

Kirk-Othmer

Encyclopedia of
Chemical Technology

Second Edition

VOLUME 1

Kirk-Othmer

ENCYCLOPEDIA
OF CHEMICAL
TECHNOLOGY

Second edition, completely revised

VOLUME 1

A to Aluminum

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PREFACE TO THE SECOND EDITION

The first edition of the Encyclopedia of Chemical Technology appeared in fifteen volumes, of which Volume 1, A to Anthrimides, was published in 1947, and the final volume, including the Index, in 1956. The years 1957 and 1960 saw the appearance of the First and Second Supplement Volumes, in which certain subjects were treated again, giving more up to date information.

It goes without saying that the entire first edition of the Encyclopedia is now in need of further treatment. This is especially true of the earlier volumes, containing the earliest letters in the alphabet. Volume 1 of the second edition, A to Aluminum, appears when Volume 1 of the first edition is already sixteen years old; by maintaining a similar schedule for the succeeding volumes of the second edition, each will be separated by a comparable time interval from the corresponding volume in the first edition.

The second edition of the Encyclopedia of Chemical Technology is more than just a revision of the first; it could be called a completely new encyclopedia. All the technological articles have been rewritten, in some cases by the same author who wrote in the first edition, in some cases by a different author. In all cases, the author has conceived of the article so as to present up-to-date chemical technology. In doing this, it often happened that certain passages from the first edition could be used unchanged, or with very little change. This was often possible, for example, in sections on History; sometimes, in sections on Physical and Chemical Properties; or in other sections. For all articles in the second edition which have a counterpart article in the first edition, the name and affiliation of the first-edition author are noted. Grateful acknowledgment is made here to the first-edition authors, for those cases where portions of their texts have been used with little or no change.

Although the general scheme of the Encyclopedia has not been changed, the list of titles is not exactly the same: The first two articles in this volume, Abherents and Ablation, are entirely new, and other changes have been made whenever, for any reason, this appeared suitable. For example, Volume 1 of the first edition contained Alcohol, industrial, but in the second edition this subject will be found under Ethanol.

Changes in format, between the first and second editions, are relatively minor. However, the reader will find, in one respect, a certain change in emphasis: The first edition concentrated on presenting United States technology; but in the second edition a number of the articles have been contributed from abroad, and the intention has been to present chemical technology, wherever it is found, without regard to national boundaries.

INTRODUCTION

The main subject of the Encyclopedia is chemical technology, and about one half of all the articles deal with chemical substances, either single substances, such as Sulfuric acid, or groups of substances, such as Aluminum compounds. There are also articles on industrial processes, such as Carbonization of coal; on uses, such as Adherents, Adhesives; on pharmaceuticals, dyes, fibers; on foods and other human uses, such as Cosmetics. There are articles on the unit operations and unit processes of chemical engineering; on fundamentals, such as Thermodynamics, Heat transfer, Film theory; on methods of analysis; and on scientific subjects, such as Catalysis, Color and constitution, Magnetic properties, and Stereochemistry. Still other articles deal with such general subjects as Computers, Literature of chemistry, Patents, or Transportation.

In general, the properties and manufacture of any substance are given in one article, which makes cross reference to one or more articles where the uses of that substance are described. Thus, the manufacture of fused alumina is described under Aluminum compounds, but for its uses the reader will be directed to such articles as Abrasives, Refractories.

For inorganic compounds, in some cases it is the anion, in others the cation that has the greater industrial significance. Thus, calcium phosphate, sodium phosphate, and ammonium phosphate are important primarily as phosphates and are discussed under Phosphoric acid and phosphates. Similarly, chromates and borates are under Chromium compounds and Boron compounds, respectively, and salts of organic acids (except acetates and formates) are discussed with the acids. On the other hand, barium chloride, barium nitrate, and barium sulfate would be thought of together and are therefore described in Barium compounds. In general, compounds of the following anions are dealt with in articles such as Aluminum compounds and Calcium compounds: acetates; carbonates; formates; chlorides, bromides and iodides (under halides); nitrates; nitrites; oxides (including hydroxides and oxygen acids and their salts, but excluding true peroxides); sulfates; sulfites; and sulfides. The organic compounds of a metal, containing a metal-to-carbon bond, are also discussed with the compounds of that metal. However, fluorine, in its industrial applications, is so different from the other halogens that the metallic fluorides are usually grouped together under Fluorine compounds, inorganic.

