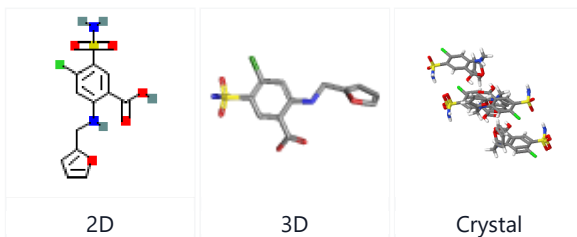


COMPOUND SUMMARY

Furosemide

PubChem CID

3440

Structure**Chemical Safety**

Irritant



Health Hazard

[Laboratory Chemical Safety Summary \(LCSS\) Datasheet](#)**Molecular Formula****C₁₂H₁₁ClN₂O₅S****Synonyms**

furosemide

54-31-9

Frusemide

Lasix

Furanthril

[View More...](#)**Molecular Weight**

330.74 g/mol

*Computed by PubChem 2.1 (PubChem release 2021.05.07)***Dates**

Create: 2005-03-25
Modify: 2023-08-12

Description

Furosemide is an odorless white to slightly yellow crystalline powder. A diuretic drug. Almost tasteless. (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](#)

Furosemide is a [chlorobenzoic acid](#) that is [4-chlorobenzoic acid](#) substituted by a (furan-2-ylmethyl)amino and a sulfamoyl group at position 2 and 5 respectively. It is a diuretic used in the treatment of congestive heart failure. It has a role as a xenobiotic, an environmental contaminant and a loop diuretic. It is a sulfonamide, a [chlorobenzoic acid](#) and a member of furans.

► [ChEBI](#)

Furosemide is a potent loop diuretic that acts on the kidneys to ultimately increase [water](#) loss from the body. It is an [anthranilic acid](#) derivative. Furosemide is used for edema secondary to various clinical conditions, such as congestive heart failure exacerbation, liver failure, renal failure, and high blood pressure. It mainly works by inhibiting electrolyte reabsorption from the kidneys and enhancing the excretion of [water](#) from the body. Furosemide has a fast onset and short duration of action and has been used safely and effectively in both pediatric and adult patients. The use of furosemide is particularly beneficial in clinical settings that require a drug with a higher diuretic potential. In addition to oral formulations, the solution for intravenous and intramuscular administration is also available, which is typically limited to patients who are unable to take oral medication or for patients in emergency clinical situations.

► [DrugBank](#)

[View More...](#)

Contents

Title and Summary

1 Structures



2 Names and Identifiers

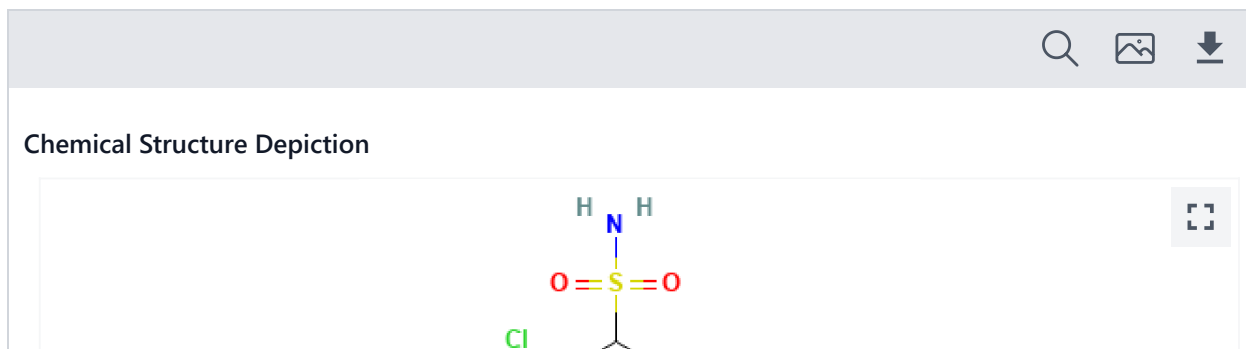


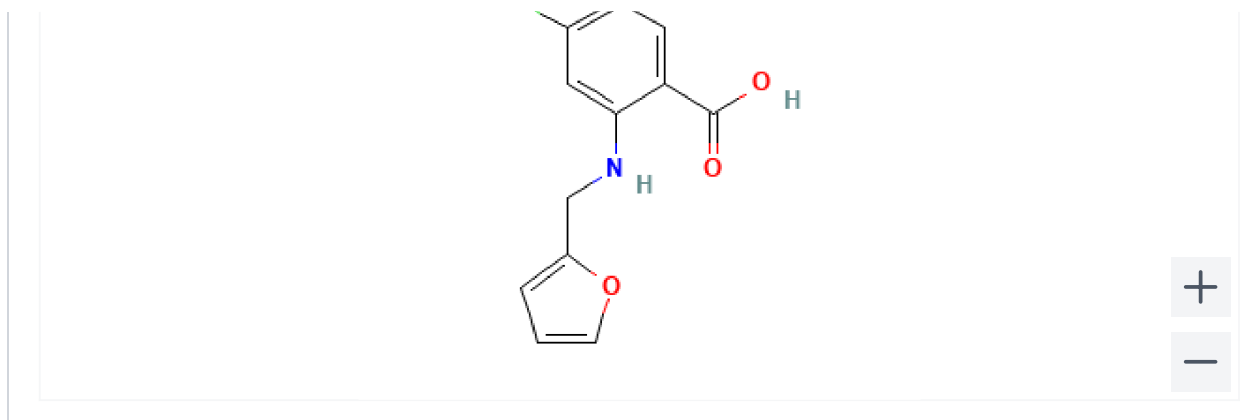
3 Chemical and Physical Properties	▼
4 Spectral Information	▼
5 Related Records	▼
6 Chemical Vendors	
7 Drug and Medication Information	▼
8 Pharmacology and Biochemistry	▼
9 Use and Manufacturing	▼
10 Identification	▼
11 Safety and Hazards	▼
12 Toxicity	▼
13 Associated Disorders and Diseases	
14 Literature	▼
15 Patents	▼
16 Interactions and Pathways	▼
17 Biological Test Results	▼
18 Classification	▼
19 Information Sources	

1 Structures

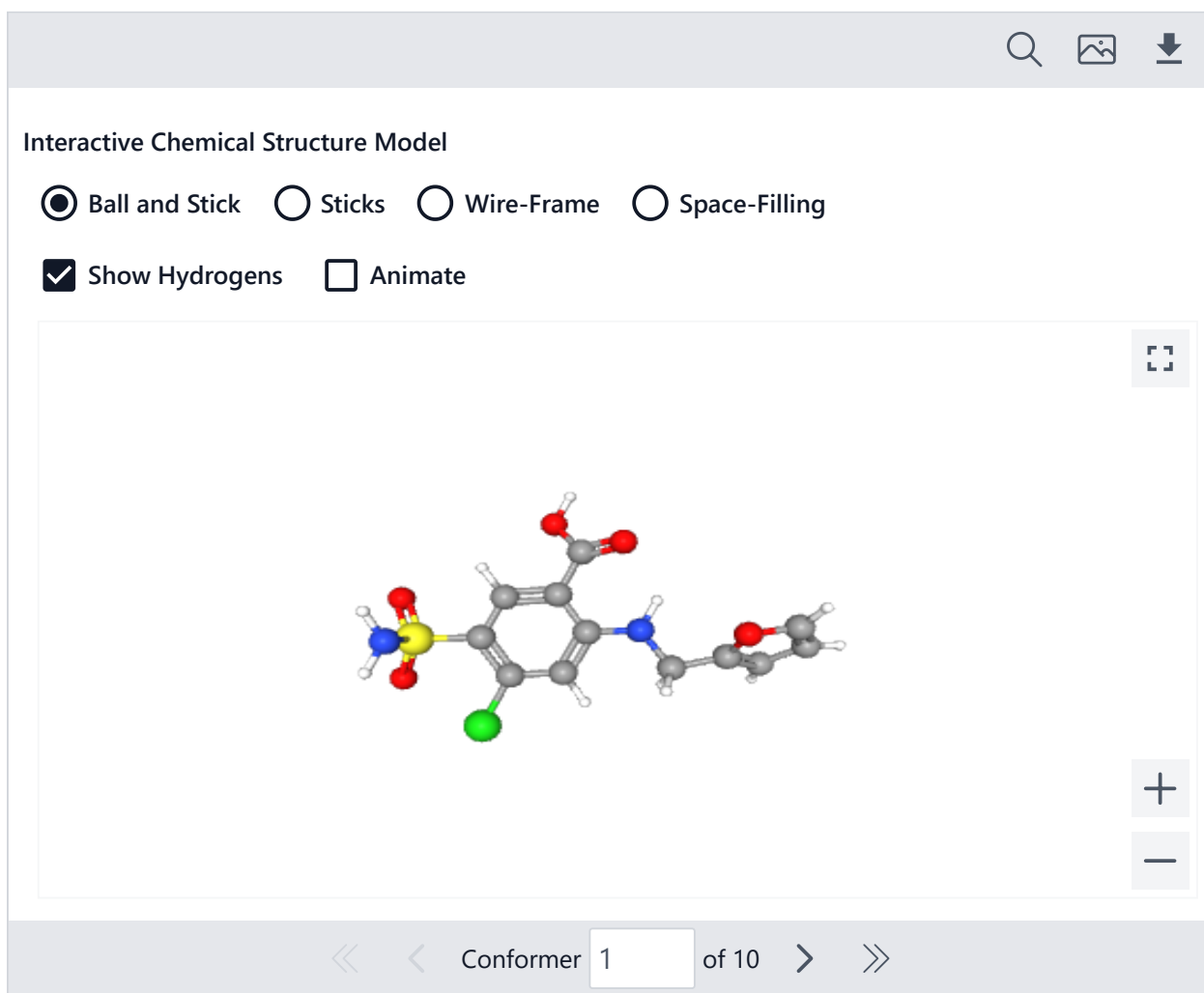


1.1 2D Structure



[► PubChem](#)

1.2 3D Conformer

[► PubChem](#)

1.3 Crystal Structures



1 of 7

View All

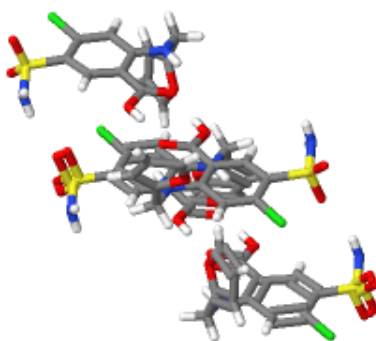
CCDC Number

[657920](#)

Crystal Structure Data

[DOI:10.5517/ccq2m7m](#)

Crystal Structure Depiction

[► The Cambridge Structural Database](#)

2 Names and Identifiers



2.1 Computed Descriptors



2.1.1 IUPAC Name



4-chloro-2-(furan-2-ylmethylamino)-5-sulfamoylbenzoic acid

Computed by Lexichem TK 2.7.0 (PubChem release 2021.05.07)[► PubChem](#)

2.1.2 InChI



InChI=1S/C12H11ClN2O5S/c13-9-5-10(15-6-7-2-1-3-20-7)8(12(16)17)4-11(9)21(14,18)19/h1-5,15H,6H2,(H,16,17)(H2,14,18,19)

Computed by InChI 1.0.6 (PubChem release 2021.05.07)

► [PubChem](#)

2.1.3 InChIKey



ZZUFCTLCJUWOSV-UHFFFAOYSA-N

Computed by InChI 1.0.6 (PubChem release 2021.05.07)

► [PubChem](#)

2.1.4 Canonical SMILES



C1=COC(=C1)CNC2=CC(=C(C=C2C(=O)O)S(=O)(=O)N)Cl

Computed by OEChem 2.3.0 (PubChem release 2021.05.07)

► [PubChem](#)

2.2 Molecular Formula



C₁₂H₁₁ClN₂O₅S

Computed by PubChem 2.1 (PubChem release 2021.05.07)

► [CAMEO Chemicals](#); [PubChem](#)

2.3 Other Identifiers



2.3.1 CAS



54-31-9

► [CAMEO Chemicals](#); [CAS Common Chemistry](#); [ChemIDplus](#); [DrugBank](#); [DTP/NCI](#); [EPA DSSTox](#); [Euro...](#)

2.3.2 Related CAS



41733-55-5 (mono-hydrochloride salt)

► ChemIDplus

2.3.3 European Community (EC) Number



200-203-6

► European Chemicals Agency (ECHA)

2.3.4 NSC Number



757039

► DTP/NCI

269420

► DTP/NCI

2.3.5 UNII



7LXU5N7ZO5

► FDA Global Substance Registration System (GSRS)

2.3.6 DSSTox Substance ID



DTXSID6020648

► EPA DSSTox

2.3.7 Nikkaji Number



J1.913E

► Japan Chemical Substance Dictionary (Nikkaji)

2.3.8 Wikipedia



Furosemide

► [Wikipedia](#)

2.3.9 Wikidata



[Q388801](#)

► [Wikidata](#)

2.3.10 NCI Thesaurus Code



[C515](#)

► [NCI Thesaurus \(NCIt\)](#)

2.3.11 RXCUI



[4603](#)

► [NLM RxNorm Terminology](#)

2.3.12 Pharos Ligand ID



[A5RF13NLPV8J](#)

► [Pharos](#)

2.3.13 Metabolomics Workbench ID



[37940](#)

► [Metabolomics Workbench](#)

2.3.14 ChEMBL ID



[CHEMBL35](#)

► [ChEMBL](#)

2.4 Synonyms



2.4.1 MeSH Entry Terms



Errolon
 Frusemid
 Frusemide
 Furanthril
 Furantral
 Furosemide
 Furosemide Monohydrochloride
 Furosemide Monosodium Salt
 Fursemide
 Fusid
 Lasix

► Medical Subject Headings (MeSH)

2.4.2 Depositor-Supplied Synonyms



furosemide	Desdemin	Trofurit	Urex	Mirfat	Impugan	Anfuramaide	Fulu
54-31-9	Frusemin	Fulsix	Marsemide	Frusemid	Rusyde	Arasemide	Furc
Frusemide	Fuluvamide	Furesis	Eutensin	Frusenex	Uremide	Bioretic	Furc
Lasix	Furanthryl	Katlex	Frusetic	Furanturil	Uresix	Disemide	Furc
Furanthril	Furantril	Lasilix	Fursemid	Furosedon	Yidoli	Diurapid	Furc
Furosemid	Fursemide	Radonna	Logirene	Profemin	Disal	Diurolasa	Furc
Errolon	Lowpstron	Seguril	Oedemex	Urosemide	Laxur	Diusemide	Furc
Fusid	Macasirool	Transit	Promedes	Aluzine	Urian	Durafurid	Furc
Aisemide	Prefemin	Lasex	Frusid	Diural	Apo-Frusemide	Fluidrol	Furc
Beronald	Rosemide	Salix	Lazix	Dryptal	Hydro-rapid	Frusedan	Furc

► PubChem

3 Chemical and Physical Properties



3.1 Computed Properties



Property Name Molecular Weight
Property Value 330.74 g/mol
Reference Computed by PubChem 2.1 (PubChem release 2021.05.07)
Property Name XLogP3
Property Value 2
Reference Computed by XLogP3 3.0 (PubChem release 2021.05.07)
Property Name Hydrogen Bond Donor Count
Property Value 3
Reference Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Property Name Hydrogen Bond Acceptor Count
Property Value 7
Reference Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Property Name Rotatable Bond Count
Property Value 5
Reference Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Property Name Exact Mass
Property Value 330.0077203 g/mol

Reference Computed by PubChem 2.1 (PubChem release 2021.05.07)
Property Name Monoisotopic Mass
Property Value 330.0077203 g/mol
Reference Computed by PubChem 2.1 (PubChem release 2021.05.07)
Property Name Topological Polar Surface Area
Property Value 131Å ²
Reference Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Property Name Heavy Atom Count
Property Value 21
Reference Computed by PubChem
Property Name Formal Charge
Property Value 0
Reference Computed by PubChem
Property Name Complexity
Property Value 481
Reference Computed by Cactvs 3.4.8.18 (PubChem release 2021.05.07)
Property Name Isotope Atom Count
Property Value

0
Reference Computed by PubChem
Property Name Defined Atom Stereocenter Count
Property Value 0
Reference Computed by PubChem
Property Name Undefined Atom Stereocenter Count
Property Value 0
Reference Computed by PubChem
Property Name Defined Bond Stereocenter Count
Property Value 0
Reference Computed by PubChem
Property Name Undefined Bond Stereocenter Count
Property Value 0
Reference Computed by PubChem
Property Name Covalently-Bonded Unit Count
Property Value 1
Reference Computed by PubChem
Property Name Compound Is Canonicalized

Property Value

Yes

Reference

Computed by PubChem (release 2021.05.07)

[► PubChem](#)

3.2 Experimental Properties



3.2.1 Physical Description



Furosemide is an odorless white to slightly yellow crystalline powder. A diuretic drug. Almost tasteless. (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](#)

Solid

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

3.2.2 Color / Form



Crystals from aqueous **ethanol**

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 792

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

White to off-white crystalline powder

US NLM; DailyMed. Current Medical Information. Furosemide. US Natl Lib Med, Natl Inst Health, Health Human Serv. Available from, as of Apr 20, 2017: <https://dailymed.nlm.nih.gov/dailymed/about.cfm>

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

Fine, white to slightly yellow, crystalline powder

Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 872

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

3.2.3 Odor



Odorless

US NLM; DailyMed. Current Medical Information. Furosemide. US Natl Lib Med, Natl Inst Health, Health Human Serv. Available from, as of Apr 20, 2017: <https://dailymed.nlm.nih.gov/dailymed/about.cfm>

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

3.2.4 Taste



Practically tasteless

Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 872

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

3.2.5 Melting Point



403 °F (decomposes) (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](#)

220

MSDS

► [DrugBank](#)

206 °C

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 792

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

295 °C

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

3.2.6 Solubility



>49.6 [ug/mL] (The mean of the results at pH 7.4)

► [Burnham Center for Chemical Genomics](#)

less than 1 mg/mL at 73 °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](#)

73.1mg/L (at 30 °C)

YALKOWSKY,SH & DANNENFELSER, RM (1992)

► [DrugBank](#)

The [sodium](#) salt can be recrystallized from [water](#); the solubility of the salt in [water](#) at room temperature is 6%. /[Furosemide sodium](#) salt/

Hropot M, Lang H-J; Diuretics. Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2017). New York, NY: John Wiley & Sons. Online Posting Date: 15 Jun 2000

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

In [water](#), 73.1 mg/L at 30 °C

Yalkowsky, S.H., He, Yan, Jain, P. Handbook of Aqueous Solubility Data Second Edition. CRC Press, Boca Raton, FL 2010, p. 866

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

Slightly soluble in water

Scriabine A, Taylor DG; Antihypertensives. Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2017). New York, NY: John Wiley & Sons. Online Posting Date: 15 Jun 2000

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

Slightly soluble in [chloroform](#), ether. Soluble in [acetone](#), [methanol](#), [DMF](#), aqueous solutions above pH 8.0. Less soluble in [ethanol](#).

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 792

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

Soluble in [methanol](#), [acetone](#), dilute NaOH

Scriabine A, Taylor DG; Antihypertensives. Ullmann's Encyclopedia of Industrial Chemistry. 7th ed. (1999-2017). New York, NY: John Wiley & Sons. Online Posting Date: 15 Jun 2000

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

Freely soluble in alkali hydroxide

McEvoy, G.K. (ed.). American Hospital Formulary Service - Drug Information 93. Bethesda, MD: American Society of Hospital Pharmacists, Inc., 1993 (Plus Supplements, 1993)., p. 1629

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

0.0731 mg/mL at 30 °C

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

3.2.7 Vapor Pressure



3.1X10⁻¹¹ mm Hg at 25 °C (est)

US EPA; Estimation Program Interface (EPI) Suite. Ver. 4.1. Nov, 2012. Available from, as of Apr 19, 2017: <https://www2.epa.gov/tsca-screening-tools>

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

3.2.8 LogP



2.03

SANGSTER (1993)

► [DrugBank](#)

log Kow = 2.03

Sangster J; LOGKOW Databank. Sangster Res. Lab., Montreal Quebec, Canada (1994)

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

2.03

SANGSTER (1993)

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

3.2.9 LogS



-3.66

ADME Research, USCD

► [DrugBank](#)

3.2.10 Stability / Shelf Life



Stable under recommended storage conditions.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

Commercially available 40-mg furosemide tablets have an expiration date of 5 years and the commercially available injection has an expiration date 42 months following the date of manufacture. The 20-mg tablets do not have a specific expiration dating period.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2832

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

3.2.11 Decomposition



When heated to decomposition it emits very toxic fumes of /[hydrogen chloride](#), nitrogen oxides and sulfur oxides/.

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 827

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

3.2.12 Caco2 Permeability



-6.5

ADME Research, USCD

► DrugBank

3.2.13 Dissociation Constants



Acidic pKa

3.65

Tested as SID 103165562 in AID 781325:

<https://pubchem.ncbi.nlm.nih.gov/bioassay/781325#sid=103165562>

Comparison of the accuracy of experimental and predicted pKa values of basic and acidic compounds. Pharm Res. 2014; 31(4):1082-95. DOI:10.1007/s11095-013-1232-z. PMID:24249037

Tested as SID 103165562 in AID 781329:

<https://pubchem.ncbi.nlm.nih.gov/bioassay/781329#sid=103165562>

Comparison of the accuracy of experimental and predicted pKa values of basic and acidic compounds. Pharm Res. 2014; 31(4):1082-95. DOI:10.1007/s11095-013-1232-z. PMID:24249037

► ChEMBL

Acidic pKa

3.52

Tested as SID 103165562 in AID 781326:

<https://pubchem.ncbi.nlm.nih.gov/bioassay/781326#sid=103165562>

Comparison of the accuracy of experimental and predicted pKa values of basic and acidic compounds. Pharm Res. 2014; 31(4):1082-95. DOI:10.1007/s11095-013-1232-z. PMID:24249037

► ChEMBL

Acidic pKa

3.5

Tested as SID 103165562 in AID 781330:

<https://pubchem.ncbi.nlm.nih.gov/bioassay/781330#sid=103165562>

Comparison of the accuracy of experimental and predicted pKa values of basic and acidic compounds. Pharm Res. 2014; 31(4):1082-95. DOI:10.1007/s11095-013-1232-z. PMID:24249037

► ChEMBL

pKa = 3.9 (carboxyl)

Khan SJ, Ongerth JE; Chemosphere 54:355-67 (2004)

► Hazardous Substances Data Bank (HSDB)

pKa1 = 3.8 (carboxyl); pKa2 = 7.5

Berthod A et al; *Anal Chem* 71: 879-88 (1999)

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

3.2.14 Collision Cross Section



169.3 Å² [M+H]⁺ [CCS Type: TW, Method: calibrated with polyalanine and drug standards]

<https://pubs.acs.org/doi/abs/10.1021/acs.analchem.7b01709>

► [CCSbase](#)

190.28 Å² [M+Na]⁺

S61 | *UJICCSLIB* | Collision Cross Section (CCS) Library from UJI | [DOI:10.5281/zenodo.3549476](https://doi.org/10.5281/zenodo.3549476)

► [NORMAN Suspect List Exchange](#)

3.2.15 Other Experimental Properties



Melts between 203-205 °C with decomposition

Osol, A. and J.E. Hoover, et al. (eds.). *Remington's Pharmaceutical Sciences*. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975., p. 872

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

A free carboxyl group gives it a strong hydrophilic character

Hropot M, Lang H-J; *Diuretics*. *Ullmann's Encyclopedia of Industrial Chemistry*. 7th ed. (1999-2017). New York, NY: John Wiley & Sons. Online Posting Date: 15 Jun 2000

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

4 Spectral Information



4.1 1D NMR Spectra



4.1.1 1H NMR Spectra



1 of 2

Spectra ID

1811

Instrument Type

Bruker

Frequency

600 MHz

Solvent

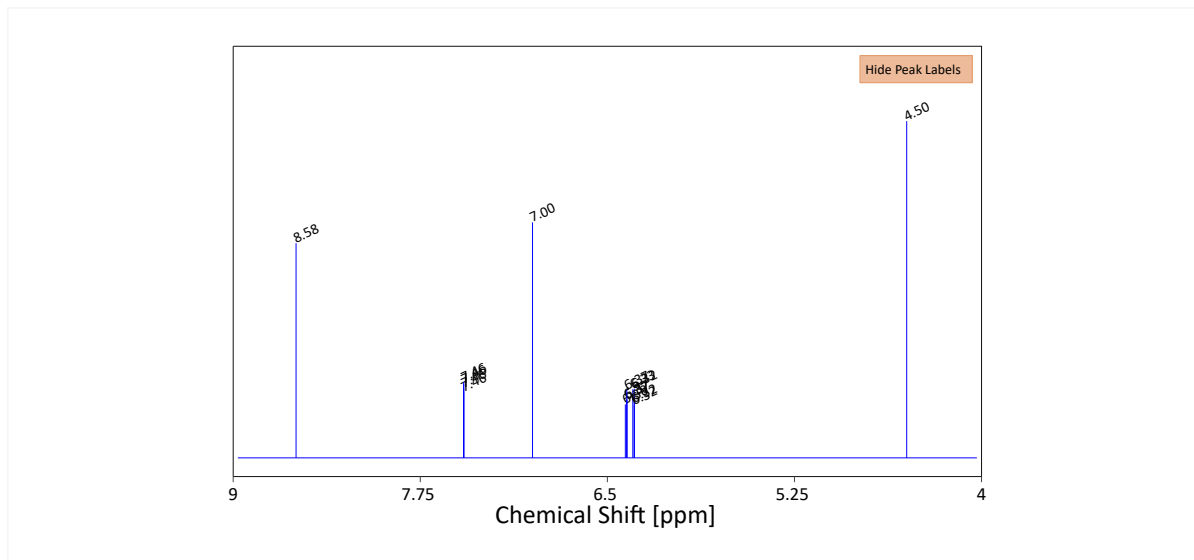
Water

pH

7.00

Shifts [ppm]:Intensity

7.46:19.59, 6.32:20.55, 7.00:69.95, 7.46:21.94, 6.33:20.37, 6.32:15.56, 6.38:15.87, 6.37:17.43, 4.50:100.00, 6.32:16.41, 6.37:17.31, 6.37:20.19, 8.58:63.76, 7.46:20.67, 7.46:22.54

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

2 of 2

Source of Spectrum

Sigma-Aldrich Co. LLC.

