SIXTH EDITION

PATTY'S TOXICOLOGY

VOLUME 4

EDITED BY
EULA BINGHAM
BARBARA COHRSSEN

WILEY

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Preface

In this Preface to the Sixth Edition, we acknowledge and note that it has been built on the work of previous editors. We especially need to note that Frank Patty's words in the Preface of the second edition are cogent:

> This book was planned as a ready, practical reference for persons interested in or responsible for safeguarding the health of others working with the chemical elements and compounds used in industry today. Although guidelines for selecting those chemical compounds of sufficient industrial importance for inclusion are not clearly drawn, those chemicals found in carload price lists seem to warrant first consideration.
>
> When available information is bountiful, an attempt has been made to limit the material presented to that of a practical nature, useful in recognizing, evaluating, controlling possible harmful exposures. Where the information is scanty, every fragment of significance, whether negative or positive, is offered the reader. The manufacturing chemist, who assumes responsibility for the safe use of his product in industry and who employs a competent staff to this end, as well as the large industry having competent industrial hygiene and medical staffs, are in strategic positions to recognize early and possibly harmful exposures in time to avoid any harmful effects by appropriate and timely action. Plant studies of individuals and their exposures regardless of whether or not the conditions caused recognized ill effects offer valuable experience. Information gleaned in this manner, though it may be fragmentary, is highly important when interpreted in terms of the practical health problem.

While we have not insisted that chemical selection be based on carload quantities, we have been most concerned about agents (chemical and physical) in the workplace that are toxicological concerns for workers. We have attempted to follow the guide as expressed by Frank Patty in 1962 regarding practical information.

This edition includes toxicological information on flavorings, metal working fluids, pharmaceuticals, and nanoparticles which were not previously covered, and reflects our concern with their technology and potential for adverse health effects in workers. It also continues to include the toxicology of physical and biological agents which were in the Fifth Edition. In the workplace of this new century, physical agents and human factors continue to be of concern as well as, nanotechnology. Traditionally, the agents or factors such as ergonomics, biorhythms, vibration, heat and cold stress were centered on how one measures them. Today, understanding the toxicology of these agents (factors) is of great importance because it can assist in the anticipation, recognition, evaluation and control of them. The mechanisms of actions and the assessment of the adverse health effects are as much a part of toxicology as dusts and heavy metals. As noted in Chapter 74 in Volume 5, the trend in toxicology is increasingly focused on molecular biology, mechanisms of action, and, molecular genetics.

The thinking and planning of this edition was a team effort by Barbara and Eula based on the framework that was established for the Fifth Edition by us and Charles H. Powell who died in September 1998. The three of us have had a long professional association with the Kettering Laboratory: Charles H. Powell received his ScD., Barbara Cohrssen received a MS, and Eula Bingham, has been a lifetime faculty member. Many of the authors were introduced to us through this relationship and association.

We are grateful for the help of our expert contributors, many of whom we have known for 10, 20 or 30 years, to complete this edition. The team effort was fostered between the current editors by many of the first contributors to Patty's such as Robert A. Kehoe, Francis F. Heyroth, William B. Deichmann, and Joseph Treon, all of whom were at the University of Cincinnati, Kettering Laboratory, sometime during their professional lives.

The authors have performed a difficult task in a short period of time for a publication that is as comprehensive as this one is. We want to thank Meghan Lobaugh whose assistance is greatly appreciated. We would like to express our deep appreciation and thanks to everyone who has helped us with this publication.

