss process based on various studies(6,7). In one study of chemical biotransformation under nitrate- and sulfate-reducing conditions, benzene was found to be stable for 60 days(6). In a related study, benzene did not undergo biodegradation in situ nor in laboratory controlled soil samples under denitrifying conditions(7).

(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Hodson J, Williams NA; Chemosphere 17: 67-77 (1988) (3) Mackay D et al; Environ Sci Tech 13: 333-36 (1979) (4) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng New York, NY: Hemisphere Pub Corp 5 Vol (1989) (5) Haider K et al; Arch Microbiol 96: 183-200 (1974) (6) Reinhard M et al; Div Environ Chem Preprints Ext Abst 36: 210-212 (1996) (7) Hutchins SR, Wilson JT; pp. 157-72 in In Situ Bioreclamation. Hinchee RE, Olfenbuttel RF, eds. Stoneham, MA: Butterworth-Heinmann (1991)

▸ Hazardous Substances Data Bank (HSDB)

AQUATIC FATE: Based on a classification scheme(1), a Koc value of 85(2), indicates that benzene is not expected to adsorb to sediment and suspended solids in water(SRC). Volatilization from water surfaces is expected(3) based upon a Henry's Law constant of 5.56X10-3 atm-cu m/mole(4). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 1 hr and 3.5 days, respectively(SRC). In aqueous solution, benzene will react with hydroxyl radical at a reaction rate of 7.8X10+9 L/mol sec; using the average OH radical concentration (1.0X10-17 molec/cu cm), benzene would have a half-life of 103 days(5). According to a classification scheme(6), BCFs ranging from 1.1-20(7) suggests the potential for bioconcentration in aquatic organisms is low. Utilizing the Japanese MITI test, 40% of the Theoretical BOD was reached in 2 weeks(8) indicating that biodegradation is important environmental fate process in water(SRC). Anaerobic degradation of benzene in water is not expected to be an important loss process based on various studies(9). In one study of chemical biotransformation under nitrate- and sulfate-reducing conditions, benzene was found to be stable for 60 days(5).

*(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Hodson J, Williams NA; Chemosphere 17: 67-77 (1988) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (4) Mackay D et al; Environ Sci Tech 13: 333-36 (1979) (5) Buxton GV et al; J Phys Chem Ref Data 17: 513-882 (1988) (6) Franke C et al; Chemosphere 29: 1501-14 (1994) (7) Neff JM, Sauer TC; Environ Sci Res 53: 163-75 (1996) (8) NITE; Chemical Risk Information Platform (CHRIP). Biodegradation and Bioconcentration. Tokyo, Japan: Natl Inst Tech Eval. Available from, as of Feb 18, 2014: **https://www.safe.nite.go.jp/english/db.html** (9) Reinhard M et al; Div Environ Chem Preprints Ext Abst 36: 210-212 (1996)*

▸ Hazardous Substances Data Bank (HSDB)

AQUATIC FATE: Evaporation was the primary loss mechanism in winter in a mesocosm experiment which simulated a northern bay where the half-life was 13 days(1). In spring and summer the half-lives were 23 and 3.1 days, respectively(1). In these cases biodegradation plays a major role and takes about 2 days(1). However, acclimation is critical and this takes much longer in the colder water in spring(1). According to one experiment, benzene has a half-life of 17 days due to photochemical degradation(2) which could contribute to benzene's removal. In situations of cold water, poor nutrients, or other conditions less conducive to microbial growth, photolysis will play a important role in degradation(SRC). The half-life of benzene in sea water is about 5 hrs(3) based on its Henry's Law constant of 5.56X10-3 atm-cu m/mole(4). The average first-order rate constant for elimination of benzene in the epilimnion region of Lake Zurich, Switzerland during summer (boating season) is 0.080/day(5).

(1) Wakeham SG et al; Bull Environ Contam Toxicol 31: 582-4 (1983) (2) Hustert K et al; Chemosphere 10: 995-8 (1981) (3) Neff JM, Sauer TC; Environ Sci Res 53: 163-75 (1996) (4) Mackay D et al; Environ Sci Tech 13: 333-36 (1979) (5) Schmidt TC et al; Water Res 38: 1520-1529 (2004)

▸ Hazardous Substances Data Bank (HSDB)

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), benzene, which has a vapor pressure of 94.8 mm Hg at 25 °C(2), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase benzene 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 13 days(SRC), calculated from its rate constant of 1.23X10-12 cu cm/molecule-sec at 25 °C(3). The half-life in polluted atmospheres which contain nitrogen oxides or sulfur dioxide has been observed to shorten to 4-6 hrs(4). Vapor-phase benzene is also degraded in the atmosphere by atmospheric ozone radicals at an extremely slow rate; the half-life for this reaction in air is estimated to be 170,000 days(5). The reaction rate of benzene with nitrate radical in the atmosphere is estimated to be less than 0.3X10-16 cu cm/molecule sec at 25 °C(3); the half-life for this reaction in air is estimated to be greater than or equal to 111 days based on an average concentration of nitrate radicals of 2.4X10+8 molec/cu cm(6). A half-life of 16.9 days was reported for photolysis of benzene dissolved in deionized water saturated with air exposed to sunlight(7). Due to benzene's high water solubility, it may be removed from the atmosphere by rainfall(8).

(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 Inst Phys Prop Data, Amer Inst Chem Eng New York, NY: Hemisphere Pub Corp 5 Vol (1989) (3) Atkinson R; J Phys Chem Ref Data, Monograph No. 2 (1994) (4) Korte F, Klein W; Ecotox Environ Safety 6: 311-27 (1982) (5) Verschueren K; Handbook of Environmental Data on Organic Chemicals. 4th ed. New York, NY: Van Nostrand Reinhold pg. 255 (2001) (6) Atkinson, R et al; Atmos Env 24: 2647-54 (1990) (7) Hustert K et al; Chemosphere 10: 995-8 (1981) (8) May WE et al; J Chem Ref Data 28: 197-200 (1983)

▸ Hazardous Substances Data Bank (HSDB)

13.2.8 Environmental Biodegradation

AEROBIC: Benzene present at 100 mg/L, reached 40% of its theoretical BOD in 2 weeks using an activated sludge inoculum at 30 mg/L in the Japanese MITI test(1). Benzene reached 24% of its theoretical oxygen demand in a non-acclimated microbial population after 15 days(2). Aerobic biodegradation of benzene was studied in pre-equilibrated soil-water slurry microcosms(3). Using an enriched aerobic bacterial culture, benzene began to degrade 12 hrs after incubation in an aqueous(soil-free) solution with 50% of benzene degrading after 60 hrs and almost complete degradation within 90 hrs. Using a pre-equilibrated soil-water slurry microcosm, benzene did not begin to degrade until 3 days after application and reached complete degradation after about 12 days(3).

*(1) NITE; Chemical Risk Information Platform (CHRIP). Biodegradation and Bioconcentration. Tokyo, Japan: Natl Inst Tech Eval. Available from, as of Feb 18, 2014: **https://www.safe.nite.go.jp/english/db.html** (2) Verschueren K; Handbook of Environmental Data on Organic Chemicals. 4th ed. New York, NY: Van Nostrand Reinhold pg. 255 (2001) (3) Zhang WX, Bouwer EJ; Biodegradation 8: 167-175 (1997)*

▸ Hazardous Substances Data Bank (HSDB)

AEROBIC: No degradation of benzene as measured by BOD was reported in coarse-filtered (through 1 cm cotton layer) Superior harbor water incubated at 21 °C for 12 days(1). Biodegradation half-lives of 28 and 16 days were reported in die-away tests using groundwater and water from Lester River, Minnesota, respectively; benzene concentration added ranged from 0-3.2 mg/L(2). The half-life in estuarine water was 6 days as measured by radio-labeled C02 produced(3). In a marine ecosystem biodegradation occurred in 2 days after an acclimation period of 2 days and 2 weeks in the summer and spring, respectively, whereas no degradation occurred in winter(4).

(1) Vaishnav DD, Babeu L; J Great Lakes Res 12: 184-91 (1986) (2) Vaishnav DD, Babeu L; Bull Environ Contam Toxicol 39: 237-44 (1987) (3) Lee RF, Ryan C; Microbial Degradation of Pollutants in Marine Environments. pp. 443-50 USEPA-600/9-72-012 (1979) (4) Wakeman SG et al; Bull Environ Contam Toxicol 31: 582-4 (1983)

▸ Hazardous Substances Data Bank (HSDB)

AEROBIC: Benzene, in a mixture with toluene and xylenes, was readily biodegraded (total degradation of 7.5 ppm total mixture) in shallow ground water in the presence of oxygen in the unconfined sand aquifer at Canada Forces' Base Borden, Ontario; laboratory batch experiments demonstrated that the degradation could be attributed to biodegradation(1). Complete biodegradation in 16 days was reported under simulated aerobic groundwater conditions at 20 °C(2). Reported metabolites of benzene using pure cultures of microorganisms include phenol and unidentified phenols(3), catechol and cis-1,2-dihydroxy-1,2-dihydrobenzene(4).

(1) Barker JF et al; Ground Water Monit Rev 7: 64-72 (1987) (2) Delfino JJ, Miles CJ; Soil Crop Sci Soc FL Proc 44: 9-14 (1985) (3) Smith RV, Rosazza SP; Arch Biochem Biophys 161: 551-8 (1974) (4) Gibson DT et al; Biochem 7: 2653-62 (1968)

▸ Hazardous Substances Data Bank (HSDB)

AEROBIC: Benzene at 50 ppm was 90% degraded by industrial wastewater seed incubated at 23 °C for 6 hrs(1). Benzene inhibited industrial seed at concentration of 100 ppm and above and municipal seed at 50 ppm and above(1). In a bench scale activated-sludge reactor with an 8 hour retention time, complete degradation occurred with 0.5% of the benzene being lost by air stripping(2). In laboratory systems, low concentrations of benzene are degraded in 6-14 days(3,4). 44-100% removal occurred at a sewage treatment plant; percentage by evaporation and biodegradation were not determined(5). In a base-rich para-brownish soil, 20 ppm benzene was 24% degraded in 1 week, 44% in 5 weeks, and 47% in 10 weeks(6).

(1) Davis EM et al; Water Res 15: 1125-7 (1981) (2) Stover EL, Kincannon DF; J Water Pollut Control Fed 55: 97-109 (1983) (3) Setzkorn EA, Huddleston RL; J Amer Oil Chem Soc 42: 1081-4 (1965) (4) Tabak HH et al; J Water Pollut Control Fed 53: 1503-18 (1981) (5) Feiler HD et al; Proc Natl Conf Munic Sludge Manag 8th, pp. 72-81 (1979) (6) Haider K et al; Arch Microbiol 96: 183-200 (1974)

▸ Hazardous Substances Data Bank (HSDB)

ANAEROBIC: Benzene was degraded under methanogenic conditions in an enrichment culture fed ferulic acid for five years. It was also degraded under sulfate-reducing conditions in microcosms containing benzene-contaminated aquifer sediment(1). Benzene was not biodegraded in aquifer sediment down gradient of the Wilder's Grove sanitary landfill near Raleigh, NC(1). In a study of chemical biotransformation under nitrate- and sulfate-reducing conditions, benzene was found to be stable under these anaerobic conditions for 60 days(2). In a related study, benzene did not undergo biodegradation in situ nor in laboratory controlled soil samples under denitrifying conditions(3). Although benzene appears to be recalcitrant under anaerobic conditions, there was one experiment in which benzene underwent degradation under methanogenic conditions. The microbial inoculum employed in the study originally had been enriched from anaerobic municipal sludge. Benzene was transformed into phenol by the microbial inoculum by using water as a source of oxygen(4).

