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## NAMES FOR INORGANIC RADICALS

### (IUPAC Recommendations 2000)

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# Names for inorganic radicals (IUPAC Recommendations 2000)

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## 1. INTRODUCTION

Knowledge of the properties and reactivities of stable inorganic radicals was obtained decades ago through gas-phase studies of various oxides of halogens, sulfur, and nitrogen. More recently, pulse radiolysis and flash photolysis techniques developed in the 1960s made it possible to study short-lived radicals, such as hydrated electrons, hydrogen atoms, and hydroxyl radicals. Because of the high time-resolution of these techniques, absorption spectra and redox properties of these inorganic radicals could be determined. The interest in radicals increased when it was shown that superoxide, or dioxide(1-), is formed *in vivo*. The discovery that in aerobic organisms enzymes catalyze the disproportionation of this radical resulted in new areas of research, such as radical biology and radicals in medicine. Interest in simple radicals was further boosted most recently by the remarkable observation that the radical nitrogen monoxide is formed enzymatically from the amino acid arginine. Radicals are important in a variety of

**Table 1** Trivial names for established radicals<sup>a</sup>

Formula	Trivial name
CN•	cyanyl
ClO•	chlorosyl <sup>b</sup>
HO•	hydroxyl
NO•	nitrosyl <sup>b,c</sup>
NO <sub>2</sub> •	nitryl <sup>b</sup>
O <sub>2</sub> • <sup>-</sup>	superoxide
PO•	phosphoryl <sup>b</sup>

<sup>a</sup> Systematic names (see Table 3) are preferred over these trivial names.

<sup>b</sup> The names chlorosyl, nitrosyl and nitryl also apply to the cations ClO<sup>+</sup>, NO<sup>+</sup> and NO<sub>2</sub><sup>+</sup>, respectively, see Table VIII in Ref. 1.

<sup>c</sup> The name nitric oxide, although widespread in the biochemical and biomedical literature, is obsolete [1,7].

catalytic processes and in the atmospheric gas and liquid phases; furthermore, a substantial number of inorganic radicals have been observed in interstellar gas clouds.

Trivial (Table 1) and systematic nomenclatures are both used at present, but, ultimately, systematic names will take precedence over allowed trivial names. The advantage is that students will have to learn only the nomenclature principles, rather than many different trivial names.

Section I-8.4 [1] does not provide names for many common radicals that are studied in, for instance, radiation chemistry. For this reason an update of this section follows. Two ways of naming inorganic radicals will be discussed, followed by a list of names of the radicals most often encountered in the literature. Names for organic radicals can be found elsewhere [2,3]; a strategy for naming them is briefly mentioned. The names given in this document, or constructed according to the rules given here, are preferred names. Where appropriate, names that are still allowed are explicitly mentioned. Some common radicals (see Table 1) are sometimes referred to by their trivial names because of their widespread use, although the systematic names are preferred.

## 2. DEFINITIONS

A radical is an atom or group of atoms with one or more unpaired electrons [4]. It may have positive, negative, or zero charge [5]. A radical is indicated in a formula by a superscript dot, which precedes any charge, e.g.,  $\text{O}_2^{\bullet-}$  (not  $\text{O}_2^{-\bullet}$ ) and  $\text{PO}_3^{\bullet-}$ . The dot is placed as an upper right superscript to the chemical symbol, so as not to interfere with indications of mass number, atomic number, or composition. In the case of diradicals, etc., the superscript dot is preceded by the appropriate superscript number, e.g.,  $\text{O}_2^{2\bullet}$ . To avoid confusion, the number and the radical dot can be placed within parentheses, as in  $\text{NO}^{(2\bullet)-}$ .

Metals and their ions or complexes often possess unpaired electrons, but, by convention, they are not considered to be radicals, and radical dots are not used in their formulae. However, there may be occasions when a radical ligand is bound to a metal or metal ion where it is desirable to use a radical dot [6].

## 3. NOMENCLATURE

### 3.1. Introduction

Free atoms without charge simply take the name of the element preceded by the prefix 'mono' if it is desired to indicate that they are monoatomic, see I-3.6.2 of Ref. 1.