Source of Sample

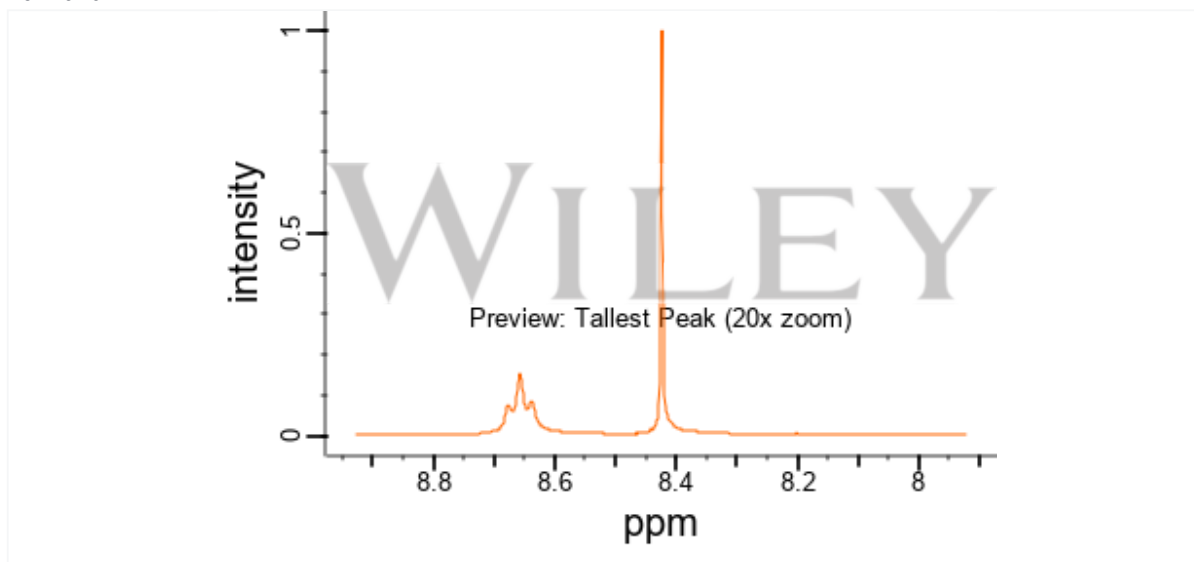
Sigma-Aldrich Co. LLC.

Catalog Number

257753

Copyright

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Thumbnail[► SpectraBase](#)

4.1.2 ¹³C NMR Spectra

**Source of Spectrum**

Sigma-Aldrich Co. LLC.

Source of Sample

Sigma-Aldrich Co. LLC.

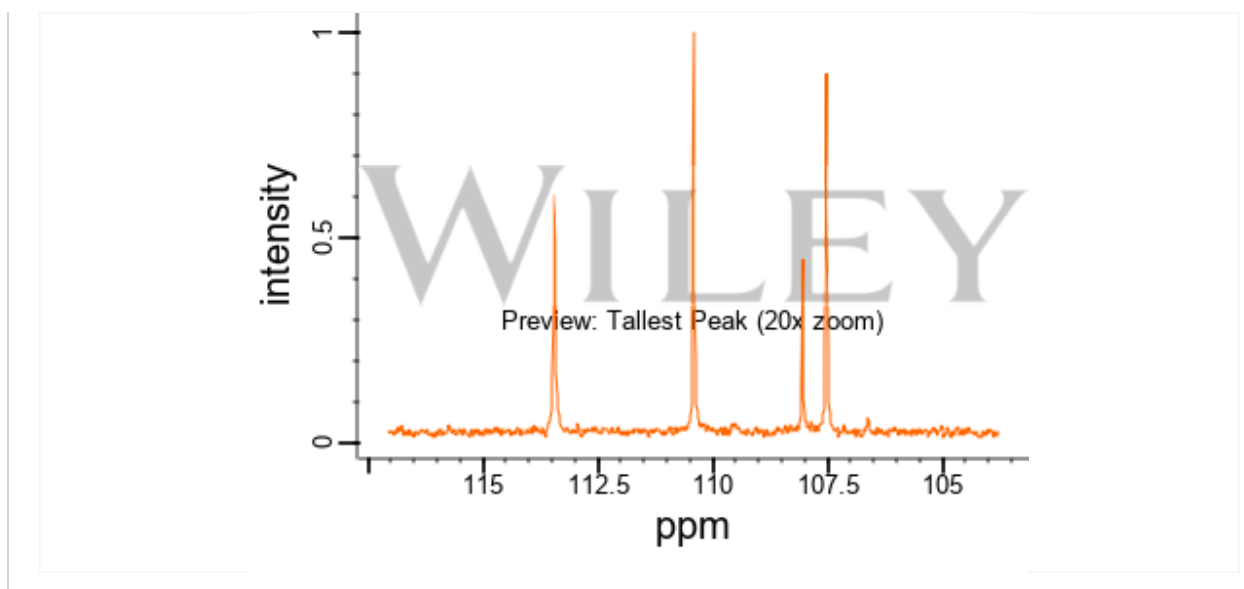
Catalog Number

257753

Copyright

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Thumbnail



► SpectraBase

4.2 2D NMR Spectra

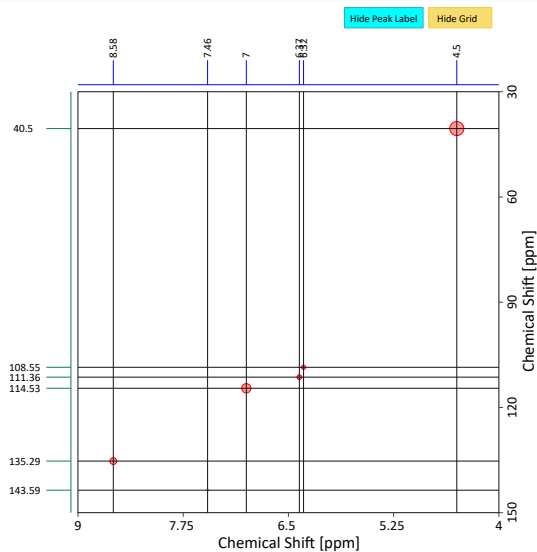


4.2.1 1H-13C NMR Spectra



2D NMR Spectra Type 1H-13C HSQC
Spectra ID 1751
Instrument Type Bruker
Frequency 600 MHz
Solvent CD3OD
pH 7.00
Shifts [ppm] (F2:F1):Intensity 6.32:108.55:0.30, 4.50:40.50:1.00, 7.46:143.59:0.05, 8.58:135.29:0.48, 7.00:114.53:0.66, 6.37:111.36:0.33

Thumbnail



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

4.3 Mass Spectrometry



4.3.1 GC-MS



1 of 4

[View All](#)

NIST Number
232586

Library
Main library

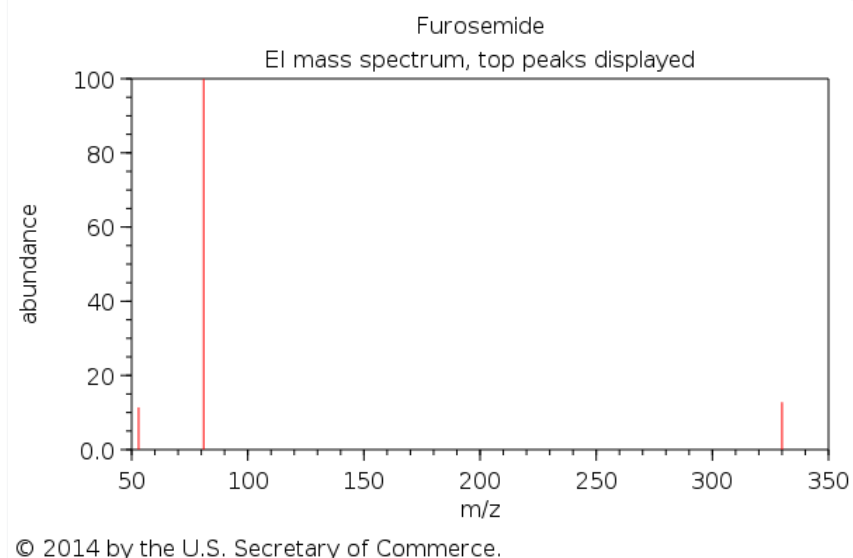
Total Peaks
210

m/z Top Peak
81

m/z 2nd Highest
330

m/z 3rd Highest
53

Thumbnail



► [NIST Mass Spectrometry Data Center](#)

2 of 4

[View All](#)

NIST Number

246956

Library

Replicate library

Total Peaks

84

m/z Top Peak

81

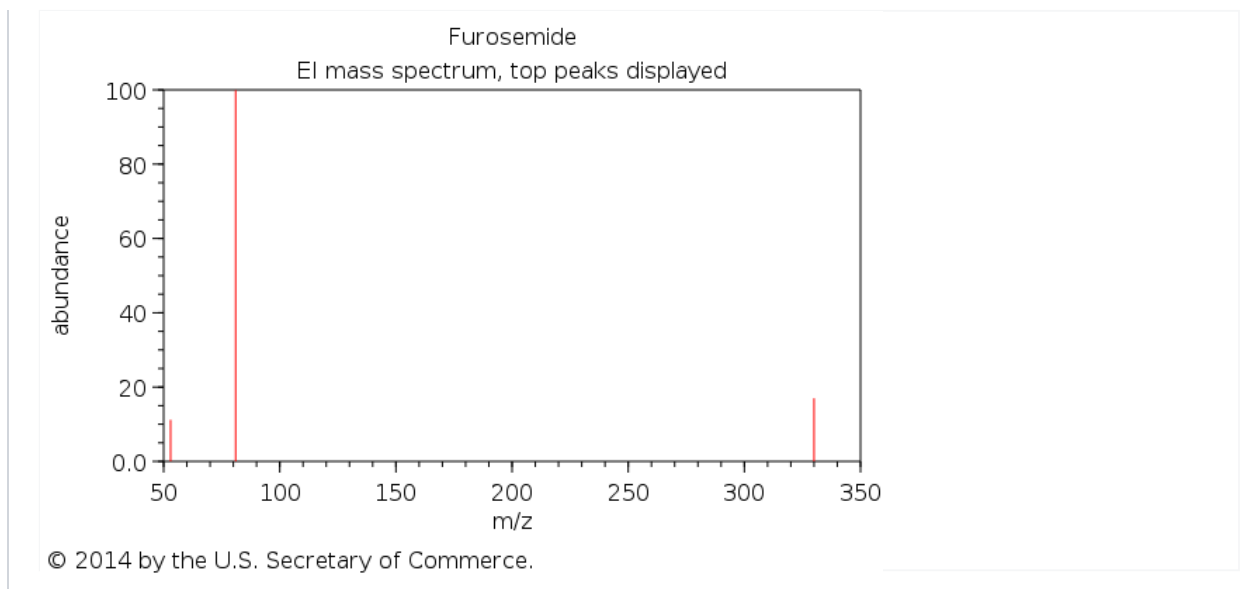
m/z 2nd Highest

330

m/z 3rd Highest

53

Thumbnail



► [NIST Mass Spectrometry Data Center](#)

4.3.2 MS-MS



1 of 9

[View All](#)

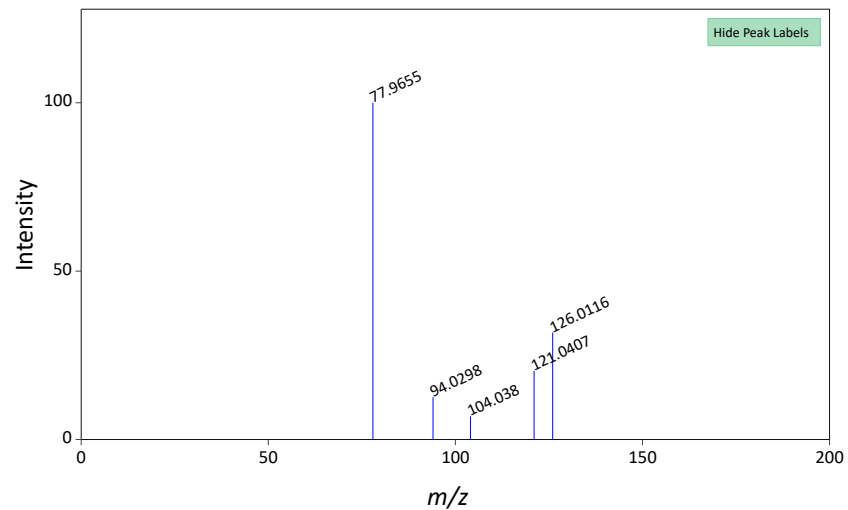
Spectra ID
[2226519](#)

Ionization Mode
Negative

SPLASH
[splash10-004i-9400000000-3ff5a4ee208ec3af518b](#)

Top 5 Peaks
77.9655 100
126.0116 31.75
121.0407 20.38
94.0298 12.56
104.038 6.89

Thumbnail



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

2 of 9

[View All](#)

Spectra ID

[2226533](#)

Ionization Mode

Positive

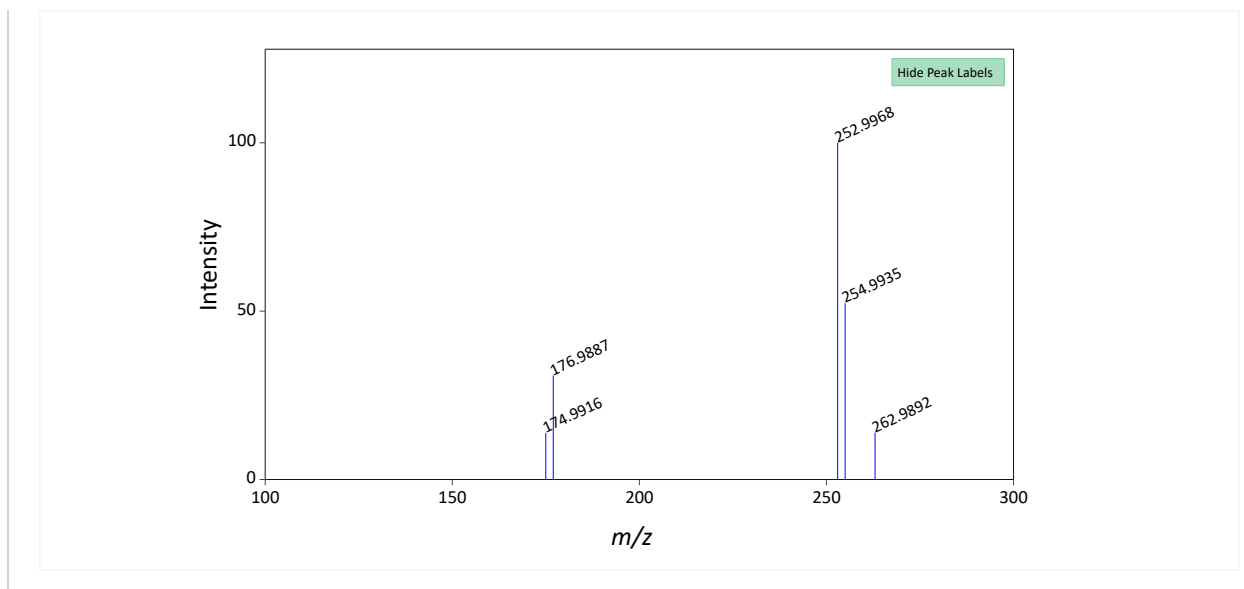
SPLASH

[splash10-0udi-0290000000-1f1017fe4370d9541f6d](#)

Top 5 Peaks

252.9968 100
254.9935 52.32
176.9887 30.86
262.9892 13.87
174.9916 13.83

Thumbnail



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

4.3.3 LC-MS



1 of 56	View All
Accession ID MSBNK-Athens_Univ-AU269201	
Authors Nikiforos Alygizakis, Katerina Galani, Nikolaos Thomaidis, University of Athens	
Instrument Bruker maXis Impact	
Instrument Type LC-ESI-QTOF	
MS Level MS2	
Ionization Mode POSITIVE	
Ionization ESI	
Collision Energy	

10 eV

Fragmentation Mode

CID

Column Name

Acclaim RSLC C18 2.2um, 2.1x100mm, Thermo

Retention Time

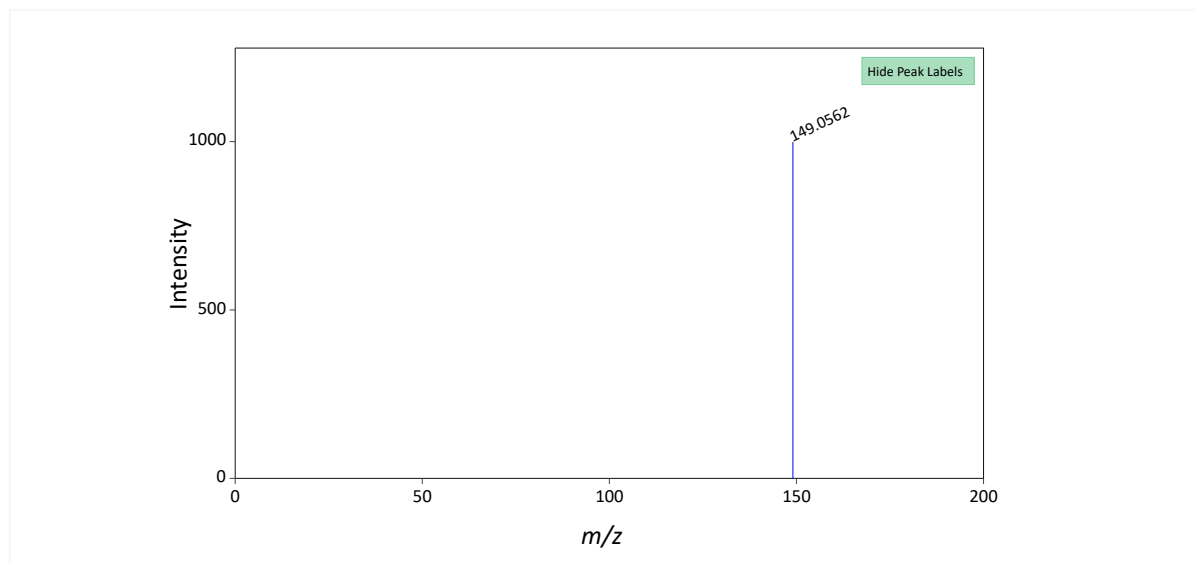
6.036 min

Precursor m/z

331.015

Precursor Adduct[M+H]⁺**Top 5 Peaks**

149.0562 999

SPLASH[splash10-0002-0900000000-36b6a610685d209cf56b](#)**Thumbnail****License**

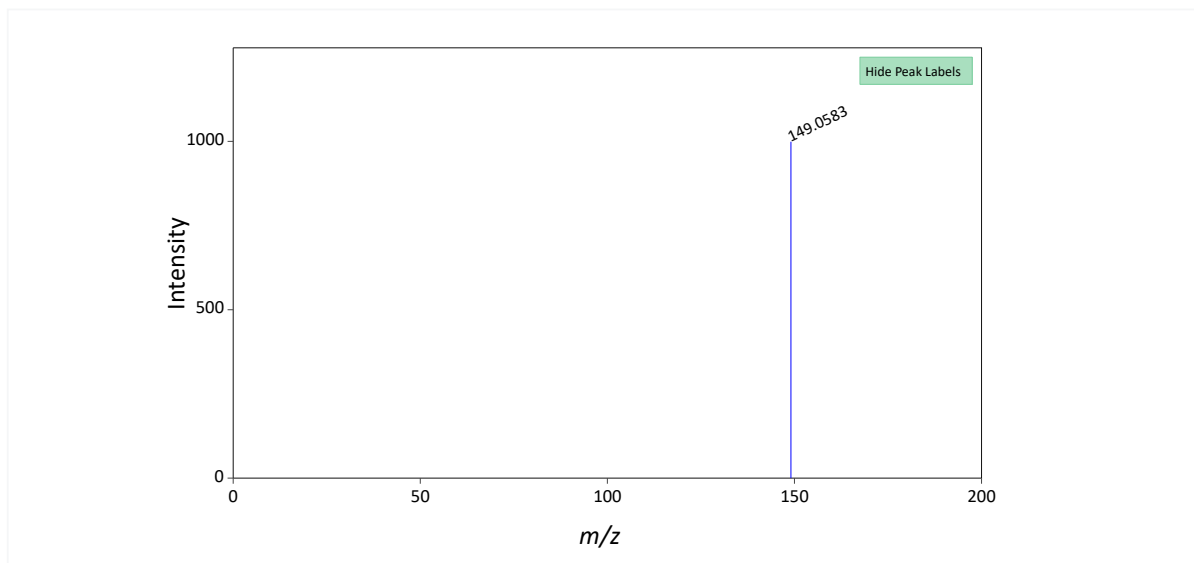
CC BY

[► MassBank Europe](#)

2 of 56		View All 
Accession ID MSBNK-Athens_Univ-AU269202		
Authors Nikiforos Alygizakis, Katerina Galani, Nikolaos Thomaidis, University of Athens		
Instrument Bruker maXis Impact		
Instrument Type LC-ESI-QTOF		
MS Level MS2		
Ionization Mode POSITIVE		
Ionization ESI		
Collision Energy 20 eV		
Fragmentation Mode CID		
Column Name Acclaim RSLC C18 2.2um, 2.1x100mm, Thermo		
Retention Time 6.019 min		
Precursor m/z 331.015		
Precursor Adduct [M+H] ⁺		
Top 5 Peaks 149.0583 999		
SPLASH		

[splash10-0002-0900000000-083048c6864cd4ec4c98](#)

Thumbnail



License

CC BY

[► MassBank Europe](#)

4.4 UV Spectra



UV Max (95% [ethanol](#)): 288, 276, 336 nm (E(1%)(1 cm): 945, 588, 144); (0.1N NaOH): 226, 273, 336 (E(1%)(1 cm): 1147, 557, 133).

