

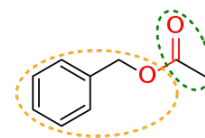
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# Functional group

In organic chemistry, a **functional group** is a substituent or moiety in a molecule that causes the molecule's characteristic chemical reactions. The same functional group will undergo the same or similar chemical reactions regardless of the rest of the molecule's composition.<sup>[1]</sup><sup>[2]</sup> This enables systematic prediction of chemical reactions and behavior of chemical compounds and the design of chemical synthesis. The reactivity of a functional group can be modified by other functional groups nearby. Functional group interconversion can be used in *retrosynthetic analysis* to plan organic synthesis.

A functional group is a group of atoms in a molecule with distinctive chemical properties, regardless of the other atoms in the molecule. The atoms in a functional group are linked to each other and to the rest of the molecule by covalent bonds. For repeating units of polymers, functional groups attach to their nonpolar core of carbon atoms and thus add chemical character to carbon chains. Functional groups can also be charged, e.g. in carboxylate salts ( $\text{--COO}^-$ ), which turns the molecule into a polyatomic ion or a complex ion. Functional groups binding to a central atom in a coordination complex are called *ligands*. Complexation and solvation are also caused by specific interactions of functional groups. In the common rule of thumb "like dissolves like", it is the shared or mutually well-interacting functional groups which give rise to solubility. For example, sugar dissolves in water because both share the hydroxyl functional group ( $\text{--OH}$ ) and hydroxyls interact strongly with each other. Plus, when functional groups are more electronegative than atoms they attach to, the functional groups will become polar, and the otherwise nonpolar molecules containing these functional groups become polar and so become soluble in some aqueous environment.

Combining the names of functional groups with the names of the parent alkanes generates what is termed a systematic nomenclature for naming organic compounds. In traditional nomenclature, the first carbon atom after the carbon that attaches to the functional group is called the alpha carbon; the second, beta carbon, the third, gamma carbon, etc. If there is another functional group at a carbon, it may be named with the Greek letter, e.g., the gamma-amine in gamma-aminobutyric acid is on the third carbon of the carbon chain attached to the carboxylic acid group. IUPAC conventions call for numeric labeling of the position, e.g. 4-aminobutanoic acid. In traditional names various qualifiers are used to label isomers, for example, isopropanol (IUPAC name: propan-2-ol) is an isomer of n-propanol (propan-1-ol). The term moiety has some overlap with the term "functional group". However, a moiety is an entire "half" of a molecule, which can be only a single functional group, but also a larger unit consisting of multiple functional groups. For example, an "aryl moiety" may be any group containing an aromatic ring, regardless of how many functional groups the said aryl has.



Benzyl acetate has an ester functional group (in red), an acetyl moiety (circled with dark green) and a benzyloxy moiety (circled with light orange). Other divisions can be made.

## Contents

### Table of common functional groups

- Hydrocarbons
- Groups containing halogen
- Groups containing oxygen
- Groups containing nitrogen
- Groups containing sulfur
- Groups containing phosphorus
- Groups containing boron
- Groups containing metals
- Names of radicals or moieties

### See also

### References


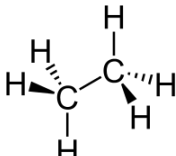


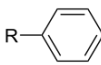
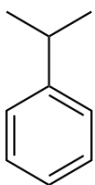
### External links

## Table of common functional groups

The following is a list of common functional groups.<sup>[3]</sup> In the formulas, the symbols R and R' usually denote an attached hydrogen, or a hydrocarbon side chain of any length, but may sometimes refer to any group of atoms.

### Hydrocarbons

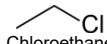
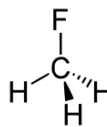
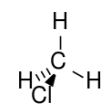
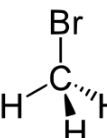
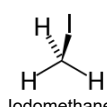
Hydrocarbons are a class of molecule that is defined by functional groups called hydrocarbyls that contain only carbon and hydrogen, but vary in the number and order of double bonds. Each one differs in type (and scope) of reactivity.