EULA BINGHAM, Ph.D

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USEFUL EQUIVALENTS AND CONVERSION FACTORS

1 kilometer = 0.6214 mile
1 meter = 3.281 feet
1 centimeter = 0.3937 inch
1 micrometer = 1/25,4000 inch = 40 microinches = 10,000 Angstrom units
1 foot = 30.48 centimeters
1 inch = 25.40 millimeters
1 square kilometer = 0.3861 square mile (U.S.)
1 square foot = 0.0929 square meter
1 square inch = 6.452 square centimeters
1 square mile (U.S.) = 2,589,998 square meters = 640 acres
1 acre = 43,560 square feet = 4047 square meters
1 cubic meter = 35.315 cubic feet
1 cubic centimeter = 0.0610 cubic inch
1 cubic foot = 28.32 liters = 0.0283 cubic meter = 7.481 gallons (U.S.)
1 cubic inch = 16.39 cubic centimeters
1 U.S. gallon = 3,7853 liters = 231 cubic inches = 0.13368 cubic foot
1 liter = 0.9081 quart (dry), 1.057 quarts (U.S., liquid)
1 cubic foot of water = 62.43 pounds (4°C)
1 U.S. gallon of water = 8.345 pounds (4°C)
1 kilogram = 2.205 pounds
1 gram = 15.43 grains
1 pound = 453.59 grams
1 ounce (avoir.) = 28.35 grams
1 gram mole of a perfect gas ≈ 24.45 liters (at 25°C and 760 mm Hg barometric pressure)
1 atmosphere = 14.7 pounds per square inch
1 foot of water pressure = 0.4335 pound per square inch
1 inch of mercury pressure = 0.4912 pound per square inch
1 dyne per square centimeter = 0.0021 pound per square foot
1 gram-calorie = 0.00397 Btu
1 Btu = 778 foot-pounds
1 Btu per minute = 12.96 foot-pounds per second
1 hp = 0.707 Btu per second = 550 foot-pounds per second
1 centimeter per second = 1.97 feet per minute = 0.0224 mile per hour
1 footcandle = 1 lumen incident per square foot = 10.764 lumens incident per square meter
1 grain per cubic foot = 2.29 grams per cubic meter
1 milligram per cubic meter = 0.000437 grain per cubic foot

To convert degrees Celsius to degrees Fahrenheit: °C (9/5) + 32 = °F
To convert degrees Fahrenheit to degrees Celsius: (5/9) (°F − 32) = °C
For solutes in water: 1 mg/liter ≈ 1 ppm (by weight)
Atmospheric contamination: 1 mg/liter ≈ 1 oz/1000 cu ft (approx)
For gases or vapors in air at 25°C and 760 mm Hg pressure:
To convert mg/liter to ppm (by volume): mg/liter (24,450/mol. wt.) = ppm
To convert ppm to mg/liter: ppm (mol. wt./24,450) = mg/liter

CONVERSION TABLE FOR GASES AND VAPORS[a]

(Milligrams per liter to parts per million, and vice versa; 25°C and 760 mm Hg barometric pressure)

Molecular Weight	1 mg/liter ppm	1 ppm mg/liter	Molecular Weight	1 mg/liter ppm	1 ppm mg/liter	Molecular Weight	1 mg/liter ppm	1 ppm mg/liter
1	24,450	0.0000409	39	627	0.001595	77	318	0.00315
2	12,230	0.0000818	40	611	0.001636	78	313	0.00319
3	8,150	0.0001227	41	596	0.001677	79	309	0.00323
4	6,113	0.0001636	42	582	0.001718	80	306	0.00327
5	4,890	0.0002045	43	569	0.001759	81	302	0.00331
6	4,075	0.0002454	44	556	0.001800	82	298	0.00335
7	3,493	0.0002863	45	543	0.001840	83	295	0.00339
8	3,056	0.000327	46	532	0.001881	84	291	0.00344
9	2,717	0.000368	47	520	0.001922	85	288	0.00348
10	2,445	0.000409	48	509	0.001963	86	284	0.00352
11	2,223	0.000450	49	499	0.002004	87	281	0.00356
12	2,038	0.000491	50	489	0.002045	88	278	0.00360
13	1,881	0.000532	51	479	0.002086	89	275	0.00364
14	1,746	0.000573	52	470	0.002127	90	272	0.00368
15	1,630	0.000614	53	461	0.002168	91	269	0.00372
16	1,528	0.000654	54	453	0.002209	92	266	0.00376
17	1,438	0.000695	55	445	0.002250	93	263	0.00380
18	1,358	0.000736	56	437	0.002290	94	260	0.00384
19	1,287	0.000777	57	429	0.002331	95	257	0.00389
20	1,223	0.000818	58	422	0.002372	96	255	0.00393
21	1,164	0.000859	59	414	0.002413	97	252	0.00397
22	1,111	0.000900	60	408	0.002554	98	249.5	0.00401
23	1,063	0.000941	61	401	0.002495	99	247.0	0.00405
24	1,019	0.000982	62	394	0.00254	100	244.5	0.00409
25	978	0.001022	63	388	0.00258	101	242.1	0.00413
26	940	0.001063	64	382	0.00262	102	239.7	0.00417
27	906	0.001104	65	376	0.00266	103	237.4	0.00421
28	873	0.001145	66	370	0.00270	104	235.1	0.00425
29	843	0.001186	67	365	0.00274	105	232.9	0.00429
30	815	0.001227	68	360	0.00278	106	230.7	0.00434
31	789	0.001268	69	354	0.00282	107	228.5	0.00438
32	764	0.001309	70	349	0.00286	108	226.4	0.00442
33	741	0.001350	71	344	0.00290	109	224.3	0.00446
34	719	0.001391	72	340	0.00294	110	222.3	0.00450
35	699	0.001432	73	335	0.00299	111	220.3	0.00454
36	679	0.001472	74	330	0.00303	112	218.3	0.00458
37	661	0.001513	75	326	0.00307	113	216.4	0.00462
38	643	0.001554	76	322	0.00311	114	214.5	0.00466

