

Ullmann's Encyclopedia of Industrial Chemistry

Sixth, Completely Revised Edition

Volume 24

Nucleic Acids

to

Paints and Coatings

 WILEY-VCH

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Ullmann's Encyclopedia of Industrial Chemistry

Volume 24

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Volumes 1 - 39: Alphabetically Arranged Articles
Volume 40: Index

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Symbols and Units

Symbols and units agree with SI standards (for conversion factors see page IX). The following list gives the most important symbols used in the encyclopedia. Articles with many specific units and symbols have a similar list as front matter.

Symbol	Unit	Physical Quantity
a_B		activity of substance B
A_r		relative atomic mass (atomic weight)
A	m^2	area
c_B	mol/m^3 , mol/L (M)	concentration of substance B
C	C/V	electric capacity
c_p, c_c	$J\,kg^{-1}\,K^{-1}$	specific heat capacity
d	cm, m	diameter
d		relative density (ρ/ρ_{water})
D	m^2/s	diffusion coefficient
D	Gy (= J/kg)	absorbed dose
e	C	elementary charge
E	J	energy
E	V/m	electric field strength
E	V	electromotive force
E_A	J	activation energy
f		activity coefficient
F	C/mol	Faraday constant
F	N	force
g	m/s^2	acceleration due to gravity
G	J	Gibbs free energy
h	m	height
$\hbar$	$W \cdot s^2$	Planck constant
H	J	enthalpy
I	A	electric current
I	cd	luminous intensity
k	(variable)	rate constant of a chemical reaction
k	J/K	Boltzmann constant
K	(variable)	equilibrium constant
l	m	length
m	g, kg, t	mass
M_r		relative molecular mass (molecular weight)
n_D^{20}		refractive index (sodium D-line, 20 °C)
n	mol	amount of substance
N_A	mol^{-1}	Avogadro constant ($6.023 \times 10^{23} \text{ mol}^{-1}$)
p	Pa, bar *	pressure
Q	J	quantity of heat
r	m	radius
R	$J\,K^{-1}\,mol^{-1}$	gas constant
R	Ω	electric resistance
S	J/K	entropy
t	s, min, h, d, month, a	time

Symbols and Units (Continued from p. VII)

Symbol	Unit	Physical Quantity
t	$^{\circ}\text{C}$	temperature
T	K	absolute temperature
u	m/s	velocity
U	V	electric potential
U	J	internal energy
V	$\text{m}^3, \text{L}, \text{mL}, \mu\text{L}$	volume
w		mass fraction
W	J	work
x_B		mole fraction of substance B
Z		proton number, atomic number
α		cubic expansion coefficient
α	$\text{W m}^{-2}\text{K}^{-1}$	heat-transfer coefficient (heat-transfer number)
α		degree of dissociation of electrolyte
$[\alpha]$	$10^{-2}\text{deg cm}^2\text{g}^{-1}$	specific rotation
η	$\text{Pa} \cdot \text{s}$	dynamic viscosity
θ	$^{\circ}\text{C}$	temperature
κ		c_p/c_v
λ	$\text{W m}^{-1}\text{K}^{-1}$	thermal conductivity
λ	nm, m	wavelength
μ		chemical potential
ν	Hz, s^{-1}	frequency
ν	m^2/s	kinematic viscosity (η/ρ)
π	Pa	osmotic pressure
ρ	g/cm^3	density
σ	N/m	surface tension
τ	$\text{Pa (N/m}^2)$	shear stress
φ		volume fraction
χ	$\text{Pa}^{-1} (\text{m}^2/\text{N})$	compressibility

* The official unit of pressure is the pascal (Pa).

Conversion Factors

SI unit	Non-SI unit	From SI to non-SI multiply by
<i>Mass</i>		
kg	pound (avoirdupois)	2.205
kg	ton (long)	9.842×10^{-4}
kg	ton (short)	1.102×10^{-3}
<i>Volume</i>		
m ³	cubic inch	6.102×10^4
m ³	cubic foot	35.315
m ³	gallon (U.S., liquid)	2.642×10^2
m ³	gallon (Imperial)	2.200×10^2
<i>Temperature</i>		
°C	°F	$^{\circ}\text{C} \times 1.8 + 32$
<i>Force</i>		
N	dyne	1.0×10^5
<i>Energy, Work</i>		
J	Btu (int.)	9.480×10^{-4}
J	cal (int.)	2.389×10^{-1}
J	eV	6.242×10^{18}
J	erg	1.0×10^7
J	kW · h	2.778×10^{-7}
J	kp · m	1.020×10^{-1}
<i>Pressure</i>		
MPa	at	10.20
MPa	atm	9.869
MPa	bar	10
kPa	mbar	10
kPa	mm Hg	7.502
kPa	psi	0.145
kPa	torr	7.502