Chemical class	Group	Formula	Structural Formula	Prefix	Suffix	Example
Alkane	Alkyl	$R(CH_2)_nH$		alkyl-	-ane	 Ethane
Alkene	Alkenyl	$R_2C=CR_2$		alkenyl-	-ene	 Ethylene (Ethere)
Alkyne	Alkynyl	$RC\equiv CR'$	$R-C\equiv C-R'$	alkynyl-	-yne	$H-C\equiv C-H$ Acetylene (Ethyne)
Benzene derivative	Phenyl	$RC_6H_5$ $RPh$		phenyl-	-benzene	 Cumene (Isopropylbenzene)

There are also a large number of branched or ring alkanes that have specific names, e.g., tert-butyl, bornyl, cyclohexyl, etc. Hydrocarbons may form charged structures: positively charged carbocations or negative carbanions. Carbocations are often named *-um*. Examples are tropylium and triphenylmethyl cations and the cyclopentadienyl anion.

## Groups containing halogen

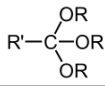

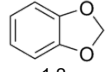
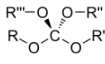
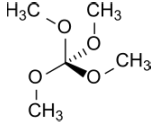
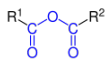
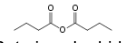
Haloalkanes are a class of molecule that is defined by a carbon–halogen bond. This bond can be relatively weak (in the case of an iodoalkane) or quite stable (as in the case of a fluoroalkane). In general, with the exception of fluorinated compounds, haloalkanes readily undergo nucleophilic substitution reactions or elimination reactions. The substitution on the carbon, the acidity of an adjacent proton, the solvent conditions, etc. all can influence the outcome of the reactivity.

Chemical class	Group	Formula	Structural Formula	Prefix	Suffix	Example
haloalkane	halo	RX	<b>R–X</b>	halo-	alkyl <b>halide</b>	 Chloroethane (Ethyl chloride)
fluoroalkane	fluoro	RF	<b>R–F</b>	fluoro-	alkyl <b>fluoride</b>	 Fluoromethane (Methyl fluoride)
chloroalkane	chloro	RCI	<b>R–Cl</b>	chloro-	alkyl <b>chloride</b>	 Chloromethane (Methyl chloride)
bromoalkane	bromo	RBr	<b>R–Br</b>	bromo-	alkyl <b>bromide</b>	 Bromomethane (Methyl bromide)
iodoalkane	iodo	RI	<b>R–I</b>	iodo-	alkyl <b>iodide</b>	 Iodomethane (Methyl iodide)

## Groups containing oxygen

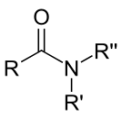
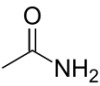
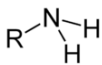
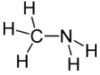

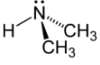

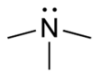
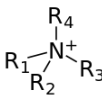
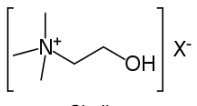
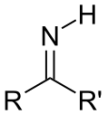
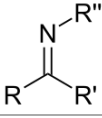
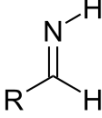

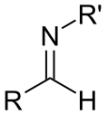
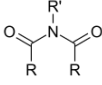
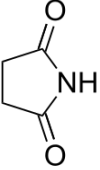
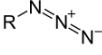
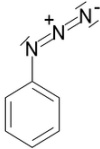
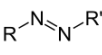
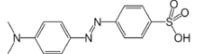
Compounds that contain C-O bonds each possess differing reactivity based upon the location and hybridization of the C-O bond, owing to the electron-withdrawing effect of sp-hybridized oxygen (carbonyl groups) and the donating effects of sp<sup>2</sup>-hybridized oxygen (alcohol groups).