Polyatomic radicals can be named by two strategies, one based on substitutive (see Ref. 1, I-1.3.3.4) nomenclature, the other on coordination (see Ref. 1, I-1.3.3.3) nomenclature.

Coordination nomenclature works reasonably well for relatively simple inorganic radicals and generally rather poorly for organic radicals, especially of the more complex type. By comparison, substitutive nomenclature works well for organic radicals, but much less effectively for simple radicals, especially in trying to generate unique names. For this reason, coordination nomenclature is preferred for the inorganic radicals and substitutive nomenclature for the organic radicals.

### 3.2. Coordination nomenclature

Elements of coordination nomenclature are used to name polyatomic radicals. To denote the radical character of the compound, a center dot,  $\bullet$ , is added in parentheses after the name of the compound. It is pronounced 'dot.' The name does not indicate the location of the unpaired electron. The general order in the name of a radical is: ligands, central atom, suitable suffix for charged radicals, followed by the dot and the charge (if applicable) included in parentheses. The procedure involves the following steps:

### 3.2.1. Selection of the central atom

This is the atom that binds other atoms or groups to itself, thereby occupying a central position in the radical. If there is a choice of atoms, the atom that occurs earliest in the sequence given in Section I-2.15.2 of Ref. 1, becomes the central atom, except for hydrogen, which is always regarded as a ligand:

Rn, Xe, Kr, Ar, Ne, He, B, Si, C, Sb, As, P, N, Te, Se, S, At, I, Br, Cl, O, F.

This sequence is a subset of Table IV in Ref. 1 and represents an approximate electronegativity sequence; it differs only with respect to the location of oxygen from the element sequence presented in that Table. In order to have names that are similar for acids and their conjugate bases, hydrogen is disregarded in the selection of the central atom.

If the central atom is attached to one or more identical atoms, then the whole group of identical atoms is treated as the central atom for the purpose of constructing a name. This rule applies to homonuclear polyatomic radicals such as  $N_3^\bullet$  and  $Cl_2^\bullet$  and to asymmetric compounds like  $HO_3^\bullet$  and  $ClOO^\bullet$ . The point of attachment of the group or atom can be indicated with a numerical prefix as locant designator, see Ref. 1, I-2.14. A symmetric radical like  $(CN)_2^\bullet$  is named with 'bis' followed by the name of the part between the parentheses, information about connectivity and with the suffixes described under 3.2.2 and 3.2.4, as follows: bis(nitridocarbonato)(C-C)(•1-), see 3.2.5.

### 3.2.2. Radicals with net charges

If the radical carries a net charge, the charge number [1] is added after the radical dot. The ending 'ide' is used for homopolyatomic radicals, such as  $O_2^{\bullet-}$ , and for radicals that contain only hydrogen and one element other than hydrogen, such as  $(HS)_2^{\bullet-}$  and 'ate' for all other heteropolyatomic radicals.

### 3.2.3. Attached atoms or groups of atoms

Atoms or groups of atoms other than the central atom are named as anionic ligands, and therefore end in 'o', 'ido', or 'ato', see Ref. 1, I-10.4.5.1. As to whether 'ido' or 'ato' is to be used, the recommendation given in 3.2.2 regarding suffixes for anions applies, and the suffixes 'ide' and 'ate' are changed to 'ido' and 'ato', respectively. Hydrogen is considered to be an anionic ligand and is named 'hydrido'. The systematic name for oxygen as a ligand is 'oxido', but 'oxo' is allowed [8]. For alkyl groups the suffix 'ido' is used as in 'methanido'. Polyatomic ligands, such as OH, CO or  $NH_2$  are named 'hydrido-oxido', 'oxidocarbonato', and 'dihydridonitrido', respectively. For OH the alternatives 'hydroxido' and 'hydroxo' are allowed. In the case of a homonuclear group, such as  $-OO-$ , the above guideline would result in 'oxidooxido'. In this case one writes instead 'dioxido'. The alternative name 'peroxido' is allowed. To avoid ambiguity the coordination names for attached groups are placed within parentheses (or brackets, see following paragraph). The exceptions to this rule are 'hydroxido', 'hydroxo' and 'peroxido'.