(1) Johnston JJ et al; J Contam Hydrol 23: 263-283 (1996) (2) Reinhard M et al; Div Environ Chem Preprints Ext Abst 36: 210-212 (1996) (3) Hutchins SR, Wilson JT; pp. 157-72 in In Situ Bioreclamation. Hinchee RE, Olfenbuttel RF eds. Stoneham, MA: Butterworth-Heinmann (1991) (4) Grbic-Galic, D; Geomicrobiology J 8: 167-200 (1990)

▸ Hazardous Substances Data Bank (HSDB)

13.2.9 Environmental Abiotic Degradation

The rate constant for the vapor-phase reaction of benzene with photochemically-produced hydroxyl radicals is 1.23X10-12 cu cm/molecule-sec(1). This corresponds to an atmospheric half-life of about 13 days at an atmospheric concentration of 5X10+5 hydroxyl radicals per cu cm(1). The half-life in polluted atmospheres which contain nitrogen oxides or sulfur dioxide has been observed to shorten to 4-6 hrs(2). Vapor phase benzene is also degraded in the atmosphere by atmospheric ozone radicals at an extremely slow rate; the half-life for this reaction in air is estimated to be 170,000 days(3). Reaction of benzene with nitrate radical is estimated to be <0.3X10-16 cu cm/molecule sec at 25 °C(1); the half-life for this reaction in air is estimated to be greater than or equal to 111 days based on an average concentration of nitrate radicals of 2.4X10+8 molec/cu cm in the ambient atmosphere(4). In aqueous solution, benzene will react with hydroxyl radical at a reaction rate of 7.8X10+9 L/mol sec; using the average OH radical concentration(1.0X10-17 molec/cu cm), benzene would have a half-life of 103 days(5). Benzene is not expected to undergo hydrolysis in the environment due to the lack of hydrolyzable functional groups(6). Benzene has a maximum absorbance frequency of 253 nm(7) and, therefore, is not expected to be susceptible to direct photolysis by sunlight(SRC). However, slight shifts in wavelength of absorption might be expected in more representative environmental media, such as water(8); eg, a half-life of 16.9 days was reported for photolysis of benzene dissolved in deionized water saturated with air exposed to sunlight(9).

(1) Atkinson R; J Phys Chem Ref Data Mongraph No. 2 p. 48 (1994) (2) Korte F, Klein W; Ecotox Environ Safety 6: 311-27 (1982) (3) Verschueren K; Handbook of Environmental Data on Organic Chemicals. 4 th ed. New York, NY: Van Nostrand Reinhold pg. 255 (2001) (4) Atkinson, R et al; Atmos Env 24: 2647-54 (1990) (5) Buxton GV et al; J Phys Chem Ref Data 17: 513-882 (1988) (6) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 7-4, 7-5 (1990) (7) Trost B et al; Atmos Environ 31: 3999-4008 (1997) (8) Howard PH, Durkin PR; Sources of Contamination, Ambient Levels, and Fate of Benzene in the Environment. USEPA-560/5-75-005 pp. 65 (1974) (9) Hustert K et al; Chemosphere 10: 995-8 (1981)

▸ Hazardous Substances Data Bank (HSDB)

While benzene is considered to be relatively unreactive in photochemical smog situations (in the presence of nitrogen oxides), its rate of degradation is accelerated with about 16% decrease in concentration in 5 hr(1). A typical experiment in the presence of active species such as NOx and SO2 showed that benzene photodegradation was considerably accelerated above that in air alone(2). Its half-life in the presence of active species was 4-6 hr with 50% mineralization to CO2 in approximately 2 days(3). Products of degradation include phenol, 2-nitrophenol, 4-nitrophenol, 2,4-dinitrophenol, 2,6-dinitrophenol, nitrobenzene, formic acid, and peroxyacetyl nitrate(4-6). Benzene has an estimated lifetime under photochemical smog conditions in southeastern England of 28 hrs(3). Benzene has an estimated global life-time of 16 days and 4.8 days in the tropics(7). Global conditions were considered as having an average temperature of 2 °C, OH radical concentration of 6.0X10+5 molecule/cu cm and an ozone radical concentration of 7.4X10+11 molecule/cu cm; while tropical conditions were considered as having an average temperature of 25 °C, OH radical concentration of 2.0X10+6 molecule/cu cm and an ozone radical concentration of 7.4X10+11 molecule/cu cm(7).

(1) Farley FF; Inter Conf on Photochemical Oxidant Pollution and Its Control. pp. 713-27 USEPA-600/3-77-001B (1977) (2) Yanagihara S et al; Proc Int Clean Air Cong 4th, pp. 472-7 (1977) (3) Korte F, Klein W; Ecotox Environ Saftey 6: 311-27 (1982) (4) Nojima K et al; Chemosphere 4: 77-82 (1975) (5) Hoshino M et al; Kokuritsu Kogai Kekyusho Kenkyu Hokoku 5: 43-59 (1978) (6) Kopczynski SL; Int J Air Water Pollut 8: 107-20 (1964) (7) Singh HB, Zimmerman PB; Adv Environ Sci Technol 24: 177-235 (1992)

▸ Hazardous Substances Data Bank (HSDB)

13.2.10 Environmental Bioconcentration

Bioconcentration Factor

4.27

▸ EPA DSSTox

Benzene has BCFs ranging from 1.1-20(1). According to a classification scheme(2), this BCF range suggests the potential for bioconcentration in aquatic organisms is low. The uptake and elimination rate constants for benzene in fathead minnows were studied(3). Fathead minnows were found to have an average uptake rate of 7 L/kg/hr with an average elimination rate of 0.384/hr which corresponds to a BCF of 19(3). In a study of BCF values for various aquatic species, benzene was found to have a BCF value of 3.5 in eels(4), 4.4 in pacific herring(5), and 4.3 in goldfish(6).

(1) Neff JM, Sauer TC; Environ Sci Res 53: 163-75 (1996) (2) Franke C et al; Chemosphere 29: 1501-14 (1994) (3) De Wolf W et al; Chemosphere 36: 1713-1724 (1998) (4) Ogata M, Miyake Y; Water Res 12: 1041-4 (1978) (5) Korn S et al; Fish Bull Natl Marine Fish Ser 75: 633-6 (1977) (6) Ogata M et al; Bull Environ Contam Toxicol 33: 561-7 (1984)

▸ Hazardous Substances Data Bank (HSDB)

13.2.11 Soil Adsorption/Mobility

Soil Adsorption Coefficient

56.23 L/kg

▸ EPA DSSTox

An experimentally derived log Koc of 1.93 (Koc = 85) was obtained via reverse phase HPLC (high performance liquid chromatography) with a cyanopropyl column and a mobile phase of water(1). According to a classification scheme(2), this estimated Koc value suggests that benzene is expected to have high mobility in soil. The sorption equilibrium for benzene in a soil/water mixture (ratio soil/water 0.12 kg/l) took 72 hrs(3). The Koc for benzene has also been experimentally determined to be 79(4).

(1) Hodson J, Williams, NA; Chemosphere 17: 67-77 (1988) (2) Swann RL et al; Res Rev 85: 17-28 (1983) (3) Zhang WX, Bouwer EJ; Biodegradation 8: 167-175 (1997) (4) Johnston CD et al; J Cont Hydrol 33: 377-404 (1998)

▸ Hazardous Substances Data Bank (HSDB)

13.2.12 Volatilization from Water/Soil

The Henry's Law constant for benzene is 5.56X10-3 atm-cu m/mole(1). This Henry's Law constant indicates that benzene is expected to volatilize rapidly from water surfaces(2). 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)(2) is estimated as 1 hr(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 3.5 days(SRC). Benzene's Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). The potential for volatilization of benzene from dry soil surfaces may exist(SRC) based upon a vapor pressure of 94.8 mm Hg(3).

(1) Mackay D et al; Environ Sci Technol 13: 333-36 (1979) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng New York, NY: Hemisphere Pub Corp 5 Vol (1989)

▸ Hazardous Substances Data Bank (HSDB)

13.2.13 Environmental Water Concentrations

GROUNDWATER: Benzene was the dominant dissolved organic compound in groundwater contaminated by gasoline in the Swan Coastal Plain near Perth, Western Australia at a concentration around 15,000 ug/L at depths greater than 4.5 m below ground surface(1). At a distance of 210 m from a petrol storage area, a chalk aquifer, located in the United Kingdom, contained benzene ranging from 1-10 ppb; at 120 m from the petrol storage area it contained benzene concentrations greater than 250 ppb; and at 10 m from the petrol storage area, benzene concentrations rose to 1250 ppb(2). Benzene occurs in both groundwater and surface public water supplies with higher levels occurring in groundwater supplies. Based upon U.S. Federal drinking water surveys, approximately 1.3% of all groundwater systems are estimated to contain benzene at levels greater than 0.5 ug/L. The highest level reported in the surveys for groundwater was 80 ug/L(3).

(1) Johnston CD et al; J Contam Hydrol 33: 377-404 (1998) (2) Tester DJ, Harker RJ; Water Pollut Control 80: 614-31 (1981) (3) USEPA; Health Advisories for 25 Organics: Benzene p. 19 (1987)

▸ Hazardous Substances Data Bank (HSDB)

DRINKING WATER: Out of 113 public drinking water supplies in 1976, 7 sites tested positive for benzene with an average concentration of <0.2 ppb(1). Of five US cities from 1974-5, benzene concentrations ranged from 0-0.3 ppb in drinking water supplies(2). Contaminated drinking water wells in NY, NJ, and CT ranged from 30-300 ppb; the highest benzene concentrations in drinking water were derived from surface water sources at 4.4 ppb(3). In three separate surveys of community water supplies: 0 of 111 samples tested positive for benzene; 7 of 113 samples tested positive with a mean concentration of 4 ppb; and 4 of 16 samples tested positive with a benzene max concentration of 0.95 ppb(4). In a USA Groundwater Supply Survey (GWS, 1982, finished drinking water), out of 466 samples selected at random from a 1000 sample survey, 0.6% tested positive for benzene at a median value of 3 ppb and max of 15 ppb(5). In a study of Wisconsin drinking water wells (data through Jun 1984), of 1174 community wells sampled, 0.34% tested positive for benzene while of 617 private wells, 2.9% tested positive(6).

(1) Brass HJ et al; Drinking Water Qual Enhancement Source Prot pp. 393-416 (1977) (2) Coleman WE et al; pp. 305-27 in Analysis and Identification of Organic Substances in Water. L Keith ed, Ann Arbor MI: Ann Arbor Press Chap 21 (1976) (3) Burmaster DE; Environ 24: 6-13,33-6 (1982) (4) NAS; Drinking Water and Health, Vol 3 (1980) (5) Cotruvo JA; Sci Total Environ 47: 7-26 (1985) (6) Krill RM, Sonzogni WC; J Am Water Works Assoc 78: 70-5 (1986)

▸ Hazardous Substances Data Bank (HSDB)

DRINKING WATER: There may be a large number of cases where well water is contaminated by benzene at low concentrations(1). A number of studies have reported finding benzene at levels on the order of 5 ng/L in surface and well waters(1). Benzene had a frequency of detection of less than 1% in 954 random drinking water sources samples from groundwater, rivers, and reservoirs throughout the USA and Puerto Rico from May 3, 1999 through Oct 23, 2000(2). A 2006 US Geol Survey of 2,401 domestic wells sampled from 1985-2002 revealed occurrence of benzene in 37 of 1,207 wells, a 3.1% detection frequency. The concentration range was 0.006-5 ug/L(3). The detection frequency in drinking water sources from California was <1% from 1995 to 2001(4).

PMID:9118882
Full text: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1469757
(1) Wallace L; Environ Health Perspect 104: 1129-1136 (1996) (2) Grady SJ; A National Survey of methyl tert-butyl ether and other volatile organic compounds in drinking-water sources. US Dept Int, U.S. Geological Survey, Water-Resources Investigations Report 02-4079 (2003) (3) Rowe BL et al; Environ Health Perspect 115(11): 1539-1546 (2007) (4) Williams P et al; Environ Sci Technol 36:4 721-4728 (2002)

▸ Hazardous Substances Data Bank (HSDB)

SURFACE WATER: Surface water samples taken from 14 heavily industrialized areas with water basins between 1975-1976, contained benzene in 20% of the samples at concentrations ranging from 1-7 ppb(1). Benzene concentrations in Lake Erie from 1975-6, ranged from 0-1 ppb(2). Benzene concentrations in Lake Michigan from 1975-6, ranged from 0-7 ppb(2). Out of 700 random surface water sites throughout the US in 1975, benzene had an average concentration of 5.4 ppb(3). In the US EPA STORET database, out of 1,271 surface water samples, 15.0% tested positive for benzene with a median concentration of 5.0 ppb(4). Benzene concentrations in seawater taken from the Gulf of Mexico in 1977, ranged from 5-15 parts per trillion in unpolluted areas and 5-175 parts per trillion in areas affected by anthropogenic activities(5). Approximately 3% of all surface water drinking systems are estimated to be contaminated at levels higher than 0.5 ug/L(6).