CONVERSION TABLE FOR GASES AND VAPORS (*Continued*)
(Milligrams per liter to parts per million, and vice versa;
25°C and 760 mm Hg barometric pressure)

Molecular Weight	1 mg/liter ppm	1 ppm mg/liter	Molecular Weight	1 mg/liter ppm	1 ppm mg/liter	Molecular Weight	1 mg/liter ppm	1 ppm mg/liter
115	212.6	0.00470	153	159.8	0.00626	191	128.0	0.00781
116	210.8	0.00474	154	158.8	0.00630	192	127.3	0.00785
117	209.0	0.00479	155	157.7	0.00634	193	126.7	0.00789
118	207.2	0.00483	156	156.7	0.00638	194	126.0	0.00793
119	205.5	0.00487	157	155.7	0.00642	195	125.4	0.00798
120	203.8	0.00491	158	154.7	0.00646	196	124.7	0.00802
121	202.1	0.00495	159	153.7	0.00650	197	124.1	0.00806
122	200.4	0.00499	160	152.8	0.00654	198	123.5	0.00810
123	198.8	0.00503	161	151.9	0.00658	199	122.9	0.00814
124	197.2	0.00507	162	150.9	0.00663	120	122.3	0.00818
125	195.6	0.00511	163	150.0	0.00667	201	121.6	0.00822
126	194.0	0.00515	164	149.1	0.00671	202	121.0	0.00826
127	192.5	0.00519	165	148.2	0.00675	203	120.4	0.00830
128	191.0	0.00524	166	147.3	0.00679	204	119.9	0.00834
129	189.5	0.00528	167	146.4	0.00683	205	119.3	0.00838
130	188.1	0.00532	168	145.5	0.00687	206	118.7	0.00843
131	186.6	0.00536	169	144.7	0.00691	207	118.1	0.00847
132	185.2	0.00540	170	143.8	0.00695	208	117.5	0.00851
133	183.8	0.00544	171	143.0	0.00699	209	117.0	0.00855
134	182.5	0.00548	172	142.2	0.00703	210	116.4	0.00859
135	181.1	0.00552	173	141.3	0.00708	211	115.9	0.00863
136	179.8	0.00556	174	140.5	0.00712	212	115.3	0.00867
137	178.5	0.00560	175	139.7	0.00716	213	114.8	0.00871
138	177.2	0.00564	176	138.9	0.00720	214	114.3	0.00875
139	175.9	0.00569	177	138.1	0.00724	215	113.7	0.00879
140	174.6	0.00573	178	137.4	0.00728	216	113.2	0.00883
141	173.4	0.00577	179	136.6	0.00732	217	112.7	0.00888
142	172.2	0.00581	180	135.8	0.00736	218	112.2	0.00892
143	171.0	0.00585	181	135.1	0.00740	219	111.6	0.00896
144	169.8	0.00589	182	134.3	0.00744	220	111.1	0.00900
145	168.6	0.00593	183	133.6	0.00748	221	110.6	0.00904
146	167.5	0.00597	184	132.9	0.00753	222	110.1	0.00908
147	166.3	0.00601	185	132.2	0.00757	223	109.6	0.00912
148	165.2	0.00605	186	131.5	0.00761	224	109.2	0.00916
149	164.1	0.00609	187	130.7	0.00765	225	108.7	0.00920
150	163.0	0.00613	188	130.1	0.00769	226	108.2	0.00924
151	161.9	0.00618	189	129.4	0.00773	227	107.7	0.00928
152	160.9	0.00622	190	128.7	0.00777	228	107.2	0.00933