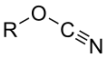
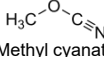
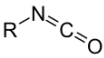
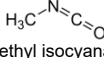
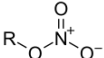
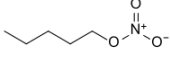
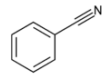
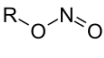
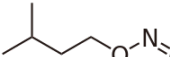
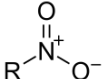
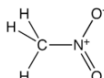
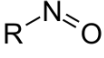
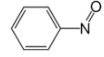
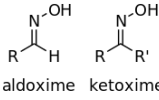
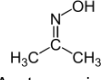
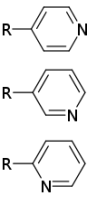
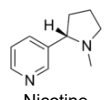
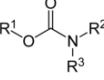
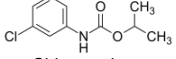
Chemical class	Group	Formula	Structural Formula	Prefix	Suffix	Example
Alcohol	Hydroxyl	ROH		hydroxy-	-ol	 Methanol
Ketone	Carbonyl	RCOR'		-oyl- (-COR') or oxo- (=O)	-one	 Butanone (Methyl ethyl ketone)
Aldehyde	Aldehyde	RCHO		formyl- (-COH) or oxo- (=O)	-al	 Acetaldehyde (Ethanal)
Acyl halide	Haloformyl	RCOX		carbonofluorido- carbonochlorido- carbonobromido- carboniodido-	-oyl <b>fluoride</b> -oyl <b>chloride</b> -oyl <b>bromide</b> -oyl <b>iodide</b>	 Acetyl chloride (Ethanoyl chloride)
Carbonate	Carbonate ester	ROCOOR'		(alkoxycarbonyl)oxy-	alkyl <b>carbonate</b>	 Triphosgene (bis(trichloromethyl) carbonate)
Carboxylate	Carboxylate	RCOO <sup>-</sup>		carboxy-	-oate	 Sodium acetate (Sodium ethanoate)
Carboxylic acid	Carboxyl	RCOOH		carboxy-	-oic <b>acid</b>	 Acetic acid (Ethanoic acid)
Ester	Carboalkoxy	RCOOR'		alkanoyloxy- or alkoxycarbonyl	alkyl <b>alkanoate</b>	 Ethyl butyrate (Ethyl butanoate)
Hydroperoxide	Hydroperoxy	ROOH		hydroperoxy-	alkyl <b>hydroperoxide</b>	 <i>tert</i> -Butyl hydroperoxide
Peroxide	Peroxy	ROOR'		peroxy-	alkyl <b>peroxide</b>	 Di- <i>tert</i> -butyl peroxide
Ether	Ether	ROR'		alkoxy-	alkyl <b>ether</b>	 Diethyl ether (Ethoxyethane)
Hemiacetal	Hemiacetal	R <sub>2</sub> CH(OR <sub>1</sub> )(OH)		alkoxy -ol	-al alkyl <b>hemiacetal</b>	
Hemiketal	Hemiketal	RC(OR'')(OH)R'		alkoxy -ol	-one alkyl <b>hemiketal</b>	
Acetal	Acetal	RCH(OR')(OR'')		dialkoxy-	-al dialkyl <b>acetal</b>	
Ketal (or Acetal)	Ketal (or Acetal)	RC(OR'')(OR'')R'		dialkoxy-	-one dialkyl <b>ketal</b>	