(1) Ewing BB et al; Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters. USEPA-560/6-77-015 pp. 75 (1977) (2) Konasewich D et al; Great Lake Water Qual Board (1978) (3) Kraybill HF; NY Acad Sci Annals 298: 80-9 (1977) (4) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (5) Sauer TC Jr; Org Geochem 3: 91-101 (1981) (6) USEPA; Health Advisories for 25 Organics: Benzene p. 19 (1987)

▸ Hazardous Substances Data Bank (HSDB)

RAIN/SNOW/FOG: Benzene was detected in rainwater in Japan and in the UK at a concentration of 87.2 ppb(1,2).

(1) Kato T et al; Yokohama Kokuritsu Daigaku Kankyo Kagaku Kenkyu Senta Kiyo 6: 11-20 (1980) (2) IARC; Monograph. Some Industrial Chemicals and Dyestuffs. 29: 99-106 (1982)

▸ Hazardous Substances Data Bank (HSDB)

13.2.14 Effluent Concentrations

Industries in which mean or max levels of benzene in raw wastewater exceeded 1 ppm are (number of samples, percent pos, mean, max, in ppm): raw wastewater: auto and other laundries (20 samples, 70% pos, <1.4 ppm mean, 23 ppm max), iron and steel manufacturing (mfg) (9 samples, 77.8% pos, <8.0 mean, 46 max), aluminum forming (32 samples, 56.2% pos, 0.70 mean, 2.1 max), photographic equipment/supplies (48 samples, 54.2% pos, 0.16 mean, 2.1 max), pharmaceutical mfg (9 samples, 100% pos, 12 mean, 87 max), organic chemical/plastics mfg (number of samples not reported (NR), 63 detections, 22, NR), paint and ink formulation (36 samples, 63.9% pos, 1.2 mean, 9.9 max), petroleum refining (11 samples, number of pos NR, <0.10, 2.4), rubber processing (4 samples, 100% pos, 0.60 mean, 3.4 max), timber products processing (14 samples, 92.9% pos, 0.2 mean, 2.8 max); treated wastewater: auto and other laundries (4 samples, 50% pos, 0.1 ppm mean, 0.2 ppm max), iron and steel manufacturing (mfg) (13 samples, 76.9% pos, <14 mean, 120 max), aluminum forming (21 samples, 81.0% pos, <0.0058 mean, 0.040 max), photographic equipment/supplies (4 samples, 100% pos, 0.016 mean, 0.021 max), pharmaceutical mfg (6 samples, 100% pos, 1.8 mean, 10 max), organic chemical/plastics mfg (number of samples not reported (NR), 42 detections, 26, max NR), paint and ink formulation (24 samples, 62.5% pos, 0.39 mean, 3.8 max), petroleum refining (13 samples, NR, NR, 0.012), rubber processing (5 samples, 100% pos, <0.0077 mean, 0.010 max), timber products processing (5 samples, 60% pos, 0.010 mean, 0.033 max)(1).

(1) USEPA; Treatability Manual. p. I.9.1-1 to I.9.1-5 USEPA-600/2-82-001A (1981)

▸ Hazardous Substances Data Bank (HSDB)

Wastewater from coal preparation plants ranged from 0.3-48 ppb while wastewater from plants which manufacture or use benzene ranged from <1-179 parts per trillion(1). Stack emissions from coking plants located in Czechoslovakia contained benzene ranging from 15-50 ppm(2). In 11.2% of groundwater samples taken from 178 CERCLA hazardous waste sites, benzene was detected(3). In the US EPA STORET database, out of 1,474 effluent samples, 16.4% tested positive for benzene at a median concn of 2.50 ppb(4).

(1) IARC; Monograph. Some Industrial Chemicals and Dyestuffs 29: 99-106 (1982) (2) SRI; Human Exposure to Atmospheric Benzene, Menlo Park, CA: SRI, Center for Resource and Environmental (1977) (3) Plumb H Jr; Ground Water Monit Rev 7: 94-100 (1987) (4) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985)

▸ Hazardous Substances Data Bank (HSDB)

In 4 municipal landfill gases in Southern Finland (1989-1990 data), benzene's average concentration ranged from 0.17-9 mg/cu m with a max concentration of 11 mg/cu m(1). Benzene emissions were studied from seven Swedish incineration plants before and after air pollution control systems (APCS) were introduced(2). Benzene concentrations emitted from plant A (3 incinerators) without APCS were 1.93, 1.95, and 21.16 ug/cu nm and with APCS were 2.46, 0.83 and 1.81 ug/cu nm, respectively. Plant B (3 incinerators) benzene levels were 21.23, 10.81, and 1.63 ug/cu nm before APCS and 14.37, 444.20, and 0.14 ug/cu nm after APCS, respectively(2). Oddly, benzene levels rose on an incinerator after APCS. At the third plant, benzene concentrations were 2.57 ug/cu nm before APCS and 0.79 ug/cu nm after APCS(2). At the fourth plant, benzene concentrations were 3.44 ug/cu nm before APCS and 1.32 ug/cu nm after APCS(2). At the fifth plant, benzene concentrations were 0.82 ug/cu nm before APCS and 0.37 ug/cu nm after APCS(2). At the sixth plant, benzene concentrations were 2.92 ug/cu nm before APCS and 1.64 ug/cu nm after APCS(2). At the seventh plant (3 incinerators) benzene concentrations were 4.31, 8.30 and 5.13 ug/cu nm before APCS and 1.49, 1.02, and 11.36 ug/cu nm after APCS, respectively(2). The amount of benzene in the gaseous emissions of medical waste incinerator in 1000-bed hospitals in Portugal ranged from 0.73 to 1.1 kg/yr(3). Benzene emission factors of 29-54 tons/yr were estimated from a large steel factory in Taranto, Italy, measured in November, December 2001 and May 2002(4).

(1) Verschueren K; Handbook of Environmental Data on Organic Chemicals. 4th ed. New York, NY: Van Nostrand Reinhold pg. 255 (2001) (2) Zhang XJ; J Environ Sci Health A33: 279-306 (1998) (3) Alvim Ferraz MCM et al; J Air Waste Manage Assoc 50: 131-36 (2000) (4) Liberti L et al; J Air Waste Manage Assoc 56: 225-260 (2005)

▸ Hazardous Substances Data Bank (HSDB)

13.2.15 Sediment/Soil Concentrations

SEDIMENT: Surface sediments taken from Walvis Bay (off Capetown, South Africa) contained benzene ranging from 0-20 ppb(1). In the US EPA STORET database, out of 355 samples, 9% tested positive for benzene at a median concentration of <5.0 ppb(2).

(1) Whelan JK et al; Geochim Cosmochim Acta 44: 1767-85 (1980) (2) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985)

▸ Hazardous Substances Data Bank (HSDB)

SOIL: Soil near factories where benzene was used or produced contained benzene ranging from 2-191 ug/kg(1).

(1) IARC; Monograph. Some Industrial Chemicals and Dyestuffs 29: 99-106 (1982)

▸ Hazardous Substances Data Bank (HSDB)

13.2.16 Atmospheric Concentrations

URBAN/SUBURBAN: Benzene concentrations in 2001-2003 exhibited an overall reduction of 60% from previous testing in 1990-2003 but were still above the health risk threshold(1).

Table: Benzene Concns, ug/cu m

Statistic	Lakawana	Brooklyn	Troy	Niagara Falls
1990-2003				

Statistic	Lakawana	Brooklyn	Troy	Niagara Falls
Mean	5.09	2.85	2.31	1.80
Median	3.09	2.33	1.88	1.26
Max	104.51	15.23	17.57	21.87
2001-2003				
Mean	2.26	2.05	1.68	1.08
Median	1.35	1.81	1.39	0.92
Max	16.71	7.52	6.91	4.10

(1) Aleksic N et al; Atmos Environ 39: 7894-7905 (2005)

▸ Hazardous Substances Data Bank (HSDB)

URBAN/SUBURBAN: Air samples taken in the US from 1977-1980, had an average benzene concentration of 2.8 ppb in 2292 samples(1). Average benzene concentrations were 13 ppb (98 ppb max) in Toronto, Canada 1971(2). Average benzene concentrations in Los Angeles, California 1966 averaged 15 ppb (57 ppb max)(2). In 24 hr sampling periods conducted in US cities in 1979, benzene concentrations in Los Angeles, CA in April ranged from 0.72-27.87 ppb(mean 6.04 ppb), in Phoenix, A Z from April-May benzene ranged from 0.39-59.89 ppb (mean 4.74 ppb), in Oakland, CA from June-July benzene ranged from 0.06-4.63 ppb (mean 1.55 ppb)(3). Atmospheric benzene concentrations were studied in New Jersey in 1978 with the following cities reporting detections: Rutherford, 149 samples, 3.8 ppb mean concentration with 107 ppb max; Newark, 110 samples, 2.6 ppb mean concentration with 24 ppb max; Piscataway/Middlesex, 18 samples, 1.0 ppb mean concentration with 1.9 ppb max; Somerset county, 30 samples, 5.6 mean concentration with 33 ppb max; Bridgewater Township, 22 samples, 1.4 ppb mean concentration with 7.9 ppb max(4). In general, the average concentration of benzene in the urban atmosphere is estimated at 0.02 ppm(5). In day-of-week patterns of benzene from 6 urban sites in the Los Angeles area, California, sampled from 1989-2001, it was noted that benzene was distinctly lower on Sundays and slightly lower on Saturdays and Wednesdays(6).

(1) Brodzinsky R, Singh HB; Volatile Organic Chemicals In The Atmosphere: An Assessment Of Available Data 198 pp. SRI Inter 68-02-3452 (1982) (2) Pilar S, Graydon WF; Environ Sci Technol 7: 628-712 (1973) (3) Singh WB et al; Atmos Environ 15: 601-20 (1981) (4) Bozzelli JW, Kebbekus BB; Analysis Of Selected Volatile Organic Substances In Ambient Air. Newark, NJ: NJ Inst Technol 80 pp. (1979) (5) IARC; monograph. Some Industrial Chemicals and Dyestuffs 29: 99-106 (1982) (6) Austin J; J Air Waste Manage Assoc 53: 889-896 (2003)

▸ Hazardous Substances Data Bank (HSDB)

URBAN/SUBURBAN: Benzene has been detected in urban air samples in London, U.K., Southampton, U.K., Budapest, Hungary, Oslo, Norweigh, St. Petersburg, Russia, Boston, Chicago, Los Angeles, Houston, Sydney, Australia, and Tokyo, Japan at 9,16, 27, 18, 30, 1, 1.3, 2.7, 18, 2.6, and 1.8 ppbv, respectively(1). The median concentration of benzene in 39 U.S. cities from 1984-1985 was 12.6 ppb(2). Benzene's ambient concentration was highest at night-time and lowest by mid-day due to deep convective mixing and chemical loss by OH radicals(2). Since the 1960's, the ambient atmospheric concentration of benzene has declined(2). Benzene concentrations were reported for 586 ambient air samples collected from 10 Canadian cities(3). The overall mean was 4.4 ug/cu m, with Ottawa and Montreal ranging between 5.1 and 7.6 ug/cu m(3). Benzene concentrations in a traffic tunnel in London, that was poorly ventilated, ranged from 0.010-0.21 ppb(4).