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 792

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

4.5 IR Spectra



4.5.1 ATR-IR Spectra

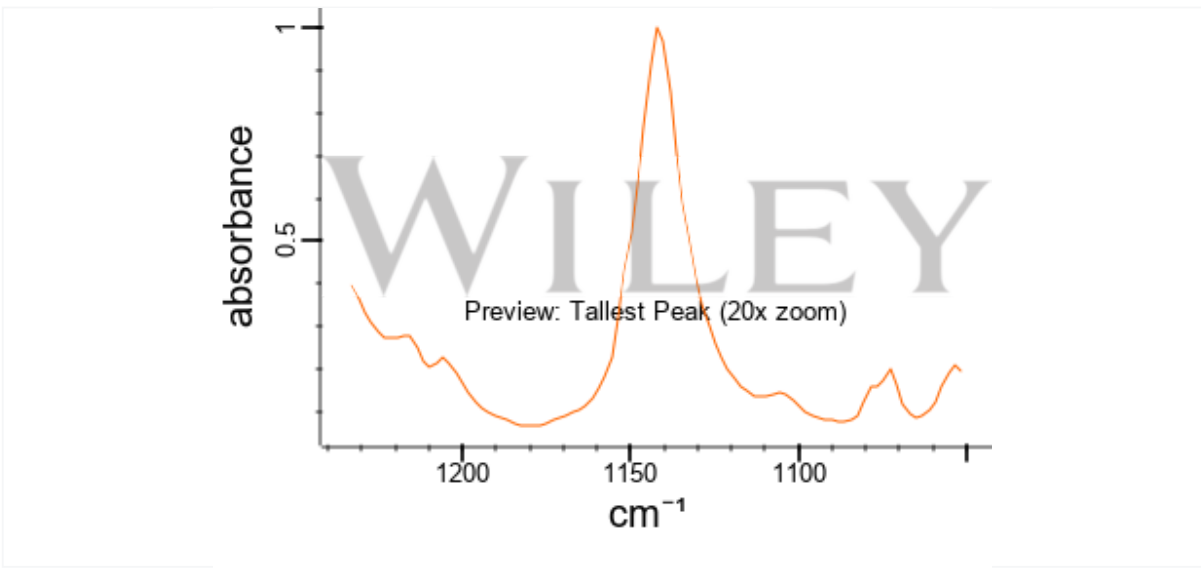


1 of 2

Instrument Name

Bio-Rad FTS

Technique

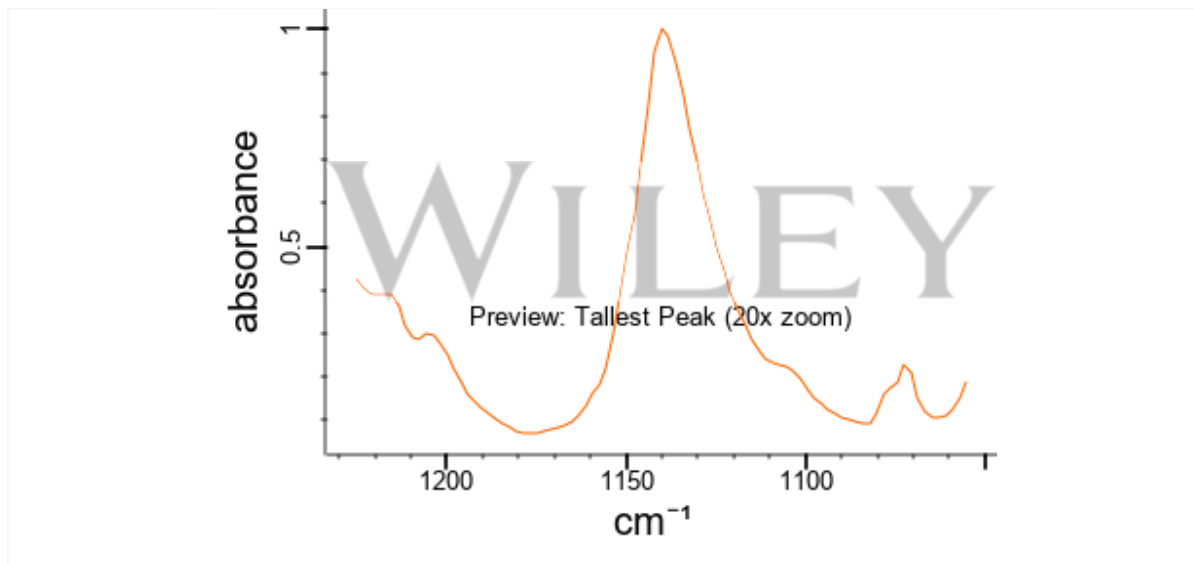
ATR-Neat (DuraSAMPLIR II)
Source of Spectrum Forensic Spectral Research
Source of Sample Alltech Associates, Inc., Grace Davison Discovery Sciences
Catalog Number 01432
Lot Number 230
Copyright Copyright © 2009-2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail 

► [SpectraBase](#)

2 of 2
Source of Sample Aldrich
Catalog Number 257753
Copyright

Copyright © 2018-2021 Sigma-Aldrich Co. LLC. - Database Compilation Copyright © 2018-2021 John Wiley & Sons, Inc. All Rights Reserved.

Thumbnail

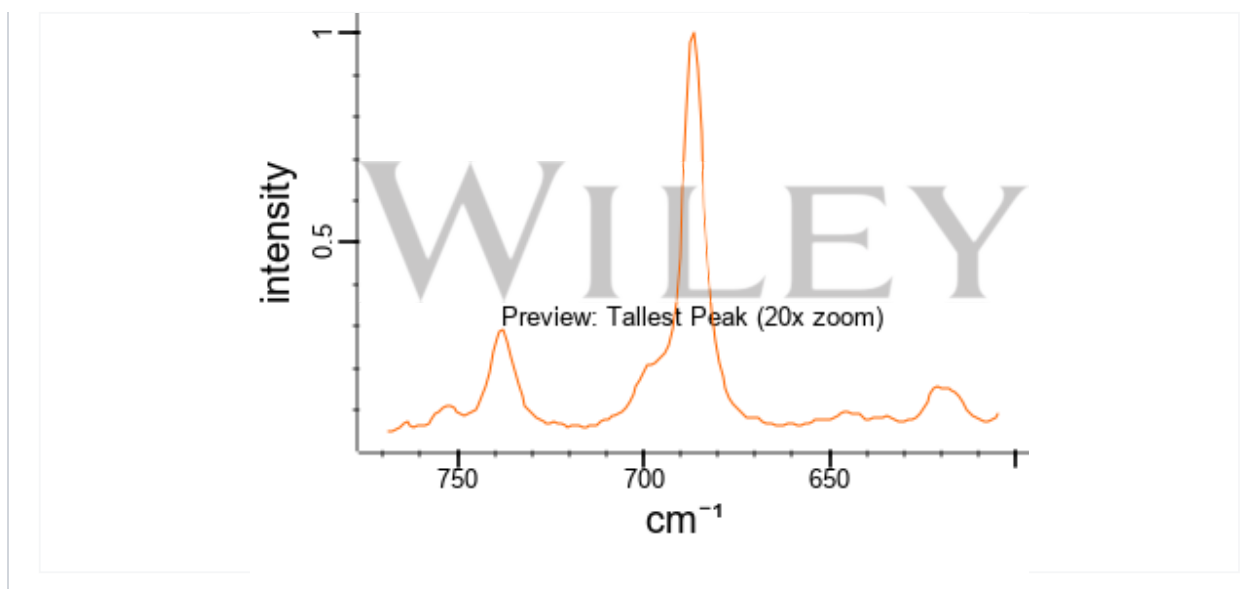


► [SpectraBase](#)

4.6 Raman Spectra



Technique FT-Raman
Source of Spectrum Forensic Spectral Research
Source of Sample Alltech Associates, Inc., Grace Davison Discovery Sciences
Catalog Number 01432
Lot Number 230
Copyright Copyright © 2012-2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail



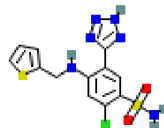
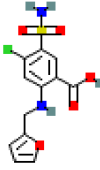
► SpectraBase

5 Related Records



5.1 Related Compounds with Annotation

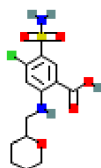


752 items 	
Search	
SORT BY Neighbor Type - A to Z 	
	azosemide, 27589-33-9, Azosemid, Diart, Azosemida, ... Compound CID: 2273 Neighbor Type: 2D+3D Annotation Types Count: 11
	furosemide, 54-31-9, Frusemide, Lasix, Furanthril, ...

Compound CID: [3440](#)

Neighbor Type: 2D+3D

Annotation Types Count: 14



DTXSID40274869, 18729-06-1, 4-Chloro-2-[[[(oxan-2-yl)methyl]amino]-5-sulfamoylbenzoic acid, Benzoic acid, 5-(aminosulfonyl)-4-chloro-2-[[[(tetrahydro-2H-pyran-2-yl)methyl]amino]-

<< < Page 1 of 151 > >>

► [PubChem](#)

5.2 Related Compounds



Same Connectivity Count

6

Same Parent, Connectivity Count

64

Same Parent, Exact Count

59

Mixtures, Components, and Neutralized Forms Count

189

Similar Compounds Count

505

Similar Conformers Count

281

► [PubChem](#)

5.3 Substances



5.3.1 Related Substances



All Count 693
Same Count 309
Mixture Count 384

► PubChem

5.3.2 Substances by Category



8 categories	↓
Chemical Vendors (78)	+
Curation Efforts (25)	+
Governmental Organizations (45)	+
Journal Publishers (4)	+
NIH Initiatives (24)	+
Research and Development (53)	+
Subscription Services (1)	+
Legacy Depositors (123)	+

► PubChem

5.4 Entrez Crosslinks



PubMed Count 4267
Protein Structures Count 8
Taxonomy Count

7

OMIM Count

16

Gene Count

188

[► PubChem](#)

5.5 NCBI LinkOut



Provider

[SIDER Side Effect Resource](#)

Information

[Chemical Information: biological properties - Side effects of furosemide](#)

Provider

[Scitegrity database](#)

Information

[Other Literature Sources: supplemental materials - This is a controlled substance. Complete access to the full Controlled Substances Squared application for 24 hours](#)[► NCBI](#)

6 Chemical Vendors



61 vendors



Santa Cruz Biotechnology, Inc.

PubChem SID: [472955382](#)Purchasable Chemical: [sc-203961](#)

AbovChem LLC

PubChem SID: [319554723](#)Purchasable Chemical: [HY-B0135](#)

LGC Standards

PubChem SID: [340509316](#)Purchasable Chemical: [DRE-C13985000](#)PubChem SID: [346398162](#)

Purchasable Chemical: [LGCAMP0014.00-01](#)

PubChem SID: [340515144](#)

Purchasable Chemical: [LGCFOR0014.00](#)

Sigma-Aldrich

PubChem SID: [329749916](#)

Purchasable Chemical: [1287008_USP](#)

PubChem SID: [348356769](#)

Purchasable Chemical: [BP547_SIAL](#)

PubChem SID: [378150176](#)

Purchasable Chemical: [F-005_CERILLIAN](#)

Hangzhou APiChem Technology

PubChem SID: [92710470](#)

Purchasable Chemical: [AC-11067](#)

BioCrick

PubChem SID: [382162249](#)

Purchasable Chemical: [BCC3782](#)

Selleck Chemicals

PubChem SID: [347912787](#)

Purchasable Chemical: [S1603](#)

Smolecule

PubChem SID: [438456706](#)

Purchasable Chemical: [S528576](#)

Clearysynth

PubChem SID: [313077116](#)

Purchasable Chemical: [CS-O-11654](#)

AbaChemScene

PubChem SID: [210279250](#)

Purchasable Chemical: [CS-1915](#)

Thermo Fisher Scientific

PubChem SID: [459220437](#)

Purchasable Chemical: [GID_900000005893904](#)

PubChem SID: [459220438](#)

Purchasable Chemical: [GID_900000005893905](#)

PubChem SID: [459265945](#)

Purchasable Chemical: [GID_900000007909784](#)

Enamine

PubChem SID: [473270517](#)

Purchasable Chemical: [EN300-126738](#)

PubChem SID: [334228188](#)

Purchasable Chemical: [Z275128584](#)

ChemShuttle

PubChem SID: [322059184](#)

Purchasable Chemical: [141411](#)

Chem-Space.com Database

PubChem SID: [434390248](#)

Purchasable Chemical: [CSSB00000038588](#)

Ambinter

PubChem SID: [369960317](#)

Purchasable Chemical: [Amb1101929](#)

Acadechem

PubChem SID: [321908101](#)

Purchasable Chemical: [ACDS-020833](#)

TargetMol

PubChem SID: [312695004](#)

Purchasable Chemical: [T0837](#)

Yuhao Chemical

PubChem SID: [318242518](#)

Purchasable Chemical: [LT7704](#)

MuseChem

PubChem SID: [355038918](#)

Purchasable Chemical: [A000323](#)

PubChem SID: [355122149](#)

Purchasable Chemical: [M008092](#)

Combi-Blocks

PubChem SID: [374018848](#)

Purchasable Chemical: [OR-4262](#)

Vitas-M Laboratory

PubChem SID: [184014651](#)

Purchasable Chemical: [BBL027780](#)

PubChem SID: [57820339](#)

Purchasable Chemical: [STK177334](#)

Biosynth

PubChem SID: [459125978](#)

Purchasable Chemical: [BF166384](#)

MolPort

PubChem SID: [88684054](#)

Purchasable Chemical: [MolPort-001-641-065](#)

AEchem Scientific Corp., USA

PubChem SID: [252316554](#)

Purchasable Chemical: [AE1-017299](#)

Oakwood Products

PubChem SID: [223362248](#)

Purchasable Chemical: [372339](#)

MedChemexpress MCE

PubChem SID: [210281573](#)
Purchasable Chemical: [HY-B0135](#)

AstaTech, Inc.

PubChem SID: [458780196](#)
Purchasable Chemical: [D87719](#)

Cooke Chemical Co., Ltd

PubChem SID: [478251239](#)
Purchasable Chemical: [A4365512](#)

Key Organics/BIONET

PubChem SID: [187072359](#)
Purchasable Chemical: [KS-1226](#)

DC Chemicals

PubChem SID: [350095930](#)
Purchasable Chemical: [DC9069](#)

CymitQuimica

PubChem SID: [470642667](#)
Purchasable Chemical: [CQ_54-31-9](#)

RR Scientific

PubChem SID: [472466612](#)
Purchasable Chemical: [R000228](#)

3WAY PHARM INC

PubChem SID: [438625367](#)
Purchasable Chemical: [SWOT-03620](#)

Matrix Scientific

PubChem SID: [406655960](#)
Purchasable Chemical: [078267](#)

Chemenu Inc.

PubChem SID: [354284007](#)
Purchasable Chemical: [CM110538](#)

MolCore BioPharmatech

PubChem SID: [446189072](#)
Purchasable Chemical: [DY445167](#)

PubChem SID: [354701633](#)
Purchasable Chemical: [MC445167](#)

AKos Consulting & Solutions

PubChem SID: [104815048](#)
Purchasable Chemical: [AKOS000266625](#)

AbMole Bioscience

PubChem SID: [387060895](#)

Purchasable Chemical: [M3436](#)

Allbio Pharm Co., Ltd

PubChem SID: [440084589](#)

Purchasable Chemical: [AD03989](#)

Yick-Vic Chemicals & Pharmaceuticals (HK) Ltd.

PubChem SID: [441072416](#)

Purchasable Chemical: [PH-0851](#)

ChemDiv

PubChem SID: [483004644](#)

Purchasable Chemical: [Y501-6275](#)

Tocris Bioscience

PubChem SID: [252157023](#)

Purchasable Chemical: [3109](#)

BioChemPartner

PubChem SID: [144115999](#)

Purchasable Chemical: [BCP9000708](#)

Achemo Scientific Limited

PubChem SID: [254754035](#)

Purchasable Chemical: [AC-14854](#)

BenchChem

PubChem SID: [446371562](#)

Purchasable Chemical: [B1674285](#)

Alfa Chemistry

PubChem SID: [438649842](#)

Purchasable Chemical: [ACM54319](#)

001Chemical

PubChem SID: [375744328](#)

Purchasable Chemical: [DY445167](#)

BroadPharm

PubChem SID: [143503811](#)

Purchasable Chemical: [BP-13261](#)

TCI (Tokyo Chemical Industry)

PubChem SID: [87569966](#)

Purchasable Chemical: [F0182](#)

abcr GmbH

PubChem SID: [316406546](#)

Purchasable Chemical: [AB136239](#)

AA BLOCKS

PubChem SID: [374222132](#)

Purchasable Chemical: [AA00I9K6](#)

Adooq BioScience

PubChem SID: [383543890](#)
Purchasable Chemical: [A10412](#)

Achemtek

PubChem SID: [381367194](#)
Purchasable Chemical: [0104-004681](#)

LEAPCHEM

PubChem SID: [439958233](#)
Purchasable Chemical: [LP063891](#)

Amadis Chemical

PubChem SID: [131318237](#)
Purchasable Chemical: [A830094](#)

Lan Pharmatech

PubChem SID: [439591861](#)
Purchasable Chemical: [LAN-B78508](#)

Starshine Chemical

PubChem SID: [476033817](#)
Purchasable Chemical: [2023-03-14B0183](#)

A2B Chem

PubChem SID: [444094047](#)
Purchasable Chemical: [A152098](#)

Sinfoo Biotech

PubChem SID: [404783709](#)
Purchasable Chemical: [S005176](#)

THE BioTek

PubChem SID: [434252441](#)
Purchasable Chemical: [bt-268870](#)

Aaron Chemicals LLC

PubChem SID: [406545598](#)
Purchasable Chemical: [AR00IABY](#)

► [PubChem](#)

7 Drug and Medication Information



7.1 Drug Indication



Furosemide is indicated for the treatment of edema associated with congestive heart failure, cirrhosis of the liver, and renal disease, including the nephrotic syndrome, in adults and

pediatric patients. Oral furosemide is indicated alone for the management of mild to moderate hypertension or severe hypertension in combination with other antihypertensive medications. Intravenous furosemide is indicated as adjunctive therapy in acute pulmonary edema when a rapid onset of diuresis is desired. Subcutaneous furosemide is indicated for the treatment of congestion due to fluid overload in adults with NYHA Class II/III chronic heart failure. This drug formulation is not indicated for emergency situations or in patients with acute pulmonary edema.

► [DrugBank](#)

Treatment of fluid retention

► [European Medicines Agency \(EMA\)](#)

7.2 WHO Essential Medicines



Drug

[Furosemide](#)

Drug Classes

Diuretics

Formulation

(1) Parenteral - General injections - IV: 10 mg per mL in 2 mL ampoule; (2) Oral - Liquid: 20 mg per 5 mL; (3) Oral - Solid: 40 mg; 10 mg; 20 mg

Indication

(1) Anuria or oliguria [co-prescribed with C03CA01]; (2) Oedema [co-prescribed with C03CA01]

Drug

[Furosemide](#)

Drug Classes

Medicines used in heart failure

Formulation

(1) Parenteral - General injections - IV: 10 mg per mL in 2 mL ampoule; (2) Oral - Liquid: 20 mg per 5 mL; (3) Oral - Solid: 40 mg

Indication

Heart failure [co-prescribed with C03CA01]

► [WHO Model Lists of Essential Medicines](#)

7.3 FDA Approved Drugs



94 items

Q

Search

SORT BY

Marketing Status - Z to A

▼

Drug

UREX

Ingredient(s)

METHENAMINE HIPPURATE

Dosage Form/Route

TABLET;ORAL

Strength

1GM

Marketing Status

Prescription

Company

ALVOGEN

Application Number

<<

<

Page 1

>

>>

► [Drugs@FDA](#)

7.4 FDA Orange Book



69 items		↓
Search		
SORT BY Trade Name - A to Z		
Trade Name	FUROSEMIDE	
Marketing Status	Discontinued	
Application Number	N018507	
Applicant		

ABRAXIS PHARMACEUTICAL PRODUCTS

<< < Page 1 of 14 > >>

[▶ FDA Orange Book](#)

7.5 FDA National Drug Code Directory



184 items



SORT BY Start Marketing Date - Most Recent



Product NDC

[60760-858](#)

Start Marketing Date

2023-06-15

Dosage Form

TABLET

Strength

40 mg/1

Labeler

ST. MARY'S MEDICAL PARK PHARMACY

Product NDC

[70518-3757](#)

Start Marketing Date

<< < Page 1 of 37 > >>

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

7.6 FDA Green Book



Active Ingredient: Furosemide

[Salix™ Injection 5%](#)[Salix® Tablets](#)[Lasix® Packets](#)

[Lasix® Syrup 1%](#)
[Furos-A-Vet](#)
[Disal® Injection](#)
[Disal®](#)
[Disal®](#)
[Furosemide Injection 5%](#)
[Furosemide Syrup 1%](#)
[Furosemide Syrup 1%](#)

► [FDA Approved Animal Drug Products \(Green Book\)](#)

7.7 Drug Labels



Drug and label

213 items

Search

SORT BY **Date - Most Recent**

Drug: furosemide

Download: [PDF label](#)

Data File: [XML](#)

Ingredient (UNII): FUROSEMIDE (UNII:7LXU5N7ZO5)

Description: Furosemide is a diuretic which is an anthranilic acid derivative. Furosemide Tablets for oral administration contain furosemide as the active ingredient and the following inactive ingredients: corn starch NF, lactose...

Category: Human prescription

Company: Preferred Pharmaceuticals Inc.

Date: 2023-06-19

FUROSEMIDE INJECTION, SOLUTION

Drug: furosemide

Download: [PDF label](#)

Data File: [XML](#)

Ingredient (UNII): FUROSEMIDE (UNII:7LXU5N7ZO5)

Description: Furosemide is a diuretic which is an anthranilic acid derivative. Chemically, it is 4-chloro-N-furfuryl-5-sulfamoylanthranilic acid. Furosemide Injection 10 mg/mL is a sterile, non-pyrogenic solution in an Ansyr™...

Indication: Parenteral therapy should be reserved for patients unable to take oral medication or for patients in emergency clinical situations.

Category: Human prescription

Company: Hospira, Inc.

Date: 2023-06-16

Drug: Furosemide

Download: [PDF label](#)

Data File: [XML](#)

Ingredient (UNII): FUROSEMIDE (UNII:7LXU5N7ZO5)

Description: Furosemide tablets are a diuretic which is an anthranilic acid derivative. Furosemide tablets for oral administration contain furosemide as the active ingredient and the following inactive ingredients: corn starch, lactose...

Indication: Furosemide tablets are indicated in adults and pediatric patients for the treatment of edema associated with congestive heart failure, cirrhosis of the liver, and renal disease, including the nephrotic syndrome. Furosemide...

Page 1 of 43

► [DailyMed](#)

Active ingredient and drug

210 items

Search

SORT BY [Ingredient - A to Z](#)

Ingredient

[FUROSEMIDE \(UNII:7LXU5N7ZO5\)](#)

Drug

Furosemide

Label

[Drug PDF label](#)

Data File

[XML](#)

Data SetID

[c14c0ec9-1b6b-4af3-9e10-464c4c86021b](#)

Ingredient

[FUROSEMIDE \(UNII:7LXU5N7ZO5\)](#)

Drug

Page 1 of 42

[► DailyMed](#)

7.8 Clinical Trials



7.8.1 ClinicalTrials.gov



148 items

SORT BY **Date - Most Recent**

Phase I, Open-Label, Study of Tumor Infiltrating Lymphocytes Engineered With Membrane Bound IL15 Plus Acetazolamide in Adult Patients With Metastatic Melanoma
CTID: [NCT05470283](#)
Phase: Phase 1
Status: Recruiting
Date: 2023-08-11

Diuretic Strategies in Acute Heart Failure Patients at High Risk for Diuretic Resistance
CTID: [NCT05986773](#)
Phase: Phase 4
Status: Not yet recruiting
Date: 2023-08-10

Voxelotor CYP and Transporter Cocktail Interaction Study
CTID: [NCT05981365](#)
Phase: Phase 1
Status: Recruiting
Date: 2023-08-08

A Study to Compare How Different Medicines (Rosuvastatin, Digoxin, Metformin, and Furosemide) Are Handled by the Body of Healthy People and People With Liver Cirrhosis
CTID: [NCT05741372](#)
Phase: N/A
Status: Recruiting
Date: 2023-07-28

Lintuzumab-Ac225 in Older Acute Myeloid Leukemia (AML) Patients

Page **1** of 30

[ClinicalTrials.gov](https://clinicaltrials.gov)

7.8.2 EU Clinical Trials Register



41 items	
Search	
SORT BY Date - Most Recent	
Withdrawal of pharmacological treatment in patients responding to cardiac resynchronization therapy: Open and randomized study EudraCT: 2021-001327-41 Phase: Phase 4 Status: Ongoing Date: 2021-07-12	
Goal directed fluid removal with furosemide in intensive care patients with fluid overload - A randomised, blinded, placebo-controlled trial (GODIF). EudraCT: 2019-004292-40 Phase: Phase 4 Status: Ongoing Date: 2020-02-17	
Randomized, controlled interventional trial to investigate the efficacy of amiloride for the treatment of edema in human nephrotic syndrome EudraCT: 2019-002607-18 Phase: Phase 3 Status: Ongoing Date: 2020-02-11	
A Multicenter, Randomized, Parallel Group, Double Blind, Active and Placebo Controlled Study of BAY 1753011, a Dual V1a/V2 Vasopressin Receptor Antagonist, in Patients with Congestive Heart Failure: AVANTI Study EudraCT: 2018-004059-18 Phase: Phase 2 Status: Completed Date: 2019-06-27	
FURosemide Stress Test to predict need of Renal Replacement THERapy in Ischemic Acute Tubular	

[► EU Clinical Trials Register](#)

7.8.3 NIPH Clinical Trials Search of Japan



30 items

SORT BY **Date - Most Recent**

Effect of Long-Acting vs. Short-Acting Loop Diuretics and Neurohormonal Agents on Patients' Quality-of-Life Among Patients with Heart Failure
CTID: [UMIN000045229](#)
Phase: Not applicable
Status: Pending
Date: 2021-08-24

Randomize Clinical Trial of hANP and Furosemide for acute kidney injury
CTID: [UMIN000043381](#)
Status: Pending
Date: 2021-02-19

A comparative study of renoprotective effect of tolvaptan as an alternative treatment for increasing loop diuretics in patients with chronic kidney disease complicated with chronic heart failure
CTID: [UMIN000036119](#)
Status: Recruiting
Date: 2019-04-01

Efficacy of tolvaptan on patients with CKD complicated by CHF
CTID: [jRCTs031180158](#)
Status: Complete
Date: 2019-02-25

A randomized phase II study of furosemide or mannitol in cisplatin-based chemotherapy using short hydration
CTID: [jRCTs051180015](#)
Status: Recruiting

Page **1** of 6

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

7.9 EMA Drug Information



Active Substance Furosemide
Therapeutic Area Uro-nephrology
Drug Form Orodispersible tablet
Administration Route Oral use
Decision Type P: decision agreeing on a investigation plan, with or without partial waiver(s) and or deferral(s)
Decision Date 2011-10-21

► [European Medicines Agency \(EMA\)](#)

7.10 Therapeutic Uses



Diuretics; Sodium Potassium Chloride Symporter Inhibitors

National Library of Medicine's Medical Subject Headings. Furosemide. Online file (MeSH, 2017). Available from, as of April 10, 2017: https://www.nlm.nih.gov/mesh/2017/mesh_browser/MBrowser.html

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

Oral Lasix may be used in adults for the treatment of hypertension alone or in combination with other antihypertensive agents. Hypertensive patients who cannot be adequately controlled with thiazides will probably also not be adequately controlled with Lasix alone.
/Included in US product labeling/

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

Lasix is indicated in adults and pediatric patients for the treatment of edema associated with congestive heart failure, cirrhosis of the liver, and renal disease, including the nephrotic syndrome. Lasix is particularly useful when an agent with greater diuretic potential is desired. /Included in US product labeling/

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

IV furosemide has been found useful as an adjunct to hypotensive agents in the treatment of hypertensive crises, especially when associated with acute pulmonary edema or renal failure. In addition to producing a rapid diuresis, furosemide enhances the effects of other hypotensive drugs and counteracts the **sodium** retention caused by some of these agents. /NOT included in US product labeling/

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2828

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

For more Therapeutic Uses (Complete) data for Furosemide (11 total), please visit the [HSDB record page](#).