<u>Orthoester</u>	<u>Orthoester</u>	$\text{RC}(\text{OR}')(\text{OR}'')(\text{OR}''')$		trialkoxo-		
<u>Heterocycle</u> (if cyclic)	<u>Methylenedioxy</u>	$(-\text{OCH}_2\text{O}-)$		methylenedioxy-	-dioxole	 1,2- Methylenedioxybenzene (1,3-Benzodioxole)
<u>Orthocarbonate ester</u>	<u>Orthocarbonate ester</u>	$\text{C}(\text{OR})(\text{OR}')(\text{OR}'')(\text{OR}''')$		tetralkoxo-	<i>tetraalkyl</i> <b>orthocarbonate</b>	 Tetramethoxymethane
<u>Organic acid anhydride</u>	<u>Carboxylic anhydride</u>	$\text{R}_1(\text{CO})\text{O}(\text{CO})\text{R}_2$			anhydride	 Butyric anhydride

## Groups containing nitrogen

Compounds that contain nitrogen in this category may contain C-O bonds, such as in the case of amides.

Chemical class	Group	Formula	Structural Formula	Prefix	Suffix	Example
Amide	Carboxamide	$\text{RCONR}''$		carboxamido- or carbamoyl-	-amide	 Acetamide (Ethanamide)
Amines	Primary amine	$\text{RNH}_2$		amino-	-amine	 Methylamine (Methanamine)
	Secondary amine	$\text{R}''\text{R}'\text{NH}$		amino-	-amine	 Dimethylamine
	Tertiary amine	$\text{R}_3\text{N}$		amino-	-amine	 Trimethylamine
	4° ammonium ion	$\text{R}_4\text{N}^+$		ammonio-	-ammonium	 Choline
Imine	Primary ketimine	$\text{RC(=NH)R}'$		imino-	-imine	
	Secondary ketimine	$\text{RC(=NR}'')\text{R}'$		imino-	-imine	
	Primary aldimine	$\text{RC(=NH)H}$		imino-	-imine	 Ethanimine
	Secondary aldimine	$\text{RC(=NR}')\text{H}$		imino-	-imine	
Imide	Imide	$(\text{RCO})_2\text{NR}'$		imido-	-imide	 Succinimide (Pyrrolidine-2,5-dione)
Azide	Azide	$\text{RN}_3$		azido-	alkyl <b>azide</b>	 Phenyl azide (Azidobenzene)
Azo compound	Azo (Diimide)	$\text{RN}_2\text{R}'$		azo-	-diazene	 Methyl orange (p-dimethylamino-azobenzenesulfonic acid)

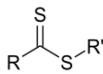
Cyanates	Cyanate	ROCN		cyanato-	alkyl <b>cyanate</b>	 Methyl cyanate
	Isocyanate	RNCO		isocyanato-	alkyl <b>isocyanate</b>	 Methyl isocyanate
Nitrate	Nitrate	RONO <sub>2</sub>		nitrooxy-, nitroxy-	alkyl <b>nitrate</b>	 Amyl nitrate (1-nitrooxypentane)
Nitrile	Nitrile	RCN	<b>R≡N</b>	ciano-	alkanenitrile alkyl <b>cyanide</b>	 Benzonitrile (Phenyl cyanide)
	Isonitrile	RNC	<b>R-N<sup>+</sup>≡C<sup>-</sup></b>	isocyano-	alkane <b>isonitrile</b> alkyl <b>isocyanide</b>	<b>H<sub>3</sub>C-N<sup>+</sup>≡C<sup>-</sup></b> Methyl isocyanide
Nitrite	Nitrosooxy	RONO		nitrosooxy-	alkyl <b>nitrite</b>	 Isoamyl nitrite (3-methyl-1-nitrosooxybutane)
Nitro compound	Nitro	RNO <sub>2</sub>		nitro-		 Nitromethane
Nitroso compound	Nitroso	RNO		nitroso- (Nitrosyl-)		 Nitrosobenzene
Oxime	Oxime	RCH=NOH	 aldoxime    ketoxime		Oxime	 Acetone oxime (2-Propanone oxime)
Pyridine derivative	Pyridyl	RC <sub>5</sub> H <sub>4</sub> N		4-pyridyl (pyridin-4-yl)  3-pyridyl (pyridin-3-yl)  2-pyridyl (pyridin-2-yl)	-pyridine	 Nicotine
Carbamate ester	Carbamate	RO(C=O)NR <sub>2</sub>		(-carbamoyl)oxy-	-carbamate	 Chlorpropham (Isopropyl (3-chlorophenyl)carbamate)