(1) Trost B et al; Atmos Environ 31: 3999-4008 (1997) (2) Singh HB, Zimmerman PB; Adv Environ Sci Technol 24: 177-235 (1992) (3) Wallace L; Environ Health Perspect 104: 1129-1136 (1996) (4) Tsani-Bazaca E et al; Environ Technol Lett 2: 303-16 (1981)

▸ Hazardous Substances Data Bank (HSDB)

INDOOR: In a recent benzene exposure study, day and night 12-hr average concentrations of benzene were measured for 58 residents of Valdez, Alaska(1). The mean benzene concentrations in the personal, indoor, and outdoor samples were 20, 16, and 5 ug/cu m during the summer, and 28, 25, and 11 ug/cu m during the winter, respectively(1). In a nationwide Canadian study which measured the 24-hr indoor air concentrations of benzene in 754 randomly selected homes, benzene had a mean indoor air concentration of 6.39, 5.60, 2.72, and 6.98 ug/cu m in the winter, spring, summer, and fall seasons, respectively(1). Indoor and outdoor 48-hr average concentrations of benzene were measured at 161 homes throughout much of California in which indoor samples had a mean concentration of 8.3 ug/cu m compared to 6.1 ug/cu m outdoor samples(1). concentrations of benzene emitted from tobacco smoke in 5 workplaces located in Finland, 1995 ranged from 1.5-8 ug/cu m(2). Gasoline leaking from an underground storage tank near an elementary school in the Midwest United States (location not specified) created elevated levels of benzene concentrations within the school property(3). Benzene was detected in air samples collected from the classrooms, offices/Libraries/corridors, boiler room, crawl space beneath floor, soil/duct/floor interface, and outdoor/background at 0-5 ppb, 3-4 ppb, 4 ppb, approx 2600 ppb, 70-80 ppb, and 0-3 ppb, respectively(3). A series of experiments were conducted in a 290 sq m single-family residence from June 11-13, 1991 to ascertain the human exposure to benzene from a contaminated groundwater source(4). It involved an individual taking a 20 min shower with the bathroom door closed, followed by five minutes for drying and dressing, and then opening the bathroom door and allowing the individual to leave and have his blood, breath and urine sampled(4). Whole air samples were collected from the bathroom, shower and living room. Mean concentration of benzene coming from the shower head for the three days was 292 ug/L(4). Peak benzene levels were measured in the shower stall at 18-20 mins (758-1670 ug/cu m), in the bathroom at 10-25 mins (366-498 ug/cu m), in the bedroom at 25.5-30 mins (81-146 ug/cu m), and in the living room at 36-70 mins (40-62 ug/cu m)(4).

(1) Wallace L; Environ Health Perspect 104: 1129-1136 (1996) (2) Rothberg M et al; Ann Occup Hyg 42: 129-134 (1998) (3) Moseley CL, Meye MR; Environ Sci Technol 26: 185-192 (1992) (4) Lindstrom AB et al; J Exp Anal Env Epidem 4: 183-195 (1994)

▸ Hazardous Substances Data Bank (HSDB)

For more Atmospheric Concentrations (Complete) data for BENZENE (11 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

13.2.17 Food Survey Values

Benzene was found in both heat treated and canned beef at 2 ug/kg; in Jamaican rum at 120 ug/kg; in eggs ranging from 500-1900 ug/kg; and it was detected (concns not specified) in fruits, nuts, vegetables, dairy products, meat, fish, poultry, eggs, and beverages(1).

(1) USEPA; Ambient Water Quality Criteria: Benzene p. C-5 USEPA-440/5-80-018 (1980)

▸ Hazardous Substances Data Bank (HSDB)

In 1990, benzene was detected in fruit flavored mineral waters at concentrations greater than 5.0 ug/kg in Canada(1). When an investigation of benzene concentrations in beverages was performed, benzene was found at an average concentration of 0.042, 0.67, 0.056, 0.14, 0.29, 0.12, 0.95, 0.062, 0.79, and 0.55 ug/kg in freshly squeezed fruit, retail juice (with benzoate additive), retail juice (without benzoate), fruit drinks (with benzoate), fruit drinks (with cranberry, without benzoate), fruit drinks (excluding cranberry, without benzoate), cranberry drinks (without benzoate), carbonated soft drinks (without benzoate), carbonated soft drinks (with benzoate), and ice tea (with benzoate), respectively(1). These data suggest the natural occurrence of benzene in fruits and fruit juices, especially from cranberries(1). Benzene is a volatile organic compound emitted by both common and pineapple guava at a concentration of 0.10 ug/g(2).

(1) Page BD et al; J AOAC Int 75: 334-340 (1992) (2) Binder RG, Flath RA; J Agric Food Chem 37: 734-736 (1989)

▸ Hazardous Substances Data Bank (HSDB)

13.2.18 Plant Concentrations

Benzene has been detected as a plant volatile(1). Benzene has been detected from 2 species of macroalgae at 20 ppb(2).

(1) Graedel TC; Chemical Compounds in the Atmosphere. New York, NY: Academic Press (1978) (2) Whelan JK et al; Nature 299: 50-2 (1982)

▸ Hazardous Substances Data Bank (HSDB)

Benzene occurrences in plants(1).

Genus species	Common name	Plant
Carthamus tinctorius	Safflower	Flower
Elsholtzia cristata	Vietnamese Balm	Shoot
Levisticum officinale	Lovage	Root
Psidium guajava	Guava	Fruit

(1) USDA; Dr. Duke's Phytochemical and Ethnobotanical Databases. Plants with a chosen chemical. Benzene. Washington, DC: US Dept Agric, Agric Res Service. Available from, as of Feb 18, 2014: https://www.ars-grin.gov/duke/

▸ Hazardous Substances Data Bank (HSDB)

13.2.19 Fish/Seafood Concentrations

Benzene was detected in 5 oyster samples from the Inner Harbor Navigational Canal in Lake Pontchartrain, LA at 220 ppb wet weight(1). Composite clam samples from Chef Menteur Pass in Lake Pontchartain, LA contained benzene at 260 ppb wet weight; however clam samples from The Rigolets did not contain benzene(1).

PMID:3978262

(1) Ferrario JB et al; Bull Environ Contam Toxicol 34: 246-55 (1985)

▸ Hazardous Substances Data Bank (HSDB)

13.2.20 Milk Concentrations

Benzene was detected in all 8 samples of mothers milk from women in 4 US urban areas(1).

(1) Pellizzari ED et al; Environ Sci Technol 16: 781-5 (1982)

▸ Hazardous Substances Data Bank (HSDB)

13.2.21 Other Environmental Concentrations

Benzene has been detected in cigarette smoke(1-4). Median benzene concentrations of 2.3 ug/cu m (0.4 minimum, 11.9 maximum, 3.7 ug/cu m mean) were measured in 41 air samples from smoking premises consisting of 37 cafes and 19 restaurants in Girona, Spain. Mean concentrations of 0.7 and 0.9 were measured in samples from nonsmoking premises and outdoors, respectively, from the same region(2). The delivery of benzene in mainstream cigarette smoke ranges from 3.7 to 56.8 mg/cigarette(3). A range of 47-64 ppm in tobacco smoke has also been reported(5).

(1) Rodgman A, Perfetti TA; The Chemical Components of Tobacco and Tobacco Smoke. Boca Raton, FL: CRC Press p. 47 (2009) (2) Alonso M et al; Environ Sci Technol 44: 8289-8294 (2010) (3) Polzin GM et al; Environ Sci Technol 41: 1297-1302 (2007) (4) Talhout R et al; Int J Environ Res Public Health 8: 613-628 (2011) (5) Clayton GD, Clayton FE; Patty's Industrial Hygiene And Toxicology, 4th ed., New York, NY: John Wiley & Sons, Vol IIB p. 1302 (1994)

▸ Hazardous Substances Data Bank (HSDB)

Benzene exposure-relevant emission factors (ug/cigarette) at three furnishing levels and three ventilation rates in a 50 m sq room(1).

Table: Emission rates in ug/cigarette

Furnishing	2/hr	0.6/hr	0.3/hr
wallboard only	517	438	387
wallboard/carpet	457	432	400
fully furnished	429	435	429

(1) Singer BC et al; Environ Sci Technol 36: 846-53 (2002)

▸ Hazardous Substances Data Bank (HSDB)

13.2.22 Probable Routes of Human Exposure

According to the 2006 TSCA Inventory Update Reporting data, the number of persons reasonably likely to be exposed in the industrial manufacturing, processing, and use of benzene is 1000 or greater; the data may be greatly underestimated(1).

(1) US EPA; Inventory Update Reporting (IUR). Non-confidential 2006 IUR Records by Chemical, including Manufacturing, Processing and Use Information. Washington, DC: U.S. Environmental Protection Agency. Available from, as of Feb 18, 2014: https://cfpub.epa.gov/iursearch/index.cfm

▶ Hazardous Substances Data Bank (HSDB)

NIOSH (NOES Survey 1981-1983) has statistically estimated that 272,275 workers (143,066 of these were female) were potentially exposed to benzene in the US(1). Occupational exposure to benzene may occur through inhalation and dermal contact with this compound at workplaces where benzene is produced or used. Monitoring data indicate that the general population may be exposed to benzene via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with consumer products containing benzene(SRC).

(1) NIOSH; NOES. National Occupational Exposure Survey conducted from 1981-1983. Estimated numbers of employees potentially exposed to specific agents by 2-digit standard industrial classification (SIC). Available from, as of Feb 18, 2014: https://www.cdc.gov/noes/

▶ Hazardous Substances Data Bank (HSDB)

The National Occupational Health Survey (conducted from 1972 to 1974) estimated that 147,600 U.S. workers potentially were exposed to benzene (NIOSH 1976).

DHHS/National Toxicology Program; Twelfth Report on Carcinogens: Benzene (71-43-2) (2011). Available from, as of February 21, 2014: https://ntp.niehs.nih.gov/ntp/roc/twelfth/profiles/Benzene.pdf

▶ Hazardous Substances Data Bank (HSDB)

Analysis and modeling of 20,000 airborne breathing zone air samples of Deepwater Horizon oil spill offshore cleanup workers were taken during the six months following the incident. Results indicate that measurements were primarily due to ship engine exhaust. Estimated contributions to airborne benzene concentration were 34% oil thickness, 23% wind speed, 21% fraction BTEX dissolved in water, and 22% BTEX content in oil(1).

Table: April 27 - October 18, 2010

	Before cap	**After cap**
Number samples	3089	1856
% Detection	98	99
Mean (ppm)	0.0056	0.013
99th percentile (ppm)	0.031	0.025
95th percentile (ppm)	0.016	0.012
average detection limit (ppm)	0.014	0.014

(1) Avens HJ et al; Environ Sci Technol 45(17): 7372-7379 (2011)

▶ Hazardous Substances Data Bank (HSDB)

For more Probable Routes of Human Exposure (Complete) data for BENZENE (8 total), please visit the HSDB record page.

▶ Hazardous Substances Data Bank (HSDB)

13.2.23 Average Daily Intake

Two studies of benzene levels in foods have confirmed the conclusion that ingesting food and beverages are an unimportant pathway for benzene exposure. In a study of more than 50 foods, most contained benzene below 2 ng/g ppbw. A Canadian review of benzene exposures concluded that food and drinking water each contributed only about 0.02 ug/kg benzene per day compared to a total intake of 2.4 ug/kg per day from airborne exposures (3.3 ug/kg/day if exposed to cigarette smoke). In a 1980's study of non-occupational benzene exposure, it was found that more than 99% of the total personal exposure was through air and that a global average personal exposure for benzene was about 15 ug/cu m. Roughly half the total benzene exposure in the United States was borne by smokers. For non-smokers, most benzene exposure ultimately was derived from auto exhaust or gasoline vapor emissions. A series of experiments were conducted in a 290 sq m single-family residence from June 11-13, 1991 to ascertain the human exposure to benzene from a contaminated groundwater source. It involved an individual taking a 20 min shower with the bathroom door closed, followed by five minutes for drying and dressing, and then opening the bathroom door and allowing the individual to leave and have his blood, breath and urine sampled. Whole air samples were collected from the bathroom, shower and living room. The inhalation exposure to benzene of an individual in the living room averaged 72 ug for the three days. The individual taking the shower had an average inhalation dose of 113 ug and an average dermal dose of 168 ug (exposure = 40% inhalation, 60% dermal). There may be a large number of cases where well water is contaminated by benzene at low concentrations. A number of studies have reported finding benzene at levels on the order of 5 ng/L in surface and well waters. However, these levels correspond to a daily intake of <10 ng benzene, assuming 2 liters of water drunk daily. This amount is only 0.5% of the average daily intake for nonsmokers of 200 ng from air. Thus, it is concluded that the effect of contaminated water on total benzene intake is negligible(1).