Powers of Ten

E (exa)	10^{18}	d (deci)	10^{-1}
P (peta)	10^{15}	c (centi)	10^{-2}
T (tera)	10^{12}	m (milli)	10^{-3}
G (giga)	10^9	μ (micro)	10^{-6}
M (mega)	10^6	n (nano)	10^{-9}
k (kilo)	10^3	p (pico)	10^{-12}
h (hecto)	10^2	f (femto)	10^{-15}
da (deca)	10	a (atto)	10^{-18}

Abbreviations

The following is a list of the abbreviations used in the text. Common terms, the names of publications and institutions, and legal agreements are included along with their full identities. Other abbreviations will be defined wherever they first occur in an article. For further abbreviations, see page VII, Symbols and Units; page XIV, Frequently Cited Companies (Abbreviations), and page XV, Country Codes in patent references. The names of periodical publications are abbreviated exactly as done by Chemical Abstracts Service.

abs.	absolute	BAM	Bundesanstalt für Materialprüfung (Federal Republic of Germany)
a.c.	alternating current	BAT	Biologischer Arbeitsstoff-Toleranz-Wert (biological tolerance value for a working material, established by MAK Commission, see MAK)
ACGIH	American Conference of Governmental Industrial Hygienists	Beilstein	Beilstein's Handbook of Organic Chemistry, Springer, Berlin – Heidelberg – New York
ACS	American Chemical Society	BET	Brunauer – Emmett – Teller
ADI	acceptable daily intake	BGA	Bundesgesundheitsamt (Federal Republic of Germany)
ADN	accord européen relatif au transport international des marchandises dangereuses par voie de navigation intérieure (European agreement concerning the international transportation of dangerous goods by inland waterways)	BGBL	Bundesgesetzblatt (Federal Republic of Germany)
ADNR	ADN par le Rhin (regulation concerning the transportation of dangerous goods on the Rhine and all national waterways of the countries concerned)	BIOS	British Intelligence Objectives Subcommittee Report (see also FIAT)
ADP	adenosine 5'-diphosphate	BOD	biological oxygen demand
ADR	accord européen relatif au transport international des marchandises dangereuses par route (European agreement concerning the international transportation of dangerous goods by road)	<i>bp</i>	boiling point
AEC	Atomic Energy Commission (United States)	B.P.	British Pharmacopeia
a.i.	Active ingredient	BS	British Standard
AICHe	American Institute of Chemical Engineers	ca.	circa
AIME	American Institute of Mining, Metallurgical, and Petroleum Engineers	calcd.	calculated
ANSI	American National Standards Institute	CAS	Chemical Abstracts Service
AMP	adenosine 5'-monophosphate	cat.	catalyst, catalyzed
APhA	American Pharmaceutical Association	CEN	Comité Européen de Normalisation
API	American Petroleum Institute	cf.	compare
ASTM	American Society for Testing and Materials	CFR	Code of Federal Regulations (United States)
ATP	adenosine 5'-triphosphate	cfu	colony forming units
		Chap.	chapter
		ChemG	Chemikaliengesetz (Federal Republic of Germany)
		C.I.	Colour Index
		CIOS	Combined Intelligence Objectives Subcommittee Report (see also FIAT)
		CNS	central nervous system
		Co.	Company
		COD	chemical oxygen demand
		conc.	concentrated
		const.	constant
		Corp.	Corporation
		crit.	critical