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

7.11 Drug Warnings



/BOXED WARNING/ Lasix (furosemide) is a potent diuretic which, if given in excessive amounts, can lead to a profound diuresis with **water** and electrolyte depletion. Therefore, careful medical supervision is required and dose and dose schedule must be adjusted to the individual patient's needs.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

Excessive diuresis may cause dehydration and blood volume reduction with circulatory collapse and possibly vascular thrombosis and embolism, particularly in elderly patients. As with any effective diuretic, electrolyte depletion may occur during Lasix therapy, especially in patients receiving higher doses and a restricted salt intake. Hypokalemia may develop with Lasix, especially with brisk diuresis, inadequate oral electrolyte intake, when cirrhosis is present, or during concomitant use of corticosteroids, ACTH, licorice in large amounts, or prolonged

use of laxatives. Digitalis therapy may exaggerate metabolic effects of hypokalemia, especially myocardial effects.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

Patients receiving furosemide must be carefully observed for signs of hypovolemia, hyponatremia, hypokalemia, hypocalcemia, hypochloremia, and hypomagnesemia. Patients should be informed of the signs and symptoms of electrolyte imbalance and instructed to report to their physicians if weakness, dizziness, fatigue, faintness, mental confusion, lassitude, muscle cramps, headache, paresthesia, thirst, anorexia, nausea, and/or vomiting occur. Excessive fluid and electrolyte loss may be minimized by initiating therapy with small doses, careful dosage adjustment, using an intermittent dosage schedule if possible, and monitoring the patient's weight. To prevent hyponatremia and hypochloremia, intake of [sodium](#) may be liberalized in most patients; however, patients with cirrhosis usually require at least moderate [sodium](#) restriction while on diuretic therapy. Determinations of serum electrolytes, BUN, and [carbon dioxide](#) should be performed early in therapy with furosemide and periodically thereafter. If excessive diuresis and/or electrolyte abnormalities occur, the drug should be withdrawn or dosage reduced until homeostasis is restored. Electrolyte abnormalities should be corrected by appropriate measures.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2830

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

Furosemide should be used with caution in patients with hepatic cirrhosis because rapid alterations in fluid and electrolyte balance may precipitate hepatic precoma or coma.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2830

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

For more Drug Warnings (Complete) data for Furosemide (29 total), please visit the [HSDB record page](#).

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

8 Pharmacology and Biochemistry



8.1 Pharmacodynamics



Furosemide manages hypertension and edema associated with congestive heart failure, cirrhosis, and renal disease, including the nephrotic syndrome. Furosemide is a potent loop diuretic that works to increase the excretion of Na⁺ and [water](#) by the kidneys by inhibiting their reabsorption from the proximal and distal tubules, as well as the loop of Henle. It works directly acts on the cells of the nephron and indirectly modifies the content of the renal filtrate. Ultimately, furosemide increases the urine output by the kidney. Protein-bound furosemide is delivered to its site of action in the kidneys and secreted via active secretion by nonspecific organic transporters expressed at the luminal site of action. Following oral administration, the onset of the diuretic effect is about 1 and 1.5 hours, and the peak effect is reached within the first 2 hours. The duration of effect following oral administration is about 4-6 hours but may last up to 8 hours. Following intravenous administration, the onset of effect is within 5 minutes, and the peak effect is reached within 30 minutes. The duration of action following intravenous administration is approximately 2 hours. Following intramuscular administration, the onset of action is somewhat delayed.

► [DrugBank](#)

8.2 MeSH Pharmacological Classification



Sodium Potassium Chloride Symporter Inhibitors

Agents that inhibit SODIUM-POTASSIUM-CHLORIDE SYMPORTERS which are concentrated in the thick ascending limb at the junction of the LOOP OF HENLE and KIDNEY TUBULES, DISTAL. They act as DIURETICS. Excess use is associated with HYPOKALEMIA and HYPERGLYCEMIA. (See [all compounds classified as Sodium Potassium Chloride Symporter Inhibitors.](#))

► [Medical Subject Headings \(MeSH\)](#)

Diuretics

Agents that promote the excretion of urine through their effects on kidney function. (See [all compounds classified as Diuretics.](#))

► [Medical Subject Headings \(MeSH\)](#)

8.3 FDA Pharmacological Classification



1 of 2

FDA UNII
7LXU5N7ZO5

Active Moiety FUROSEMIDE
Pharmacological Classes Physiologic Effects [PE] - Increased Diuresis at Loop of Henle
Pharmacological Classes Established Pharmacologic Class [EPC] - Loop Diuretic
FDA Pharmacology Summary Furosemide is a Loop Diuretic. The physiologic effect of furosemide is by means of Increased Diuresis at Loop of Henle.

► [FDA Pharm Classes](#)

2 of 2
Non-Proprietary Name FUROSEMIDE
Pharmacological Classes Loop Diuretic [EPC]; Increased Diuresis at Loop of Henle [PE]

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

8.4 ATC Code



C03CA01

S76 | LUXPHARMA | *Pharmaceuticals Marketed in Luxembourg* | *Pharmaceuticals marketed in Luxembourg, as published by d'Gesondheetskeess (CNS, la caisse nationale de sante, www.cns.lu), mapped by name to structures using CompTox by R. Singh et al. (in prep.). List downloaded from <https://cns.public.lu/en/legislations/textes-coordonnes/liste-med-comm.html>. Dataset DOI:10.5281/zenodo.4587355*

► [NORMAN Suspect List Exchange](#)

C - Cardiovascular system

C03 - Diuretics

C03C - High-ceiling diuretics

C03CA - Sulfonamides, plain

C03CA01 - Furosemide

► **WHO Anatomical Therapeutic Chemical (ATC) Classification**

8.5 Absorption, Distribution and Excretion



Absorption

Following oral administration, furosemide is absorbed from the gastrointestinal tract. It displays variable bioavailability from oral dosage forms, ranging from 10 to 90%. The oral bioavailability of furosemide from oral tablets or oral solution is about 64% and 60%, respectively, of that from an intravenous injection of the drug.

► [DrugBank](#)

Route of Elimination

The kidneys are responsible for 85% of total furosemide total clearance, where about 43% of the drug undergoes renal excretion. Significantly more furosemide is excreted in urine following the I.V. injection than after the tablet or oral solution. Approximately 50% of the furosemide load is excreted unchanged in urine, and the rest is metabolized into glucuronide in the kidney.

► [DrugBank](#)

Volume of Distribution

The volume of distribution following intravenous administration of 40 mg furosemide were 0.181 L/kg in healthy subjects and 0.140 L/kg in patients with heart failure.

► [DrugBank](#)

Clearance

Following intravenous administration of 400 mg furosemide, the plasma clearance was 1.23 mL/kg/min in patients with heart failure and 2.34 mL/kg/min in healthy subjects, respectively.

► [DrugBank](#)

Significantly more furosemide is excreted in urine following the IV injection than after the tablet or oral solution. There are no significant differences between the two oral formulations in the amount of unchanged drug excreted in urine.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

After oral administration of furosemide to 18 pregnant women on the day of delivery, substantial concentrations of the drug were detected in umbilical cord vein plasma as well as in amniotic fluid. The ratio between the furosemide concentrations in maternal vein plasma and in umbilical cord plasma increased with time and approximated unity at 8 to 10 hr after administration of the drug. The plasma half-life of furosemide appeared to be longer in the mothers than in nonpregnant healthy volunteers. In one patient the plasma level of furosemide was constant during 5 hr of observation.

[PMID:699480](#)

Beermann B et al; Clin Pharmacol Ther 24 (5): 560-2 (1978)

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

In one study in patients with normal renal function, approx 60% of a single 80 mg oral dose of furosemide was absorbed from the GI tract. When admin to fasting adults in this dosage, the drug appeared in the serum within 10 min, reached a peak concn of 2.3 ug/mL in 60-70 min, & was almost completely cleared from the serum in 4 hr. When the same dose was given after a meal, the serum concn of furosemide increased slowly to a peak of about 1 ug/ml after 2 hr & similar concns were present 4 hr after ingestion. However, a similar diuretic response occurred regardless of whether the drug was given with food or to fasting patients. In another study, the rate & extent of absorption varied considerably when 1 g of furosemide was given orally to uremic patients. An avg of 76% of a dose was absorbed, & peak plasma concns were achieved within 2-9 hr (avg 4.4 hr). Serum concns required to produce max diuresis are not known, & it has been reported that the magnitude of response does not correlate with either the peak or the mean serum concns.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2831

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

The diuretic effect of orally administered furosemide is apparent within 30 minutes to 1 hr and is maximal in the first or second hour. The duration of action is usually 6-8 hr. The maximum hypotensive effect may not be apparent until several days after furosemide therapy is begun. After iv administration of furosemide, diuresis occurs within 5 min, reaches a maximum within 20-60 min, and persists for approximately 2 hr. After im administration, peak plasma concentrations are attained within 30 min; onset of diuresis occurs somewhat later than after iv administration. In patients with severely impaired renal function, the diuretic response may be prolonged.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2831

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

For more Absorption, Distribution and Excretion (Complete) data for Furosemide (15 total), please visit the [HSDB record page](#).

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

8.6 Metabolism / Metabolites



The metabolism of furosemide occurs mainly in the kidneys and the liver, to a smaller extent. The kidneys are responsible for about 85% of total furosemide total clearance, where about 40% involves biotransformation. Two major metabolites of furosemide are [furosemide glucuronide](#), which is pharmacologically active, and [saluamine \(CSA\)](#) or [4-chloro-5-sulfamoylanthranilic acid](#).

► [DrugBank](#)

It would appear that frusemide glucuronide is the only or at least the major biotransformation metabolite in man. [2-amino-4-chloro-5-sulfamoylanthranilic acid](#) has been reported in some studies but not in others; and is thought to be an analytical artifact.

International Programme on Chemical Safety (IPCS); Poisons Information Monograph (PIM) No. 240, Furosemide (July 1997). Available from, as of April 18, 2017: <https://www.inchem.org/pages/pims.html>

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

In patients with normal renal function, a small amount of furosemide is metabolized in the liver to the defurfurlylated derivative, [4-chloro-5-sulfamoylanthranilic acid](#). ...

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2831

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

8.7 Biological Half-Life



The half-life from the dose of 40 mg furosemide was 4 hours following oral administration and 4.5 hours following intravenous administration. The terminal half-life of furosemide is approximately 2 hours following parenteral administration. The terminal half-life may be increased up to 24 hours in patients with severe renal failure.

► [DrugBank](#)

To study the pharmacokinetics of furosemide (furseamide; Lasix) and its acyl glucuronide and to analyze the pharmacodynamic response, a study was conducted in 7 healthy subjects, mean age 34 yr, who received a single oral 80 mg dose of furosemide in tablet form. Two half-lives

were distinguished in the plasma elimination of furosemide and its conjugate, with values of 1.25 and 30.4 hr for furosemide and 1.31 and 33.2 hr for the conjugate. ...

Vree TB et al; *J Pharm Pharmacol* (Nov): 964-9 (1995)

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

In dogs, ... the elimination half life /is/ approximately 1-1.5 hours.

Plumb D.C. *Veterinary Drug Handbook*. 8th ed. (pocket). Ames, IA: Wiley-Blackwell, 2015., p. 644

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

Various investigators have reported a wide range of elimination half-lives for furosemide. In one study, the elimination half-life averaged about 30 minutes in healthy patients who received 20-120 mg of the drug IV. In another study, the elimination half-life averaged 9.7 hours in patients with advanced renal failure who received 1 g of furosemide IV. The elimination half-life was more prolonged in 1 patient with concomitant liver disease.

American Society of Health-System Pharmacists 2016; *Drug Information* 2016. Bethesda, MD. 2016, p. 2831

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

The serum half-life in therapeutic doses is 92 minutes; increasing in patients with uremia; congestive heart failure and cirrhosis as well as in the neonate and aged patients. In such patients the half-life may be extended to 20 hours.

International Programme on Chemical Safety (IPCS); *Poisons Information Monograph (PIM) No. 240, Furosemide* (July 1997). Available from, as of April 18, 2017: <https://www.inchem.org/pages/pims.html>

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

8.8 Mechanism of Action



Furosemide promotes diuresis by blocking tubular reabsorption of **sodium** and **chloride** in the proximal and distal tubules, as well as in the thick ascending loop of Henle. This diuretic effect is achieved through the competitive inhibition of sodium-potassium-chloride cotransporters (NKCC2) expressed along these tubules in the nephron, preventing the transport of **sodium** ions from the luminal side into the basolateral side for reabsorption. This inhibition results in increased excretion of **water** along with **sodium**, **chloride**, **magnesium**, **calcium**, **hydrogen**, and **potassium** ions. As with other loop diuretics, furosemide decreases the excretion of **uric acid**. Furosemide exerts direct vasodilatory effects, which results in its therapeutic effectiveness in the treatment of acute pulmonary edema. Vasodilation leads to reduced responsiveness to vasoconstrictors, such as **angiotensin II** and **noradrenaline**, and decreased production of endogenous natriuretic hormones with vasoconstricting properties. It also leads to increased

production of prostaglandins with vasodilating properties. Furosemide may also open [potassium](#) channels in resistance arteries. The main mechanism of action of furosemide is independent of its inhibitory effect on carbonic anhydrase and [aldosterone](#).

► [DrugBank](#)

Though both in vivo and in vitro studies have demonstrated an anticonvulsant effect of the loop diuretic furosemide, the precise mechanism behind this effect is still debated. The current study investigates the effect of furosemide on Cs-induced epileptiform activity (Cs-FP) evoked in area CA1 of rat hippocampal slices in the presence of Cs(+) (5mM) and ionotropic glutamatergic and GABAergic receptor antagonists. As this model diverges in several respects from other epilepsy models it can offer new insight into the mechanism behind the anticonvulsive effect of furosemide. The present study shows that furosemide suppresses the Cs-FP in a dose-dependent manner with a near complete block at concentrations = 1.25 mM. Because furosemide targets several types of ion transporters we examined the effect of more selective antagonists. [Bumetanide](#) (20 uM), which selectively inhibits the Na-K-2Cl co-transporter (NKCC1), had no significant effect on the Cs-FP. [VU0240551](#) (10 uM), a selective antagonist of the K-Cl co-transporter (KCC2), reduced the ictal-like phase by 51.73 +/- 8.5% without affecting the interictal-like phase of the Cs-FP. [DIDS](#) (50 uM), a nonselective antagonist of Cl(-)/HCO3(-)-exchangers, Na(+)-HCO3(-)-cotransporters, [chloride](#) channels and KCC2, suppressed the ictal-like phase by 60.8 +/- 8.1% without affecting the interictal-like phase. At 500 uM, [DIDS](#) completely suppressed the Cs-FP. Based on these results we propose that the anticonvulsant action of furosemide in the Cs(+)-model is exerted through blockade of the neuronal KCC2 and Na(+)-independent Cl(-)/HCO3(-)-exchanger (AE3) leading to stabilization of the activity-induced intracellular acidification in CA1 pyramidal neurons.

[PMID:26301821](#)

Uwera J et al; Brain Res 1625: 1-8 (2015)

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

[Sodium chloride](#) reabsorption in the thick ascending limb of the loop of Henle is mediated by the Na(+)-K(+)-2Cl(-) cotransporter (NKCC2). The loop diuretic furosemide is a potent inhibitor of NKCC2. However, less is known about the mechanism regulating the electrolyte transporter. Considering the well-established effects of [nitric oxide](#) on NKCC2 activity, [cGMP](#) is likely involved in this regulation. [cGMP](#)-dependent protein kinase I (cGKI; PKGI) is a [cGMP](#) target protein that phosphorylates different substrates after activation through [cGMP](#). We investigated the potential correlation between the [cGMP](#)/cGKI pathway and NKCC2 regulation. We treated wild-type (wt) and cGKIa-rescue mice with furosemide. cGKIa-rescue mice expressed cGKIa only under the control of the smooth muscle-specific transgelin (SM22) promoter in a cGKI deficient background. Furosemide treatment increased the urine excretion of [sodium](#) and [chloride](#) in cGKIa-rescue mice compared to that in wt mice. We analyzed the

phosphorylation of NKCC2 by western blotting and immunostaining using the phosphospecific antibody R5. The administration of furosemide significantly increased the phosphorylated NKCC2 signal in wt but not in cGKIa-rescue mice. NKCC2 activation led to its phosphorylation and membrane translocation. To examine whether cGKI was involved in this process, we analyzed vasodilator-stimulated phosphoprotein, which is phosphorylated by cGKI. Furosemide injection resulted in increased vasodilator-stimulated phosphoprotein phosphorylation in wt mice. We hypothesize that furosemide administration activated cGKI, leading to NKCC2 phosphorylation and membrane translocation. This cGKI-mediated pathway could be a mechanism to compensate for the inhibitory effect of furosemide on NKCC2.

[PMID:26183401](#)

Limmer F et al; FEBS J 282 (19): 3786-98 (2015)

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

8.9 Human Metabolite Information



8.9.1 Tissue Locations



Kidney

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

8.9.2 Metabolite Pathways



[Furosemide Action Pathway](#)

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

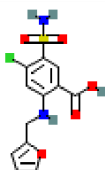
8.10 Transformations



1 item



Predecessor



Predecessor Name

Furosemide

[▶ NORMAN Suspect List Exchange](#)

9 Use and Manufacturing



9.1 Uses



EPA CPDat Chemical and Product Categories

1 item



diuretic antihypertensive

Categorization Type: Reported Functional Use

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

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

Diuretics; Sodium Potassium Chloride Symporter Inhibitors

National Library of Medicine's Medical Subject Headings. Furosemide. Online file (MeSH, 2017). Available from, as of April 10, 2017: https://www.nlm.nih.gov/mesh/2017/mesh_browser/MBrowser.html

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

Furosemide has been used empirically and has been legally approved for many years by the US racing industry for the control of exercise-induced pulmonary haemorrhage (EIPH) or bleeding.

Soma LR, Uboh CE; Review of furosemide in horse racing: its effects and regulation. J Vet Pharmacol Ther 21 (3): 228-40 (1998). Available from, as of May 24, 2002:

https://www.ncbi.nlm.nih.gov/80/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uid

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

MEDICATION (VET)

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

MEDICATION

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

9.1.1 Use Classification



Human Drugs -> EU pediatric investigation plans

- ▶ [European Medicines Agency \(EMA\)](#)

Animal Drugs -> FDA Approved Animal Drug Products (Green Book) -> Active Ingredients

- ▶ [FDA Approved Animal Drug Products \(Green Book\)](#)

Human Drugs -> FDA Approved Drug Products with Therapeutic Equivalence Evaluations (Orange Book) -> Active Ingredients

- ▶ [FDA Orange Book](#)

Pharmaceuticals

S72 | NTUPHTW | *Pharmaceutically Active Substances from National Taiwan University* |
[DOI:10.5281/zenodo.3955664](https://doi.org/10.5281/zenodo.3955664)

- ▶ [NORMAN Suspect List Exchange](#)

9.2 Methods of Manufacturing



2,4-Dichlorobenzoic acid is heated with **chlorosulfonic acid**, and the resulting 5-chlorosulfonyl derivative is reacted with concentrated **ammonia** to convert it to the 5-sulfamoyl analogue (I). Refluxing I with **furfurylamine** in large excess or in the presence of **sodium bicarbonate** yields crude furosemide, which is recrystallized from aqueous **ethanol**.

Troy, D.B. (Ed); Remington The Science and Practice of Pharmacy. 21 st Edition. Lippincott Williams & Williams, Philadelphia, PA 2005, p. 1430

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

Produced by treatment of **2,4-dichloro-5-sulfamoylbenzoic acid** with excess **furfurylamine** in the absence of solvent at 120-130 °C.

Hropot M, Lang H-J; Diuretics. Ullmann's Encyclopedia of Industrial Chemistry 7th ed. (1999-2017). NY, NY: John Wiley & Sons. Online Posting Date: June 15, 2000

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

Preparation: K. Sturm et al., Germany patent 1122541; eidem United States of America patent 3058882 (both 1962 to Hoechst)

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 792

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

Prepared in 85% yield from [2-fluoro-4-chloro-5-sulfamoylbenzoic acid](#) and [furfurylamine](#) at 95 °C for 2 hr

Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY: John Wiley and Sons, 1991-Present., p. V11 (1994) 573

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

9.3 Formulations / Preparations



Table: Furosemide Preparations

Route of Administration Oral
Dosage Form Solution
Strength 40 mg/5 mL
Brand or Generic Form (Manufacturer) Furosemide Solution (Available from one or more manufacturer, distributor, and/or repackager by generic (nonproprietary) name)
Route of Administration Oral
Dosage Form Solution
Strength 10 mg/mL
Brand or Generic Form (Manufacturer) Furosemide Solution (Available from one or more manufacturer, distributor, and/or repackager by generic (nonproprietary) name)
Route of Administration Oral
Dosage Form Tablets
Strength

20 mg
Brand or Generic Form (Manufacturer) Furosemide Tablets (Available from one or more manufacturer, distributor, and/or repackager by generic (nonproprietary) name)
Route of Administration Oral
Dosage Form Tablets
Strength 20 mg
Brand or Generic Form (Manufacturer) Lasix (Sanofi-Aventis)
Route of Administration Oral
Dosage Form Tablets
Strength 40 mg
Brand or Generic Form (Manufacturer) Furosemide Tablets (Available from one or more manufacturer, distributor, and/or repackager by generic (nonproprietary) name)
Route of Administration Oral
Dosage Form Tablets
Strength 40 mg
Brand or Generic Form (Manufacturer) Lasix (Sanofi-Aventis)
Route of Administration Oral
Dosage Form Tablets
Strength 80 mg
Brand or Generic Form (Manufacturer)

Furosemide Tablets (Available from one or more manufacturer, distributor, and/or repackager by generic (nonproprietary) name)
Route of Administration Oral
Dosage Form Tablets
Strength 80 mg
Brand or Generic Form (Manufacturer) Lasix (Sanofi-Aventis)
Route of Administration Parenteral
Dosage Form Injection
Strength 10 mg/mL
Brand or Generic Form (Manufacturer) Furosemide Injection (Available from one or more manufacturer, distributor, and/or repackager by generic (nonproprietary) name)

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2832

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

9.4 U.S. Production



(1976) NOT PRODUCED COMMERCIALY IN US

SRI

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

(1978) NOT PRODUCED COMMERCIALY IN US

SRI

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

9.5 U.S. Imports



(1976) 1.82X10+3 GRAMS (PRINCPL CUSTMS DIST)

SRI

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

(1978) 1.25X10+6 GRAMS (PRINCPL CUSTMS DIST)

SRI

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

9.6 General Manufacturing Information



The first high-ceiling diuretic on the market and is still the most important product in this group.

Hropot M, Lang H-J; Diuretics. Ullmann's Encyclopedia of Industrial Chemistry 7th ed. (1999-2017). NY, NY: John Wiley & Sons. Online Posting Date: June 15, 2000

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

Furosemide use in horses for /the control of exercise-induced pulmonary haemorrhage (EIPH) or bleeding/ is highly controversial and has been criticized by organizations outside and inside of the racing industry. ... The existing literature references suggest that furosemide has the potential of increasing performance in horses without significantly changing the bleeding status.

Soma LR, Uboh CE; Review of furosemide in horse racing: its effects and regulation. J Vet Pharmacol Ther 21 (3): 228-40 (1998). Available from, as of May 24, 2002:

https://www.ncbi.nlm.nih.gov/80/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uid

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

Furosemid was on the top ten list of pharmaceuticals used in Denmark in 1995.

[PMID:9569937](#)

Halling-Sorenson B et al; Chemosphere 36: 357-93 (1998)

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

10 Identification



10.1 Analytic Laboratory Methods



LC/MS DRUG ANALYSIS WITH CONTINUOUS MONITORING BY QUADRUPOLE MS.

[PMID:717783](#)

HENION JD; ANAL CHEM 50 (OCT): 1687-93 (1978)

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

Determination of furosemide using LC equipped with a detector capable of recording at both 254 nm and 272 nm. Flow rate is about 1.0 ml/min.

USP Convention. The United States Pharmacopeia XXII/National Formulary XVII. Rockville, MD: United States Pharmacopeial Convention, Inc., 1990., p. 597

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

10.2 Clinical Laboratory Methods



Determination of furosemide in plasma or urine by HPLC method on a reverse phase column with spectrophotometric detection at 280 nm.