PMID:9118882
Full text: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1469757
(1) Wallace L; Environ Health Perspect 104: 1129-1136 (1996)

▶ Hazardous Substances Data Bank (HSDB)

13.2.24 Body Burden

Benzene was detected in all 8 samples of mothers' milk from women living in 4 USA urban areas(1). Breath samples from persons without specific exposure to benzene ranged from 8 to 20 ppb(2). Whole blood samples from 250 subjects (121 males, 129 females) ranged from not detected to 5.9 ppb, (mean 0.8 ppb)(3). In FY82, the National Human Adipose Tissue Survey specimens found that of 46 composite samples, 96% tested positive to benzene (concentrations were >4 ppb for wet tissue) with a max concentration of 97 ppb max(4).

(1) Pellizzari ED et al; Environ Sci Technol 16: 781-5 (1982) (2) IARC; Monograph. Some Industrial Chemicals and Dyestuffs. 29: 99-106 (1982) (3) Antoine SR et al; Bull Environ Contam Toxicol 36: 364-71 (1986) (4) Stanley JS; Broad Scan Analysis of the FY82 National Human Adipose Tissue Survey Specimens Vol. I Executive Summary p. 5 USEPA-560/5-86-035 (1986)

▸ Hazardous Substances Data Bank (HSDB)

In a 1980's study of non-occupational benzene exposure, it was found that smokers had an average benzene body burden about 6 to 10 times that of nonsmokers, and received about 90% of their benzene exposure from smoking(1). The mean benzene concentration found in the breath and blood of 1,683 individuals was 13.1 and 131 ng/L, respectively(1).

PMID:9118882
Full text: ***https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1469757***
(1) Wallace L; Environ Health Perspect 104: 1129-1136 (1996)

▸ Hazardous Substances Data Bank (HSDB)

14 Associated Disorders and Diseases

Comparative Toxicogenomics Database (CTD)

Disease	References
Autism	PubMed: 20423563, 7687150, 6150139, 15585776, 3410814, 12205654, 24130822
Pervasive developmental disorder not otherwise specified	PubMed: 24130822
Celiac disease	PubMed: 3816078, 16425363, 10063930, 6182605, 6182788, 24657864, 21970810, 27452636

Human Metabolome Database (HMDB)

15 Literature

15.1 NLM Curated PubMed Citations

▸ PubChem

15.2 Springer Nature References

▸ Springer Nature

15.3 Thieme References

- Thieme Chemistry

15.4 Wiley References

- Wiley

15.5 Depositor Provided PubMed Citations

- PubChem

15.6 Synthesis References

Copisarow, Maurice; Long, Cyril N H. The Friedel-Crafts' reaction. II. Migration of halogen atoms in the benzene nucleus. Journal of the Chemical Society, Transactions (1921), 119 442-7.

- Human Metabolome Database (HMDB)

15.7 Metabolite References

- Human Metabolome Database (HMDB)

15.8 General References

Southgate et al. Dearomative dihydroxylation with arenophiles. Nature Chemistry, doi: 10.1038/nchem.2594, published online 22 August 2016

- Nature Chemistry

Saper et al. Nickel-catalysed anti-Markovnikov hydroarylation of unactivated alkenes with unactivated arenes facilitated by non-covalent interactions. Nature Chemistry, DOI: 10.1038/s41557-019-0409-4, published online 10 February 2020

- Nature Chemistry

15.9 Chemical Co-Occurrences in Literature

- PubChem

15.10 Chemical-Gene Co-Occurrences in Literature

PubChem

15.11 Chemical-Disease Co-Occurrences in Literature

PubChem

16 Patents

16.1 Depositor-Supplied Patent Identifiers

- PubChem

Link to all deposited patent identifiers

- PubChem

16.2 WIPO PATENTSCOPE

Patents are available for this chemical structure:

https://patentscope.wipo.int/search/en/result.jsf?inchikey=UHOVQNZJYSORNB-UHFFFAOYSA-N

- PATENTSCOPE (WIPO)

17 Biomolecular Interactions and Pathways

17.1 Protein Bound 3D Structures

- RCSB Protein Data Bank (RCSB PDB)

View 22 proteins in NCBI Structure

- PubChem

17.1.1 Ligands from Protein Bound 3D Structures

PDBe Ligand Code	BNZ
PDBe Structure Code	1A7Z
PDBe Conformer	

- Protein Data Bank in Europe (PDBe)

17.2 Drug-Gene Interactions

- Drug Gene Interaction database (DGIdb)

17.3 Chemical-Gene Interactions

17.3.1 CTD Chemical-Gene Interactions

- Comparative Toxicogenomics Database (CTD)

17.4 Pathways

- PubChem

18 Biological Test Results

18.1 BioAssay Results

▸ PubChem

19 Classification

19.1 Ontologies

19.1.1 MeSH Tree

- Medical Subject Headings (MeSH)

19.1.2 ChEBI Ontology

- ChEBI

19.1.3 ChemIDplus

▸ ChemIDplus

19.1.4 CAMEO Chemicals

▸ CAMEO Chemicals

19.1.5 ChEMBL Target Tree

▸ ChEMBL

19.1.6 UN GHS Classification

- UN Globally Harmonized System of Classification and Labelling of Chemicals (GHS)

19.1.7 EPA CPDat Classification

- EPA Chemical and Products Database (CPDat)

19.1.8 NORMAN Suspect List Exchange Classification

- NORMAN Suspect List Exchange

19.1.9 EPA DSSTox Classification

- EPA DSSTox

19.1.10 International Agency for Research on Cancer (IARC) Classification

- International Agency for Research on Cancer (IARC)

19.1.11 Consumer Product Information Database Classification

- Consumer Product Information Database (CPID)

20 Information Sources

FILTER BY SOURCE ALL SOURCES

1. CAMEO Chemicals

> LICENSE
> CAMEO Chemicals and all other CAMEO products are available at no charge to those organizations and individuals (recipients) responsible for the safe handling of chemicals. However, some of the chemical data itself is subject to the copyright restrictions of the companies or organizations that provided the data.
> https://cameochemicals.noaa.gov/help/reference/terms_and_conditions.htm?d_f=false

BENZENE
https://cameochemicals.noaa.gov/chemical/2577
CAMEO Chemical Reactivity Classification
https://cameochemicals.noaa.gov/browse/react

2. CAS Common Chemistry

> LICENSE
> The data from CAS Common Chemistry is provided under a CC-BY-NC 4.0 license, unless otherwise stated.
> https://creativecommons.org/licenses/by-nc/4.0/

Benzene
https://commonchemistry.cas.org/detail?cas_rn=71-43-2
Benzene, homopolymer
https://commonchemistry.cas.org/detail?cas_rn=25053-22-9
Benzene, dimer
https://commonchemistry.cas.org/detail?cas_rn=6842-25-7
Benzene, trimer
https://commonchemistry.cas.org/detail?cas_rn=79086-19-4

3. ChemIDplus

> LICENSE
> https://www.nlm.nih.gov/copyright.html

Benzene
https://chem.nlm.nih.gov/chemidplus/sid/0000071432
Benzene, labeled with carbon-14 and tritium
https://chem.nlm.nih.gov/chemidplus/sid/0026181884
ChemIDplus Chemical Information Classification
https://chem.nlm.nih.gov/chemidplus/

4. DTP/NCI

> LICENSE
> Unless otherwise indicated, all text within NCI products is free of copyright and may be reused without our permission. Credit the National Cancer Institute as the source.
> https://www.cancer.gov/policies/copyright-reuse

benzene
https://dtp.cancer.gov/dtpstandard/servlet/dwindex?searchtype=NSC&outputformat=html&searchlist=67315

5. EPA Acute Exposure Guideline Levels (AEGLs)

> LICENSE
> https://www.epa.gov/privacy/privacy-act-laws-policies-and-resources

Benzene
https://www.epa.gov/aegl/benzene-results-acute-exposure-guideline-levels-aegl-program

6. EPA Chemicals under the TSCA

> LICENSE
> https://www.epa.gov/privacy/privacy-act-laws-policies-and-resources

Benzene
https://www.epa.gov/chemicals-under-tsca

7. EPA DSSTox

> LICENSE
> https://www.epa.gov/privacy/privacy-act-laws-policies-and-resources

Benzene
https://comptox.epa.gov/dashboard/DTXSID3039242
CompTox Chemicals Dashboard Chemical Lists

https://comptox.epa.gov/dashboard/chemical_lists/

8. European Chemicals Agency (ECHA)

> LICENSE
>
> Use of the information, documents and data from the ECHA website is subject to the terms and conditions of this Legal Notice, and subject to other binding limitations provided for under applicable law, the information, documents and data made available on the ECHA website may be reproduced, distributed and/or used, totally or in part, for non-commercial purposes provided that ECHA is acknowledged as the source: "Source: European Chemicals Agency, http://echa.europa.eu/". Such acknowledgement must be included in each copy of the material. ECHA permits and encourages organisations and individuals to create links to the ECHA website under the following cumulative conditions: Links can only be made to webpages that provide a link to the Legal Notice page.
>
> https://echa.europa.eu/web/guest/legal-notice

Benzene
https://echa.europa.eu/substance-information/-/substanceinfo/100.000.685

Benzene
https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/127390

[No public or meaningful name is available]
https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/215765

Benzene
https://www.echa.europa.eu/substances-restricted-under-reach

9. Hazardous Substances Data Bank (HSDB)

BENZENE
https://pubchem.ncbi.nlm.nih.gov/source/hsdb/35

10. Human Metabolome Database (HMDB)

> LICENSE
>
> HMDB is offered to the public as a freely available resource. Use and re-distribution of the data, in whole or in part, for commercial purposes requires explicit permission of the authors and explicit acknowledgment of the source material (HMDB) and the original publication (see the HMDB citing page). We ask that users who download significant portions of the database cite the HMDB paper in any resulting publications.
>
> http://www.hmdb.ca/citing

Benzene
http://www.hmdb.ca/metabolites/HMDB0001505

11. ILO International Chemical Safety Cards (ICSC)

> LICENSE
>
> The reproduction of ILO material is generally authorized for non-commercial purposes and within established limits. For non-commercial purposes of reproduction of data, any required permission is hereby granted and no further permission must be obtained from the ILO, but acknowledgement to the ILO as the original source must be made.
>
> https://www.ilo.org/global/copyright/request-for-permission/lang--en/index.htm

BENZENE
https://www.ilo.org/dyn/icsc/showcard.display?p_version=2&p_card_id=0015

12. Occupational Safety and Health Administration (OSHA)

> LICENSE
>
> Materials created by the federal government are generally part of the public domain and may be used, reproduced and distributed without permission. Therefore, content on this website which is in the public domain may be used without the prior permission of the U.S. Department of Labor (DOL). Warning: Some content - including both images and text - may be the copyrighted property of others and used by the DOL under a license.
>
> https://www.dol.gov/general/aboutdol/copyright

BENZENE
http://www.osha.gov/chemicaldata/chemResult.html?RecNo=491

13. The National Institute for Occupational Safety and Health (NIOSH)

> LICENSE
>
> The information provided using CDC Web site is only intended to be general summary information to the public. It is not intended to take the place of either the written law or regulations.
>
> https://www.cdc.gov/Other/disclaimer.html