CTFA	The Cosmetic, Toiletry and Fragrance Association (United States)	FIAT	Field Information Agency, Technical (United States reports on the chemical industry in Germany, 1945)
DAB 9	Deutsches Arzneibuch, 9th ed., Deutscher Apotheker-Verlag, Stuttgart 1986	Fig.	figure
d.c.	direct current	<i>fp</i>	freezing point
decomp.	decompose, decomposition	Friedländer	P. Friedländer, Fortschritte der Teerfarbenfabrikation und verwandter Industriezweige, Vol. 1 – 25, Springer, Berlin 1888 – 1942
DFG	Deutsche Forschungsgemeinschaft (German Science Foundation)	FT	Fourier transform
dil.	dilute, diluted	(g)	gas, gaseous
DIN	Deutsche Industrie-Norm (Federal Republic of Germany)	GC	gas chromatography
DMF	dimethylformamide	GefStoffV	Gefahrstoffverordnung (regulations in the Federal Republic of Germany concerning hazardous substances)
DNA	deoxyribonucleic acid	GGVE	Verordnung in der Bundesrepublik Deutschland über die Beförderung gefährlicher Güter mit der Eisenbahn (regulation in the Federal Republic of Germany concerning the transportation of dangerous goods by rail)
DOE	Department of Energy (United States)	GGVS	Verordnung in der Bundesrepublik Deutschland über die Beförderung gefährlicher Güter auf der Straße (regulation in the Federal Republic of Germany concerning the transportation of dangerous goods by road)
DOT	Department of Transportation – Materials Transportation Bureau (United States)	GGVSee	Verordnung in der Bundesrepublik Deutschland über die Beförderung gefährlicher Güter mit Seeschiffen (regulation in the Federal Republic of Germany concerning the transportation of dangerous goods by sea-going vessels)
DTA	differential thermal analysis	GLC	gas-liquid chromatography
EC	effective concentration	Gmelin	Gmelin's Handbook of Inorganic Chemistry, 8th ed., Springer, Berlin – Heidelberg – New York
EC	European Community	GRAS	generally recognized as safe
ed.	editor, edition, edited	Hal	halogen substituent (–F, –Cl, –Br, –I)
e.g.	for example	Houben-Weyl	Methoden der organischen Chemie, 4th ed., Georg Thieme Verlag, Stuttgart
emf	electromotive force	HPLC	high performance liquid chromatography
EmS	Emergency Schedule	IAEA	International Atomic Energy Agency
EN	European Standard (European Community)	IARC	International Agency for Research on Cancer, Lyon, France
EPA	Environmental Protection Agency (United States)		
EPR	electron paramagnetic resonance		
Eq.	equation		
ESCA	electron spectroscopy for chemical analysis		
esp.	especially		
ESR	electron spin resonance		
Et	ethyl substituent (–C ₂ H ₅)		
et al.	and others		
etc.	et cetera		
EVO	Eisenbahnverkehrsordnung (Federal Republic of Germany)		
exp (...)	e ^(...) , mathematical exponent		
FAO	Food and Agriculture Organization (United Nations)		
FDA	Food and Drug Administration (United States)		
FD & C	Food, Drug and Cosmetic Act (United States)		
FHSA	Federal Hazardous Substances Act (United States)		