CONVERSION TABLE FOR GASES AND VAPORS *(Continued)*
(Milligrams per liter to parts per million, and vice versa;
25°C and 760 mm Hg barometric pressure)

Molecular Weight	1 mg/liter ppm	1 ppm mg/liter	Molecular Weight	1 mg/liter ppm	1 ppm mg/liter	Molecular Weight	1 mg/liter ppm	1 ppm mg/liter
229	106.8	0.00937	253	96.6	0.01035	227	88.3	0.01133
230	106.3	0.00941	254	96.3	0.01039	278	87.9	0.01137
231	105.8	0.00945	255	95.9	0.01043	279	87.6	0.01141
232	105.4	0.00949	256	95.5	0.01047	280	87.3	0.01145
233	104.9	0.00953	257	95.1	0.01051	281	87.0	0.01149
234	104.5	0.00957	258	94.8	0.01055	282	86.7	0.01153
235	104.0	0.00961	259	94.4	0.01059	283	86.4	0.01157
236	103.6	0.00965	260	94.0	0.01063	284	86.1	0.01162
237	103.2	0.00969	261	93.7	0.01067	285	85.8	0.01166
238	102.7	0.00973	262	93.3	0.01072	286	85.5	0.01170
239	102.3	0.00978	263	93.0	0.01076	287	85.2	0.01174
240	101.9	0.00982	264	92.6	0.01080	288	84.9	0.01178
241	101.5	0.00986	265	92.3	0.01084	289	84.6	0.01182
242	101.0	0.00990	266	91.9	0.01088	290	84.3	0.01186
243	100.6	0.00994	267	91.6	0.01092	291	84.0	0.01190
244	100.2	0.00998	268	91.2	0.01096	292	83.7	0.01194
245	99.8	0.01002	269	90.9	0.01100	293	83.4	0.01198
246	99.4	0.01006	270	90.6	0.01104	294	83.2	0.01202
247	99.0	0.01010	271	90.2	0.01108	295	82.9	0.01207
248	98.6	0.01014	272	89.9	0.01112	296	82.6	0.01211
249	98.2	0.01018	273	89.6	0.01117	297	82.3	0.01215
250	97.8	0.01022	274	89.2	0.01121	298	82.0	0.01219
251	97.4	0.01027	275	88.9	0.01125	299	81.8	0.01223
252	97.0	0.01031	276	88.6	0.01129	300	81.5	0.01227

[a]A. C. Fieldner, S. H. Katz, and S. P. Kinney, "Gas Masks for Gases Met in Fighting Fires," *U.S. Bureau of Mines, Technical Paper No. 248*, 1921.

PATTY'S TOXICOLOGY

Sixth Edition

Volume 4

Alcohols
Esters
Epoxy Compounds
Organic Peroxides
Glycols and Glycol Ethers
Synthetic Polymers
Organic Sulfur Compounds
Organic Phosphates

Contents

Monohydric Alcohols—C_7 to C_{18}, Aromatic, and Other Alcohols

Chris Bevan, Ph.D., DABT

This chapter reviews linear and branched C_7 to C_{18} monohydric aliphatic alcohols, as well as aromatic, alicyclic, aliphatic unsaturated, and aliphatic halogenated alcohols. The CAS registry number and molecular structures have been provided for all the alcohols, except for the oxo alcohols. These alcohols are mixtures of isomeric alcohols with the composition and CAS registry number dependent on the olefin feedstock.

CHEMICAL AND PHYSICAL PROPERTIES

The physical and chemical properties of these alcohols are listed in Table 56.1. The NFPA has prepared a rating system to assess the physical and chemical hazards of chemicals with respect to flammability, health, and reactivity (1, 2). In general, these alcohols are not reactive chemicals, except for the unsaturated alcohols.

PRODUCTION AND USE

Alcohols represent an important class of industrial chemicals with a wide number of uses. Based on production volume, monohydric alcohols represent the most important group of the alcohol family (3). The most important alcohols in this chapter are the plasticizer alcohols (C_7 to C_{11}) and the detergent range alcohols (C_{12} to C_{18}). In general, alcohols of commercial significance are produced synthetically, although some alcohols are made by fermentation of natural products. The most significant industrial process is the oxo process that can be used to produce alcohols in the C_3 to C_{20} range by using alkenes as starting materials (3).