## Groups containing sulfur

Compounds that contain sulfur exhibit unique chemistry due to their ability to form more bonds than oxygen, their lighter analogue on the periodic table. Substitutive nomenclature (marked as prefix in table) is preferred over functional class nomenclature (marked as suffix in table) for sulfides, disulfides, sulfoxides and sulfones.

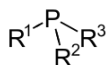







Chemical class	Group	Formula	Structural Formula	Prefix	Suffix	Example
Thiol	<u>Sulfhydryl</u>	RSH		sulfanyl- (-SH)	<b>-thiol</b>	 Ethanethiol
Sulfide (Thioether)	<u>Sulfide</u>	RSR'		<i>substituent</i> sulfanyl- (-SR')	di( <i>substituent</i> ) <b>sulfide</b>	 (Methylsulfanyl)methane (prefix) or Dimethyl sulfide (suffix)
Disulfide	<u>Disulfide</u>	RSSR'		<i>substituent</i> disulfanyl- (-SSR')	di( <i>substituent</i> ) <b>disulfide</b>	 (Methyldisulfanyl)methane (prefix) or Dimethyl disulfide (suffix)
Sulfoxide	<u>Sulfinyl</u>	RSOR'		-sulfinyl- (-SOR')	di( <i>substituent</i> ) <b>sulfoxide</b>	 (Methanesulfinyl)methane (prefix) or Dimethyl sulfoxide (suffix)
Sulfone	<u>Sulfonyl</u>	RSO <sub>2</sub> R'		-sulfonyl- (-SO <sub>2</sub> R')	di( <i>substituent</i> ) <b>sulfone</b>	 (Methanesulfonyl)methane (prefix) or Dimethyl sulfone (suffix)
Sulfinic acid	<u>Sulfino</u>	RSO <sub>2</sub> H		sulfino- (-SO <sub>2</sub> H)	<b>-sulfinic acid</b>	 2-Aminoethanesulfinic acid
Sulfonic acid	<u>Sulfo</u>	RSO <sub>3</sub> H		sulfo- (-SO <sub>3</sub> H)	<b>-sulfonic acid</b>	 Benzenesulfonic acid
Sulfonate ester	<u>Sulfo</u>	RSO <sub>3</sub> R'		(-sulfonyl)oxy- or alkoxysulfonyl-	<b>R' R-sulfonate</b>	 Methyl trifluoromethanesulfonate or Methoxysulfonyl trifluoromethane (prefix)
Thiocyanate	<u>Thiocyanate</u>	RSCN		thiocyanato- (-SCN)	<i>substituent</i> <b>thiocyanate</b>	 Phenyl thiocyanate
	<u>Isothiocyanate</u>	RNCS		isothiocyanato- (-NCS)	<i>substituent</i> <b>isothiocyanate</b>	 Allyl isothiocyanate
Thioketone	<u>Carbonothioyl</u>	RCSR'		-thioyl- (-CSR') or sulfanylidene- (=S)	<b>-thione</b>	 Diphenylmethanethione (Thiobenzophenone)
Thial	<u>Carbonothioyl</u>	RCSH		methanethioyl- (-CSH) or sulfanylidene- (=S)	<b>-thial</b>	
Thiocarboxylic acid	Carbothioic S-acid	RC=OSH		mercaptocarbonyl-	<b>-thioic S-acid</b>	 Thiobenzoic acid (benzothioic S-acid)
	Carbothioic O-acid	RC=SOH		hydroxy(thiocarbonyl)-	<b>-thioic O-acid</b>	
Thioester	Thiolester	RC=OSR'			<b>S-alkyl-alkane-thioate</b>	 S-methyl thioacrylate (S-methyl prop-2-enethioate)
	Thionoester	RC=SOR'			<b>O-alkyl-alkane-thioate</b>	