IATA-DGR	International Air Transport Association, Dangerous Goods Regulations		
ICAO	International Civil Aviation Organization		
i.e.	that is		
i.m.	intramuscular		
IMDG	International Maritime Dangerous Goods Code		
IMO	Inter-Governmental Maritime Consultative Organization (in the past: IMCO)		
Inst.	Institute		
i.p.	intraperitoneal		
IR	infrared		
ISO	International Organization for Standardization		
IUPAC	International Union of Pure and Applied Chemistry		
i.v.	intravenous		
Kirk-Othmer	Encyclopedia of Chemical Technology, 3rd ed., J. Wiley & Sons, New York – Chichester – Brisbane – Toronto 1978 – 1984; 4th ed., J. Wiley & Sons, New York – Chichester – Brisbane – Toronto 1991 – 1998		
(l)	liquid		
Landolt-Börnstein	Zahlenwerte u. Funktionen aus Physik, Chemie, Astronomie, Geophysik u. Technik, Springer, Heidelberg 1950 – 1980; Zahlenwerte und Funktionen aus Naturwissenschaften und Technik, Neue Serie, Springer, Heidelberg, since 1961		
LC ₅₀	lethal concentration for 50 % of the test animals		
LCLo	lowest published lethal concentration		
LD ₅₀	lethal dose for 50 % of the test animals		
LDLo	lowest published lethal dose		
ln	logarithm (base e)		
LNG	liquefied natural gas		
log	logarithm (base 10)		
LPG	liquefied petroleum gas		
M	mol/L		
M	metal (in chemical formulas)		
MAK	Maximale Arbeitsplatz-Konzentration (maximum concentration at the workplace in the Federal Republic of Germany); cf. Deutsche Forschungsgemeinschaft (ed.): Maximale Arbeitsplatz-konzentrationen (MAK) und Biologische Arbeitsstoff-Toleranz-Werte (BAT), WILEY-VCH Verlag, Weinheim (published annually)		
max.	maximum		
MCA	Manufacturing Chemists Association (United States)		
Me	methyl substituent ($-\text{CH}_3$)		
Methodicum	Chimicum Methodicum Chimicum, Georg Thieme Verlag, Stuttgart		
MFAG	Medical First Aid Guide for Use in Accidents Involving Dangerous Goods		
MIK	maximale Immissionskonzentration (maximum immission concentration)		
min.	minimum		
mp	melting point		
MS	mass spectrum, mass spectrometry		
NAS	National Academy of Sciences (United States)		
NASA	National Aeronautics and Space Administration (United States)		
NBS	National Bureau of Standards (United States)		
NCTC	National Collection of Type Cultures (United States)		
NIH	National Institutes of Health (United States)		
NIOSH	National Institute for Occupational Safety and Health (United States)		
NMR	nuclear magnetic resonance		
no.	number		
NOEL	no observed effect level		
NRC	Nuclear Regulatory Commission (United States)		
NRDC	National Research Development Corporation (United States)		
NSC	National Service Center (United States)		
NSF	National Science Foundation (United States)		
NTSB	National Transportation Safety Board (United States)		
OECD	Organization for Economic Cooperation and Development		
OSHA	Occupational Safety and Health Administration (United States)		

p., pp.	page, pages		
Patty	G. D. Clayton, F. E. Clayton (eds.): Patty's Industrial Hygiene and Toxicology, 3rd ed., Wiley Interscience, New York	TA Lärm	Technische Anleitung zum Schutz gegen Lärm (low noise regulation in Federal Republic of Germany)
PB	Publication Board Report (U.S.	TDL ₀	lowest published toxic dose
report	Department of Commerce, Scientific and Industrial Reports)	THF	tetrahydrofuran
PEL	permitted exposure limit	TLC	thin layer chromatography
Ph	phenyl substituent ($-\text{C}_6\text{H}_5$)	TLV	Threshold Limit Value (TWA and STEL); published annually by the American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, Ohio
Ph. Eur.	European Pharmacopoeia, 2nd. ed., Council of Europe, Strasbourg 1981	TOD	total oxygen demand
phr	part per hundred rubber (resin)	TRK	Technische Richtkonzentration (lowest technically feasible level)
PNS	peripheral nervous system	TSCA	Toxic Substances Control Act (United States)
ppm	parts per million	TÜV	Technischer Überwachungsverein (Technical Control Board of the Federal Republic of Germany)
q. v.	which see (quod vide)	TWA	Time Weighted Average
ref.	refer. reference	UBA	Umweltbundesamt (Federal Environmental Agency)
resp.	respectively	Ullmann	Ullmann's Encyclopedia of Industrial Chemistry, 5th ed., VCH Verlagsgesellschaft, Weinheim, 1985 – 1996; Ullmanns Encyklopädie der Technischen Chemie, 4th ed., Verlag Chemie, Weinheim 1972 – 1984; 3rd ed., Urban und Schwarzenberg, München 1951 – 1970
R_f	retention factor (TLC)	USAEC	United States Atomic Energy Commission
R. H.	relative humidity	USAN	United States Adopted Names
RID	règlement international concernant le transport des marchandises dangereuses par chemin de fer (international convention concerning the transportation of dangerous goods by rail)	USD	United States Dispensatory
RNA	ribonucleic acid	USDA	United States Department of Agriculture
R-phr	risk phrase according to	U.S.P.	United States Pharmacopoeia
(R-Satz)	ChemG and GefStoffV (Federal Republic of Germany)	UV	ultraviolet
rpm	revolutions per minute	UVV	Unfallverhütungsvorschriften der Berufsgenossenschaft (workplace safety regulations in the Federal Republic of Germany)
RTECS	Registry of Toxic Effects of Chemical Substances, edited by the National Institute of Occupational Safety and Health (United States)	VbF	Verordnung in der Bundesrepublik Deutschland über die Errichtung und den Betrieb von Anlagen zur Lagerung, Abfüllung und Beförderung brennbarer Flüssigkeiten (regulation in the Federal Republic of Germany)
(s)	solid		
SAE	Society of Automotive Engineers (United States)		
s.c.	subcutaneous		
SI	International System of Units		
SIMS	secondary ion mass spectrometry		
S phrase	safety phrase according to		
(S-Satz)	ChemG and GefStoffV (Federal Republic of Germany)		
STEL	Short Term Exposure Limit (see TLV)		
STP	standard temperature and pressure (0° C, 101.325 kPa)		
T_g	glass transition temperature		
TA Luft	Technische Anleitung zur Reinhaltung der Luft (clean air		