Organic compounds containing fluorine (with or without other halogens) are discussed under Fluorine compounds, organic, and there are articles on Bromine

compounds, organic, and Iodine compounds, organic. Chlorine is treated somewhat differently: The article Chlorocarbons and chlorohydrocarbons covers a large number of industrially important compounds; compounds containing other elements as well as carbon, hydrogen, and chlorine are sometimes grouped together (as, Chlorophenols; Chlorohydrins), sometimes treated as derivatives under a parent compound (thus chloroacetophenone appears as a derivative under Acetophenone).

In general, the treatment of a compound will be found either under its own name, or under a group of substances (for example, ethyl acetate under Esters, organic), or as a derivative under a parent compound (for example, *p*-aminobenzoic acid under Benzoic acid). The cross references provided will, it is hoped, in almost all cases direct the reader to the appropriate part of the Encyclopedia.

ABBREVIATIONS AND SYMBOLS

A	angstrom unit(s) (after Ångström)	ar-	aromatic (eg, <i>ar</i> -derivatives of tetrahydronaphthalene)
A	anion (eg, HA)	Ar	aryl
AATCC	American Association of Textile Chemists and Colorists	as-	asymmetric(al)
abs	absolute	ASA	American Standards Association
ac	alternating current	ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ac-	alicyclic (eg, <i>ac</i> -derivatives of tetrahydronaphthalene)	ASM	American Society for Metals
accel(d)	accelerate(d)	ASME	American Society of Mechanical Engineers
acceln	acceleration	ASTM	American Society for Testing and Materials
ACS	American Chemical Society	atm	atmosphere(s), atmospheric
addn	addition	at. no.	atomic number
AGA	American Gas Association	at. wt	atomic weight
ah,		av	average
amp-hr	ampere-hour(s)	b	barn(s)
AIChE	American Institute of Chemical Engineers	b(as in b ₁₁)	boiling (at 11 mm)
AIME	American Institute of Mining and Metallurgical Engineers	bbl	barrel(s)
AIP	American Institute of Physics	BC	body-centered
alc	alcohol(ic)	Bé	Baumé
alk	alkaline (not alkali)	Bhn	Brinell hardness number
Alk	alkyl	bp	boiling point
amp	ampere(s)	Btu	British thermal unit(s)
amp-hr,		bu	bushel(s)
ah	ampere-hour(s)	C	centigrade; curie
amt	amount (noun)	C-	denoting attachment to carbon (eg, <i>C</i> -alkyl derivatives of aniline)
anhyd	anhydrous	ca	circa, approximately
API	American Petroleum Institute	cal	calorie(s)
app	apparatus	calcd	calculated
approx	approximate(ly)		
aq	aqueous		

cfm,		dc	direct current
ft ³ /min	cubic foot (feet) per minute	dec,	
cg	centigram(s)	decomp	decompose(s)
cgs	centimeter-gram-second	decompd	decomposed
chem	chemical	decompn	decomposition
CI	Colour Index (number); the CI numbers given in <i>ECT</i> , 2nd ed., are from the new <i>Colour Index</i> (1956) and Suppl. (1963), <i>Soc. Dyers Colourists</i> , Bradford, England	den	denier
		den/fil	denier per filament
		deriv	derivative
		detd	determined
		detn	determination
		diam	diameter
		dielec	dielectric (adj.)
cks	centistokes	dil	dilute
cl	car lots	distd	distilled
cm	centimeter(s)	distn	distillation
coeff	coefficient	dl	deciliter
compd,		dl-, DL-	racemic
cpd	compound (noun)	dm	decimeter
compn	composition	dp	dewpoint
concd	concentrated	<i>e</i>	electron
concn	concentration	ed.	edited, edition, editor
cond	conductivity	elec	electric(al)
const	constant	emf	electromotive force
cont	continued	en	entropy unit(s)
cor	corrected	eng	engineering
cp	chemically pure	equil	equilibrium(s)
cp(s)	centipoise(s)	equiv	equivalent
cpd,		esp	especially
compd	compound (noun)	est(d)	estimate(d)
crit	critical	estn	estimation
cryst	crystalline	esu	electrostatic unit(s)
crystd	crystallized	ev	electron volt(s)
crystn	crystallization	expt(l)	experiment(al)
cu	cubic	ext(d)	extract(ed)
d	density (conveniently, specific gravity)	extn	extraction
<i>d</i>	differential operator	F	Fahrenheit
<i>d-</i>	<i>dextro-</i> , dextrorotatory	FC	face-centered
<i>d-</i>	denoting configurational relationship (as to <i>dextro-glyceraldehyde</i>)	Fed, Fedl	Federal (as in Fed Spec)
db	decibel; dry-bulb	fl oz	fluid ounce(s)
		fob	free on board
		fp	freezing point