<u>Dithiocarboxylic acid</u>	Carbodithioic acid	$\text{RCS}_2\text{H}$		dithiocarboxy-	<b>-dithioic acid</b>	 Dithiobenzoic acid (Benzenecarbodithioic acid)
<u>Dithiocarboxylic acid ester</u>	Carbodithio	$\text{RC=SSR}'$			<b>-dithioate</b>	


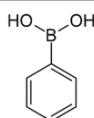



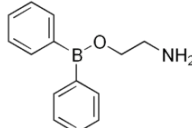
## Groups containing phosphorus

Compounds that contain phosphorus exhibit unique chemistry due to their ability to form more bonds than nitrogen, their lighter analogues on the periodic table.

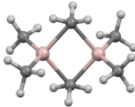
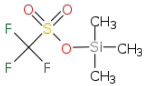
Chemical class	Group	Formula	Structural Formula	Prefix	Suffix	Example
<u>Phosphine</u> (Phosphane)	Phosphino	$\text{R}_3\text{P}$		phosphanyl-	-phosphane	 Methylpropylphosphane
<u>Phosphonic acid</u>	Phosphono	$\text{RP(=O)(OH)}_2$		phosphono-	<i>substituent</i> <b>phosphonic acid</b>	 Benzyolphosphonic acid
<u>Phosphate</u>	Phosphate	$\text{ROP(=O)(OH)}_2$		phosphonooxy- or O-phosphono- (phospho-)	<i>substituent</i> <b>phosphate</b>	 Glyceraldehyde 3-phosphate (suffix)
						 O-Phosphonocholine (prefix) (Phosphocholine)
<u>Phosphodiester</u>	<u>Phosphate</u>	$\text{HOPO(OR)}_2$		[[alkoxy]hydroxyphosphoryl]oxy- or O-[[alkoxy]hydroxyphosphoryl]-	di( <i>substituent</i> ) hydrogen <b>phosphate</b> or phosphoric acid di( <i>substituent</i> ) <b>ester</b>	DNA
						O-[(2-Guanidinoethoxy)hydroxyphosphoryl]-L-serine (prefix) (Lombricine)

## Groups containing boron

Compounds containing boron exhibit unique chemistry due to their having partially filled octets and therefore acting as Lewis acids.

Chemical class	Group	Formula	Structural Formula	Prefix	Suffix	Example
<u>Boronic acid</u>	Borono	$\text{RB(OH)}_2$		Borono-	<i>substituent</i> <b>boronic acid</b>	 Phenylboronic acid
<u>Boronic ester</u>	Boronate	$\text{RB(OR)}_2$		O-[bis(alkoxy)alkylboronyl]-	<i>substituent</i> <b>boronic acid</b> di( <i>substituent</i> ) <b>ester</b>	
<u>Borinic acid</u>	Borino	$\text{R}_2\text{BOH}$		Hydroxyborino-	di( <i>substituent</i> ) <b>borinic acid</b>	
<u>Borinic ester</u>	Borinate	$\text{R}_2\text{BOR}$		O-[alkoxydialkylboronyl]-	di( <i>substituent</i> ) <b>borinic acid</b> <i>substituent</i> <b>ester</b>	 Diphenylborinic acid 2-aminoethyl ester (2-Aminoethoxydiphenyl borate)