U.S. Department of Health, Education & Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety & Health. Registry of Toxic Effects of Chemical Substances. 1977 edition. Washington, D. C.: U.S. Government Printing Office, 1977., p. V2 47

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

11 Safety and Hazards



11.1 Hazards Identification



11.1.1 GHS Classification



1 of 2		View All
Pictogram(s)		
Irritant	Health Hazard	
Signal		
<u>Danger</u>		

GHS Hazard Statements

H315 (11.97%): Causes skin irritation [[Warning](#) Skin corrosion/irritation]

H319 (11.11%): Causes serious eye irritation [[Warning](#) Serious eye damage/eye irritation]

H335 (11.97%): May cause respiratory irritation [[Warning](#) Specific target organ toxicity, single exposure; Respiratory tract irritation]

H351 (13.68%): Suspected of causing cancer [[Warning](#) Carcinogenicity]

H360 (79.91%): May damage fertility or the unborn child [[Danger](#) Reproductive toxicity]

H361 (14.96%): Suspected of damaging fertility or the unborn child [[Warning](#) Reproductive toxicity]

Precautionary Statement Codes

P203, P261, P264, P264+P265, P271, P280, P302+P352, P304+P340, P305+P351+P338, P318, P319, P321, P332+P317, P337+P317, P362+P364, P403+P233, P405, and P501

(The corresponding statement to each P-code can be found at the [GHS Classification](#) page.)

ECHA C&L Notifications Summary

Aggregated GHS information provided by 235 companies from 24 notifications to the ECHA C&L Inventory. Each notification may be associated with multiple companies.

Reported as not meeting GHS hazard criteria by 1 of 235 companies. For more detailed information, please visit [ECHA C&L website](#).

Of the 23 notification(s) provided by 234 of 235 companies with hazard statement code(s).

Information may vary between notifications depending on impurities, additives, and other factors. The percentage value in parenthesis indicates the notified classification ratio from companies that provide hazard codes. Only hazard codes with percentage values above 10% are shown.

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

11.1.2 Hazard Classes and Categories

Skin Irrit. 2 (11.97%)

Eye Irrit. 2A (11.11%)

STOT SE 3 (11.97%)

Carc. 2 (13.68%)

Repr. 1B (79.91%)

Repr. 2 (14.96%)

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

11.1.3 Health Hazards

SYMPTOMS: Gastrointestinal system reactions to this compound may include anorexia, oral and gastric irritation, nausea, vomiting, cramping, diarrhea, constipation, jaundice and pancreatitis. Central nervous system reactions may include dizziness, vertigo, paresthesia, headache, xanthopsia, blurred vision, tinnitus and hearing loss. Hematologic reactions may include anemia, leukopenia, agranulocytosis, thrombocytopenia and aplastic anemia. Dermatologic-hypersensitivity reactions may include purpura, photosensitivity, rash, urticaria, necrotizing angitis, exfoliative dermatitis, erythema multiforme and pruritus. Cardiovascular reactions may include orthostatic hypotension. Other symptoms may include hyperglycemia, glycosuria, hyperuricemia, muscle spasm, weakness, restlessness, urinary bladder spasm and thrombophlebitis. Fluid and electrolyte imbalance, allergies and liver damage may also occur. It may also cause tetany and dehydration. Other symptoms may include increased thirst, lethargy, drowsiness, fatigue, oliguria, tachycardia, reduction of plasma volume, circulatory collapse, thrombosis, embolism, convulsions, ataxia, paralysis and collapse.

ACUTE/CHRONIC HAZARDS: When heated to decomposition this compound emits very toxic fumes of **carbon monoxide**, **carbon dioxide**, nitrogen oxides, sulfur oxides and **hydrogen chloride** gas. (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**

11.1.4 Fire Hazards



Flash point data for this chemical are not available; however, it is probably combustible. (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**

11.2 First Aid Measures



11.2.1 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**. If symptoms such as redness or irritation develop, IMMEDIATELY call a physician and be prepared to transport the victim to a hospital for treatment.

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. 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. Be prepared to transport the victim to a hospital if advised by a physician. 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**

11.3 Fire Fighting



Fires involving this material can be controlled with a **carbon dioxide**, dry chemical or **Halon** extinguisher. (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**

11.3.1 Fire Fighting Procedures



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

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <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; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

11.4 Accidental Release Measures



11.4.1 Cleanup Methods



ACCIDENTAL RELEASE MEASURES: Personal precautions, protective equipment and emergency procedures: Use personal protective equipment. Avoid dust formation. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust. Environmental precautions: Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Methods and materials for containment and cleaning up: Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

11.4.2 Disposal Methods



SRP: Expired or waste pharmaceuticals shall carefully take into consideration applicable DEA, EPA, and FDA regulations. It is not appropriate to dispose by flushing the pharmaceutical down the toilet or discarding to trash. If possible return the pharmaceutical to the manufacturer for proper disposal being careful to properly label and securely package the material.

Alternatively, the waste pharmaceutical shall be labeled, securely packaged and transported by

a state licensed medical waste contractor to dispose by burial in a licensed hazardous or toxic waste landfill or incinerator.

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

Product: Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber; Contaminated packaging: Dispose of as unused product.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

11.4.3 Preventive Measures



ACCIDENTAL RELEASE MEASURES: Personal precautions, protective equipment and emergency procedures: Use personal protective equipment. Avoid dust formation. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust. Environmental precautions: Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

Precautions for safe handling: Avoid formation of dust and aerosols. Provide appropriate exhaust ventilation at places where dust is formed.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

Appropriate engineering controls: Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves

after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

SRP: Local exhaust ventilation should be applied wherever there is an incidence of point source emissions 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. Ensure that the local ventilation moves the contaminant away from the worker.

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

11.5 Handling and Storage



11.5.1 Nonfire Spill Response



SMALL SPILLS AND LEAKAGE: Should a spill occur while you are handling this chemical, FIRST REMOVE ALL SOURCES OF IGNITION, then you should dampen the solid spill material with 60-70% [ethanol](#) and transfer the dampened material to a suitable container. Use absorbent paper dampened with 60-70% [ethanol](#) to pick up any remaining material. Seal the absorbent paper, and any of your clothes, which may be contaminated, in a vapor-tight plastic bag for eventual disposal. Solvent wash all contaminated surfaces with 60-70% [ethanol](#) followed by washing with a soap and [water](#) solution. Do not reenter the contaminated area until the Safety Officer (or other responsible person) has verified that the area has been properly cleaned.

STORAGE PRECAUTIONS: You should protect this chemical from exposure to light. Keep the container tightly closed under an inert atmosphere, and store under refrigerated temperatures. (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](#)

11.5.2 Storage Conditions



Keep container tightly closed in a dry and well-ventilated place.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

Furosemide injection should be stored at a temperature of 15-30 °C and protected from light; injections having a yellow color should not be used. Exposure of furosemide tablets to light may cause discoloration; discolored tablets should not be dispensed. Furosemide tablets should be stored and dispensed in well-closed, light-resistant containers at a controlled room temperature of 15-30 °C. ... The 20-mg tablets do not have a specific expiration dating period. Furosemide oral solutions should be stored at 15-30 °C and protected from light and freezing; once opened, unused portions of the oral solution should be discarded after the time period recommended by the manufacturer.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2832

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

11.6 Exposure Control and Personal Protection



11.6.1 Personal Protective Equipment (PPE)



RECOMMENDED RESPIRATOR: Where the neat test chemical is weighed and diluted, wear a NIOSH-approved half face respirator equipped with a combination filter cartridge, i.e. organic vapor/acid gas/HEPA (specific for organic vapors, HCl, acid gas, SO₂ and a high efficiency particulate filter). (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](#)

Eye/face protection: Safety glasses with side-shields conforming to EN166. Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

Skin protection: Handle with gloves.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

Body Protection: Impervious clothing. The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

Respiratory protection: Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N100 (US) or type P3 (EN 143) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

11.7 Stability and Reactivity



11.7.1 Air and Water Reactions



Light sensitive. Air sensitive. Slightly soluble in [water](#).

► [CAMEO Chemicals](#)

11.7.2 Reactive Group



Acids, Carboxylic

Amides and Imides

Amines, Phosphines, and Pyridines

Ethers

Aryl Halides

► [CAMEO Chemicals](#)

11.7.3 Reactivity Profile



FUROSEMIDE may undergo hydrolysis at sufficiently low pH. The pH of aqueous solutions should be maintained in the basic range to prevent hydrolysis. Alcohol has been shown to improve the stability of this compound. Incompatible with strong oxidizing agents (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](#)

11.7.4 Hazardous Reactivities and Incompatibilities



Incompatible materials: Strong oxidizing agents.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

Furosemide is soluble in alkaline soln that is prepared as a mildly buffered alkaline product. It should not be mixed with acidic solns have a pH below 5.5. Furosemide may precipitate if combined with [ascorbic acid](#), [epinephrine](#), [norepinephrine](#), or [tetracycline](#). The acidic pH of aminoglycoside admixtures may cause transient cloudiness or frank precipitation if furosemide is added, depending on which aminoglycoside is used & the concn of the additives. Avoiding the admixture of furosemide & aminoglycosides has been recommended.

Trissel, L.A. Handbook on Injectable Drugs. 9th ed. Bethesda, MD. American Society of Health-System Pharmacists' Product Development. 1996., p. 496

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

Furosemide may precipitate if mixed with [milrinone lactate](#) infusions.

Trissel, L.A. Handbook on Injectable Drugs. 9th ed. Bethesda, MD. American Society of Health-System Pharmacists' Product Development. 1996., p. 496

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

11.8 Regulatory Information



11.8.1 FDA Requirements



The Approved Drug Products with Therapeutic Equivalence Evaluations identifies currently marketed prescription drug products, including furosemide, approved on the basis of safety

and effectiveness by FDA under sections 505 of the Federal Food, Drug, and Cosmetic Act.

DHHS/FDA; *Electronic Orange Book-Approved Drug Products with Therapeutic Equivalence Evaluations*. Available from, as of April 21, 2017: <https://www.fda.gov/cder/ob/>

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

The Generic Animal Drug and Patent Restoration act requires that each sponsor of an approved animal drug must submit to the FDA certain information regarding patents held for the animal drug or its method of use. The Act requires that this information, as well as a list of all animal drug products approved for safety and effectiveness, be made available to the public. Furosemide is included on this list.

US FDA/Center for Veterinary Medicine; *The Green Book - On Line, Active Ingredients. Furosemide (54-31-9)*. Available from, as of April 21, 2017:

<https://www.fda.gov/AnimalVeterinary/Products/ApprovedAnimalDrugProducts/default.htm>

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

Oral dosage form new animal drugs. Furosemide. ... (1) Cattle ... Indications for use. For treatment of physiological parturient edema of the mammary gland and associated structures. Limitations. Treatment not to exceed 48 hours post-parturition. Milk taken during treatment and for 48 hours after the last treatment must not be used for food. Cattle must not be slaughtered for food within 48 hours following last treatment. (2) Dogs ... Indications for use- (A) For treatment of edema (pulmonary congestion, ascites) associated with cardiac insufficiency and acute noninflammatory tissue edema. (B) For treatment of edema (pulmonary congestion, ascites) associated with cardiac insufficiency. (3) Cats ... Indications for use. For treatment of edema (pulmonary congestion, ascites) associated with cardiac insufficiency and acute noninflammatory tissue edema.

21 CFR 520.1010 (USFDA); U.S. National Archives and Records Administration's *Electronic Code of Federal Regulations*. Available from, as of April 20, 2017: <https://www.ecfr.gov>

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

Implantation or injectable dosage form new animal drugs. Furosemide. ... (1) Dogs and cats ... Indications for use. For the treatment of edema (pulmonary congestion, ascites) associated with cardiac insufficiency and acute noninflammatory tissue edema. ... (2) Horses ... Indications for use. For the treatment of edema (pulmonary congestion, ascites) associated with cardiac insufficiency, and acute noninflammatory tissue edema. Limitations. Do not use in horses intended for human consumption. ... (3) Cattle ... Indications for use. For the treatment of physiological parturient edema of the mammary gland and associated structures. Limitations. Treatment not to exceed 48 hours post-parturition. Milk taken during treatment and for 48 hours (four milkings) after the last treatment must not be used for food. Cattle must not be slaughtered for food within 48 hours following last treatment.

21 CFR 522.1010 (USFDA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of April 20, 2017: <https://www.ecfr.gov>

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

11.9 Other Safety Information



11.9.1 Toxic Combustion Products



Special hazards arising from the substance or mixture: Carbon oxides, nitrogen oxides (NO_x), sulfur oxides, **hydrogen chloride** gas.

Sigma-Aldrich; Safety Data Sheet for Furosemide. Product Number: F4381, Version 5.1 (Revision Date 06/30/2014). Available from, as of April 7, 2017: <https://www.sigmaaldrich.com/safety-center.html>

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

11.9.2 Special Reports



BENET LZ; PHARMACOKINETICS/PHARMACODYNAMICS OF FUROSEMIDE IN MAN: REVIEW; J PHARMACOKINET BIOPHARM 7 (FEB): 1-27 (1979); PHARMACOKINETICS IN NORMAL & DISEASED SUBJECTS, METABOLISM, & RELATIONSHIPS BETWEEN DOSAGE & PHARMACOKINETIC RESPONSE ARE REVIEWED.

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

DHHS/NTP; Toxicology & Carcinogenesis Studies of Furosemide in F344/N Rats and B6C3F1 Mice Technical Report Series No. 356 (1989) NIH Publication No. 89-2811

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

Aranda JV et al; Furosemide and vitamin E. Two problem drugs in neonatology.; *Pediatr Clin North Am* 33 (3): 583-602 (1986). This article focuses on some of the problems encountered with two of the drugs currently given to newborns.

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

Hammarlund-Udenaes M, Benet LZ; Furosemide pharmacokinetics and pharmacodynamics in health and disease--update; *J Pharmacokinet Biopharm* 17 (Feb) 1-46 (1989). A review of the pharmacokinetics and pharmacodynamics of furosemide is presented, including iv and oral data for healthy volunteers and for patients with various disease states. Inter and intraindividual variations in bioavailability, the metabolism of furosemide to its glucuronide conjugate, and the pharmacokinetics of furosemide in children are discussed.

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

Ponto LL, Schoenwald RD; Furosemide (frusemide). A pharmacokinetic/pharmacodynamic review (Part II).; Clin Pharmacokinet 18 (6): 460-71 (1990). The pharmacodynamics of the drug furosemide are examined, and various areas for future study are suggested.

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

12 Toxicity



12.1 Toxicological Information



12.1.1 Toxicity Summary



Clinical consequences from overdose depend on the extent of electrolyte and fluid loss and include dehydration, blood volume reduction, hypotension, electrolyte imbalance, hypokalemia, hypochloremic alkalosis, hemoconcentration, cardiac arrhythmias (including A-V block and ventricular fibrillation). Symptoms of overdose include acute renal failure, thrombosis, delirious states, flaccid paralysis, apathy and confusion. In cirrhotic patients, overdosage might precipitate hepatic coma. In rats, the oral LD₅₀, intraperitoneal LD₅₀, and subcutaneous LD₅₀ is 2600 mg/kg, 800 mg/kg, and 4600 mg/kg, respectively. The Lowest published toxic dose (TDLo) in a female is 6250 µg/kg.

► [DrugBank](#)

IDENTIFICATION AND USE: Furosemide is white or slightly yellow, solid powder or crystals. Furosemide is used to treat edema associated with many diseases (either as the sole drug or as an adjunct to other antihypertensives). HUMAN STUDIES: Overdoses of diuretics are uncommon and infrequently serious. Problems most frequently involve chronic over medication or poor monitoring and/or lack of anticipation of drug interactions or not compensating for concomitant hepatic or renal dysfunction. Main toxic effects are on the kidneys with diuresis of **water**, **sodium**, and **potassium** leading most frequently to a hyponatremic, hypokalemic, and hypochloremic dehydration. More caution is warranted with patients at higher risk for abnormal renal function including patients with any renal disease, diabetes mellitus, and borderline fluid and/or electrolyte status. In a hospital-based study of adverse reactions to medications there was a 21% rate of adverse affects to frusemide with most common ones being hypovolemia, hyperuricemia, and hypokalemia which for the most part were mild, but the rate and severity increased with increasing daily doses. Hypersensitivity reactions such as rash, photosensitivity, thrombocytopenia, and pancreatitis are rare. Life threatening hyperkalemia and reversible renal failure occurred in an elderly male taking

captopril concomitantly with furosemide. Acute rhabdomyolysis and myoglobinuria due to hypokalaemia occurred in a 74-year-old male taking furosemide. Severe anaphylactic reaction to furosemide involving urticaria; angioedema and hypotension occurred in an adult 5 minutes after receiving intravenous furosemide. Furosemide abuse (400 mg daily) was associated with severe hyponatremia and central pontine myelinolysis. Self-administration of furosemide over 6 years resulted in calcification of the renal medulla. Nephrocalcinosis and nephrolithiasis occurred in 5 children after treatment with furosemide. It has also reported nephrocalcinosis in premature infants being treated with furosemide. Cholelithiasis in infants was caused by furosemide. Tachycardia was reported following a high dose intravenous regimen using furosemide. Renal calcifications were encountered in premature infants when given furosemide. Furosemide-induced renal calcifications in low birth weight infants may lead to glomerular and tubular dysfunction in the long-term. A concentration-dependent increase in the frequency of chromosomal aberrations was observed in human lymphocytes exposed in vitro to furosemide for 24 and 72 hr. No such effect was detected in the human fibroblast cell line. ANIMAL STUDIES: Chronic administration to rats has caused tubular degeneration in the kidneys. Calcification and damage to the renal parenchyma occurred in a subchronic study in dogs. Developmental studies have been conducted in mice, rats and rabbits. An increase in the incidence and severity of hydronephrosis (distention of the renal pelvis and occasionally the ureters) was seen in a mouse study and one of three rabbit studies. In male mice treated intraperitoneally with furosemide at 0.3-50 mg/kg bw, a non-dose-dependent increase in the percentage of meiotic cells with chromosomal aberrations was observed during the whole spermatogenic cycle. Furosemide was tested over a wide range of doses (0, 100, 333, 1000, 3333, and 10,000 ug/plate) in four *Salmonella typhimurium* strains (TA98, TA100, TA1535, and TA1537) with and without metabolic activation. Furosemide was negative in these tests and the highest ineffective dose level tested in any *Salmonella* tester strain was 10,000 ug/plate. Furosemide was reported to induce mutations in L5178Y mouse lymphoma cells in the presence of an exogenous metabolic system only at the highest concentration tested (1500 ug/mL). It was also reported to induce sister chromatid exchange and chromosomal aberrations in Chinese hamster CHO cells at 3750 and 500 ug/mL in the presence and absence of an exogenous metabolic system. Furosemide induced chromosomal damage in Chinese hamster lung fibroblasts in vitro, but only in the absence of an exogenous metabolic system. ECOTOXICITY STUDIES: Furosemide in combination with other drugs found in waste **water** was genotoxic to zebrafish, and exhibited toxic effects on riverine microbial communities.

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

12.1.2 Drug Induced Liver Injury



Compound

furosemide
DILI Annotation Ambiguous DILI-concern
Severity Grade 2
Label Section Adverse reactions
References M Chen, V Vijay, Q Shi, Z Liu, H Fang, W Tong. FDA-Approved Drug Labeling for the Study of Drug-Induced Liver Injury, Drug Discovery Today, 16(15-16):697-703, 2011. PMID:21624500 DOI:10.1016/j.drudis.2011.05.007 M Chen, A Suzuki, S Thakkar, K Yu, C Hu, W Tong. DILIRank: the largest reference drug list ranked by the risk for developing drug-induced liver injury in humans. Drug Discov Today 2016, 21(4): 648-653. PMID:26948801 DOI:10.1016/j.drudis.2016.02.015

► [Drug Induced Liver Injury Rank \(DILIRank\) Dataset](#)

12.1.3 Evidence for Carcinogenicity



Evaluation: There is inadequate evidence for the carcinogenicity of furosemide in humans. There is inadequate evidence for the carcinogenicity of furosemide in experimental animals. Overall evaluation: Furosemide is not classifiable as to its carcinogenicity to humans (Group 3).

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. V50 287 (1990)

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

12.1.4 Carcinogen Classification



IARC Carcinogenic Agent Furosemide
IARC Carcinogenic Classes Group 3: Not classifiable as to its carcinogenicity to humans
IARC Monographs

Volume 50: (1990) Pharmaceutical Drugs

► [International Agency for Research on Cancer \(IARC\)](#)

12.1.5 Effects During Pregnancy and Lactation



● Summary of Use during Lactation

Because little information is available on the use of furosemide during breastfeeding and because intense diuresis from high doses might decrease lactation, an alternate drug may be preferred, especially while nursing a newborn or preterm infant. Low doses of furosemide (20 mg daily) do not suppress lactation.

● Effects in Breastfed Infants

Anecdotal, short-term observations at one medical center found no adverse infant effects from maternal use of furosemide in the immediate postpartum period.

● Effects on Lactation and Breastmilk

Furosemide 20 mg intramuscularly on the first postpartum day followed by 40 mg orally for 4 days has been used in conjunction with fluid restriction and breast binding to suppress lactation within 3 days postpartum. The added contribution of furosemide to fluid restriction and breast binding, which are effective in suppressing lactation, is not known. No data exist on the effects of loop diuretics on established lactation.

A randomized, controlled trial compared postpartum furosemide (n = 192) to placebo (n = 192) in women who had gestational hypertension and preeclampsia. Patients received either a 4- to 5-day course of 20 mg oral furosemide daily or placebo. The first dose was given 6 to 24 hours postpartum and then every 24 hours thereafter until hospital discharge. No difference was found in patient-reported breastfeeding difficulties between the two groups.

► [Drugs and Lactation Database \(LactMed\)](#)

12.1.6 Acute Effects



17 items

Compound CID
3440

Organism
women

Test Type
TDLo
Route
oral
Dose
120 mg/kg/21W-
Effect
KIDNEY, URETER, AND BLADDER: INTERSTITIAL NEPHRITIS
Reference
Journal of the Royal Society of Medicine., 79(239), 1986
Compound CID
3440
Organism
man
Test Type
TDLo
Route
intravenous
Dose

<< < Page 1 of 4 > >>

► [ChemIDplus](#)

12.1.7 Interactions



Methotrexate and other drugs that, like Lasix, undergo significant renal tubular secretion may reduce the effect of Lasix. Conversely, Lasix may decrease renal elimination of other drugs that undergo tubular secretion. High-dose treatment of both Lasix and these other drugs may result in elevated serum levels of these drugs and may potentiate their toxicity as well as the toxicity of Lasix.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

Phenytoin interferes directly with renal action of Lasix. There is evidence that treatment with **phenytoin** leads to decreased intestinal absorption of Lasix, and consequently to lower peak

serum furosemide concentrations.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

Lasix may decrease arterial responsiveness to [norepinephrine](#). However, [norepinephrine](#) may still be used effectively.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

There is a risk of ototoxic effects if [cisplatin](#) and Lasix are given concomitantly. In addition, nephrotoxicity of nephrotoxic drugs such as [cisplatin](#) may be enhanced if Lasix is not given in lower doses and with positive fluid balance when used to achieve forced diuresis during [cisplatin](#) treatment.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

For more Interactions (Complete) data for Furosemide (36 total), please visit the [HSDB record page](#).

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

12.1.8 Antidote and Emergency Treatment



/SRP:/ 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 if necessary. Immediately flush contaminated eyes with gently flowing [water](#). Do not induce vomiting. If vomiting occurs, lean patient forward or place on the 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. /Poisons A and B/

Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; *Emergency Care For Hazardous Materials Exposure*. 3rd revised edition, Elsevier Mosby, St. Louis, MO 2007, p. 160

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

/SRP:/ 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 needed. 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 Cover skin burns with dry sterile dressings after decontamination /Poisons A and B/

Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3rd revised edition, Elsevier Mosby, St. Louis, MO 2007, p. 160

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

/SRP:/ 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 TKO /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 /Poisons A and B/

Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3rd revised edition, Elsevier Mosby, St. Louis, MO 2007, p. 160-1

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

Treatment of overdosage is supportive and consists of replacement of excessive fluid and electrolyte losses. Serum electrolytes, **carbon dioxide** level and blood pressure should be determined frequently. Adequate drainage must be assured in patients with urinary bladder outlet obstruction (such as prostatic hypertrophy). Hemodialysis does not accelerate furosemide elimination.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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



12.1.9 Human Toxicity Excerpts

/HUMAN EXPOSURE STUDIES/ The pharmacokinetics and pharmacodynamics of the combination of **amiloride** (2 x 2.5 mg) and long acting furosemide (2 x 10 mg) were compared with **amiloride** (5 mg) and furosemide (20 mg) in 12 healthy male volunteers aged 26.2 + or - 1.6 yr and weighing 68.8 + or - 6.2 kg, after random order administration. Furosemide and **amiloride** plasma or urine concn were determined by HPLC with fluorimetric detection. The rate of absorption (tmax = 3 hr) and the bioavailability of the two diuretics were not significantly modified by their combination. Furosemide plasma half life was 2.77 + or - 1.04 hr after the combination treatment and 2.76 + or - 0.98 hr alone, **amiloride** plasma half life was respectively 15.7 + or - 4.6 hr and 14.6 + or - 3.7 hr. The urinary elimination of furosemide was significantly higher in the 2-4 hr interval in the combination treatment, accompanying its delayed maximum effect of diuresis. A synergistic effect was observed after the combination administration of the two diuretics; between the 2nd and the 8th hour, the **sodium** elimination was significantly increased (p < 0.01) and the potassium excretion was significantly decreased (p = 0.05). After a single dose, no modification of plasma or erythrocyte magnesium levels was observed. This study shows that the combination of the two drugs entails a synergy of their activities which does not involve pharmacokinetic changes.