With larger groups different connectivities are possible. As an example, SCN could be attached to phosphorus, the central atom of a large radical, through the sulfur or the nitrogen atom. The carbon is selected as the central atom of the attached group, and the name of this group is therefore '(nitridosulfidocarbonato)'. The connectivity is indicated in the usual way: '[nitridosulfidocarbonato(N-P)]' or '[nitridosulfidocarbonato(S-P)]'.

The ligand names precede, in alphabetical order, the name of the central atom (see examples in 3.2.5 and Table 2).

*Examples of ligands*

1.  $-\text{OH}$  (hydridooxido) or hydroxido or hydroxo
2.  $-\text{CH}_3$  (methanido)
3.  $-\text{CN}$  (nitridocarbonato)
4.  $-\text{CO}$  (oxidocarbonato)
5.  $-\text{CS}$  (sulfidocarbonato)
6.  $-\text{NH}$  (hydridonitrido)
7.  $-\text{NH}_2$  (dihydridonitrido)
8.  $-\text{SH}$  (hydridosulfido)
9.  $-\text{OO}$  (dioxido) or peroxido
10.  $-\text{OOH}$  (hydridodioxido)
11.  $-\text{NN}$  (dinitrido)
12.  $-\text{SS}$  (disulfido)
13.  $-\text{SeSe}$  (diselenido)

*3.2.4. The radical dot*

In analogy with the charge number system a radical is indicated by '(•)', and pronounced 'dot,' after the name to denote the presence of an unpaired electron. Diradicals and polyradicals are indicated by the appropriate numerical prefix to the dot.

*3.2.5. Examples of the application of the procedure*

1.  $\text{Cl}_2^{\bullet-}$  dichloride(•1-)
2.  $\text{OCO}^{\bullet-}$  dioxidocarbonate(•1-)
3.  $\text{HOCO}^{\bullet}$  hydroxidooxidocarbon(•)
4.  $\text{ClOO}^{\bullet}$  chloridodioxxygen(•)
5.  $\text{HN}^{2\bullet}$  hydridonitrogen(2•) (triplet)
6.  $\text{PO}_3^{\bullet 2-}$  trioxidophosphate(•2-)
7.  $\text{NO}^{(2\bullet)-}$  oxidonitrate(2•1-) (triplet)
8.  $\text{HON}^{2\bullet}$  hydroxidonitrogen(2•) (triplet)
9.  $\text{HON}_3^{\bullet-}$  1-hydroxidotrinitrate(2N-N)(•1-)
10.  $(\text{CN})_2^{\bullet-}$  bis(nitridocarbonato)(C-C)(•1-)
11.  $\text{HO}_3^{\bullet}$  hydridotrioxxygen(•)

Consider the radical obtained by hydrogen atom abstraction from formate. The formula is  $\text{CO}_2^{\bullet-}$ . Carbon is considered the central atom with 2 O as ligands; the ending '(•1-)' is added after 'dioxidocarbonate' with 'dioxidocarbonate(•1-)' as the result. It is pronounced: 'dioxocarbonate dot one minus.' The name for compound 7 above would be pronounced 'oxidonitrate two dot one minus triplet.' A symmetric radical like  $(\text{CN})_2^{\bullet-}$  could be named in different ways. Following the guidelines described above it is named 'bis(nitridocarbonato)(C-C)(•1-)' as shown, but 'dinitridodicarbonato(C-C)(•1-),' or even '(nitridocarbonato)nitridocarbonato(C-C)(•1-)' are possible alternatives. The last name is less transparent than the first two: it does not convey the fact that the compound consists of two equal halves. The first two names are systematic; however, a preference for the first name becomes clear when one names  $(\text{SCN})_2^{\bullet-}$ . The two possible names are 'bis(nitridosulfidocarbonato)(S-S)(•1-)' and 'dinitridodithiodicarbonato(S-S)(•1-).' As it takes less time to work out the connectivity from the first than from the second name, the first name is preferred.