The uses of alcohols are numerous and can vary depending on their chemical and physical properties. In general, alcohols are used as solvents, cosolvents, and chemical intermediates. Among the higher alcohols, defined as containing six carbons or more, the C_6 to C_{11} alcohols are used to manufacture plasticizers. Some of the alcohols are pure chemicals, but higher monohydric alcohols (C_6 to C_{18}) are also complex isomeric mixtures (3–5). The major routes of industrial or occupational exposure to alcohols are by dermal contact and inhalation. The extent of exposure pathways depends on the use of chemical and the physical properties of the alcohol.

METABOLISM AND DISPOSITION

A comparative uptake study has been conducted using human abdominal skin *in vitro* for C_1 to C_{10} linear alcohols (6). The rate of dermal uptake for the neat material decreases with increasing carbon number.

Williams prepared an early general review on the metabolism and disposition of alcohols (7). Primary alcohols are readily oxidized to the corresponding aldehydes, which are further converted to the corresponding acids. Secondary alcohols are converted to ketones. Alcohols can be conjugated directly or as a metabolite with glucuronic acid, sulfuric acid, or glycine and excreted. Tertiary alcohols are more resistant to metabolism and are generally conjugated more readily than secondary or primary alcohols.

HEALTH EFFECTS

A common property of some of the alcohols is to produce local irritation to the skin, eyes, and respiratory tract, and the

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Table 56.1. Chemical and Physical Properties of Alcohols