PMID:1783363

Flouvat B et al; Fundam Clin Pharmacol 5 (8): 741-52 (1991)

► **Hazardous Substances Data Bank (HSDB)**

/HUMAN EXPOSURE STUDIES/ Interactions between **sodium** and **calcium** regulating systems are poorly characterized but clinically important. Parathyroid hormone (PTH) levels are increased shortly after furosemide treatment by an unknown mechanism, and this effect is blunted by the previous administration of a calcimimetic in animal studies. Here, we explored further the possible underlying mechanisms of this observation in a randomized crossover placebo-controlled study performed in 18 human males. Volunteers took either **cinacalcet** (60 mg) or placebo and received a 20 mg furosemide injection 3 hr later. Plasma samples were collected at 15-min intervals and analyzed for intact PTH, **calcium**, **sodium**, **potassium**, **magnesium**, **phosphate**, plasma renin activity (PRA), and **aldosterone** up to 6 hr after furosemide injection. Urinary electrolyte excretion was also monitored. Subjects under placebo presented a sharp increase in PTH levels after furosemide injection. In the presence of **cinacalcet**, PTH levels were suppressed and marginal increase of PTH was observed. No significant changes in electrolytes and urinary excretion were identified that could explain the furosemide-induced increase in PTH levels. PRA and **aldosterone** were stimulated by furosemide injection but were not affected by previous **cinacalcet** ingestion. Expression of NKCC1, but not NKCC2, was found in parathyroid tissue. In conclusion, our results indicate that

furosemide acutely stimulates PTH secretion in the absence of any detectable electrolyte changes in healthy adults. ...

[PMID:26089029](#)

Muller ME et al; *Pflugers Arch* 467 (12): 2413-21 (2015)

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

/SIGNS AND SYMPTOMS/ The principal signs and symptoms of overdose with Lasix are dehydration, blood volume reduction, hypotension, electrolyte imbalance, hypokalemia and hypochloremic alkalosis, and are extensions of its diuretic action.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016).

Available from, as of April 19, 2017: [https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?](https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a)

[setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a](https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a)

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

/SIGNS AND SYMPTOMS/ Furosemide may produce profound diuresis resulting in fluid and electrolyte depletion. Fluid and electrolyte depletion are especially likely to occur when large doses are given and/or in patients with restricted **sodium** intake.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2829

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

For more Human Toxicity Excerpts (Complete) data for Furosemide (20 total), please visit the [HSDB record page](#).

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

12.1.10 Non-Human Toxicity Excerpts



/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ In a 13-week study, male rats given a diet containing furosemide at 12.5 g/kg or more and females given a diet containing 15 g/kg had increased liver:body weight ratios; dose-related diuresis was also observed. Compound-related minimal-to-moderate nephrosis occurred in male rats given 5 or 10 g/kg and in females given 7.5 or 15 g/kg. Mineralization was observed at the corticomedullary junction in male rats given 0.625 g/kg or more.

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. V50 282 (1990)

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

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Two of five male and three of five female rats that were fed diets containing furosemide at up to 46 g/kg for 14 days died before the end of the studies. Minimal-to-mild nephrosis was found in all rats that received furosemide at 1.3 or 46 g/kg and in one male receiving 5.1 g/kg. Microscopically, the toxic lesion was subcapsular or cortical and was characterized by tubular-cell regeneration; mineralization was present at the corticomedullary junction. Dose-related nephrosis was also observed in mice in a 14-day study.

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. V50 281-2 (1990)

► **Hazardous Substances Data Bank (HSDB)**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ Groups of 50 male and 50 female F344/N rats, seven weeks old, were fed furosemide (99% pure; USP grade) at 0, 350 or 700 mg/kg of diet for 104 weeks. The average amounts of furosemide consumed per day were approximately 15 and 30 mg/kg bw for low- and high-dose groups, respectively. Mean body weights of treated and control mice were comparable. Survivors at 104-106 weeks in males were: controls, 17/50; low-dose, 17/50; and high-dose, 20/50; those in females were: controls, 35/50; low-dose, 31/50; and high-dose, 34/50. About 40 different tissues were examined microscopically. No statistically significant increase in the incidence of tumors at any site was reported; however, in males, meningiomas of the brain were observed in 3/50 low-dose rats versus 2/1928 in historical controls. The authors noted that these rare tumors occurred early in the study in low-dose animals.

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. V50 280 (1990)

► **Hazardous Substances Data Bank (HSDB)**

/LABORATORY ANIMALS: Chronic Exposure or Carcinogenicity/ Groups of 50 male and 50 female B6C3F1 mice, eight weeks old, were fed furosemide (99% pure, USP grade) at 0, 700 or 1400 mg/kg of diet for 104 weeks. The average amounts of furosemide consumed per day were approximately 100 and 200 mg/kg bw for low- and high-dose groups, respectively. Mean body weights of treated and control mice were comparable. Final survival rates in males were: control, 31/50; low-dose, 24/50; and high-dose, 26/50; and those in females were: control, 36/50; low-dose, 29/50; and high-dose, 18/50. Survival in high-dose females was significantly lower than that in controls ($p = 0.03$). All survivors were killed at weeks 105-107 then necropsied, and about 40 different tissues were examined microscopically. In female mice, a small but statistically significant increase in the incidence of mammary gland carcinomas was observed: control, 0/50; low-dose, 2/50; and high-dose, 5/48 ($p = 0.01$, logistic regression test for trend taking account of survival).

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. V50 279-80 (1990)

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

For more Non-Human Toxicity Excerpts (Complete) data for Furosemide (20 total), please visit the [HSDB record page](#).

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

12.1.11 Non-Human Toxicity Values



LD50 Rat (female) oral 2600 mg/kg

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 792

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

LD50 Rat (male) oral 2820 mg/kg

O'Neil, M.J. (ed.). *The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals*. Cambridge, UK: Royal Society of Chemistry, 2013., p. 792

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

LD50 Rat ip 800 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. 827

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

LD50 Rat iv 800 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. 827

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

For more Non-Human Toxicity Values (Complete) data for Furosemide (11 total), please visit the [HSDB record page](#).

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

12.1.12 Ecotoxicity Excerpts



/AQUATIC SPECIES/ Over the past few years, the increasing and uncontrolled use of pharmaceutical substances in agriculture, fish farming, human health and in veterinary medicine, together with an improper use of out-of-date medicines, has led to a consequent increase in the environmental problems linked to their disposal. In some Italian waste **water** treatment plants were found furosemide, a diuretic; **ranitidine**, an antiulcer drug; **bezafibrate**, a lipid regulator and **ibuprofen**, a painkiller. The present paper shows, by means of the synergic application of three tests (the Comet Test, the Diffusion Assay and the RAPD-PCR technique), how the DNA of zebrafish can be damaged after exposure to the above mentioned drugs. The data from the Comet Test, the Diffusion Assay and the RAPD-PCR technique were generally in agreement; these results show that all four drugs are genotoxic.

PMID:20696478

Rocco L et al; *Ecotoxicol Environ Saf* 73 (7): 1530-6 (2010)

► **Hazardous Substances Data Bank (HSDB)**

/AQUATIC SPECIES/ Although pharmaceutical and therapeutic products are widely found in the natural environment, there is limited understanding of their ecological effects. ...Rotating annular bioreactors /were used/ to assess the impact of 10 ug/L of the selected pharmaceuticals **ibuprofen**, **carbamazepine**, furosemide, and **caffeine** on riverine biofilms. After 8 weeks of development, community structure was assessed using in situ microscopic analyses, fluor-conjugated lectin binding, standard plate counts, fluorescent in situ hybridization, **carbon** utilization spectra, and stable **carbon** isotope analyses. The biofilm communities varied markedly in architecture although only **caffeine** treated biofilms were significantly thicker. Cyanobacteria were suppressed by all 4 compounds, whereas the **nitrogen** containing **caffeine**, furosemide, and **carbamazepine** increased algal biomass. **Ibuprofen** and **carbamazepine** reduced bacterial biomass, while **caffeine** and furosemide increased it. Exopolymer content and composition of the biofilms was also influenced. Significant positive and negative effects were observed in **carbon** utilization spectra. In situ hybridization analyses indicated all treatments significantly decreased the gamma-proteobacterial populations and increased beta-proteobacteria. **Ibuprofen** in particular increased the alpha-proteobacteria, beta-proteobacteria, cytophaga-flavobacteria, and SRB385 probe positive populations. **Caffeine** and **carbamazepine** additions resulted in significant increases in the high GC354c and low GC69a probe positive cells. Live-dead analyses of the biofilms indicated that all treatments influenced the ratio of live-to-dead cells with controls having a ratio of 2.4, **carbamazepine** and **ibuprofen** being 3.2 and 3.5, respectively, and furosemide and **caffeine** being 1.9 and 1.7, respectively. Stable isotope analyses of the biofilms indicated delta 13C values shifted to more negative values relative to control biofilms. This shift may be consistent with proportional loss of cyanobacteria and relative increase in algal biomass rather than incorporation of pharmaceutical **carbon** into microbial biofilm. Thus, at 10

ug/L levels pharmaceuticals exhibit both nutrient-like and toxic effects on riverine microbial communities.

[PMID:16234864](#)

Lawrence JR et al; Can J Microbiol 51 (8): 655-69 (2005)

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

12.1.13 Ongoing Test Status



EPA has released the Interactive Chemical Safety for Sustainability (iCSS) Dashboard. The iCSS Dashboard provides an interactive tool to explore rapid, automated (or in vitro high-throughput) chemical screening data generated by the Toxicity Forecaster (ToxCast) project and the federal Toxicity Testing in the 21st century (Tox21) collaboration. /The title compound was tested by ToxCast and/or Tox21 assays/[USEPA; iCSS Dashboard Application; Available from, as of May 1, 2017: <http://actor.epa.gov/dashboard/>]

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

The following link will take the user to the National Toxicology Program (NTP) Test Status of Agents Search page, which tabulates the results and current status of tests such as "Short-Term Toxicity Studies", "Long-term Carcinogenicity Studies", "Developmental Studies", "Genetic Toxicology Studies", etc., performed with this chemical. Testing status for furosemide is available.[Available from, as of July 26, 2017: <https://ntpsearch.niehs.nih.gov/?e=True&ContentType=Testing+Status>]

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

12.1.14 National Toxicology Program Studies



2 Yr studies were /conducted by feeding/ 0, 350, or 700 ppm furosemide in the diet /to/ groups of 50 F344/N rats of each sex. Groups of 50 B6C3F1 mice of each sex were fed diets containing 0, 700, or 1,400 ppm furosemide for 104 weeks. Mean body weights of dosed and control rats were comparable throughout the studies. No significant differences in survival were observed between any groups of rats of either sex (final survival--male: control, 17/50; low dose, 17/50; high dose, 20/50; female 35/50; 31/50; 34/50). The final survival of all groups of male rats was low, reflecting the large number of moribund animals killed after week 91. Survival at week 90 was 35/50, 28/50, and 34/50. Mean body weights of high dose male mice were up to 17% lower than those of controls, and mean body weights of low dose female mice were 5%-13% lower than those of controls after week 82. The survival ... week 99 (final survival--male: 21/50; 24/50; 26/50; female: 36/50; 29/50; 18/50). Feed consumption by dosed

rats was similar to that by controls. The estimated average amount of furosemide consumed per day was approximately 14-16 or 29-31 mg/kg for low dose or high dose rats. Feed consumption by dosed mice was approximately 5%-7% greater than that by controls. The average amount of furosemide consumed per day was approximately 91-99 or 191-214 mg/kg for low dose or high dose mice. Under the conditions of these 2 yr studies, there was equivocal evidence of carcinogenic activity of furosemide for male F344/N rats, as shown by marginal increases in uncommon tubular cell neoplasms of the kidney and meningiomas of the brain. There was no evidence of carcinogenic activity of furosemide for female F344/N rats fed diets containing 350 or 700 ppm furosemide for 2 years. There was no evidence of carcinogenic activity for male B6C3F1 mice fed diets containing 700 or 1,400 ppm furosemide for 2 years. There was some evidence of carcinogenic activity of furosemide for female mice, as shown by an increase in malignant tumors of the mammary gland. Nephropathy was more severe in the kidney of male rats of male and female mice fed diets containing furosemide than in controls.

DHHS/NTP; Toxicology and Carcinogenesis Studies of Furosemide in F344/N Rats and B6C3F1 Mice (Feed Studies) p.4 (1989) Technical Rpt Series No. 356 NIH Pub No. 89-2811

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

12.1.15 Populations at Special Risk



Furosemide is contraindicated in patients with anuria. The drug is contraindicated for further use if increasing azotemia and/or oliguria occur during the treatment of severe, progressive renal disease. In patients with hepatic coma or electrolyte depletion, therapy should not be instituted until the basic condition is improved or corrected.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2830

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

Furosemide should be used with caution in patients with hepatic cirrhosis because rapid alterations in fluid and electrolyte balance may precipitate hepatic precoma or coma.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2830

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

Too vigorous diuresis, as evidenced by rapid and excessive weight loss, may induce orthostatic hypotension or acute hypotensive episodes, and the patient's blood pressure should be closely monitored. Excessive dehydration is most likely to occur in geriatric patients and/or patients with chronic cardiac disease treated with prolonged [sodium](#) restriction or those receiving sympatholytic agents. The resultant hypovolemia may cause hemoconcentration, which could lead to circulatory collapse or thromboembolic episodes such as possibly fatal

vascular thromboses and/or emboli. Pronounced reductions in plasma volume associated with rapid or excessive diuresis may also result in an abrupt fall in glomerular filtration rate and renal blood flow, which may be restored by replacement of fluid loss. Rarely, sudden death from cardiac arrest has been reported following IV or IM administration of furosemide.

American Society of Health-System Pharmacists 2016; Drug Information 2016. Bethesda, MD. 2016, p. 2829

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

Excessive diuresis may cause dehydration and blood volume reduction with circulatory collapse and possibly vascular thrombosis and embolism, particularly in elderly patients.

NIH; DailyMed. Current Medication Information for Lasix (Furosemide Tablet) (Updated: April 2016). Available from, as of April 19, 2017: <https://dailymed.nlm.nih.gov/dailymed/drugInfo.cfm?setid=2c9b4d8f-0770-482d-a9e6-9c616a440b1a>

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

For more Populations at Special Risk (Complete) data for Furosemide (12 total), please visit the [HSDB record page](#).

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

12.1.16 Protein Binding



Plasma concentrations ranging from 1 to 400 mcg/mL are about 91-99% bound in healthy individuals. The unbound fraction is about 2.3-4.1% at therapeutic concentrations. Furosemide mainly binds to serum albumin.

► [DrugBank](#)

12.2 Ecological Information



12.2.1 Environmental Fate / Exposure Summary



Furosemide's production and administration as a human and veterinary diuretic and human antihypertensive may result in its release to the environment through various waste streams. If released to air, an estimated vapor pressure of 3.1×10^{-11} mm Hg at 25 °C indicates furosemide will exist solely in the particulate phase in the atmosphere. Particulate-phase furosemide will be removed from the atmosphere by wet and dry deposition. Furosemide absorbs UV light at wavelengths >290 nm and, therefore, may be susceptible to direct photolysis by sunlight. If released to soil, furosemide is expected to have high mobility based upon an estimated Koc of 110. The pKa of furosemide is 3.9, indicating that this compound will

exist almost entirely in anion form in the environment and anions generally do not adsorb more strongly to soils containing organic **carbon** and clay than their neutral counterparts. Volatilization from moist soil is not expected because the compound exists as an anion and anions do not volatilize. Furosemide is not expected to volatilize from dry soil surfaces based upon its estimated vapor pressure. If released into **water**, furosemide is expected to adsorb to suspended solids and sediment based upon the estimated Koc. Furosemide had a biodegradation half-life of 14-20 days in various river sediments under aerobic conditions. Volatilization from **water** surfaces is not expected to be an important fate process based upon this compound's pKa. An estimated BCF of 3 suggests the potential for bioconcentration in aquatic organisms is low. Hydrolysis is not expected to be an important environmental fate process since this compound lacks functional groups that hydrolyze under environmental conditions (pH 5 to 9). Occupational exposure to furosemide may occur through inhalation and dermal contact with this compound at workplaces where furosemide is produced or used. Direct human exposure occurs through ingestion of the drug when dispensed in tablet form. (SRC)

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

12.2.2 Artificial Pollution Sources



Furosemide's production and administration as a human and veterinary diuretic and human antihypertensive(1) may result in its release to the environment through various waste streams(SRC).

(1) O'Neil, M.J, ed; *The Merck Index. 15th ed., Cambridge, UK: Royal Society of Chemistry, p. 792 (2013)*

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

12.2.3 Environmental Fate



TERRESTRIAL FATE: Based on a classification scheme(1), an estimated Koc value of 110(SRC), determined from a structure estimation method(2), indicates that furosemide is expected to have high mobility in soil(SRC). The pKa of furosemide is 3.9(3), indicating that this compound will exist almost entirely in anion form in the environment and anions generally do not adsorb more strongly to soils containing organic **carbon** and clay than their neutral counterparts(4). Volatilization of the anion from moist soil is not expected because anions do not volatilize(SRC). Furosemide is not expected to volatilize from dry soil surfaces(SRC) based upon an estimated vapor pressure of 3.1×10^{-11} mm Hg at 25 °C(SRC), determined from a fragment constant method(2). Furosemide may biodegrade in soil based upon half-lives of 14-20 days in river sediments(5).

(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) US EPA; Estimation Program Interface (EPI) Suite. Ver. 4.1. Nov, 2012. Available from, as of Apr 19, 2017: <https://www2.epa.gov/tsca-screening-tools> (3) Khan SJ, Ongerth JE; Chemosphere 54: 355-67 (2004) (4) Doucette WJ; pp. 141-188 in Handbook of Property Estimation Methods for Chemicals. Boethling RS, Mackay D, eds. Boca Raton, FL: Lewis Publ (2000) (5) Radke M, Maier MP; Water Res 55: 63-73 (2014)

► **Hazardous Substances Data Bank (HSDB)**

AQUATIC FATE: Based on a classification scheme(1), an estimated Koc value of 110(SRC), determined from a structure estimation method(2), indicates that furosemide is expected to adsorb to suspended solids and sediment(SRC). A pKa of 3.9(3) indicates furosemide will exist almost entirely in the anion form at pH values of 5 to 9 and, therefore, volatilization from **water** surfaces is not expected(SRC). Furosemide is not expected to undergo hydrolysis in the environment due to the lack of functional groups that hydrolyze under environmental conditions(4). According to a classification scheme(5), an estimated BCF of 3(SRC), from its log Kow of 2.03(6) and a regression-derived equation(2), suggests the potential for bioconcentration in aquatic organisms is low. Furosemide had a biodegradation half-life of 14-20 days in various river sediments under aerobic conditions; furosemide was degraded at a slower rate under anaerobic conditions(7).

(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) US EPA; Estimation Program Interface (EPI) Suite. Ver. 4.1. Nov, 2012. Available from, as of Apr 19, 2017: <https://www2.epa.gov/tsca-screening-tools> (3) Khan SJ, Ongerth JE; Chemosphere 54: 355-67 (2004) (4) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 7-4, 7-5, 15-1 to 15-29 (1990) (5) Franke C et al; Chemosphere 29: 1501-14 (1994) (6) Sangster J; LOGKOW Databank. Sangster Res. Lab., Montreal Quebec, Canada (1994) (7) Radke M, Maier MP; Water Res 55: 63-73 (2014)

► **Hazardous Substances Data Bank (HSDB)**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), furosemide, which has an estimated vapor pressure of 3.1×10^{-11} mm Hg at 25 °C(SRC), determined from a fragment constant method(2), is expected to exist solely in the particulate phase in the ambient atmosphere. Particulate-phase furosemide may be removed from the air by wet and dry deposition(SRC). Furosemide absorbs UV light at wavelengths >290 nm(3) and, therefore, may be susceptible to direct photolysis by sunlight(SRC).

(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) US EPA; Estimation Program Interface (EPI) Suite. Ver. 4.1. Nov, 2012. Available from, as of Apr 19, 2017: <https://www2.epa.gov/tsca-screening-tools> (3) Devarakonda B et al; Int J Pharm 345: 142-53 (2007)

► **Hazardous Substances Data Bank (HSDB)**

12.2.4 Environmental Biodegradation



AEROBIC: Furosemide is stated as not readily biodegraded(1). Furosemide had a biodegradation half-life of 14-20 days in various river sediments under aerobic conditions; furosemide was degraded at a slower rate under anaerobic conditions(2). In an Australian sewage treatment plant, 20% of furosemide was removed, 15% was attributed to biodegradation(3).

(1) Carlsson C et al; *Sci Total Environ* 364: 67-87 (2006) (2) Radke M, Maier MP; *Water Res* 55: 63-73 (2014)
(3) Khan SJ, Ongerth JE; *Chemosphere* 54: 355-67 (2004)

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

12.2.5 Environmental Abiotic Degradation



Furosemide is not expected to undergo hydrolysis in the environment due to the lack of functional groups that hydrolyze under environmental conditions(1). Furosemide absorbs UV light at wavelengths >290 nm(2) and, therefore, may be susceptible to direct photolysis by sunlight(SRC).

(1) Lyman WJ et al; *Handbook of Chemical Property Estimation Methods*. Washington, DC: Amer Chem Soc pp. 7-4, 7-5 (1990) (2) Devarakonda B et al; *Int J Pharm* 345:142-53 (2007)

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

12.2.6 Environmental Bioconcentration



An estimated BCF of 3 was calculated in fish for furosemide(SRC), using a log Kow of 2.03(1) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is low.

(1) Sangster J; *LOGKOW Databank*. Sangster Res. Lab., Montreal Quebec, Canada (1994) (2) US EPA; *Estimation Program Interface (EPI) Suite*. Ver. 4.1. Nov, 2012. Available from, as of Apr 19, 2017: <https://www2.epa.gov/tsca-screening-tools> (3) Franke C et al; *Chemosphere* 29: 1501-14 (1994)

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

12.2.7 Soil Adsorption / Mobility



Using a structure estimation method based on molecular connectivity indices(1), the Koc of furosemide can be estimated to be 110(SRC). According to a classification scheme(2), this estimated Koc value suggests that furosemide is expected to have high mobility in soil. The pKa of furosemide is 3.9(3), indicating that this compound will exist almost entirely in anion

form in the environment and anions generally do not adsorb to soils containing organic **carbon** and clay than their neutral counterparts(4).

(1) US EPA; Estimation Program Interface (EPI) Suite. Ver. 4.1. Nov, 2012. Available from, as of Apr 19, 2017: <https://www2.epa.gov/tsca-screening-tools> (2) Swann RL et al; Res Rev 85: 17-28 (1983) (3) Khan SJ, Ongerth JE; Chemosphere 54: 355-67 (2004) (4) Doucette WJ; pp. 141-188 in Handbook of Property Estimation Methods for Chemicals. Boethling RS, Mackay D, eds. Boca Raton, FL: Lewis Publ (2000)

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

12.2.8 Volatilization from Water / Soil



A pKa of 3.9(1) indicates furosemide will exist almost entirely in the anion form at pH values of 5 to 9 and, therefore, volatilization from **water** and moist soil surfaces is not expected to be an important fate process(SRC). Furosemide is not expected to volatilize from dry soil surfaces(SRC) based upon an estimated vapor pressure of 3.1×10^{-11} mm Hg(SRC), determined from a fragment constant method(2).

(1) Khan SJ, Ongerth JE; Chemosphere 54: 355-67 (2004) (2) US EPA; Estimation Program Interface (EPI) Suite. Ver. 4.1. Nov, 2012. Available from, as of Apr 19, 2017: <https://www2.epa.gov/tsca-screening-tools>

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

12.2.9 Environmental Water Concentrations



DRINKING **WATER**: Furosemide was not detected (detection limit 0.0386 ug/L) in 24 stream, raw, settled, filtered and finished **water** samples collected over four consecutive weeks during Nov and Dec 2001 from a drinking **water** treatment plant in the US(1). Furosemide was not detected (detection limit 2 ng/L) in tap-**water** samples collected Oct 25-30, 2007 from five locations in Madrid, Spain(2). Furosemide was not detected (detection limit 8 ng/L) in drinking **water** samples collected Mar-Apr 2007, Jan and Sep-Oct 2008 from eight drinking **water** plants in France(3). Furosemide was not detected (detection limit 9 ng/L) in 12 drinking **water** samples collected Oct 2008 to Jan 2009 from a treatment plant in Spain(4).