Benzene
https://www.cdc.gov/niosh-rtecs/CY155CC0.html

Benzene
https://www.cdc.gov/niosh/npg/npgd0049.html

BENZENE
https://www.cdc.gov/niosh/ershdb/emergencyresponsecard_29750032.html

Benzin
https://www.cdc.gov/niosh-rtecs/DE2E3BF0.html

14. Wikipedia

benzene
https://en.wikipedia.org/wiki/Benzene

15. DOT Emergency Response Guidebook

benzene
https://www.phmsa.dot.gov/hazmat/erg/emergency-response-guidebook-erg

16. NJDOH RTK Hazardous Substance List

benzene
http://nj.gov/health/eoh/rtkweb/documents/fs/0197.pdf

17. CDC-ATSDR Toxic Substances Portal

> LICENSE
> The information provided using CDC Web site is only intended to be general summary information to the public. It is not intended to take the place of either the written law or regulations.
> https://www.cdc.gov/Other/disclaimer.html

Benzene
https://wwwn.cdc.gov/TSP/substances/ToxSubstance.aspx?toxid=14

18. ChEBI

Benzene
http://www.ebi.ac.uk/chebi/searchId.do?chebiId=CHEBI:16716
ChEBI Ontology
http://www.ebi.ac.uk/chebi/userManualForward.do#ChEBI%20Ontology

19. EPA Air Toxics

> LICENSE
> https://www.epa.gov/privacy/privacy-act-laws-policies-and-resources

Benzene
https://www.epa.gov/sites/production/files/2016-09/documents/benzene.pdf

20. NCI Thesaurus (NCIt)

> LICENSE
> Unless otherwise indicated, all text within NCI products is free of copyright and may be reused without our permission. Credit the National Cancer Institute as the source.
> https://www.cancer.gov/policies/copyright-reuse

Benzene
https://ncit.nci.nih.gov/ncitbrowser/ConceptReport.jsp?dictionary=NCI_Thesaurus&ns=NCI_Thesaurus&code=C302

21. Joint FAO/WHO Expert Committee on Food Additives (JECFA)

> LICENSE
> Permission from WHO is not required for the use of WHO materials issued under the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Intergovernmental Organization (CC BY-NC-SA 3.0 IGO) licence.
> https://www.who.int/about/who-we-are/publishing-policies/copyright

BENZENE
https://apps.who.int/food-additives-contaminants-jecfa-database/chemical.aspx?chemID=170

22. USGS Columbia Environmental Research Center

BENZENE
https://www.cerc.usgs.gov/data/acute/qrychemdesc.asp?Chemical=B0090

23. Comparative Toxicogenomics Database (CTD)

> LICENSE
> It is to be used only for research and educational purposes. Any reproduction or use for commercial purpose is prohibited without the prior express written permission of the MDI Biological Laboratory and NC State University.
> http://ctdbase.org/about/legal.jsp

http://ctdbase.org/detail.go?type=chem&acc=D001554

24. Consumer Product Information Database (CPID)

> LICENSE
> https://www.whatsinproducts.com/contents/view/1/6

Benzene
https://www.whatsinproducts.com/chemicals/view/1/2118/000071-43-2
Consumer Products Category Classification
https://www.whatsinproducts.com/

25. Drug Gene Interaction database (DGIdb)

> LICENSE
> The data used in DGIdb is all open access and where possible made available as raw data dumps in the downloads section.
> http://www.dgidb.org/downloads

https://www.dgidb.org/drugs/BENZENE

26. EPA Chemical and Products Database (CPDat)

> LICENSE
> https://www.epa.gov/privacy/privacy-act-laws-policies-and-resources

benzene
https://comptox.epa.gov/dashboard/DTXSID3039242#exposure
EPA CPDat Classification
https://www.epa.gov/chemical-research/chemical-and-products-database-cpdat

27. EU REGULATION (EC) No 1272/2008

benzene
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008R1272

28. Hazardous Chemical Information System (HCIS), Safe Work Australia

benzene
http://hcis.safeworkaustralia.gov.au/HazardousChemical/Details?chemicalID=359

29. NITE-CMC

Benzene - FY2006
https://www.nite.go.jp/chem/english/ghs/06-imcg-0191e.html

Benzene - FY2014
https://www.nite.go.jp/chem/english/ghs/14-mhlw-2197e.html

30. FDA Center for Food Safety and Applied Nutrition (CFSAN)

> LICENSE
>
>
> https://www.fda.gov/about-fda/about-website/website-policies#linking

BENZENE
https://www.cfsanappsexternal.fda.gov/scripts/fdcc/index.cfm?set=FoodSubstances&id=BENZENE

31. FDA/SPL Indexing Data

> LICENSE
>
>
> https://www.fda.gov/about-fda/about-website/website-policies#linking

J64922108F
https://www.fda.gov/ForIndustry/DataStandards/SubstanceRegistrationSystem-UniqueIngredientIdentifierUNII/

32. NORMAN Suspect List Exchange

> LICENSE
>
>
> https://creativecommons.org/licenses/by/4.0/

benzene

NORMAN Suspect List Exchange Classification
https://www.norman-network.com/nds/SLE/

33. MassBank of North America (MoNA)

> LICENSE
>
>
> https://mona.fiehnlab.ucdavis.edu/documentation/license

Benzene
http://mona.fiehnlab.ucdavis.edu/spectra/browse?inchikey=UHOVQNZJYSORNB-UHFFFAOYSA-N