frz	freezing	kv	kilovolt(s)
ft	foot (feet)	kv-amp	kilovolt-ampere(s)
ft-c	foot-candle	kw	kilowatt(s)
ft ³ /min, cfm	cubic foot (feet) per minute	kw-hr	kilowatt-hour(s)
ft-lb	foot-pound(s)	l	liter(s)
g	gram(s)	l-	<i>levo-</i> , levorotatory
<i>g</i>	gravitational acceleration	L-	denoting configurational relationship (as to <i>levo-</i> glyceraldehyde)
gal	gallon(s)	lb	pound(s)
g/den	gram(s) per denier	LC ₅₀	concentration lethal to 50% of the animals tested
<i>gem-</i>	geminal (attached to the same atom)	lcl	less than car lots
g-mol	gram-molecular (as in g-mol wt)	LD ₅₀	dose lethal to 50% of the animals tested
g-mole	gram-mole	liq	liquid
hp	horsepower	ln	logarithm (natural)
hr	hr(s)	log	logarithm (common)
hyd	hydrated, hydrous	m	meter(s)
hyg	hygroscopic	<i>m-</i>	meta (eg, <i>m</i> -xylene)
i, insol	insoluble	M	metal
ⁱ (eg, Pr ⁱ)	iso (eg, isopropyl)	<i>M</i>	molar (as applied to concentration; not molal, which is written out)
<i>i-</i>	inactive (eg, <i>i</i> -methionine)	ma	milliampere(s)
IACS	International Annealed Copper Standard	manuf	manufacture
ibp	initial boiling point	manufd, mfd	manufactured
ICC	Interstate Commerce Commission	manufg, mfg	manufacturing
ICT	International Critical Tables	max	maximum
ID	inner diameter	MCA	Manufacturing Chemists' Association
in.	inch(es)	mcf	million cubic feet
insol, i	insoluble	mech	mechanical
IPT	Institute of Petroleum Technologists	meq	milliequivalent(s)
IU	International Unit(s)	Mev	million electron volts
IUPAC	International Union of Pure and Applied Chemistry	mfd, manufd	manufactured
K	Kelvin	mfg, manufg	manufacturing
<i>K</i>	dissociation constant	mg	milligram(s)
kcal	kilogram-calorie(s)	min	minimum; minute(s)
kev	kilo electron volt(s)		
kg	kilogram(s)		

misc	miscellaneous	oz	ounce(s)
mixt	mixture	<i>p</i> -	para (eg, <i>p</i> -xylene)
ml	milliliter(s)	pdr	powder
MLD	minimum lethal dose	pos	positive (adj.)
mm	millimeter(s)	powd	powdered
mM	millimole(s)	ppm	parts per million
mo(s)	month(s)	ppt(d)	precipitate(d)
mol	molecule, molecular	pptn	precipitation
mol wt	molecular weight	Pr. (no.)	Foreign prototype (number); dyestuff designation used in <i>AATCC Year Books</i> for dyes not listed in the old <i>Colour Index</i> (1924 ed.; 1928 Suppl.); obsolete since new <i>Colour Index</i> was published (1956 ed.; 1963 Suppl.)
mp	melting point	prepd	prepared
mph	miles per hour	prepn	preparation
MR	molar refraction	psi	pound(s) per square inch
mv	millivolt(s)	psia	pound(s) per square inch absolute
mμ	millimicron(s)	psig	pound(s) per square inch gage
ⁿ (as Bu ⁿ),		pt	point
<i>n</i> -	normal (as, normal butyl)	pts	parts
<i>n</i> (as, <i>n</i> _D ²⁰)	index of refraction (for 20°C and sodium light)	qual	qualitative
<i>n</i> -, ⁿ	normal (eg, <i>n</i> -butyl)	quant	quantitative
<i>N</i>	normal (as applied to concentration)	qv	which see (quod vide)
<i>N</i> -	denoting attachment to nitrogen (eg, <i>N</i> -methylaniline)	<i>r</i>	roentgen
neg	negative (adj.)	<i>R</i>	univalent hydrocarbon radical (or hydrogen); Rankine
NF	<i>National Formulary</i> (American Pharmaceutical Association, Washington, D.C.)	rep	roentgen(s) equivalent physical
NMR	nuclear magnetic resonance	resp	respectively
NND	<i>New and Nonofficial Drugs</i> (American Medical Association)	rh	relative humidity
no.	number	RI	Ring Index (number); from <i>The Ring Index</i> , Reinhold Publishing Corp., N.Y., 1940
NOIBN	not otherwise indexed by name (ICC specification for shipping containers)	rpm	revolutions per minute
<i>o</i> -	ortho (eg, <i>o</i> -xylene)	rps	revolutions per second
<i>O</i> -	denoting attachment to oxygen (eg, <i>O</i> -acetylhydroxylamine)		
OD	outer diameter		
owf	on weight of fiber		