(1) Stackelberg PE et al; Sci Total Environ 329: 99-113 (2004) (2) Valcarcel Y et al; Chemosphere 82: 1062-71 (2011) (3) Vulliet E et al; Environ Chem Lett 9: 103-14 (2011) (4) Huerta-Fontela M et al; Water Res 45: 1432-42 (2011)

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

SURFACE **WATER**: Furosemide was not detected (detection limit 39 ng/L) in surface **water** samples collected from Assunpink Creek, NJ(1). Furosemide was detected at 1.72-254.7 ng/L in samples collected Oct 2001 from 8 sites along the Po and Lambro Rivers, Italy(2). In **water** samples collected Oct 2007 from five rivers in Madrid, Spain, furosemide was detected at 262-

3228 ng/L(3). Furosemide was detected in two of 12 **water** samples collected from the Llobregat River, Spain over the period of Oct 2008 to Jan 2009 at a maximum of 110 ng/L(4). Furosemide was detected at 1.66-139 ng/L and

(1) Alvarez DA et al; Chemosphere 61: 610-22 (2005) (2) Calamari D et al; Environ Sci Technol 37: 1241-8 (2003) (3) Valcarcel Y et al; Chemosphere 82: 1062-71 (2011) (4) Huerta-Fontela M et al; Water Res 45: 1432-42 (2011) (5) Silva BF et al; Chemosphere 85: 1331-9 (2011) (6) Vulliet E et al; Environ Chem Lett 9: 103-14 (2011)

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

12.2.10 Effluent Concentrations



Samples collected May 18-19 and Oct 19-20, 2009 from a wastewater treatment plant in Los Angeles, CA contained furosemide at mean concentrations of 93 and 57 ng/L, respectively(1). Furosemide was removed 0-17% and 15-62% in samples collected Jan-Mar and Jun-Sep 2004, respectively, from six sewage treatment plants in Italy(2). Furosemide was detected in 100, 96 and 83% of waste **water** influent, effluent and sludge samples at respective LOQ's of 4.0 ng/L, 2.0 ng/L and 1.0 ng/g, samples were collected from three Spanish treatment plants in eight campaigns over a two year period (July 2007-March 2009)(3). Furosemide was detected in the effluents of waste **water** treatment plants in Spain at 128-937 ng/L(4).

(1) Nelson ED et al; Environ Sci Technol 45: 1228-34 (2011) (2) Castiglioni S et al; Environ Sci Technol 40: 357-63 (2006) (3) Jelic A et al; Water Research 45: 1165-76 (2011) (4) Silva BF et al; Chemosphere 85: 1331-9 (2011)

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

12.2.11 Sediment / Soil Concentrations



SEDIMENT: Furosemide was not detected in 18 sediment samples collected Dec 2009 from the Ebro River Basin, Spain(1).

(1) Silva BF et al; Chemosphere 85: 1331-9 (2011)

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

12.2.12 Probable Routes of Human Exposure



NIOSH (NOES Survey 1981-1983) has statistically estimated that 14,103 workers (11,997 of these are female) were potentially exposed to furosemide in the US(1). Occupational exposure to furosemide may occur through inhalation and dermal contact with this compound at

workplaces where furosemide is produced or used(SRC). Direct human exposure occurs through ingestion of the drug when dispensed in tablet form(SRC).

(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)

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

13 Associated Disorders and Diseases



144 items	Download
Search	
Disease Acidosis	
Evidence Type marker/mechanism	
Evidence PMID 3769383	
Disease Hypomagnesemia primary	
Evidence Type marker/mechanism	
Evidence PMID 11041285	
Disease Aortitis	
Page 1 of 29	

► [Comparative Toxicogenomics Database \(CTD\)](#)

1 item	Download
Indication Congestive heart failure	
ICD-11 Code ⓘ BD10	

[► Therapeutic Target Database \(TTD\)](#)**Disease**

Colorectal cancer

References

PubMed: [7482520](#), [22148915](#), [19006102](#), [23940645](#), [24424155](#), [20156336](#), [19678709](#), [25105552](#), [21773981](#), [25037050](#), [27015276](#), [27107423](#), [27275383](#), [28587349](#)

Silke Matysik, Caroline Ivanne Le Roy, Gerhard Liebisch, Sandrine Paule Claus. Metabolomics of fecal samples: A practical consideration. Trends in Food Science & Technology. Vol. 57, Part B, Nov. 2016, p.244-255: <http://www.sciencedirect.com/science/article/pii/S0924224416301984>

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

14 Literature



14.1 Consolidated References



40,380 items



SORT BY Publication Date - Most Recent



[Occurrence and fate of an emerging drug pollutant and its by-products during conventional and advanced wastewater treatment: Case study of furosemide](#)

Publication Name: Chemosphere

Publication Date: 2023-05

PMID: [36822517](#)DOI: [10.1016/j.chemosphere.2023.138212](#)

[Comparative effectiveness and safety of bolus vs. continuous infusion of loop diuretics: Results from the MIMIC-III Database](#)

Publication Name: The American Journal of the Medical Sciences

Publication Date: 2023-04

PMID: [36572341](#)DOI: [10.1016/j.amjms.2022.12.013](#)

[Intraoperative hemodialysis during open-heart surgery in patients with severe chronic kidney disease: a retrospective cohort study](#)

Publication Name: BMC nephrology

Publication Date: 2023-03-30

PMID: 36991338

DOI: 10.1186/s12882-023-03142-0

Impact of Prostate-Specific Membrane Antigen Positron Emission Tomography/Computed Tomography on the Therapeutic Decision of Prostate Carcinoma Primary Staging: A Retrospective Analysis at the Brazilian National Public Health System

Publication Name: Annals of surgical oncology

Publication Date: 2023-03-30

PMID: 36995451

DOI: 10.1245/s10434-023-13365-y

Clinical deterioration following arterial switch surgery due to extensive aortopulmonary collaterals, unusual condition but worth considering: case report

<< < Page 1 of 8,076 > >>

[► PubChem](#)

14.2 NLM Curated PubMed Citations



All NLM Curated PubMed Citations



administration and dosage	isolation and purification
adverse effects	metabolism
analogs and derivatives	pharmacokinetics
analysis	pharmacology
antagonists and inhibitors	poisoning
blood	radiation effects
cerebrospinal fluid	standards
chemical synthesis	supply and distribution
chemistry	therapeutic use
classification	toxicity
economics	urine
immunology	

[► PubChem](#)

14.3 Springer Nature References



27,458 items



SORT BY Publication Date - Oldest

**Subcutaneous furosemide for the treatment of heart failure: a state-of-the art review**

PMID: 30617666

Publication Date: 2019

Publication Name: Heart Failure Reviews

Efficacy of furosemide-albumin compared with furosemide in critically ill hypoalbuminemia patients admitted to intensive care unit: a prospective randomized clinical trial

PMID: 32291620

Publication Date: 2020

Publication Name: DARU Journal of Pharmaceutical Sciences

**Biotransformation of furosemide in kidney transplant patients**

Publication Date: 1983

Publication Name: European Journal of Clinical Pharmacology



<< < Page 1 of 5,492 > >>

► Springer Nature

14.4 Thieme References



3 items

**Visible Light as the Key for the Formation of Carbon–Sulfur Bonds in Sulfones, Thioethers, and Sulfonamides: An Update**

DOI: 10.1055/a-1509-5541

Publication Date: 2021

Publication Name: Synthesis

Ring Enlargement of 2-(Aminomethyl)furans

Publication Date: 2016

Publication Name: Science of Synthesis

Furosemide

Publication Date: 2003

Publication Name: Pharmaceutical Substances

[► Thieme Chemistry](#)

14.5 Wiley References



1 item

**Sustainable synthesis of sulfonamides using supported ionic liquid phase catalyst containing Keggin-type anion**DOI: [10.1002/aoc.3407](https://doi.org/10.1002/aoc.3407)

Publication Date: 2016

Publication Name: Appl. Organometal. Chem.

[► Wiley](#)

14.6 Depositor Provided PubMed Citations



4,392 items



Search

SORT BY Publication Date - Most Recent

**Extracellular Vesicles from Human Plasma Show a Distinctive Proteome and miRNome Profile in Patients with Severe Cutaneous Adverse Reactions**PMID: [34142820](https://pubmed.ncbi.nlm.nih.gov/34142820/)

Publication Date: 2021-07-19

Journal: Chemical research in toxicology

A Gene Expression Biomarker Predicts Heat Shock Factor 1 Activation in a Gene Expression CompendiumPMID: [34170685](https://pubmed.ncbi.nlm.nih.gov/34170685/)

Publication Date: 2021-07-19

Journal: Chemical research in toxicology

Investigation around the Oxadiazole Core in the Discovery of a New Chemotype of Potent and Selective FXR Antagonists

PMID: [30996787](#)

Publication Date: 2019-04-11

Journal: ACS medicinal chemistry letters

International Union of Basic and Clinical Pharmacology. CVI: GABAA Receptor Subtype- and Function-selective Ligands: Key Issues in Translation to Humans

PMID: [30275042](#)

Publication Date: 2018-10-01

Journal: Pharmacological reviews

Alteration of renal excretion pathways in gentamicin-induced renal injury in rats

PMID: [29460972](#)

Publication Date: 2018-07-01

Journal: Journal of applied toxicology : JAT

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14.7 Synthesis References



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► [DrugBank](#)

14.8 Metabolite References



26 items



Search

SORT BY **PMID - Increasing**



PMID

[7482520](#)

Reference

Ishiwata S, Itoh K, Yamaguchi T, Ishida N, Mizugaki M: Comparison of serum and urinary levels of modified nucleoside, 1-methyladenosine, in cancer patients using a monoclonal antibody-based inhibition ELISA. Tohoku J Exp Med. 1995 May;176(1):61-8.

PMID

[22148915](#)

Reference

Cheng Y, Xie G, Chen T, Qiu Y, Zou X, Zheng M, Tan B, Feng B, Dong T, He P, Zhao L, Zhao A, Xu LX, Zhang Y, Jia W: Distinct urinary metabolic profile of human colorectal cancer. *J Proteome Res.* 2012 Feb 3;11(2):1354-63. doi: 10.1021/pr201001a. Epub 2011 Dec 28.

PMID

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

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10. [Furosemide - StatPearls - NCBI Bookshelf](#)
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12. [Lasix Oral \(furosemide\) Product Monograph](#)
13. [FDA Approved Drug Products: Furoscix \(furosemide injection\), for subcutaneous use \(October 2022\)](#)
 - ▶ [DrugBank](#)

14.10 Chemical Co-Occurrences in Literature



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Chemical



Sodium

[CID 5360545](#)

Selected evidence

2,436 articles

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[Furosemide and albumin for the treatment of nephrotic edema: a systematic review](#)

PMID 35239032; DOI 10.1007/s00467-021-05358-4; Pediatric nephrology (Berlin, Germany) 2022 08; 37(8):1747-1757 (Review Article)

Name matches: **sodium furosemide**

[Furosemide exacerbated the impairment of renal function, oxygenation and medullary damage in a rat model of renal ischemia/reperfusion induced AKI](#)

PMID 37121963; DOI 10.1186/s40635-023-00509-3; Intensive care medicine experimental 2023 May; 11(1):25

Name matches: **sodium furosemide**

[Continuous Infusion Versus Intermittent Boluses of Furosemide in Acute Heart Failure: A Systematic Review and Meta-Analysis](#)

PMID 31730917; DOI 10.1016/j.cardfail.2019.11.013; Journal of cardiac failure 2020 Sep; 26(9):786-793 (Review Article)

Name matches: **sodium furosemide**

Chemical



Potassium

CID 5462222

Selected evidence

1,276 articles

[View All](#) 

Potassium-sparing effects of furosemide in mice on high-potassium diets

PMID 30838871; DOI 10.1152/ajprenal.00614.2018; American journal of physiology. Renal physiology 2019 05; 316(5):F970-F973 (Review Article)

Name matches: **potassium furosemide**

Torasefide versus furosemide in treatment of heart failure: A systematic review and meta-analysis of randomized controlled trials

PMID 31436024; DOI 10.1111/jep.13261; Journal of evaluation in clinical practice 2020 Jun; 26(3):842-851 (Review Article)

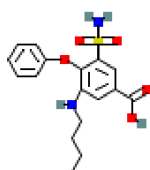
Name matches: **potassium furosemide**

Continuous Infusion Versus Intermittent Boluses of Furosemide in Acute Heart Failure: A Systematic Review and Meta-Analysis

PMID 31730917; DOI 10.1016/j.cardfail.2019.11.013; Journal of cardiac failure 2020 Sep; 26(9):786-793 (Review Article)

Name matches: **potassium furosemide**

Chemical



Bumetanide

CID 2471

Selected evidence

734 articles

[View All](#) 

Bumetanide Exposure Association with Alzheimer's Disease Risk

PMID 36909637; DOI 10.21203/rs.3.rs-2574215/v1; Research square 2023 Feb; ?(?):

Name matches: **bumetanide furosemide**

The extracellular space and epileptic activity in the adult brain: explaining the antiepileptic effects of furosemide and bumetanide

PMID 22612805; DOI 10.1111/j.1528-1167.2012.03471.x; Epilepsia 2012 Jun; 53 Suppl 1(?):18-25 (Review Article)

Name matches: **bumetanide furosemide**

Clinical pharmacology of the loop diuretics furosemide and bumetanide in neonates and infants

PMID 22702741; DOI 10.2165/11596620-000000000-00000; Paediatric drugs 2012 Aug; 14(4):233-46 (Review Article)

Name matches: **bumetanide furosemide**

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14.11 Chemical-Gene Co-Occurrences in Literature

Showing 3 of 100 [View More](#)

Gene/Protein/Enzyme

[ren](#)

Selected evidence

1,235 articles

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Everything we always wanted to know about furosemide but were afraid to ask

PMID 26911852; DOI 10.1152/ajprenal.00476.2015; American journal of physiology. Renal physiology 2016 05; 310(10):F958-71 (Review Article)

Name matches: **renin** *furosemide*

MANP (M-Atrial Natriuretic Peptide) Reduces Blood Pressure and Furosemide-Induced Increase in Aldosterone in Hypertension

PMID 35045724; DOI 10.1161/hypertensionaha.121.18837; Hypertension (Dallas, Tex. : 1979) 2022 04; 79(4):750-760

Name matches: **renin** *furosemide*

Effect of 3% saline and furosemide on biomarkers of kidney injury and renal tubular function and GFR in healthy subjects - a randomized controlled trial

PMID 31159750; DOI 10.1186/s12882-019-1342-x; BMC nephrology 2019 06; 20(1):200

Name matches: **renin** *furosemide*

Gene/Protein/Enzyme

[alb](#)

Selected evidence

417 articles

[View All](#)

Furosemide and albumin for the treatment of nephrotic edema: a systematic review

PMID 35239032; DOI 10.1007/s00467-021-05358-4; Pediatric nephrology (Berlin, Germany) 2022 08; 37(8):1747-1757 (Review Article)

Name matches: **albumin** *furosemide*

Co-Administration of Albumin and Furosemide in Acute Heart Failure with Diuretics Resistance

PMID 36762993; DOI 10.20344/amp.17714; Acta medica portuguesa 2023 Feb; ?(?): (Review Article)

Name matches: **albumin** *furosemide*

Impact of Albumin Binding Function on Pharmacokinetics and Pharmacodynamics of Furosemide

PMID 36556982; DOI 10.3390/medicina58121780; Medicina (Kaunas, Lithuania) 2022 Dec; 58(12):
Name matches: **albumin** *furosemide*

Gene/Protein/Enzyme

[ace](#)

Selected evidence

321 articles

[View All](#)

[Captopril Combined with Furosemide or Hydrochlorothiazide Affects Macrophage Functions in Mouse Contact Hypersensitivity Response](#)

PMID 35008498; DOI 10.3390/ijms23010074; International journal of molecular sciences 2021 Dec; 23(1):
Name matches: **angiotensin-converting enzyme** *furosemide*

[Effect of spironolactone and benazepril on furosemide-induced diuresis and renin-angiotensin-aldosterone system activation in normal dogs](#)

PMID 33713485; DOI 10.1111/jvim.16097; Journal of veterinary internal medicine 2021 May; 35(3):1245-1254
Name matches: **angiotensin-converting enzyme** *furosemide*

[Aldosterone breakthrough with benazepril in furosemide-activated renin-angiotensin-aldosterone system in normal dogs](#)

PMID 25224804; DOI 10.1111/jvp.12154; Journal of veterinary pharmacology and therapeutics 2015 Feb; 38(1):65-73
Name matches: **angiotensin-converting enzyme** *furosemide*

[► PubChem](#)

14.12 Chemical-Disease Co-Occurrences in Literature



Showing 3 of 25 [View More](#)



Disease

[Heart Failure](#)

Selected evidence

1,750 articles

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[The blunted loop diuretic response in acute heart failure is driven by reduced tubular responsiveness rather than insufficient tubular delivery. The role of furosemide urine excretion on diuretic and natriuretic response in acute heart failure](#)

PMID 37042083; DOI 10.1002/ehf.2852; European journal of heart failure 2023 Apr; ?(?): (Review Article)
Name matches: **acute heart failure**; **heart failure** *furosemide*

From Oral to Subcutaneous Furosemide: The Road to Novel Opportunities to Manage Congestion

PMID 37288336; DOI 10.1016/j.shj.2022.100076; Structural heart : the journal of the Heart Team 2022 Aug; 6(4):100076 (Review Article)

Name matches: heart failure *furosemide*

The added value of hypertonic saline solution to furosemide monotherapy in patients with acute decompensated heart failure: A meta-analysis and trial sequential analysis

PMID 37340592; DOI 10.1002/clc.24033; Clinical cardiology 2023 Jun; ?(?): (Review Article)

Name matches: acute decompensated heart failure; heart failure *furosemide*

Disease**Hypertension****Selected evidence**

1,426 articles

[View All](#) 

Furosemide for postpartum blood pressure control in patients with hypertensive disorders

PMID 37214156; DOI 10.1016/j.eurox.2023.100195; European journal of obstetrics & gynecology and reproductive biology: X 2023 Jun; 18(?):100195

Name matches: chronic hypertension; hypertensive disorders *furosemide*

Poly(3,4-ethylenedioxythiophene):Polystyrene Sulfonate-Modified Electrode for the Detection of Furosemide in Pharmaceutical Products

PMID 37214665; DOI 10.1021/acsomega.3c00463; ACS omega 2023 May; 8(19):16851-16858

Name matches: high blood pressure 4-chloro-2-(furan-2-ylmethylamino)-5-sulfamoyl-benzoic acid; *furosemide*

Administration of Intravenous Furosemide in Patients with Acute Infection: Patient Characteristics and Impact on In-Hospital Outcome

PMID 37240603; DOI 10.3390/jcm12103496; Journal of clinical medicine 2023 May; 12(10):

Name matches: hypertension *furosemide*

Disease**Edema****Selected evidence**

885 articles

[View All](#) 

Furosemide and albumin for the treatment of nephrotic edema: a systematic review

PMID 35239032; DOI 10.1007/s00467-021-05358-4; Pediatric nephrology (Berlin, Germany) 2022 08; 37(8):1747-1757 (Review Article)

Name matches: anasarca; edema; edematous; generalized oedema *furosemide*

Torsemide versus furosemide in treatment of heart failure: A systematic review and meta-analysis of randomized controlled trials

PMID 31436024; DOI 10.1111/jep.13261; Journal of evaluation in clinical practice 2020 Jun; 26(3):842-851 (Review Article)

Name matches: edema *furosemide*

Development of a quaternary ammonium poly (amidoamine) dendrimer-based drug carrier for the solubility enhancement and sustained release of furosemide

PMID 36874076; DOI 10.3389/fchem.2023.1123775; Frontiers in chemistry 2023; 11(?):1123775

Name matches: **edema** *furosemide*

► [PubChem](#)

15 Patents



[US11433044](#)

[US9884039](#)

[US10272064](#)

► [DrugBank](#)

15.1 Depositor-Supplied Patent Identifiers



111,950 items



Search

SORT BY **Priority Date - Most Recent**



[A kind of triptolide coumarin derivatives and preparation method and application thereof](#)

Publication Number: [CN-115057907-A](#)

Priority Date: 2022-08-18

[A kind of triptolide coumarin derivatives and preparation method and application thereof](#)

Publication Number: [CN-115057907-B](#)

Priority Date: 2022-08-18

Grant Date: 2022-11-04

[Display method, device, electronic device and medium for treatment plan](#)

Publication Number: [CN-115050441-B](#)

Priority Date: 2022-08-16

Grant Date: 2022-11-01

[Hyperspectral Panchromatic Sharpening Method Based on Spectral Constraints and Residual Attention Networks](#)

Publication Number: [CN-115100075-A](#)

Priority Date: 2022-07-24

A kind of para-substituted biohenvl sulfide compound. composition and use thereof

<< < Page 1 of 22,390 > >>

► PubChem

Link to all deposited patent identifiers

► PubChem

15.2 WIPO PATENTSCOPE



Patents are available for this chemical structure:

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

► PATENTSCOPE (WIPO)

15.3 FDA Orange Book Patents



1 of 3

Patent

[10272064](#)

Expiration

Apr 3, 2034

Applicant

SCPHARMACEUTICALS

Drug Application

[N209988](#) (Prescription Drug: FUROSCIX. Ingredients: FUROSEMIDE)

► FDA Orange Book

2 of 3

Patent

[11433044](#)

Expiration

Apr 3, 2034
Applicant SCPHARMACEUTICALS
Drug Application N209988 (Prescription Drug: FUROSCIX. Ingredients: FUROSEMIDE)

► [FDA Orange Book](#)

3 of 3
Patent 9884039
Expiration Apr 3, 2034
Applicant SCPHARMACEUTICALS
Drug Application N209988 (Prescription Drug: FUROSCIX. Ingredients: FUROSEMIDE)

► [FDA Orange Book](#)

16 Interactions and Pathways

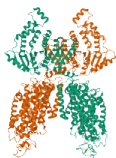


16.1 Protein Bound 3D Structures



8 items 

SORT BY Resolution - Increasing 



Cryo-EM structure of human NKCC1 state Fu-I

PDB Code: [7N3N](#)

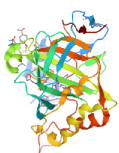
Resolution: 0 Å



human NKCC1 state Fu-II

PDB Code: [7SFL](#)

Resolution: 0 Å



Atomic resolution structure of Human Carbonic Anhydrase II in complex with furosemide

PDB Code: [6SG0](#)

Resolution: 1.13 Å

<< < Page 1 of 2 > >>

[▶ RCSB Protein Data Bank \(RCSB PDB\)](#)[View 8 proteins in NCBI Structure](#)[▶ PubChem](#)

16.1.1 Ligands from Protein Bound 3D Structures



PDBe Ligand Code

[FUN](#)

PDBe Structure Code

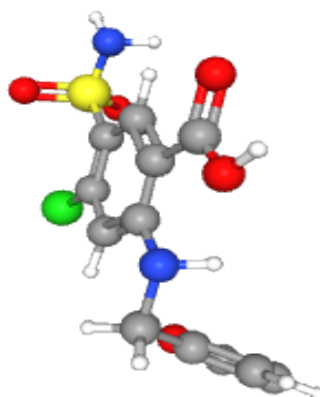
[1Z9Y](#)

PDBe Conformer



Interactive Chemical Structure Model

☒ Ball and Stick ☐ Sticks ☐ Wire-Frame ☐ Space-Filling

☒ Show Hydrogens ☐ Animate

► [Protein Data Bank in Europe \(PDBe\)](#)

16.2 Chemical-Target Interactions



264 items

SORT BY Data Source - A to Z

Structure

Protein
[Solute carrier family 12 member 2](#)

Gene
[SLC12A2](#)

Taxonomy
[Homo sapiens \(human\)](#)

Action

Inhibition

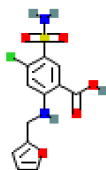
Evidence IDs ⓘ

[PMID:11882915](#)

Data Source

IUPHAR/BPS Guide to PHARMACOLOGY

Structure



Protein

[Solute carrier family 12 member 1](#)

Page 1 of 53

► [BindingDB](#); [ChEMBL](#); [Comparative Toxicogenomics Database \(CTD\)](#); [Drug Gene Interaction datab...](#)

16.3 Drug-Drug Interactions



1,414 items

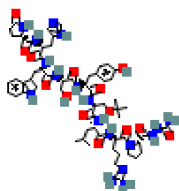


Search



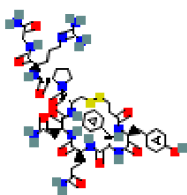
Drug: [Leuprolide](#)

Interaction: Leuprolide may increase the excretion rate of Furosemide which could result in a lower serum level and potentially a reduction in efficacy.



Drug: [Goserelin](#)

Interaction: Goserelin may increase the excretion rate of Furosemide which could result in a lower serum level and potentially a reduction in efficacy.



Drug: [Desmopressin](#)

Interaction: Desmopressin may increase the excretion rate of Furosemide which could result in a lower serum level and potentially a reduction in efficacy.

<< < Page 1 of 283 > >>

► [DrugBank](#)

16.4 Drug-Food Interactions



- Avoid excessive or chronic alcohol consumption. Alcohol increases the risk of orthostatic hypotension.
- Avoid natural licorice. Avoid licorice in large amounts, as it may lead to hypokalemia.
- Increase consumption of [potassium](#)-rich foods. This medication may cause [potassium](#) depletion. Foods containing [potassium](#) include bananas and orange juice.

► [DrugBank](#)

16.5 Pathways



1 item



[Furosemide Action Pathway](#)

Source: [PathBank](#)

External ID: [SMP0000115](#)

Taxonomy: [Homo sapiens \(human\)](#)

► [PubChem](#)

17 Biological Test Results



17.1 BioAssay Results



5,203 items



	Search
SORT BY Activity Value - Increasing	
	BK Channel Variant Modulator Selectivity Assay Activity: Inactive Activity Value: -0.0468189 μM BioAssay AID: 1259406 Substance SID: 363920424 Compound CID: 3440
	BK Channel Variant Modulator Selectivity Assay Activity: Inactive Activity Value: -0.0280431 μM BioAssay AID: 1259406 Substance SID: 363920424 Compound CID: 3440
	
Page 1 of 1,041	

► PubChem

18 Classification



18.1 MeSH Tree



1 item

View in Classification Browser

MeSH Tree > Chemicals and Drugs Category > Organic Chemicals > Amines > Aniline Compounds

Furosemide

► [Medical Subject Headings \(MeSH\)](#)

18.2 NCI Thesaurus Tree



1 item

[View in Classification Browser](#)

NCI Thesaurus Tree > Drug, Food, Chemical or Biomedical Material > Pharmacologic Substance > Agent Affecting Blood or Body Fluid > Diuretic

Furosemide

A sulfamoylanthranilic acid derivative, also known as frusemide, and potent loop diuretic. Furosemide is widely used to treat hypertension and edema. This agent is highly bound to albumin and is largely excreted unchanged in the urine.