	concerning the construction and operation of plants for storage, filling, and transportation of flammable liquids; classification according to the flash point of liquids, in accordance with the classification in the United States)	vs.	versus
VDE	Verband Deutscher Elektroingenieure (Federal Republic of Germany)	WGK	Wassergefährdungsklasse (water hazard class)
VDI	Verein Deutscher Ingenieure (Federal Republic of Germany)	WHO	World Health Organization (United Nations)
vol	volume	Winnacker-Küchler	Chemische Technologie, 4th ed., Carl Hanser Verlag, München, 1982-1986;
vol.	volume (of a series of books)	wt	weight
		\$	U.S. dollar, unless otherwise stated
			Winnacker-Küchler, Chemische Technik: Prozesse und Produkte, Wiley-VCH, Weinheim, from 2003

Frequently Cited Companies (Abbreviations)

Air Products	Air Products and Chemicals	ICI	Imperial Chemical Industries
Akzo	Algemene Koninklijke Zout Organon	IFP	Institut Français du Pétrole
Alcoa	Aluminum Company of America	INCO	International Nickel Company
Allied	Allied Corporation	3M	Minnesota Mining and Manufacturing Company
Amer.	American Cyanamid Company	Mitsubishi	Mitsubishi Chemical Industries
Cyanamid	Company	Chemical	Industries
BASF	BASF Aktiengesellschaft	Monsanto	Monsanto Company
Bayer	Bayer AG	Nippon	Nippon Shokubai Kagaku
BP	British Petroleum Company	Shokubai	Kogyo
Celanese	Celanese Corporation	PCUK	Pechiney Ugine Kuhlmann
Daicel	Daicel Chemical Industries	PPG	Pittsburg Plate Glass Industries
Dainippon	Dainippon Ink and Chemicals Inc.	Searle	G.D. Searle & Company
Dow Chemical	The Dow Chemical Company	SKF	Smith Kline & French Laboratories
DSM	Dutch Staats Mijnen	SNAM	Società Nazionale Metandotti
Du Pont	E.I. du Pont de Nemours & Company	Sohio	Standard Oil of Ohio
Exxon	Exxon Corporation	Stauffer	Stauffer Chemical Company
FMC	Food Machinery & Chemical Corporation	Sumitomo	Sumitomo Chemical Company
GAF	General Aniline & Film Corporation	Toray	Toray Industries Inc.
W.R. Grace	W.R. Grace & Company	UCB	Union Chimique Belge
Hoechst	Hoechst Aktiengesellschaft	Union Carbide	Union Carbide Corporation
IBM	International Business Machines Corporation	UOP	Universal Oil Products Company
		VEBA	Vereinigte Elektrizitäts- und Bergwerks-AG
		Wacker	Wacker Chemie GmbH

Country Codes

The following list contains a selection of standard country codes used in the patent references.

AT	Austria	ID	Indonesia
AU	Australia	IL	Israel
BE	Belgium	IT	Italy
BG	Bulgaria	JP	Japan *
BR	Brazil	LU	Luxembourg
CA	Canada	MA	Morocco
CH	Switzerland	NL	Netherlands *
CS	Czechoslovakia	NO	Norway
DD	German Democratic Republic	NZ	New Zealand
DE	Federal Republic of Germany (and Germany before 1949) *	PL	Poland
DK	Denmark	PT	Portugal
ES	Spain	SE	Sweden
FI	Finland	SU	Soviet Union
FR	France	US	United States of America
GB	United Kingdom	YU	Yugoslavia
GR	Greece	ZA	South Africa
HU	Hungary	EP	European Patent Office *
		WO	World Intellectual Property Organization

* For Europe, Federal Republic of Germany, Japan, and the Netherlands, the type of patent is specified: EP (patent), EP-A (application), DE (patent), DE-OS (Offenlegungsschrift), DE-AS (Auslegeschrift), JP (patent), JP-Kokai (Kokai tokkyo koho), NL (patent), and NL-A (application).