*Text continues on page 9*

**Table 2** Names of inorganic radicals <sup>a</sup>

Formula	Coordination Name or Element Name	Substitutive Name (Allowed Name in Parentheses)
BH <sub>3</sub> <sup>•-</sup>	trihydridoboride(•1-)	boranuidyl
CN <sup>•</sup>	nitridocarbon(•)	
(CN) <sub>2</sub> <sup>•-</sup>	bis(nitridocarbonate)(C-C)(•1-) <sup>b</sup>	
CO <sub>2</sub> <sup>•-</sup>	dioxidocarbonate(•1-)	oxidooxomethyl
	see also HOCO <sup>•</sup>	
CO <sub>3</sub> <sup>•-</sup>		
CO <sub>3</sub> <sup>•-</sup>	trioxidocarbonate(•1-)	
OCOO <sup>•-</sup>	(dioxido)oxidocarbonate(•1-)	(oxidoperoxidocarbonate(•1-))
	see also HOCO <sub>2</sub> <sup>•</sup>	
CS <sub>2</sub> <sup>•-</sup>	disulfidocarbonate(•1-)	
C <sub>2</sub> H <sup>•</sup>	hydridodicarbon(•)	
C <sub>3</sub> H <sup>•</sup>	hydridotricarbon(•)	
C <sub>3</sub> N <sup>•</sup>	nitridotricarbon(•)	
C <sub>4</sub> H <sup>•</sup>	hydridotetracarbon(•)	
C <sub>5</sub> H <sup>•</sup>	hydridopentacarbon(•)	
Cl <sup>•a</sup>	chlorine, monochlorine(•)	(chlorine atom) <sup>c</sup>
ClO <sup>•</sup>	oxidochlorine(•)	(chlorine monoxide)
ClO <sub>2</sub> <sup>•</sup>	dioxidochlorine(•)	(chlorine dioxide)
ClOO <sup>•</sup>	chloridodioxygen(•)	(chlorine peroxide)
ClO <sub>3</sub> <sup>•</sup>	trioxidochlorine(•)	(chlorine trioxide)
ClO <sub>4</sub> <sup>•</sup>	tetraoxidochlorine(•)	(chlorine tetraoxide)
ClSCN <sup>•-</sup>	(chloridosulfato)nitridocarbonate(•1-)	
Cl <sub>2</sub> <sup>•-</sup>	dichloride(•1-)	
H <sup>•</sup>	hydrogen, monohydrogen(•)	(hydrogen atom) <sup>c</sup>
HCO <sup>•</sup>	hydridooxidocarbon(•)	oxomethyl
HN <sup>2•</sup>	hydridonitrogen(2•) (triplet)	azanediy
HNCO <sup>•-</sup>		
	HNCO <sup>•-</sup>	(hydridonitrido)oxidocarbonate(•1-)
	HOCN <sup>•-</sup>	hydroxidonitridocarbonate(•1-)
	see also H <sub>2</sub> NCO <sup>•</sup>	
HNCOH <sup>•</sup>	see H <sub>2</sub> NCO <sup>•</sup>	
	see also HNCO <sup>•-</sup>	
HO <sup>•</sup>	hydridoxygen(•)	oxidanyl
	see also O <sup>•-</sup>	
HOCO <sup>•</sup>	hydroxidooxidocarbon(•)	
	see also CO <sub>2</sub> <sup>•-</sup>	
HOCO <sub>2</sub> <sup>•</sup>		
	HOCO <sub>2</sub> <sup>•</sup>	hydroxidodioxidocarbon(•)
	OCOOH <sup>•</sup>	(hydridodioxido)oxidocarbon(•)
	see also CO <sub>3</sub> <sup>•-</sup>	
HOCN <sup>•-</sup>	see HNCO <sup>•-</sup>	
HOCS <sub>2</sub> <sup>•</sup>	hydroxidodisulfidocarbon(•)	
HOCl <sup>•-</sup>	hydroxidochlorate(•1-)	
HOIO <sub>2</sub> <sup>•-</sup>	hydroxidodioxidoiodate(•1-)	
HON <sup>2•</sup>	hydroxidonitrogen(2•) (triplet)	hydroxyazanediy
	see also NO <sup>(2•)-</sup>	
HONCO <sup>•-</sup>	(hydroxidonitrato)oxidocarbonate(•1-)	
HONCS <sup>•-</sup>	hydroxido(sulfidocarbonato)nitrate(•1-)	