34. SpectraBase

Benzene
https://spectrabase.com/spectrum/7t3HAA7IUpk

Benzene
https://spectrabase.com/spectrum/FPYhs9jhklR

Benzene
https://spectrabase.com/spectrum/8u1hTmTKjpQ

BENZOL
https://spectrabase.com/spectrum/FFoLRboL8VW

BENZENE
https://spectrabase.com/spectrum/evSfLgarCy

BENZENE
https://spectrabase.com/spectrum/4lAAQ18ZDD9

BENZENE
https://spectrabase.com/spectrum/8Y6BvKan99q

BENZENE
https://spectrabase.com/spectrum/DMugcQhmRAv

BENZENE
https://spectrabase.com/spectrum/HqR5XQYGXsS

BENZENE
https://spectrabase.com/spectrum/4fAEikWR7Q

BENZENE

https://spectrabase.com/spectrum/He7uGjt1Uu4

BENZENE
https://spectrabase.com/spectrum/2cglfHinfq4

BENZENE
https://spectrabase.com/spectrum/I9jQroFNgSi

BENZENE
https://spectrabase.com/spectrum/2QNl0khpkZE

BENZENE
https://spectrabase.com/spectrum/I05Fja9N0Ro

BENZENE
https://spectrabase.com/spectrum/3Zy9ZAYUWUt

BENZENE
https://spectrabase.com/spectrum/2NNwTfNRJ8a

BENZENE
https://spectrabase.com/spectrum/As9TrDpvgHm

BENZENE
https://spectrabase.com/spectrum/2APVpXeXXKa

BENZENE
https://spectrabase.com/spectrum/1tRYjIPaFpI

BENZENE
https://spectrabase.com/spectrum/38MA2w2nKGZ

BENZENE
https://spectrabase.com/spectrum/LmH3ODqtMXx

BENZENE
https://spectrabase.com/spectrum/3ewGwHe1LBN

BENZENE
https://spectrabase.com/spectrum/9FQo7mIbq5M

BENZENE
https://spectrabase.com/spectrum/2ysIeJ4yt50

BENZENE
https://spectrabase.com/spectrum/5N6i4ecqH7U

BENZENE
https://spectrabase.com/spectrum/9A5UMYc83Gr

BENZENE
https://spectrabase.com/spectrum/3OzTzTANGz4

BENZENE
https://spectrabase.com/spectrum/HZ5vjiOYnvc

BENZENE
https://spectrabase.com/spectrum/9a3eD01vElz

BENZOL
https://spectrabase.com/spectrum/8wjMpdVbA0

BENZENE
https://spectrabase.com/spectrum/6Ge3HPH1YKG

BENZENE
https://spectrabase.com/spectrum/AqB11j6o6rR

BENZENE
https://spectrabase.com/spectrum/4Qt3rnup0tV

BENZENE
https://spectrabase.com/spectrum/JSVnozyY9U9

BENZENE
https://spectrabase.com/spectrum/2cTs4fhPMYY

BENZENE
https://spectrabase.com/spectrum/JHCV5V9FITx

BENZENE
https://spectrabase.com/spectrum/BMhFpCzAjy5

BENZENE
https://spectrabase.com/spectrum/IPF8ObTZXXw

BENZENE
https://spectrabase.com/spectrum/BBNx5i9rsxt

BENZENE
https://spectrabase.com/spectrum/2jP9j5FuKQi

FREE-BENZENE
https://spectrabase.com/spectrum/45J6efeYKWX

BENZENE
https://spectrabase.com/spectrum/LB0sjl3LL3Y

Benzene
https://spectrabase.com/spectrum/1aetIngj2rY

Benzene
https://spectrabase.com/spectrum/1fyup9UOk2a

Benzene
https://spectrabase.com/spectrum/1Q0qG65NeVU

Benzene
https://spectrabase.com/spectrum/1VKrmRt3LgW

Benzene
https://spectrabase.com/spectrum/3zhZue7YXqS

Benzene
https://spectrabase.com/spectrum/451bQzvEF1U

Benzene
https://spectrabase.com/spectrum/3p3WrwWD9UO

Benzene
https://spectrabase.com/spectrum/3uNYOIJsqfQ

Benzene
https://spectrabase.com/spectrum/3ePTpEurl8K

Benzene
https://spectrabase.com/spectrum/3jjVLaiXSJM

Benzene
https://spectrabase.com/spectrum/3TlQmXJWMmG

Benzene
https://spectrabase.com/spectrum/3Z5SIt7C3xI

Benzene
https://spectrabase.com/spectrum/3J7NjpiAyQC

Benzene
https://spectrabase.com/spectrum/3ORPGBVqfbE

Benzene
https://spectrabase.com/spectrum/38TKh86pa48

Benzene
https://spectrabase.com/spectrum/3DnMDTuVHFA

Benzene
https://spectrabase.com/spectrum/2xpHeQVUBi4

Benzene
https://spectrabase.com/spectrum/339JAmJ9st6

Benzene
https://spectrabase.com/spectrum/2nBEbiu8nM0

Benzene
https://spectrabase.com/spectrum/2sVG84hoUX2

Benzene
https://spectrabase.com/spectrum/5MryGGwJggy

Benzene
https://spectrabase.com/spectrum/5SBzmcjzNs0

Benzene
https://spectrabase.com/spectrum/5CDvDZKyIKu

Benzene
https://spectrabase.com/spectrum/5HXwjv8dzVw

Benzene
https://spectrabase.com/spectrum/51ZsArjctyq

Benzene
https://spectrabase.com/spectrum/56tthDXIb9s

Benzene
https://spectrabase.com/spectrum/4qvp8A8HVcm

Benzene
https://spectrabase.com/spectrum/JqfFeZ2pheK

Benzene
https://spectrabase.com/spectrum/JahB5Vdoc7E

Benzene
https://spectrabase.com/spectrum/Jg1CbrRUJIG

Benzene
https://spectrabase.com/spectrum/JQ382o2TDlA

Benzene
https://spectrabase.com/spectrum/JVN9Z9q8uwC

Benzene
https://spectrabase.com/spectrum/JFP506R7pP6

Benzene
https://spectrabase.com/spectrum/JKj6WSEnWa8

Benzene
https://spectrabase.com/spectrum/Lp5oeeTlik4

Benzene
https://spectrabase.com/spectrum/LuPqB0GyPv6

Benzene
https://spectrabase.com/spectrum/LeRlbwrxKO0

Benzene
https://spectrabase.com/spectrum/Ljln8Ifd1Z2

Benzene
https://spectrabase.com/spectrum/LTniZFGbw1w

Benzene
https://spectrabase.com/spectrum/LZ7k5b4HdCy

Benzene
https://spectrabase.com/spectrum/LJ9fWXfGXfs

Benzene
https://spectrabase.com/spectrum/LOTh2tSwEqu

Benzene
https://spectrabase.com/spectrum/L8VcTq3v9Jo

Benzene
https://spectrabase.com/spectrum/LDpe0BraqUq

Benzene
https://spectrabase.com/spectrum/KxrZR8SZkxk

Benzene
https://spectrabase.com/spectrum/L3BaxUGFS8m

Benzene
https://spectrabase.com/spectrum/KnDWOQrEMbg

Benzene
https://spectrabase.com/spectrum/KsXXumeu3mi

Benzene
https://spectrabase.com/spectrum/KcZTLjFsyFc

Benzene
https://spectrabase.com/spectrum/KhtUs53YfQe

Benzene
https://spectrabase.com/spectrum/CCv4DGjyioS

Benzene
https://spectrabase.com/spectrum/CIF5jcXePzU

Benzene
https://spectrabase.com/spectrum/C2H1AZ8dKSO

Benzene
https://spectrabase.com/spectrum/C7b2guwJ1dQ

Benzene
https://spectrabase.com/spectrum/4Paa32Hq3L6

Benzene
https://spectrabase.com/spectrum/49cVTysoxo0

Benzene
https://spectrabase.com/spectrum/4EwX0KgUez2

Benzene
https://spectrabase.com/spectrum/Hid600vhpKy

Benzene
https://spectrabase.com/spectrum/Hnx7WMjNWW0

Benzene
https://spectrabase.com/spectrum/HXz2xJKMQyu

Benzene
https://spectrabase.com/spectrum/HdJ4Tf8289w

Benzene
https://spectrabase.com/spectrum/HNKzubj12cq

Benzene
https://spectrabase.com/spectrum/HSf1QxWgjns

Benzene
https://spectrabase.com/spectrum/HCgwru7feGm

Benzene
https://spectrabase.com/spectrum/HI0yOFvLLRo

Benzene
https://spectrabase.com/spectrum/H22tpCWKFui

Benzene
https://spectrabase.com/spectrum/H7MvLYJzx5k

Benzene
https://spectrabase.com/spectrum/GrOqmUuyrYe

Benzene
https://spectrabase.com/spectrum/GwisIqieYjg

Benzene
https://spectrabase.com/spectrum/GgknjnJdTCa

Benzene
https://spectrabase.com/spectrum/Gm4pG97JANc

Benzene

https://spectrabase.com/spectrum/GW6kh5iI4qW

Benzene
https://spectrabase.com/spectrum/GbQmDRVxm1Y

Benzene
https://spectrabase.com/spectrum/J5nULdkSyBU

Benzene
https://spectrabase.com/spectrum/JB7VrzY8fMW

Benzene
https://spectrabase.com/spectrum/Iv9RIw97ZpQ

Benzene
https://spectrabase.com/spectrum/J0TSpHwnH0S

Benzene
https://spectrabase.com/spectrum/IkVOGEXmBTM

Benzene
https://spectrabase.com/spectrum/IppPmaLRseO

Benzene
https://spectrabase.com/spectrum/IZrLDWwQn7I

Benzene
https://spectrabase.com/spectrum/IfBMjsk6UIK

Benzene
https://spectrabase.com/spectrum/JicLH6YtuJs

Benzene
https://spectrabase.com/spectrum/JSeGi39somm

Benzene
https://spectrabase.com/spectrum/JXyIEOxYVxo

Benzene
https://spectrabase.com/spectrum/JI0DfLYXQQi

Benzene
https://spectrabase.com/spectrum/JNKFBhMD7bk

Benzene
https://spectrabase.com/spectrum/LrgxJtaiJlg

Benzene
https://spectrabase.com/spectrum/Lx0yqFOO0wi

Benzene
https://spectrabase.com/spectrum/Lh2uHBzMvPc

Benzene
https://spectrabase.com/spectrum/LmMvnXn2cae

Benzene
https://spectrabase.com/spectrum/LWOrEUO1X3Y

Benzene
https://spectrabase.com/spectrum/LbiskqBhEEa

Benzene
https://spectrabase.com/spectrum/LLkoBmmg8hU

Benzene
https://spectrabase.com/spectrum/LR4pi8aLpsW

Benzene
https://spectrabase.com/spectrum/LB6l95BKkLQ

Benzene
https://spectrabase.com/spectrum/LGQmfQz0RWS

Benzene
https://spectrabase.com/spectrum/L0Si6NZzLzM

Benzene
https://spectrabase.com/spectrum/L5mjcjNf3AO

Benzene
https://spectrabase.com/spectrum/Kpof3fydxdI

Benzene
https://spectrabase.com/spectrum/Kv8ga1mJeoK

Benzene
https://spectrabase.com/spectrum/KfAc0yNIZHE

Benzene
https://spectrabase.com/spectrum/KkUdXKAyGSG

Benzene
https://spectrabase.com/spectrum/CFWCsVrOJq4

Benzene
https://spectrabase.com/spectrum/CKqEOrf4116

Benzene
https://spectrabase.com/spectrum/C4s9poG2vU0

Benzene
https://spectrabase.com/spectrum/CACBMA3icf2

Benzene
https://spectrabase.com/spectrum/BuE6n6ehX7w

Benzene
https://spectrabase.com/spectrum/BzY8JSSNEIy

BENZENE
https://spectrabase.com/spectrum/AGUFyCp5Lqa

Benzene
https://spectrabase.com/spectrum/JO8WNALmmKm

Benzene
https://spectrabase.com/spectrum/LsVEVMaHyUi

Benzene
https://spectrabase.com/spectrum/LxpG1iNxffk

Benzene
https://spectrabase.com/spectrum/LhrBSeywa8e

Benzene
https://spectrabase.com/spectrum/LnBCz0mcHJg

Benzene
https://spectrabase.com/spectrum/LXD8PxNbBma

Benzene
https://spectrabase.com/spectrum/LcX9wJBGsxc

Benzene
https://spectrabase.com/spectrum/LMZ5NFmFnQW

Benzene
https://spectrabase.com/spectrum/LRt6tbZvUbY

Benzene
https://spectrabase.com/spectrum/LBv2KYAuP4S

Benzene
https://spectrabase.com/spectrum/LHF3qtya6FU

Benzene
https://spectrabase.com/spectrum/L1GzHqZZ0iO

Benzene
https://spectrabase.com/spectrum/L6b0oCNEhtQ

Benzene
https://spectrabase.com/spectrum/KqcwF8yDcMK

Benzene
https://spectrabase.com/spectrum/KvwxlUltJXM

Benzene
https://spectrabase.com/spectrum/KfytCRMsE0G

Benzene
https://spectrabase.com/spectrum/KlIuinAXvBI

Benzene
https://spectrabase.com/spectrum/CGKU3yqxyZ6

Benzene
https://spectrabase.com/spectrum/CLeVaKedfk8

Benzene
https://spectrabase.com/spectrum/C5gR1HFcaD2

Benzene
https://spectrabase.com/spectrum/CB0SXd3IHO4

Benzene
https://spectrabase.com/spectrum/Bv2NyZeHBqy

Benzene
https://spectrabase.com/spectrum/C0MPUvRwt20

Benzene
https://spectrabase.com/spectrum/BkOKvs2vnUu

Benzene
https://spectrabase.com/spectrum/BpiMSDqbUfw

Benzene
https://spectrabase.com/spectrum/BZkHtARaP8q

Benzene
https://spectrabase.com/spectrum/Bf4JPWFG6Js

BENZENE
https://spectrabase.com/spectrum/3aKnf1FJZ6W

Benzene
https://spectrabase.com/spectrum/GfAouYEvl6G

Benzene
https://spectrabase.com/spectrum/90azPjKQk1j

Benzene
https://spectrabase.com/spectrum/GUWlrqdaMkC

Benzene
https://spectrabase.com/spectrum/GZqnOCRG3vE

Benzene
https://spectrabase.com/spectrum/J4DVWOflG5A

Benzene
https://spectrabase.com/spectrum/J9XX2kTQxGC

Benzene
https://spectrabase.com/spectrum/ItZSTh4Prj6

Benzene
https://spectrabase.com/spectrum/IytU02s5Yu8

Benzene
https://spectrabase.com/spectrum/IivPQzT4TN2

Benzene
https://spectrabase.com/spectrum/IoFQxLGkAY4

Benzene
https://spectrabase.com/spectrum/IYHMOHrj50y

Benzene
https://spectrabase.com/spectrum/IdbNudfOmC0

Benzene
https://spectrabase.com/spectrum/INdJLaGNgeu

Benzene
https://spectrabase.com/spectrum/ISxKrw43Npw

Benzene
https://spectrabase.com/spectrum/ICzGIsf2IIq

Benzene
https://spectrabase.com/spectrum/IIJHpEShzTs

Benzene
https://spectrabase.com/spectrum/I2LDGB3gtwm

Benzene
https://spectrabase.com/spectrum/I7fEmWrMb7o

Benzene
https://spectrabase.com/spectrum/HrhADTSLVai

Benzene
https://spectrabase.com/spectrum/Hx1BjpG1Clk

Benzene
https://spectrabase.com/spectrum/KRNts1UWOvg

Benzene
https://spectrabase.com/spectrum/KWhvONIC66i

Benzene
https://spectrabase.com/spectrum/KGjqpJtB0Zc

Benzene
https://spectrabase.com/spectrum/KM3sLfgqhke