Periodic Table of Elements

element symbol, atomic number, and relative atomic mass (atomic weight)

1A "European" group designation and old IUPAC recommendation
1 group designation to 1986 IUPAC proposal
1A "American" group designation, also used by the Chemical Abstracts Service until the end of 1986

1A		2A		3A		4A		5A		6A		7A		8		9		10		11		12		13		14		15		16		17		18																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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49	Uuq	1251	Uut	1253	Uuq	1255	Uut	1257	Uuq	1259	Uut	1261	Uuq	1263	Uut	1265	Uuq	1267	Uut	1269	Uuq	1271	Uut	1273	Uuq	1275	Uut	1277	Uuq	1279	Uut	1281	Uuq	1283	Uut	1285	Uuq	1287	Uut	1289	Uuq	1291	Uut	1293	Uuq	1295	Uut	1297	Uuq	1299	Uut	1301	Uuq	1303	Uut	1305	Uuq	1307	Uut	1309	Uuq	1311	Uut	1313	Uuq	1315	Uut	1317	Uuq	1319	Uut	1321	Uuq	1323	Uut	1325	Uuq	1327	Uut	1329	Uuq	1331	Uut	1333	Uuq	1335	Uut	1337	Uuq	1339	Uut	1341	Uuq	1343	Uut	1345	Uuq	1347	Uut	1349	Uuq	1351	Uut	1353	Uuq	1355	Uut	1357	Uuq	1359	Uut	1361	Uuq	1363	Uut	1365	Uuq	1367	Uut	1369	Uuq	1371	Uut	1373	Uuq	1375	Uut	1377	Uuq	1379	Uut	1381	Uuq	1383	Uut	1385	Uuq	1387	Uut	1389	Uuq	1391	Uut	1393	Uuq	1395	Uut	1397	Uuq	1399	Uut	1401	Uuq	1403	Uut	1405	Uuq	1407	Uut	1409	Uuq	1411	Uut	1413	Uuq	1415	Uut	1417	Uuq	1419	Uut	1421	Uuq	1423	Uut	1425	Uuq	1427	Uut	1429	Uuq	1431	Uut	1433	Uuq	1435	Uut	1437	Uuq	1439	Uut	1441	Uuq	1443	Uut	1445	Uuq	1447	Uut	1449	Uuq	1451	Uut	1453	Uuq	1455	Uut	1457	Uuq	1459	Uut	1461	Uuq	1463	Uut	1465	Uuq	1467	Uut	1469	Uuq	1471	Uut	1473	Uuq	1475	Uut	1477	Uuq	1479	Uut	1481	Uuq	1483	Uut	1485	Uuq	1487	Uut	1489	Uuq	1491	Uut	1493	Uuq	1495	Uut	1497	Uuq	1499	Uut	1501	Uuq	1503	Uut

Contents

Nucleic Acids	1	Optical Materials	401
Occupational Health and Safety	39	Oral Hygiene Products	421
Octane Enhancers	101	Organometallic Compounds and Homogeneous Catalysis	429
Oil and Gas	117	Oxalic Acid	473
Oil Refining	205	Oxidation	487
Oil Shale	257	Oxocarboxylic Acids	545
On-Line Monitoring of Chemical Reactions	285	Oxo Synthesis	553
Ophthalmological Preparations	335	Oxygen	561
Optical Brighteners	363	Ozone	581
Optically Active Compounds	387	Paints and Coatings	591