Table 2 Continued

Formula	Coordination Name or Element Name	Substitutive Name (Allowed Name in Parentheses)
HONH•	hydridohydroxidodinitrogen(•)	hydroxyazanyl
HONH <sub>2</sub> <sup>•+</sup>	dihydridohydroxidodinitrogen(•1+)	hydroxyazanumyl
HON <sub>3</sub> <sup>•-</sup>	1-hydroxidotrinitrate(2 <i>N-N</i> )(•1-)	
HOPO•	hydroxidooxidophosphate(•1-)	
HOPO <sub>2</sub> <sup>•-</sup>	hydroxidodioxidophosphate(•1-)	
	see also PO <sub>3</sub> <sup>•2-</sup>	
HOPO <sub>3</sub> <sup>•-</sup>	hydroxidotrioxidophosphate(•1-)	
	see also (HO) <sub>2</sub> PO <sub>2</sub> <sup>•</sup>	
	see also PO <sub>4</sub> <sup>•2-</sup>	
HOPO <sub>4</sub> <sup>•-</sup>	(dioxido)hydroxidodioxidophosphate(•1-)	
	see also PO <sub>5</sub> <sup>•2-</sup>	
HOSCN•	(hydroxidosulfato)nitridocarbonate(•1-)	
HOSO•	see HSO <sub>2</sub> <sup>•</sup>	
HOSO <sub>3</sub> <sup>•</sup>	hydroxidotrioxidosulfur(•)	
	see also SO <sub>4</sub> <sup>•-</sup>	
HOSO <sub>4</sub> <sup>•</sup>	(dioxido)hydroxidodioxidosulfur(•)	
	see also SO <sub>5</sub> <sup>•-</sup>	
HOSeO <sub>2</sub> <sup>•</sup>	hydroxidodioxidoselenium(•)	
(HO) <sub>2</sub> PO <sub>2</sub> <sup>•</sup>	dihydroxidodioxidophosphorus(•)	
	see also HOPO <sub>3</sub> <sup>•-</sup>	
HO <sub>2</sub> <sup>•</sup>	hydridodioxygen(•)	dioxidanyl, (hydrogen dioxide) <sup>d</sup>
	see also O <sub>2</sub> <sup>•-</sup>	
HOOCN•	(hydridodioxido)nitridocarbonate(•1-)	
HOOCO•	(hydridodioxido)oxidocarbon(•)	
HOOS•	see HSO <sub>2</sub> <sup>•</sup>	
HO <sub>3</sub> <sup>•</sup>	hydridotrioxxygen(•)	trioxidanyl, (hydrogen trioxide)
	see also O <sub>3</sub> <sup>•-</sup>	
HS•	hydridosulfur(•)	sulfanyl
HSO <sub>2</sub> <sup>•</sup>		
	HOOS•	hydridosulfidodioxygen(•)
	HOSO•	hydroxidooxidosulfur(•)
	HSOO•	(hydridosulfido)dioxygen(•)
HSe•	hydridoselenium(•)	selanyl
H <sub>2</sub> CN•	dihydridonitridocarbon(•)	
H <sub>2</sub> NO•	dihydridooxidodinitrogen	aminoxyl
H <sub>2</sub> NCO•		
	H <sub>2</sub> NCO•	(dihydridonitrido)oxidocarbon(•)
	H <sub>2</sub> NCOH•	(hydridonitrido)hydroxidocarbon(•)
	see also HNCO•	
(HO) <sub>2</sub> <sup>•+</sup>	bis(hydridoxygen)( <i>O-O</i> )(•1+) <sup>e</sup>	dioxidaniumyl
H <sub>2</sub> S <sup>•+</sup>	dihydridosulfur(•1+)	sulfaniumyl
(HS) <sub>2</sub> <sup>•-</sup>	bis(hydridosulfide)( <i>S-S</i> )(•1-) <sup>e</sup>	disulfanuidyl
(HSe) <sub>2</sub> <sup>•-</sup>	bis(hydridoselenide)( <i>Se-Se</i> )(•1-) <sup>e</sup>	diselanuidyl
ICl <sub>2</sub> <sup>•</sup>	dichloridoiodine(•)	
IO <sub>2</sub> <sup>•2-</sup>	oxidoiodate(•2-)	
NH <sub>2</sub> <sup>•</sup>	dihydridonitrogen(•)	azanyl
NH <sub>2</sub> NH•	hydridobis(hydridonitrogen)( <i>N-N</i> )(•)	diazanyl, (hydrazinyl)
	trihydridodinitrogen( <i>N-N</i> )(•) <sup>e</sup>	