## Groups containing metals

Chemical Class	Structural Formula	Prefix	Suffix	Example
<u>Alkyl</u> lithium	RLi	(tri/di)alkyl-	-lithium	H <sub>3</sub> C—Li <u>methyl</u> lithium
<u>Alkyl</u> magnesium halide	RMgX (X=Cl, Br, I) <sup>[note 1]</sup>		-magnesium halide	H <sub>3</sub> C—MgCl <u>methyl</u> magnesium chloride
<u>Alkyl</u> aluminium	Al <sub>2</sub> R <sub>6</sub>		-aluminium	 <u>trimethyl</u> aluminium
<u>Silyl ether</u>	R <sub>3</sub> SiOR		-silyl ether	 <u>trimethylsilyl</u> triflate

**note 1** Fluorine is too electronegative to be bonded to magnesium; it becomes an ionic salt instead.

## Names of radicals or moieties

These names are used to refer to the moieties themselves or to radical species, and also to form the names of halides and substituents in larger molecules.

When the parent hydrocarbon is unsaturated, the suffix ("-yl", "-ylidene", or "-ylidyne") replaces "-ane" (e.g. "ethane" becomes "ethyl"); otherwise, the suffix replaces only the final "-e" (e.g. "ethyne" becomes "ethynyl").<sup>[4]</sup>

When used to refer to moieties, multiple single bonds differ from a single multiple bond. For example, a methylene bridge (methanediyl) has two single bonds, whereas a methylene group (methylidene) has one double bond. Suffixes can be combined, as in methylidyne (triple bond) vs. methylidene (single bond and double bond) vs. methanetriyl (three double bonds).

There are some retained names, such as methylene for methanediyl, 1,x-phenylene for phenyl-1,x-diyl (where x is 2, 3, or 4),<sup>[5]</sup> carbyne for methylidyne, and trityl for triphenylmethyl.

Chemical class	Group	Formula	Structural Formula	Prefix	Suffix	Example
Single bond		R•		Ylo- <sup>[6]</sup>	-yl	Methyl group Methyl radical
Double bond		R:		?	-ylidene	Methylidene
Triple bond		R:		?	-ylidyne	Methylidyne
Carboxylic acyl radical	Acyl	R−C(=O)•		?	-oyl	Acetyl

## See also

- Category:Functional groups
- Group contribution method

## References

- Compendium of Chemical Terminology (IUPAC "Gold Book") functional group (<http://goldbook.iupac.org/html/F/F02555.html>)
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- Brown, Theodore (2002). *Chemistry: the central science*. Upper Saddle River, NJ: Prentice Hall. p. 1001. ISBN 0130669970.
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- "R-2. 5 Substituent Prefix Names Derived from Parent Hydrides" ([https://www.acdlabs.com/iupac/nomenclature/93/r93\\_271.htm](https://www.acdlabs.com/iupac/nomenclature/93/r93_271.htm)). IUPAC. 1993. section P-56.2.1
- "Revised Nomenclature for Radicals, Ions, Radical Ions and Related Species (IUPAC Recommendations 1993: RC-81.3. Multiple radical centers)" (<https://web.archive.org/web/20170611171918/http://www.chem.qmul.ac.uk/iupac/ions/RC813.html>). Archived from the original (<http://www.chem.qmul.ac.uk/iupac/ions/RC813.html>) on 2017-06-11. Retrieved 2014-12-02.

## External links

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- IUPAC Blue Book (organic nomenclature) (<https://www.acdlabs.com/iupac/nomenclature/>)
  - "IUPAC ligand abbreviations" (<https://web.archive.org/web/20070927121055/http://www.iupac.org/reports/provisional/abstract04/RB-prs310804/TableVII-3.04.pdf>) (PDF). IUPAC. 2 April 2004. Archived from the original (<http://www.iupac.org/reports/provisional/abstract04/RB-prs310804/TableVII-3.04.pdf>) (PDF) on 27 September 2007. Retrieved 25 February 2015.
  - Functional group video (<https://www.clutchprep.com/organic-chemistry/functional-groups>)
  - Functional group synthesis (<https://www.organic-reaction.com/organic-synthesis/functional-group-synthesis/>) from organic-reaction.com
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