RR1	New Ring Index (number): from <i>The Ring Index</i> , Reinhold Publishing Corp., N.Y., 1960	pressure (760 mm Hg, 0°C)	
RT	room temperature	subl SU's	sublime(s). subliming Saybolt Universal second(s)
s, sol	soluble	<i>sym</i> -, <i>s</i> -,	symmetrical (eg, <i>sym-m</i> - xylydene)
^s (eg. Bu ^s), secondary (eg. secondary sec- butyl)		t, temp	temperature
<i>s</i> -, <i>sym</i> -	symmetrical (eg. <i>s-m</i> - xylydene)	^t (as, Bu ^t), <i>t</i> -, <i>tert</i> -	tertiary (eg. tertiary butyl)
<i>S</i> -	denoting attachment to sulfur (eg, <i>S</i> -methyl- cysteine)	<i>t</i> -, <i>tert</i> -, ^t	tertiary (eg, <i>t</i> -butyl)
SAE	Society of Automotive Engineers	TAPPI	Technical Association of the Pulp and Paper Industry
satd	saturated	tech	technical
satn	saturation	temp, t	temperature
SCF	standard cubic foot (feet) (760 mm Hg, 60°F)	<i>tert</i> -, <i>t</i> -, ^t	tertiary (eg. <i>tert</i> -butyl)
Sch	Schultz number (designa- tion for dyes from <i>Farb- stofftabellen</i> , 4 vols., Akademie Verlag, Leipzig, 1931-1939)	theoret	theoretical
sec	second(s)	Twad	Twaddell
<i>sec</i> -, ^s	secondary (eg, <i>sec</i> -butyl)	USP	(<i>The United States Pharmacopeia</i> (Mack Publishing Co., Easton, Pa.)
SFs	Saybolt Furol second(s)	uv	ultraviolet
sl s,		v	volt(s)
sl sol	slightly soluble	var	variety
sol, s	soluble	<i>vic</i> -	vicinal (attached to adjacent atoms)
soln	solution	vol	volume(s) (not volatile)
soly	solubility	v s, v sol	very soluble
sp	specific	vs	versus
sp, spp	species (sing. and pl.)	w	watt(s)
spec	specification	xu (ca 10 ⁻¹¹ cm)	x unit(s)
sp gr	specific gravity	yd	yard(s)
sq	square	yr	year(s)
STP	standard temperature and		

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A

ABACA FIBER. See Fibers, vegetable.

ABHERENTS

Abherents or release agents (parting agents) are defined as solid or liquid films that reduce or prevent adhesion between two surfaces. Industrial fields in which abherents have attained great importance include metal casting and processing, food preparation and packaging, rubber and polymer processing, paper coating, the production of pressure-sensitive tapes, and glass fabrication. A number of factors influence adhesion of two materials to each other. The most important ones are penetration, chemical reaction and compatibility, low surface tension, surface configuration, and polarity differences between the two materials. Two solid surfaces generally do not adhere to each other because wetting does not take place and neither does penetration of one into the other. The only exception occurs when one of the surfaces is "tacky" or when chemical reaction takes place between the two surfaces at the interface. Frequently high static charges can also lead to adhesion. Therefore, the use of abherents becomes of technical importance when a solid and a liquid, or even more so, when a solid and a paste or dough form an interface and adhere to each other. For many centuries adhesion of a highly viscous material (paste, dough) has been a disturbing factor in the home in baking and cooking. Abherents in the form of fats, oils, or solids like flour have been used in order to prevent the sticking of dough to wooden kneading boards or to various metal baking dishes. With the greater industrial use of polymeric materials, both natural and synthetic, and also with the industrialization of baking, the commercial use of abherents has become widespread. As a matter of fact, some industries which are of great importance today could not have developed without the availability of modern abherents. As an example let us mention the pressure-sensitive tapes, which could not be unwound if the tape backing were not coated with a release agent.

Properties Required of an Abherent. Since many of the factors causing adhesion are of a chemical nature, one of the first requirements of a good abherent is complete chemical inertness toward the two materials whose adhesion is to be prevented. Adhesion is often due to opposing polarities of the surfaces, therefore the polarity relation of the abherent and of one or both of the surfaces in contact with it have to be taken into consideration in the choice of an abherent. Besides these two factors one physical property is of great importance, namely, good spreading ability (low surface tension), so that the abherent will form a continuous film between the surfaces and in this