Continued on next page

Table 2 Continued

Formula	Coordination Name or Element Name	Substitutive Name (Allowed Name in Parentheses)	
$(\text{NH}_2)_2^{*+}$	bis(dihydridonitrogen)( <i>N-N</i> )(•1+) <sup>c</sup>	diazaniumyl, (hydrazaniumyl)	
$\text{NH}_3^{*+}$	tetrahyrido-dinitrogen ( <i>N-N</i> )(•1+) <sup>c</sup>	azaniumyl, ammoniumyl	
$\text{NO}^\bullet$	trihydridonitrogen(•1+)	oxoazanyl, (nitrogen monoxide)	
$\text{NO}^{(2+)-}$	oxidonitrogen(•)		
	oxidonitrate(2•1-) (triplet)		
	see also $\text{HON}^{2+}$		
$\text{NO}_2^\bullet$	dioxidonitrogen(•)	nitrosooxidanyl, (nitrogen dioxide)	
$\text{NO}_2^{*2-}$	dioxidonitrate(•2-)		
$\text{NO}_3^\bullet$	trioxidonitrogen(•)	nitrooxidanyl, (nitrogen trioxide)	
$\text{NO}_3^\bullet$	$\text{ONOO}^\bullet$	(dioxido)oxidonitrogen(•) (oxidoperoxidonitrogen(•))	nitrosodioxidanyl
$\text{NO}_3^{*2-}$	trioxidonitrate(•2-)		
$\text{N}_2\text{O}^{*+}$	oxidodinitrate(•1-)		
$(\text{NO})_2^{*+}$	bis(oxidonitrate)( <i>N-N</i> )(•1-)		
$\text{N}_3^\bullet$	trinitrogen(2 <i>N-N</i> )(•)		
$\text{NS}^\bullet$	sulfidonitrogen(•)	(nitrogen monosulfide)	
$\text{N}_6^{*-}$	hexanitride(•1-)		
$\text{O}_2^\bullet$	oxygen, monooxygen(2•)(triplet)	oxidanediyl, (oxygen atom) <sup>c</sup>	
$\text{O}^-$	oxide(•1-)	oxidanidyl, (oxide(1-))	
	see also $\text{HO}^\bullet$		
$\text{OCN}^\bullet$	nitridooxidocarbon(•)		
$\text{OCN}^{*2-}$	nitridooxidocarbonate(•2-)		
$\text{ONOO}^\bullet$	see $\text{NO}_3^\bullet$		
$\text{O}_2^{2+}$	dioxygen(2•)(triplet)	dioxidanediyl	
$\text{O}_2^{*+}$	dioxygen(•1+)		
$\text{O}_2^{*-}$	dioxide(•1-)	dioxidanidyl	
	see also $\text{HO}_2^\bullet$		
$(\text{OCN})_2^{*+}$	bis(nitridooxidocarbonate)( <i>N-N</i> )(•1-)		
	bis(nitridooxidocarbonate)( <i>O-O</i> )(•1-)		
$\text{O}_3^{*-}$	trioxide(•1-)	trioxidanidyl	
	see also $\text{HO}_3^\bullet$		
$\text{PH}_2^\bullet$	dihydridophosphorus(•)	phosphanyl	
$\text{PO}^\bullet$	oxidophosphorus(•)	oxophosphanyl (phosphorus monoxide)	
$\text{PO}_3^{*2-}$	trioxidophosphate(•2-)		
	see also $\text{HOPO}_2^{*-}$		
$\text{PO}_4^{*2-}$	tetraoxidophosphate(•2-)		
	see also $\text{HOPO}_3^{*-}$		
$\text{PO}_5^{*2-}$	(dioxido)trioxidophosphate(•2-)		
	see also $\text{HOPO}_4^{*-}$		
$\text{S}^-$	sulfide(•1-)	sulfanidyl	
$\text{SCN}^\bullet$	nitridosulfidocarbon(•)		
$\text{SO}_2^\bullet$	dioxidosulfate(•1-)		
$\text{SO}_3^\bullet$	trioxidosulfate(•1-)		
$\text{SO}_4^\bullet$	tetraoxidosulfate(•1-)		
	see also $\text{HOSO}_3^\bullet$		