Compound	CAS Number	Mol. Formula	Mol. Wt.	Boiling Point (°C)	Melting Point (°C)	Specific Gravity	Refractive Index (20°C)	Vapor Pressure (mm Hg) (°C)	Maximum Vapor Conc. % (°C)	Flammability		Solubility in Water (%) (°C)	Conversion Factors[a]	
										Lower Limit	Upper Limit		1 ppm = mg/m^3	1 mg/L = ppm
1-Heptanol	117-70-6	$C_7H_{16}O$	116.2	176	−35.0	0.824	1.4233	—	0.085 (37)	—	—	—	4.75	210.4
2-Heptanol[b]	543-47-7	$C_7H_{16}O$	116.2	159	—	0.817	1.4213	—	—	—	—	0.35	4.75	210.4
3-Heptanol[b]	3913-02-8	$C_7H_{16}O$	116.2	156	−70.0	0.821	1.4222	—	—	—	—	—	4.75	210.4
2,3-Dimethyl-1-pentanol	143-23-4	$C_7H_{16}O$	116.2	—	—	—	—	—	—	—	—	—	4.75	210.4
1-Octanol	111-87-5	$C_8H_{18}O$	130.2	195	−16.3	0.827	1.4300	—	0.034 (37)	—	—	0.01–0.05	5.32	187.8
2-Octanol	123-96-6	$C_8H_{18}O$	130.2	179	−38.6	0.821	1.4260	1.0 (32.8)	—	—	—	—	5.32	187.8
3-Octanol	589-29-1	$C_8H_{18}O$	130.2	—	—	—	—	—	—	—	—	—	5.32	187.8
2-Ethyl-1-hexanol	104-76-7	$C_8H_{18}O$	130.2	185	<−75.0	0.833	1.4315	0.05 (20)	0.0066 (20)	—	—	0.07	5.32	187.8
2,2,4-Trimethyl-1-pentanol	123-44-4	$C_8H_{18}O$	130.2	168	−70.0	0.839	1.4300	—	—	—	—	—	5.32	187.8
2-Ethyl-4-methyl-1-pentanol	106-67-2	$C_8H_{18}O$	130.2	—	—	—	—	—	—	—	—	—	5.32	187.8
1-Nonanol	143-08-8	$C_9H_{20}O$	144.3	214	−5.0	0.827	1.4323	0.3 (20)	—	2.8	6.1	—	5.90	169.6
2,6-dimethyl-4-heptanol	108-82	$C_9H_{20}O$	144.3	178	−65.0	0.812	1.4231	0.21(20)	0.027	0.8	6.1	—	5.90	169.6
3,5,5-Trimethyl hexanol	3452-97-9	$C_9H_{20}O$	144.3	194	−70.0	0.824	1.4330	—	—	—	—	—	5.90	169.6
1-Decanol	112-30-1	$C_{10}H_{22}O$	158.3	234	6.4	0.832	1.4359	10 (695)	—	—	—	Insoluble	6.47	154.5
Isodecanol	2533-17-7	$C_{10}H_{22}O$	158.3	226	—	—	—	—	—	—	—	—	6.47	154.5
1-Undecanol[b]	112-42-5	$C_{11}H_{24}O$	172.3	245	14.3	0.830	1.4392	—	—	—	—	Insoluble	7.05	141.8
1-Dodecanol	112-53-8	$C_{12}H_{26}O$	186.3	259	23.8	0.831	1.4428	—	—	—	—	Insoluble	7.62	131.3
1-Tetradecanol[b]	112-72-1	$C_{14}H_{30}O$	214.4	—	38.0	0.817	1.4358	—	—	—	—	Insoluble	8.76	114.2
1-Hexadecanol	36653-82-4	$C_{16}H_{34}O$	242.5	—	49.0	0.816	1.4392	1 (127.3)	—	—	—	Insoluble	9.91	100.9
1-Octadecanol	112-92-5	$C_{18}H_{38}O$	270.5	—	58.0	0.812	—	—	—	—	—	Insoluble	11.06	90.4
Eicosanol	629-96-9	$C_{20}H_{42}O$	298.6	—	66.0	—	—	—	—	—	—	Insoluble	12.21	81.9
Benzyl alcohol	100-51-6	C_7H_8O	108.1	205	15.2	—	1.5404	0.15 (25)	0.02	—	—	4.0	4.42	226.1
2-Phenylethanol	60-12-8	$C_8H_{10}O$	122.2	220	−25.8	—	1.5300	1.0 (58)	0.13 (52)	—	—	2.0	5.00	200.2
1-Phenylethanol	98-85-1	$C_8H_{10}O$	122.2	202	20.1	—	—	—	—	—	—	—	5.00	200.2
2-Phenyl-1-propanol	1123-85-9	$C_9H_{12}O$	134.2	—	—	—	—	—	—	—	—	—	5.49	182.1
p-tolyl alcohol	589-18-4	$C_8H_{10}O$	122.2	—	—	—	—	—	—	—	—	3.6	5.00	200.2
Cyclohexanol	108-93-0	$C_6H_{12}O$	100.2	161	24.0	—	1.4656	3.5 (34)	—	—	—	—	4.10	244.1
Methylcyclohexanol	25639-42-3	$C_7H_{14}O$	114.2	174	−50.0	0.913	1.4610	1.5 (30)	0.2 (30)	—	—	3.4	4.67	214.2
3,5,5-Trimethylcyclohexanol[b]	116-02-9	$C_9H_{18}O$	142.0	—	—	—	—	—	—	—	—	—	5.81	172.1
Furfuryl alcohol	98-00-0	$C_5H_6O_2$	98.1	170	−14.6	—	1.4840	1.0 (31.5)	0.13 (30.2)	1.8	16.3	Misc[c]	4.01	249.4
Tetrahydrofuran methanol	97-99-4	$C_5H_{10}O_2$	102.1	178	<−80.0	1.050	1.4520	2.3 (40)	—	1.5	9.7	Misc[c]	4.18	239.5
Allyl alcohol	107-18-6	C_3H_6O	58.1	94	−50.0	0.848	1.4135	23.8 (25)	3.13 (25)	2.5	18.6	Misc[c]	2.37	422
Propargyl alcohol	107-19-7	C_3H_4O	56.1	114	−50.0	0.972	1.4306	11.6 (20)	—	—	—	Misc[c]	2.29	437
Hexynol	105-31-7	$C_6H_{10}O$	98.1	142	−80.0	0.882	—	13.0 (25)	—	—	—	38	4.01	249
Butynol[b]	2028-69-9	C_4H_8O	70.1	107	—	—	—	—	—	—	—	—	2.87	348
Methyl butynol[b]	115-9-5	C_5H_8O	84.1	—	—	—	—	—	—	—	—	—	3.44	291
Methyl pentynol[b]	77-75-8	$C_6H_{10}O$	98.1	121	−197.2	—	—	—	—	—	—	—	4.01	249
Ethyl octynol[b]	5877-42-9	$C_{10}H_{18}O$	154.2	—	—	0.871	—	—	—	—	—	—	6.31	158
2-Chloroethanol	107-07-3	C_2H_5ClO	80.5	129	—	1.205	1.4419	4.9 (20)	—	0.64	4.9	Misc[c]	3.29	303.8
1-Chloro-2-propanol	127-00-4	C_3H_7ClO	94.5	—	—	—	—	—	—	—	—	—	3.90	258
2-Chloro-1-propanol	78-89-7	C_3H_7ClO	94.5	—	—	—	—	—	—	—	—	—	3.90	258