► [NCI Thesaurus \(NCIt\)](#)

18.3 ChEBI Ontology



1 item

[View in Classification Browser](#)

ChEBI Ontology > chemical entity > molecular entity > main group molecular entity > p-block molecular entity > carbon group molecular entity > organic molecular entity > organic acid > carboxylic acid > chlorocarboxylic acid

furosemide

A chlorobenzoic acid that is 4-chlorobenzoic acid substituted by a (furan-2-ylmethyl)amino and a sulfamoyl group at position 2 and 5 respectively. It is a diuretic used in the treatment of congestive heart failure.

► [ChEBI](#)

18.4 KEGG: Drug



1 item

[View in Classification Browser](#)

Therapeutic category of drugs in Japan > 2 Agents affecting individual organs > 21 Cardiovascular agents > 213 Diuretics

Furosemide (JP18/USP/INN)

► [KEGG](#)

18.5 KEGG: USP



1 item

View in Classification Browser 

USP drug classification > Cardiovascular Agents > Diuretics, Loop
[Furosemide \(JP18/USP/INN\)](#)

[▶ KEGG](#)

18.6 KEGG: ATC



1 item

View in Classification Browser 

Anatomical Therapeutic Chemical (ATC) classification > C CARDIOVASCULAR SYSTEM > C03 DIURETICS > C03C HIGH-CEILING DIURETICS > C03CA Sulfonamides, plain
[Furosemide \(JP18/USP/INN\)](#)

[▶ KEGG](#)

18.7 KEGG: Target-based Classification of Drugs



1 item

View in Classification Browser 

Target-based classification of drugs > Transporters > Solute carrier family > SLC12
[Furosemide \(JP18/USP/INN\)](#)

[▶ KEGG](#)

18.8 KEGG: JP15



1 item

View in Classification Browser 

Drugs listed in the Japanese Pharmacopoeia
[Furosemide](#)

[▶ KEGG](#)

18.9 KEGG: Animal Drugs



1 item

[View in Classification Browser](#) 

Animal drugs in Japan > 92 Agents affecting circulatory organs, respiratory organs and urinary organs > 922 Diuretics
[Furosemide](#)

[▶ KEGG](#)

18.10 KEGG: Drug Groups



1 item

[View in Classification Browser](#) 

Drug Groups > Cardiovascular agent > DG01690 Sulfonamide diuretic > DG01747 Furosemide type diuretic
[Furosemide](#)

[▶ KEGG](#)

18.11 WHO ATC Classification System



1 item

[View in Classification Browser](#) 

ATC Code > C - Cardiovascular system > C03 - Diuretics > C03C - High-ceiling diuretics
[C03CA01 - Furosemide](#)

[▶ WHO Anatomical Therapeutic Chemical \(ATC\) Classification](#)

18.12 FDA Pharm Classes



2 items

[View in Classification Browser](#) 

FDA Pharmacological Classification > Physiological Effects [PE] > Organ System Specific Effects [PE] >
Renal/Urological Activity Alteration [PE] > Diuresis Alteration [PE]

Increased Diuresis at Loop of Henle [PE]

FDA Pharmacological Classification > Established Pharmacologic Classes [EPC]

Loop Diuretic [EPC]

[▶ FDA Pharm Classes](#)

18.13 ChemIDplus



58 items	View in Classification Browser
ChemIDplus Chemical Information Classification CAMEO Computer-Aided Management of Emergency Operation - CAMEO Chemicals is a library of datasheets containing response-related information and recommendations for hazardous materials that are commonly transported, used, or stored in the United States	
ChemIDplus Chemical Information Classification CCRIS Chemical Carcinogenesis Research Information System - Carcinogenicity, mutagenicity, tumor promotion and tumor inhibition data from the National Cancer Institute (NCI). CCRIS provides historical information from the years 1985 - 2011. It is no longer updated.	
ChemIDplus Chemical Information Classification CTD Comparative Toxicogenomics Database - CTD selects and organizes gene, sequence, chemical, reference, and taxonomic data about gene-chemical interactions. It is hosted at North Carolina State University (NCSU).	
ChemIDplus Chemical Information Classification ChEBI Chemical Entities of Biological Interest - Dictionary of molecular entities focused on "small" chemical compounds. ChEBI is part of the EMBL-European Bioinformatics Institute.	
ChemIDplus Chemical Information Classification ClinicalTrials.gov ClinicalTrials.gov - ClinicalTrials.gov offers up-to-date information for locating federally and privately supported clinical	
Page 1 of 12	

► [ChemIDplus](#)

18.14 CAMEO Chemicals



5 items	View in Classification Browser
Acids, Carboxylic Reactive group: Acids, Carboxylic	
Amides and Imides Reactive group: Amides and Imides	
Amines, Phosphines, and Pyridines Reactive group: Amines, Phosphines, and Pyridines	

Aryl Halides

Reactive group: Aryl Halides

Ethers

Reactive group: Ethers

► **CAMEO Chemicals****18.15 IUPHAR / BPS Guide to PHARMACOLOGY Target Classification**

3 items

View in Classification Browser

Guide to Pharmacology Target Classification > Receptors > G protein-coupled receptors

Class A Orphans

Table 1 lists a number of putative GPCRs identified by **NC-IUPHAR**, for which preliminary evidence for an endogenous ligand has been published, or for which there exists a potential link to a disease, or disorder. These GPCRs have recently been reviewed in detail. The GPCRs in Table 1 are all Class A, rhodopsin-like GPCRs. Class A orphan GPCRs not listed in Table 1 are putative GPCRs with as-yet unidentified endogenous ligands.

Table 1: Class A orphan GPCRs with putative endogenous ligands

GPR3 GPR4 GPR6 GPR12 GPR15 GPR17 GPR20
GPR22 GPR26 GPR31 GPR34 GPR35 GPR37 GPR39
GPR50 GPR63 GPR65 GPR68 GPR75 GPR84 GPR87
GPR88 GPR132 GPR149 GPR161 GPR183 LGR4 LGR5
LGR6 MAS1 MRGPRD MRGPRX1 MRGPRX2 P2RY10 TAAR2

In addition the orphan receptors *GPR18*, *GPR55* and *GPR119* which are reported to respond to endogenous agents analogous to the endogenous cannabinoid ligands have been grouped together (*GPR18*, *GPR55* and *GPR119*).

Guide to Pharmacology Target Classification > Ion channels

GABAA receptors

The GABA_A receptor is a ligand-gated ion channel of the Cys-loop family that includes the nicotinic acetylcholine, 5-HT₃ and strychnine-sensitive glycine receptors. GABA_A receptor-mediated inhibition within the CNS occurs by fast synaptic transmission, sustained tonic inhibition and temporally intermediate events that have been termed 'GABA_A, slow'. GABA_A receptors exist as pentamers of 4TM subunits that form an intrinsic anion selective channel. Sequences of six α , three β , three γ , one δ , three ρ , one ϵ , one π and one θ GABA_A receptor subunits have been reported in mammals. The π -subunit is restricted to reproductive tissue. Alternatively spliced versions of many subunits exist (e.g. $\alpha 4$ - and $\alpha 6$ - (both not functional) $\alpha 5$ -, $\beta 2$ -, $\beta 3$ - and $\gamma 2$), along with RNA editing of the $\alpha 3$ subunit. The three ρ -subunits, ($\rho 1$ -3) function as either homo- or hetero-oligomeric assemblies. Receptors formed from ρ -subunits, because of their distinctive pharmacology that includes insensitivity to bicuculline, benzodiazepines and barbiturates, have sometimes been termed GABA_C receptors, **but they are classified as GABA_A receptors by NC-IUPHAR on the basis of structural and functional criteria**.

Many GABA_A receptor subtypes contain α -, β - and γ -subunits with the likely stoichiometry 2 α :2 β :1 γ . It is thought that the majority of GABA_A receptors harbour a single type of α - and β -subunit variant. The $\alpha 1\beta 2\gamma 2$ hetero-oligomer constitutes the largest population of GABA_A receptors in the CNS, followed by the $\alpha 2\beta 3\gamma 2$ and $\alpha 3\beta 3\gamma 2$ isoforms. Receptors that incorporate the $\alpha 4$ - $\alpha 5$ -or $\alpha 6$ -subunit, or the $\beta 1$ -, $\gamma 1$ -, $\gamma 3$ -, δ -, ϵ - and θ -subunits, are less numerous, but they may nonetheless serve important functions. For example, extrasynaptically located receptors that contain $\alpha 6$ - and δ -subunits in cerebellar granule cells, or an $\alpha 4$ - and δ -subunit in dentate gyrus granule cells and thalamic neurones, mediate a tonic current that is important for neuronal excitability in response to ambient concentrations of GABA. GABA binding occurs at the β +/ α - subunit interface and the homologous γ +/ α - subunits interface creates the

benzodiazepine site. A second site for benzodiazepine binding has recently been postulated to occur at the α +/ β -interface (reviewed by). The particular α - and γ -subunit isoforms exhibit marked effects on recognition and/or efficacy at the benzodiazepine site. Thus, receptors incorporating either α 4- or α 6-subunits are not recognised by classical benzodiazepines, such as flunitrazepam (but see). The trafficking, cell surface expression, internalisation and function of GABA_A receptors and their subunits are discussed in detail in several recent reviews but one point worthy of note is that receptors incorporating the γ 2 subunit (except when associated with α 5) cluster at the postsynaptic membrane (but may distribute dynamically between synaptic and extrasynaptic locations), whereas those incorporating the δ subunit appear to be exclusively extrasynaptic.

NC-IUPHAR class the GABA_A receptors according to their subunit structure, pharmacology and receptor function. Currently, eleven native GABA_A receptors are classed as conclusively identified (*i.e.*, α 1 β 2 γ 2, α 2 β γ 2, α 3 β γ 2, α 4 β γ 2, α 4 β 2 δ , α 4 β 3 δ , α 5 β γ 2, α 6 β γ 2, α 6 β 2 δ , α 6 β 3 δ and ρ) with further receptor isoforms occurring with high probability, or only tentatively. It is beyond the scope of this Guide to discuss the pharmacology of individual GABA_A receptor isoforms in detail; such information can be gleaned in the reviews. Agents that discriminate between α -subunit isoforms are noted in the table and additional agents that demonstrate selectivity between receptor isoforms, for example *via* β -subunit selectivity, are indicated in the text below. The distinctive agonist and antagonist pharmacology of ρ receptors is summarised in the table and additional aspects are reviewed in.

Several high-resolution cryo-electron microscopy structures have been described in which the full-length human α 1 β 3 γ 2L GABA_A receptor in lipid nanodiscs is bound to the channel-blocker picrotoxin, the competitive antagonist bicuculline, the agonist GABA (γ -aminobutyric acid), and the classical benzodiazepines alprazolam and diazepam.

Guide to Pharmacology Target Classification > Transporters

SLC12 family of cation-coupled chloride transporters

The SLC12 family of chloride transporters contribute to ion fluxes across a variety of tissues, particularly in the kidney and choroid plexus of the brain. Within this family, further subfamilies are identifiable: NKCC1, NKCC2 and NCC.

► IUPHAR/BPS Guide to PHARMACOLOGY

18.16 ChEMBL Target Tree



71 items	View in Classification Browser
Enzyme Biological molecules that possess catalytic activity. They may occur naturally or be synthetically created. Enzymes are usually proteins, however CATALYTIC RNA and CATALYTIC DNA molecules have also been identified. [MESH:D004798]	
Secreted protein	
ChEMBL Protein Target Tree Oxidoreductase The class of all enzymes catalyzing oxidoreduction reactions. The substrate that is oxidized is regarded as a hydrogen donor. The systematic name is based on donor:acceptor oxidoreductase. The recommended name will be dehydrogenase, wherever this is possible; as an alternative, reductase can be used. Oxidase is only used in cases where O ₂ is the acceptor. (Enzyme Nomenclature, 1992, p9) [MESH:D010088]	
Membrane receptor Cell surface proteins that bind signalling molecules external to the cell with high affinity and convert this extracellular event into one or more intracellular signals that alter the behavior of the target cell (From Alberts, Molecular Biology of the Cell, 2nd ed, pp693-5). Cell surface receptors, unlike enzymes, do not chemically alter their ligands. [MESH:D011956]	

ChEMBL Protein Target Tree > Enzyme > Protease > Metallo protease

<< < Page 1 of 15 > >>

[▶ ChEMBL](#)

18.17 UN GHS Classification



30 items

View in Classification Browser

GHS Classification Tree > Hazard Statement Codes

H315: Causes skin irritation [Warning Skin corrosion/irritation]

GHS Classification Tree > Hazard Statement Codes

H319: Causes serious eye irritation [Warning Serious eye damage/eye irritation]

GHS Classification Tree > Hazard Statement Codes

H335: May cause respiratory irritation [Warning Specific target organ toxicity, single exposure; Respiratory tract irritation]

GHS Classification Tree > Hazard Statement Codes

H351: Suspected of causing cancer [Warning Carcinogenicity]

GHS Classification Tree > Hazard Statement Codes

H360: May damage fertility or the unborn child [Danger Reproductive toxicity]

<< < Page 1 of 6 > >>

[▶ UN Globally Harmonized System of Classification and Labelling of Chemicals \(GHS\)](#)

18.18 EPA CPDat Classification



1 item

View in Classification Browser

EPA CPDat Classification > Functional Use

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

18.19 NORMAN Suspect List Exchange Classification



30 items	View in Classification Browser 
NORMAN Suspect List Exchange Classification Parents (Predecessors) These are parent compounds (predecessors) documented in the Parent-Transformation Product Pairs from HSDB (S68).	
NORMAN Suspect List Exchange Classification Pharmaceuticals	
NORMAN Suspect List Exchange Classification [M+Na]⁺	
S32 REACH2017 2017 List of REACH Chemicals A 2017 list of REACH chemicals including InChIKeys and spectral information, provided by N. Alygizakis and J. Slobodnik, EI. Dataset DOI:10.5281/zenodo.2653020	
S76 LUXPHARMA Pharmaceuticals Marketed in Luxembourg Pharmaceuticals marketed in Luxembourg, as published by d'Gesondheetskeess (CNS, la caisse nationale de sante, www.cns.lu), mapped by name to structures using CompTox by R. Singh et al. (in prep.). List downloaded from https://cns.public.lu/en/legislations/textes-coordonnes/liste-med-comm.html. Dataset DOI:10.5281/zenodo.4587355	
  Page 1 of 6  	

► [NORMAN Suspect List Exchange](#)

18.20 CCSBase Classification



1 item	View in Classification Browser 
[M+H] ⁺	

► [CCSbase](#)

18.21 EPA DSSTox Classification



78 items	View in Classification Browser 
CompTox Chemicals Dashboard Chemical Lists [APCRARETRO] LIST: APCRA Chemicals for Retrospective Analysis Short_Description: A list related to a publication comparing point-of-departure calculations based on high-throughput predictions of bioactivity, exposure predictions, and traditional hazard information. Long_Description: Accelerating the Pace of Chemical Risk Assessment (APCRA) is a government-to-government	

initiative whose aim is to promote collaboration and dialogue on the scientific and regulatory needs for the application and acceptance of "New Approach Methodologies" (NAMs) in regulatory decision making. A recent publication "Utility of In Vitro Bioactivity as a Lower Bound Estimate of In Vivo Adverse Effect Levels and in Risk-Based Prioritization" related to APCRA has compared point-of-departure based on high-throughput predictions of bioactivity, exposure predictions, and traditional hazard information for the 448 chemicals in this list.

CompTox Chemicals Dashboard Chemical Lists

[\[BLOODEXPOSOME\] LIST: BLOODEXPOSOME Chemicals identified as part of the blood exposome](#)

Short_Description: Chemicals identified as part of the blood exposome

Long_Description: Barupal et al report on Generating the Blood Exposome Database Using a Comprehensive Text Mining and Database Fusion Approach. The database can be used for prioritizing chemicals for systematic reviews, developing target assays in exposome research, identifying compounds in untargeted mass spectrometry, and biological interpretation in metabolomics data. (Last remapped February 17th 2023)

CompTox Chemicals Dashboard Chemical Lists

[\[CANADADSL\] Canadian Domestic Substances List 2019](#)

Short_Description: The domestic substances list (DSL) is the sole standard against which a substance is judged to be "new" to Canada.

Long_Description: On May 4, 1994, Environment and Climate Change Canada published the domestic substances list (DSL) in Part II of the Canada Gazette. The DSL is an inventory of approximately 23 000 substances manufactured in, imported into or used in Canada on a commercial scale. It is based on substances present in Canada, under certain conditions, between January 1, 1984 and December 31, 1986. The DSL is the sole standard against which a substance is judged to be "new" to Canada. With few exemptions, all substances not on this list are considered new and must be reported prior to importation or manufacture in order that they can be assessed to determine if they are toxic or could become toxic to the environment or human health.

CompTox Chemicals Dashboard Chemical Lists

[\[CASMI2016TEST\] MASSSPEC: CASMI2016 Challenge Dataset](#)

Short_Description: The 2016 Critical Assessment of Small Molecules (CASMI) contest dataset

Long_Description: The Critical Assessment of Small Molecules (CASMI) contests were initiated in 2012 to provide a means to evaluate compound identification tools on standardized sets of MS/MS data. In the publication "Revisiting Five Years of CASMI Contests with EPA Identification Tools" by McEachran et al, compound identification was performed on all 5 CASMI contest datasets using Dashboard tools and data in order to critically evaluate Dashboard performance relative to that of other applications. CASMI data were accessed via <http://casmi-contest.org/> and processed for use in our spectral matching and identification workflow. We conducted an in-depth review of the CASMI structure sets which sometimes resulted in edits to structures as described in the publication and we are providing these edited datasets via the Dashboard as reference data. This is the CASMI2016 TEST dataset.

CompTox Chemicals Dashboard Chemical Lists

[\[CASMI2016TRAIN\] MASSSPEC: CASMI2016 Training dataset](#)

Short_Description: The 2016 Critical Assessment of Small Molecules (CASMI) contest dataset

Long_Description: The Critical Assessment of Small Molecules (CASMI) contests were initiated in 2012 to provide a means to evaluate compound identification tools on standardized sets of MS/MS data. In the publication "Revisiting Five Years of CASMI Contests with EPA Identification Tools" by McEachran et al, compound identification was performed

18.22 International Agency for Research on Cancer (IARC) Classification



1 item

View in Classification Browser

Group 3: Not classifiable as to its carcinogenicity to humans

This category is used most commonly when the evidence of carcinogenicity in humans is inadequate, the evidence of carcinogenicity in experimental animals is limited (or inadequate), and the mechanistic evidence is limited (or inadequate). Limited evidence of carcinogenicity in experimental animals means that the available information suggests a carcinogenic effect but is not conclusive.

► [International Agency for Research on Cancer \(IARC\)](#)

18.23 FDA Drug Type and Pharmacologic Classification



2 items

View in Classification Browser

FDA Drug Type and Pharmacologic Classification > Pharmacologic Class

Increased Diuresis at Loop of Henle [PE]

FDA Drug Type and Pharmacologic Classification > Pharmacologic Class

Loop Diuretic [EPC]

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

18.24 EPA Substance Registry Services Tree



6 items

View in Classification Browser

EPA SRS List Classification

CAMEO Chemicals

CAMEO Chemicals is an emergency response and planning tool. This program includes an extensive chemical database with critical response information for thousands of chemicals, as well as a reactivity prediction tool that allows you to see what hazards might occur if chemicals in your collection were mixed together. CAMEO Chemicals is available as a website, mobile website, and a desktop application. CAMEO Chemicals is part of a software suite of programs called CAMEO (Computer-Aided Management of Emergency Operations). The CAMEO suite also includes a hazard modeling tool (ALOHA), a mapping program (MARPLOT), and two database applications (CAMEOfm and Tier2 Submit) designed to assist with the data management requirements under the Emergency Planning and Community Right-to-Know Act (EPCRA, also known as SARA Title III). The CAMEO suite programs can be used (individually or together) to help first responders and emergency planners access and manage crucial chemical property and emergency response information for hazardous chemical releases. The CAMEO programs are developed jointly by EPA's Office of Emergency Management and NOAA's Office of Response and Restoration.

EPA SRS List Classification

Ecotoxicology Database

ECOTOX :: Comprehensive database providing adverse effects of single chemical stressors to ecologically relevant aquatic and terrestrial species.

EPA SRS List Classification

ICIS-Air

ICIS-Air manages stationary source air program compliance and enforcement information. The data stored in ICIS-Air are primarily collected by State and local agencies and submitted to ICIS-Air as required by rule. The data stored in ICIS-Air are needed by EPA and state/local air agencies to carry out air program compliance management.

EPA SRS List Classification

Chemical Abstracts Index Name

CA Index :: The Chemical Abstracts Services (CAS) Registry File is a chemical structure and dictionary database containing unique records for chemical substances that have been published. All substance records are assigned a unique CAS Registry Number and a Chemical Abstracts (CA) index name. The records may also contain additional information, such as other names, molecular formulas, and structure diagrams related to the specific substance. The CA Index name is used as the name source in CRS when an 8th or 9th CI name is not available.

EPA SRS List Classification

Chemical Identification

ChemIDStd :: The Chemical Identification Data Standard was developed by a Chemical Data Standard Work Group comprised of representatives from across U.S. EPA programs. The consensus standard defines what information is required to identify a chemical substance and how that information should be recorded. The Chemical Identification Data Standard provides for the use of 4 specific identifiers for chemical substances in the Substance Registry System: the Chemical Abstracts Service Registry Number (CASRN) - the unique number assigned by Chemical Abstracts Service (CAS) to a chemical substance; the Chemical Substance Systematic Name - the name assigned to a chemical substance that describes it in terms of its molecular composition; the EPA Chemical Internal Tracking Number - the unique record

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► EPA Substance Registry Services

19 Information Sources



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ChEMBL Protein Target Tree

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<https://www.dgldb.org/drugs/FUROSEMIDE>

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<https://www.guidetopharmacology.org/GRAC/LigandDisplayForward?ligandId=4839>

Guide to Pharmacology Target Classification

<https://www.guidetopharmacology.org/targets.jsp>

7. Therapeutic Target Database (TTD)

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<https://idrblab.net/ttd/data/drug/details/D0PQ3G>

8. Burnham Center for Chemical Genomics

SID47193739

<https://pubchem.ncbi.nlm.nih.gov/bioassay/1996#section=Data-Table>

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CAMEO Chemical Reactivity Classification

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<http://www.hmdb.ca/metabolites/HMDB0001933>

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<https://gsrs.ncats.nih.gov/ginas/app/beta/substances/7LXU5N7ZO5>

18. ChEBI

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<http://www.ebi.ac.uk/chebi/searchId.do?chebiId=ChEBI:47426>

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<https://dailymed.nlm.nih.gov/dailymed/browse-drug-classes.cfm>

FDA Pharmacological Classification

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NCI Thesaurus Tree

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<https://www.epa.gov/chemical-research/chemical-and-products-database-cpdatt>

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<https://www.fda.gov/drugs/drug-approvals-and-databases/national-drug-code-directory>

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IARC Classification

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41. Metabolomics Workbench

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<https://www.metabolomicsworkbench.org/data/StructureData.php?RegNo=37940>

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48. Springer Nature

<https://pubchem.ncbi.nlm.nih.gov/substance/?source=15745&sourceid=21052225-818488403>

49. The Cambridge Structural Database

<https://www.ccdc.cam.ac.uk/structures/Search?Ccdcid=657920>

<https://www.ccdc.cam.ac.uk/structures/Search?Ccdcid=761769>

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<https://list.essentialmeds.org/medicines/143>

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Therapeutic category of drugs in Japan
http://www.genome.jp/kegg-bin/get_htext?br08301.keg

USP drug classification
http://www.genome.jp/kegg-bin/get_htext?br08302.keg

Anatomical Therapeutic Chemical (ATC) classification
http://www.genome.jp/kegg-bin/get_htext?br08303.keg

Target-based classification of drugs
http://www.genome.jp/kegg-bin/get_htext?br08310.keg

Drugs listed in the Japanese Pharmacopoeia

http://www.genome.jp/kegg-bin/get_htext?br08311.keg

Animal drugs in Japan

http://www.genome.jp/kegg-bin/get_htext?br08331.keg

Drug Groups

http://www.genome.jp/kegg-bin/get_htext?br08330.keg

58. 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

59. EPA Substance Registry Services

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

EPA SRS List Classification

https://sor.epa.gov/sor_internet/registry/substreg/LandingPage.do

60. PATENTSCOPE (WIPO)

SID 403387743

<https://pubchem.ncbi.nlm.nih.gov/substance/403387743>

61. NCBI

<https://www.ncbi.nlm.nih.gov/projects/linkout>