Cross References

Nylon — Fibers, 4. Synthetic Organic 13 ; → Polyamides 28	Orthophosphoric Acid → Phosphoric Acid and Phosphates 26
Octanol → Alcohols, Aliphatic 2 ; → 2-Ethylhexanol 12	Osmium → Platinum Group Metals and Compounds 27
Odorants → Flavors and Fragrances 14	Osmosis → Membranes and Membrane Separation Processes 21
Oil Sand → Tar Sands 35	Oxazine → Azine Dyes 4
Oils, Essential → Flavors and Fragrances 14	Oxide Ceramics → Ceramics, Advanced Structural Products 7 ; → Superconductors 35
Oils, Mineral → Natural Gas 22 ; → Oil Refining 24	Oxirane → Ethylene Oxide 12
Olefin Polymers → Polyolefins 28	Packaging Materials → Films 13 ; → Foods, 4. Food Packaging 14 ; → Paper and Pulp 25
Olefins → Butadiene 5 ; → Butenes 6 ; → Ethylene 12 ; → Hydrocarbons 17 ; → Isoprene 18 ; → Propene 30 ; → Styrene 34 ; → Terpenes 35	Paint and Varnish Removers → Paints and Coatings 24
Oleic Acid → Fatty Acids 13	Palladium → Platinum Group Metals and Compounds 27
Oleoresins → Resins, Natural 31	Palm Oil → Fats and Fatty Oils 13
Olivine → Silicates 32	Palmitic Acid → Fatty Acids 13
Oral Antidiabetics → Antidiabetic Drugs 3	Pantothenic Acid → Vitamins 38
Orthoformates → Esters, Organic 12	

Nucleic Acids

Genetic Engineering is a separate keyword.

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1.	Introduction	1	7.1.	Synthesis Strategy	14
2.	Structure	2	7.2.	Protecting Groups	16
2.1.	Structure of DNA	2	7.3.	Functionalization of the Support	17
2.2.	Structure of RNA	5	7.4.	Methods of Synthesis	17
3.	Properties	6	7.5.	Cleavage of Protecting Groups and Purification of Oligonucleotides	19
3.1.	Physical and Chemical Properties	6	7.6.	Synthesis of Modified Oligonucleotides	19
3.2.	Interaction with Proteins	7	8.	Uses	21
4.	Biosynthesis and Biological Function	7	8.1.	Hybridization Techniques for Nucleic Acid Detection	22
4.1.	DNA Replication	7	8.2.	Labeling and Detection Systems	23
4.2.	Gene Expression	8	8.3.	Amplification Systems	24
4.2.1.	Transcription	9	8.4.	Applications of Probe Technology	25
4.2.2.	Translation	10	9.	Nucleosides and Nucleotides	26
4.3.	Modification and Degradation	10	9.1.	Nucleosides	26
4.4.	Recombination	11	9.2.	Nucleotides	29
4.5.	DNA Repair	11	9.3.	Therapeutically Important Nucleoside and Nucleotide Derivatives	31
4.6.	Nucleic Acids as Enzymes	11	10.	References	31
5.	Isolation, Purification, and Transfer	12			
6.	Analysis of Nucleic Acids	12			
7.	Chemical Synthesis	14			

1. Introduction

Nucleic acids are high molecular mass compounds found in all living cells and viruses. Their name originates from their discovery in the nuclei of eucaryotic cells. They can be chemically degraded to yield phosphoric acid, pentoses, and nitrogen-containing heterocycles (bases). Nucleic acids can be divided into two main classes depending on the sugar they contain: *deoxyribonucleic acids* (DNA) contain 2-deoxy-D-ribose and *ribonucleic acids* (RNA) contain D-ribose.

Nucleic acids are long, unbranched chains of sugar and phosphate (Fig. 1, see next page): the C-3' atom of each sugar is linked by a phosphodiester bond to the C-5' atom of the neighboring sugar. Either a purine (adenine, guanine) or a pyrimidine (cytosine and thymine in DNA;

cytosine and uracil in RNA) is attached to C-1' of the sugar by a β -glycosidic bond. For a detailed description of purines and pyrimidines, see $\rightarrow$ Purine Derivatives, $\rightarrow$ Pyrimidine and Pyrimidine Derivatives.

Although nucleic acids have been known since the second half of the nineteenth century it was only in the 1940s that their importance as the carrier of genetic information became clear. Genetic engineering and improved physical and biochemical methods of analysis have led to enormous progress in the understanding of the structure of DNA, DNA-protein interactions, and gene organization, expression, regulation, and transfer. The importance of nucleic acids became even more obvious after the discovery that they can have other functions in addition to their ability to store and transfer genetic information. It is widely assumed that in the course