[a] At 25°C, 760 mm Hg.
[b] Toxicity of these chemicals is given in Table 56.3.
[c] Miscible.

effect or potency varies with the type of alcohol. Many alcohols produce minimal or no adverse effects in humans, possibly because of low exposure combined with the low toxicity potential of the alcohol.

A HEPTANOLS

The most important commercial member of this group is isoheptyl alcohol, which is a mixture of branched C_7 alcohols. This alcohol is used for the manufacture of esters, such as phthalate plasticizers. 1-Heptanol has little commercial value. Other C_7 alcohols are 2,3-dimethyl-1-pentanol and the secondary alcohols 2-heptanol, 3-heptanol, 4-heptanol, and 2,4-dimethyl-3-pentanol. 2-Heptanol and 3-heptanol can exist as enantiomers.

The available toxicity data indicate that heptanols have a low order of acute toxicity.

1.0 1-Heptanol

1.0.1 CAS Number

[*117-70-6*]

1.0.2 Synonyms

n-Heptanol; *n*-heptyl alcohol, 1-hydroxyheptane; heptyl alcohol; alcohol C7; enanthyl alcohol; enanthic alcohol

1.0.3 Trade Names

NA

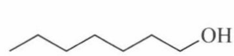
1.0.4 Molecular Weight

116.2

1.0.5 Molecular Formula

$C_7H_{16}O$

1.0.6 Molecular Structure



1.1 Chemical and Physical Properties

1-Heptanol is a colorless liquid; other physical and chemical properties are listed in Table 56.1.

1.2 Production and Use

1-Heptanol is produced by reacting hexenes with carbon monoxide in the oxo process (3) or by the catalytic reduction of heptaldehyde (8). It has little commercial value except in fragrances and as an artificial flavoring agent (8).

1.3 Toxic Effects

1.3.1 Experimental Studies

1.3.1.1 Acute Toxicity. The acute oral LD_{50} was reported to be 6.2 g/kg (male rats) and 5.5 g/kg (female rats) (9) and 3.25 mg/kg (8) in rats and 4.3 g/kg (10) and 6 g/kg (11) in mice. The dermal LD_{50} in rabbits was reported to be about 2 g/kg (9) and greater than 5 g/kg (8). The acute inhalation LC_{50} was reported as 6.6 mg/L (1390 ppm) in mice (10). No deaths occurred in rats exposed to saturated vapors for 4 h (9). Aspiration of 0.2 mL 1-heptanol caused deaths in 10 out of 10 rats. Death was instant and due to respiratory arrest (12).

1-Heptanol was moderately irritating to intact or abraded rabbit skin when applied for 24 h under occlusive conditions (8). It was moderately irritating to the eyes of rabbits (9). Exposure of mice to 1-heptanol in a sensory irritation (Alarie) test produced sensory irritation with RD_{50} values of 100 (13) and 700 ppm (14).

1.3.1.2 Chronic and Subchronic Toxicity. In a Russian study, subacute inhalation exposure in rabbits and rats led to conjunctivitis and a decrease in blood cholinesterase activity (10). In another Russian study, inhalation of 0.18–0.35 mg/L (38–74 ppm) 1-heptanol 2 h/day for 4.5 months caused minor hematological changes and some unspecified histological changes (11).

1.3.1.3 Pharmacokinetics, Metabolism, and Mechanisms. In the rabbit, 1-heptanol is primarily oxidized to heptanoic acid, which either undergoes further oxidation to CO_2 or forms an ester glucuronide (7). There is also a lesser metabolic pathway using direct conjugation with glucuronic acid to form an ether glucuronide conjugate (7).

1.3.2 Human Experience

1.3.2.1 General Information

1.3.2.1.1 Acute toxicity. 1-Heptanol (1% in petrolatum) was not irritating after a 48 h closed skin patch test, and it did not produce a skin sensitization reaction in 20 human volunteers (8).