Benzene
https://spectrabase.com/spectrum/K65nmcHpcDY

Benzene
https://spectrabase.com/spectrum/KBPpIy5VJOa

Benzene
https://spectrabase.com/spectrum/JvRkjugUDrU

BENZENE
https://spectrabase.com/spectrum/5Ey5NUE05RQ

Benzene
https://spectrabase.com/spectrum/GlMzOweIcki

Benzene
https://spectrabase.com/spectrum/GVOuptFHXDc

Benzene
https://spectrabase.com/spectrum/GaiwMF2xEOe

Benzene
https://spectrabase.com/spectrum/J55eURHSQYa

Benzene
https://spectrabase.com/spectrum/JAPg0n587jc

Benzene
https://spectrabase.com/spectrum/IuRbRjg72CW

Benzene
https://spectrabase.com/spectrum/Izlcy5TmjNY

Benzene
https://spectrabase.com/spectrum/IjnYP24ldqS

Benzene
https://spectrabase.com/spectrum/Ip7ZvNsRL1U

Benzene
https://spectrabase.com/spectrum/IZ9VMKTQFUO

Benzene

https://spectrabase.com/spectrum/IeTWsgH5wfQ

Benzene
https://spectrabase.com/spectrum/IOVSJcs4r8K

Benzene
https://spectrabase.com/spectrum/ITpTpyfkYJM

Benzene
https://spectrabase.com/spectrum/IDrPGvGjSmG

Benzene
https://spectrabase.com/spectrum/IJBQnH4P9xI

Benzene
https://spectrabase.com/spectrum/I3DMEDfO4QC

Benzene
https://spectrabase.com/spectrum/I8XNkZT3lbE

Benzene
https://spectrabase.com/spectrum/HsZJBW42g48

Benzene
https://spectrabase.com/spectrum/HxtKhrriNFA

Benzene
https://spectrabase.com/spectrum/KSG2q46DZP6

Benzene
https://spectrabase.com/spectrum/KXa4MPttGa8

Benzene
https://spectrabase.com/spectrum/KHbznMUsB32

Benzene
https://spectrabase.com/spectrum/KMw1JiIXsE4

Benzene
https://spectrabase.com/spectrum/K6xwketWmgy

Benzene
https://spectrabase.com/spectrum/KCHyH0hCTs0

Benzene
https://spectrabase.com/spectrum/JwJthxIBOKu

Benzene
https://spectrabase.com/spectrum/K1dvEJ5r5Vw

Benzene
https://spectrabase.com/spectrum/FcZOrbcTgkq

Benzene
https://spectrabase.com/spectrum/FMbKIYDSbDk

Benzene
https://spectrabase.com/spectrum/FRvLou18IOm

Benzene
https://spectrabase.com/spectrum/FBxHFqc7Crg

Benzene
https://spectrabase.com/spectrum/FHHImCPmu2i

Benzene
https://spectrabase.com/spectrum/6mIs7O6CxQW

Benzene
https://spectrabase.com/spectrum/6rctdjtsebY

Benzene
https://spectrabase.com/spectrum/6bep4gUrZ4S

Benzene
https://spectrabase.com/spectrum/6gyqb2IXGFU

Benzene
https://spectrabase.com/spectrum/6R0m1ytWAiO

Benzene
https://spectrabase.com/spectrum/6WKnYKhBrtQ

Benzene
https://spectrabase.com/spectrum/6GMizHIAmMK

Benzene
https://spectrabase.com/spectrum/6LgkVd5qTXM

Benzene
https://spectrabase.com/spectrum/65ifwZgpO0G

Benzene
https://spectrabase.com/spectrum/6B2hSvUV5BI

Benzene
https://spectrabase.com/spectrum/5v4cts5TzeC

Benzene
https://spectrabase.com/spectrum/60OeQDt9gpE

Benzene
https://spectrabase.com/spectrum/5kQZrAU8bI8

Benzene
https://spectrabase.com/spectrum/5pkbNWHoITA

Benzene
https://spectrabase.com/spectrum/5ZmWoSsnCw4

Benzene
https://spectrabase.com/spectrum/5f6YKogSu76

Benzene
https://spectrabase.com/spectrum/89TGT0uy6H2

Benzene
https://spectrabase.com/spectrum/8EnHzMidnS4

Benzene
https://spectrabase.com/spectrum/7ypDQJJchuy

Benzene
https://spectrabase.com/spectrum/849Ewf7IP60

Benzene
https://spectrabase.com/spectrum/7oBANbiHJYu

Benzene
https://spectrabase.com/spectrum/7tVBtxVx0jw

Benzene
https://spectrabase.com/spectrum/Fe6nWRS8JsO

Benzene
https://spectrabase.com/spectrum/FjQp2nFo13Q

Benzene
https://spectrabase.com/spectrum/FTSkTjqmvWK

Benzene
https://spectrabase.com/spectrum/FYmm05eSchM

Benzene
https://spectrabase.com/spectrum/FIohR2FRXAG

Benzene
https://spectrabase.com/spectrum/FO8ixO37ELI

Benzene
https://spectrabase.com/spectrum/F8AeOKe68oC

Benzene
https://spectrabase.com/spectrum/FDUfugRlpzE

Benzene
https://spectrabase.com/spectrum/6iWFFs8BtN2

Benzene
https://spectrabase.com/spectrum/6nqGmDvraY4

Benzene
https://spectrabase.com/spectrum/6XsCDAWqV0y

Benzene
https://spectrabase.com/spectrum/6dCDjWKWCC0

Benzene
https://spectrabase.com/spectrum/6NE9ASvV6eu

Benzene
https://spectrabase.com/spectrum/6SYAgojAnpw

Benzene
https://spectrabase.com/spectrum/6Ca67lK9iIq

Benzene
https://spectrabase.com/spectrum/6Hu7e77pPTs

Benzene
https://spectrabase.com/spectrum/61w353ioJwm

Benzene
https://spectrabase.com/spectrum/67G4bPWU17o

Benzene
https://spectrabase.com/spectrum/5rI02M7Svai

Benzene
https://spectrabase.com/spectrum/5wc1Yhv8clk

Benzene
https://spectrabase.com/spectrum/5gdwzeW7XEe

Benzene
https://spectrabase.com/spectrum/5lxyW0JnEPg

Benzene
https://spectrabase.com/spectrum/5Vztwwum8sa

Benzene
https://spectrabase.com/spectrum/5bJvTIiRq3c

Benzene
https://spectrabase.com/spectrum/85gdbUwx2DY

Benzene
https://spectrabase.com/spectrum/8B0f7qkcjOa

Benzene
https://spectrabase.com/spectrum/7v2aYnLbdrU

Benzene
https://spectrabase.com/spectrum/LvOQ9xEvxg8

Benzene
https://spectrabase.com/spectrum/LfQLatpus92

Benzene
https://spectrabase.com/spectrum/LkkN7FdaZK4

Benzene
https://spectrabase.com/spectrum/LUmIYCEZTmy

Benzene
https://spectrabase.com/spectrum/La6K4Y2FAy0

Benzene
https://spectrabase.com/spectrum/LK8FVUdE5Qu

Benzene
https://spectrabase.com/spectrum/LPSH1qQtmbw

Benzene
https://spectrabase.com/spectrum/L9UCSn1sh4q

Benzene
https://spectrabase.com/spectrum/LEoDz8pYOFs

Benzene
https://spectrabase.com/spectrum/Kyq9Q5QXIim

Benzene
https://spectrabase.com/spectrum/L4AAwRECzto

Benzene
https://spectrabase.com/spectrum/KoC6NNpBuMi

Benzene
https://spectrabase.com/spectrum/KtW7tjcrbXk

Benzene
https://spectrabase.com/spectrum/KdY3KgDqW0e

Benzene
https://spectrabase.com/spectrum/Kis4r21WDBg

Benzene
https://spectrabase.com/spectrum/CDteCDhwGZU

Benzene
https://spectrabase.com/spectrum/CJDfiZVbxkW

Benzene
https://spectrabase.com/spectrum/C3Fb9W6asDQ

Benzene
https://spectrabase.com/spectrum/C8ZcfruGZOS

Benzene
https://spectrabase.com/spectrum/BsbY6oVFTrM

Benzene
https://spectrabase.com/spectrum/BxvZdAIvB2O

Benzene
https://spectrabase.com/spectrum/BhxV46tu5VI

Benzene
https://spectrabase.com/spectrum/BnHWaShZmgK

Benzene
https://spectrabase.com/spectrum/BXJS1PIYh9E

Benzene
https://spectrabase.com/spectrum/BcdTXl6EOKG

Benzene
https://spectrabase.com/spectrum/BMfOyhhDInA

Benzene
https://spectrabase.com/spectrum/BRzQV3UszyC

Benzene
https://spectrabase.com/spectrum/8Rg0D6240Tf

Benzene
https://spectrabase.com/spectrum/DnbHcXa9F2q

Benzene
https://spectrabase.com/spectrum/JUP436NPljG

Benzene
https://spectrabase.com/spectrum/7v9ITdq3c7v

Benzene
https://spectrabase.com/spectrum/IZCzFm1jeXY

benzene
https://spectrabase.com/spectrum/4Oyh2MFOyA2

Benzene

https://spectrabase.com/spectrum/1kPEhwDaw6W

Benzene
https://spectrabase.com/spectrum/5LddczO6JNw

Benzene
https://spectrabase.com/spectrum/9Nwb4cBjdxO

Benzene
https://spectrabase.com/spectrum/5vKeDJFFHrQ

Benzene
https://spectrabase.com/spectrum/GRP4eXbzyWb

Benzene
https://spectrabase.com/spectrum/E74hj25v6Lt

Benzene
https://spectrabase.com/spectrum/Li4oe3GX51g

BENZENE
https://spectrabase.com/spectrum/1BRjHhO3tNm

BENZENE-1,3,5-D3
https://spectrabase.com/spectrum/7TkLSQ18nox

BENZENE-D6
https://spectrabase.com/spectrum/26ZXujUM59r

BENZENE
https://spectrabase.com/spectrum/ApYr8ohvkB2

BENZENE
https://spectrabase.com/spectrum/9pdurpn3Eov

Benzene
https://spectrabase.com/spectrum/6lDpvKUrh7g

Benzene
https://spectrabase.com/spectrum/DTFbgslJZtg

Benzene
https://spectrabase.com/spectrum/BUwLs9pstl2

Benzol
https://spectrabase.com/spectrum/BHx3Mz0xkC2

Benzene
https://spectrabase.com/spectrum/3k51orIPKgi

Benzene
https://spectrabase.com/spectrum/FJXlDLTzFpY

Benzene
https://spectrabase.com/spectrum/EwWxXTP6tma

Benzene
https://spectrabase.com/spectrum/lTEpZtdz3w

Benzene
https://spectrabase.com/spectrum/KgETPadul3Q

Benzene
https://spectrabase.com/spectrum/GiwBIxUgpzU

Benzene
https://spectrabase.com/spectrum/9pTtYL3dnjU

Benzene
https://spectrabase.com/spectrum/GnCCjulNGbo

Benzene
https://spectrabase.com/spectrum/CiPszM9qF6W

Benzene
https://spectrabase.com/spectrum/6zIMhBGyGAq

Benzene
https://spectrabase.com/spectrum/LU3vxghuxfM

Benzene
https://spectrabase.com/spectrum/36Yoh9ng3Ky

Benzene
https://spectrabase.com/spectrum/7wQ7AWUTQJc

Benzene
https://spectrabase.com/spectrum/9IX3cTf0SW0

Benzene
https://spectrabase.com/spectrum/8hbn8gCO57w

Benzene
https://spectrabase.com/spectrum/4vtiooBzshs

Benzene
https://spectrabase.com/spectrum/6WbJzaGvyBk

Benzene
https://spectrabase.com/spectrum/6edew2aE8jg

35. **NMRShiftDB**
https://pubchem.ncbi.nlm.nih.gov/substance/587088

36. **NIST Mass Spectrometry Data Center**

Benzene
http://www.nist.gov/srd/nist1a.cfm

37. **International Agency for Research on Cancer (IARC)**

> LICENSE
>
> https://publications.iarc.fr/Terms-Of-Use

Benzene
https://monographs.iarc.who.int/list-of-classifications

IARC Classification
https://www.iarc.fr/

38. **Nature Chemistry**

https://pubchem.ncbi.nlm.nih.gov/substance/316388899
https://pubchem.ncbi.nlm.nih.gov/substance/387271231

39. **NIOSH Manual of Analytical Methods**

> LICENSE
>
> https://www.cdc.gov/Other/disclaimer.html

71-43-2
https://www.cdc.gov/niosh/docs/2003-154/pdfs/1501.pdf

71-43-2
https://www.cdc.gov/niosh/docs/2003-154/pdfs/2549.pdf

71-43-2
https://www.cdc.gov/niosh/docs/2003-154/pdfs/3700.pdf

71-43-2
https://www.cdc.gov/niosh/docs/2003-154/pdfs/3800.pdf

40. **Protein Data Bank in Europe (PDBe)**

http://www.ebi.ac.uk/pdbe-srv/pdbechem/chemicalCompound/show/BNZ

41. **RCSB Protein Data Bank (RCSB PDB)**

> LICENSE
>
> https://www.rcsb.org/pages/policies

https://www.rcsb.org/

42. **Rhea - Annotated Reactions Database**

> LICENSE
>
> https://www.rhea-db.org/help/license-disclaimer

https://www.rhea-db.org/rhea?query=CHEBI:16716

43. **Springer Nature**

44. **SpringerMaterials**

benzene
https://materials.springer.com/substanceprofile/docs/smsid_cdqphgnpefyyocwt

45. **The Cambridge Structural Database**

https://www.ccdc.cam.ac.uk/structures/Search?Ccdcid=298305
https://www.ccdc.cam.ac.uk/structures/Search?Ccdcid=298306
https://www.ccdc.cam.ac.uk/structures/Search?Ccdcid=298307
https://www.ccdc.cam.ac.uk/structures/Search?Ccdcid=725244
https://www.ccdc.cam.ac.uk/structures/Search?Ccdcid=757059
https://www.ccdc.cam.ac.uk/structures/Search?Ccdcid=757060
https://www.ccdc.cam.ac.uk/structures/Search?Ccdcid=757061

46. **Thieme Chemistry**

> LICENSE
>
> https://creativecommons.org/licenses/by-nc-nd/4.0/

47. **US EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites**

> LICENSE

> https://www.epa.gov/privacy/privacy-act-laws-policies-and-resources

Benzene
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Benzene
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search?tool=rml

48. **Wiley**
https://pubchem.ncbi.nlm.nih.gov/substance/?source=wiley&sourceid=124150

49. **Medical Subject Headings (MeSH)**
Benzene
https://www.ncbi.nlm.nih.gov/mesh/68001554
MeSH Tree
http://www.nlm.nih.gov/mesh/meshhome.html

50. **PubChem**
https://pubchem.ncbi.nlm.nih.gov

51. **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

52. **ChEMBL**
Target Tree
https://www.ebi.ac.uk/chembl/target/browser

53. **PATENTSCOPE (WIPO)**
SID 403032543
https://pubchem.ncbi.nlm.nih.gov/substance/403032543

54. **NCBI**
https://www.ncbi.nlm.nih.gov/projects/linkout