1.3.2.1.2 Pharmacokinetics, metabolism, and mechanisms. The dermal flux for 1-heptanol in human skin (epidermis) *in vitro* is 0.021 mg/cm^2/h (6).

1.4 Standards, Regulations, or Guidelines of Exposure

No commonly recognized workplace exposure limits have been established for 1-heptanol, although there may exist standards within individual countries (15).

2.0 Isoheptyl Alcohol

*2.0.1 CAS Number**

2.0.2 Synonym

C_7 oxo alcohols

2.0.3 Molecular Weight

2.0.4 Molecular Formula

2.1 Chemical and Physical Properties

Isoheptyl alcohol is a colorless liquid.

2.2 Production and Use

Isoheptyl alcohol is produced in the oxo process by reacting hexenes with carbon monoxide and hydrogen, followed by hydrogenation (3). The commercial product typically consists of methyl-1-hexanols. A major use is in producing ester compounds, such as phthalate plasticizers and esters of dicarboxylic acids (3). Isoheptyl alcohols are also used as solvents or solubilizers in the paint and printing inks, as components in textile auxiliaries and pesticides, for hormone extraction, and in the surfactant field as foam boosters or antifrothing agents (3).

2.3 Toxic Effects

2.3.1 Experimental Studies

2.3.1.1 Acute Toxicity. The acute oral LD_{50} was reported to be 3.9 g/kg in rats, and the acute dermal LD_{50} was greater than 3.16 g/kg in rabbits (15). There were no deaths or treatment-related effects in rats, mice, and guinea pigs exposed to 152 ppm isoheptyl alcohol vapor for 6 h (15). Isoheptyl alcohol was severely irritating to both skin and eyes of rabbits (15).

2.3.2 Human Experience

2.3.2.1 General Information. Prolonged exposure to excessive concentrations of isoheptyl alcohol is expected to be very irritating to the eyes, nose, and respiratory tract.

*These sections are for the oxo alcohols. As explained in the chapter, oxo alcohols are produced from olefin feedstocks that vary in composition. The resulting mixtures of isomeric alcohols will vary in molecular weight and molecular formula. It should be noted that there may be a range of carbon numbers for a particular oxo alcohol product, that is, isononyl alcohol may also contain small quantities of C8 and/or C10 alcohols. An example of the variations in composition can be found in section 11.3.1.3. It is not practical to list all of the CAS registry numbers that may apply for each oxo alcohol section. However, the CAS registry numbers (or in some cases the composition) for the oxo alcohols used in the toxicity tests can be found in the text or in the reference to the study (OECD-SIDS documents, U.S. EPA HPVIS).

2.4 Standards, Regulations, or Guidelines of Exposure

No commonly recognized workplace exposure limits have been established for the isoheptyl alcohol, although there may exist standards within individual countries (16).

3.0 2,3-Dimethyl-1-Pentanol

3.0.1 CAS Number

[*10143-23-4*]

3.0.2 Synonym

1-Hydroxy-2,3-dimethylpentane; 2,3-dimethylpentanol.

3.0.3 Trade Names

NA

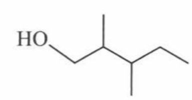
3.0.4 Molecular Weight

116.2

3.0.5 Molecular Formula

$C_7H_{16}O$

3.0.6 Molecular Structure



3.1 Chemical and Physical Properties

2,3-Dimethylpentanol is a liquid; other chemical and physical properties are listed in Table 56.1.

3.2 Toxic Effects

3.2.1 Experimental Studies

3.2.1.1 Acute Toxicity. The acute oral LD_{50} in rats is 2.38 mL/kg, and the acute dermal LD_{50} in rabbits is 2.5 mL/kg (17). There were no deaths among rats exposed to saturated vapors for 8 h (17). 2,3-Dimethylpentanol was slightly irritating to the skin of rabbits, but it was severely irritating to rabbit eyes (17).

3.2.1.2 Genetic and Related Cellular Effects Studies. 2,3-Dimethylpentanol was not mutagenic to *Salmonella typhimurium* in an *in vitro* bacterial mutation assay with or without metabolic activation (18).

3.3 Standards, Regulations, or Guidelines of Exposure

No commonly recognized workplace exposure limits have been established for 2,3-dimethylpentanol, although there may exist standards within individual countries (15).