Table 2 Continued

Formula	Coordination Name or Element Name	Substitutive Name (Allowed Name in Parentheses)
SO <sub>5</sub> <sup>•-</sup> see also HOSO <sub>4</sub> <sup>•</sup>	(dioxido)trioxidosulfate(•1-)	
S <sub>2</sub> <sup>•-</sup>	disulfide(•1-)	disulfanidyl
(SCN) <sub>2</sub> <sup>•-</sup>	bis(nitridosulfidocarbonate)(S-S)(•1-)	
S <sub>2</sub> O <sub>3</sub> <sup>•-</sup>	trioxidosulfidosulfate(S-S)(•1-)	
S <sub>4</sub> O <sub>6</sub> <sup>•3-</sup>	bis[(trioxidosulfato)sulfate](S-S)(•3-)	
Se <sup>•-</sup>	selenide(•1-)	selanidyl
SeO <sub>3</sub> <sup>•-</sup>	trioxidoselenate(•1-)	
SiO <sub>3</sub> <sup>•-</sup>	trioxidosilicate(•1-)	
TeO <sub>3</sub> <sup>•-</sup>	trioxidotellurate(•1-)	

<sup>a</sup> The formulae for the radicals are listed in alphabetical order, according to the principles outlined in section I-4.6.1.3 of Ref. 1. The halogens have mostly similar radical species. To avoid unnecessary repetition only the names of chlorine containing radicals are given. For all radicals a coordination name is given; sometimes a substitutive or an allowed name is also mentioned.

<sup>b</sup> As an example, in case of a N-N bond the name would be bis(nitridocarbonate)(N-N)(•1-).

<sup>c</sup> Compared to monohydrogen(•) or monochlorine(•), the names hydrogen atom or chlorine atom are less desirable.

<sup>d</sup> The name perhydroxyl is sometimes used, but is undesirable.

<sup>e</sup> With respect to the first name, the connectivity is stated, but as there are no other possibilities, it can be omitted. The second name leads to the same structure and is also allowed.

### 3.3. Substitutive nomenclature

The substitutive names are derived from the names of the parent hydrides, e.g., methane, azane, oxidane, phosphane, and sulfane for CH<sub>4</sub>, NH<sub>3</sub>, H<sub>2</sub>O, PH<sub>3</sub> and H<sub>2</sub>S, respectively [3]. They contain appropriate suffixes to indicate the radical nature ('yl') and charge, see Table 3. The suffixes -iumyl and -idyl indicate positive and negative charge, respectively, in addition to the presence of an unpaired electron. As shown, when suffixes are combined, 'yl' is placed at the end. The following two examples, based on dioxidane for hydrogen peroxide, explain how names of radicals are created by the operations shown in Table 3. The name for O<sub>2</sub><sup>•-</sup> is derived from dioxidane by loss of H<sub>2</sub><sup>•+</sup> in two steps: first a hydron, H<sup>+</sup>, is removed to give dioxidanide, followed by loss of H<sup>•</sup>, which then gives the name dioxidanidyl.

Table 3 Suffixes used for designating radicals and radical ions (after Table 1 of Ref. 3)

Operation <sup>a</sup>	Suffix for (i)	Suffix for (i) + (ii)
(a) Loss of H <sub>2</sub>	(i) loss of H <sup>•</sup> -yl	(ii) loss of H <sup>•</sup> ylo...yl -diyl
(b) Loss of H <sub>2</sub> <sup>•+</sup>	(i) loss of H <sup>+</sup> -ide	(ii) loss of H <sup>•</sup> -idyl
(c) Loss of H <sub>2</sub> <sup>•-</sup>	(i) loss of H <sup>-</sup> -ylum	(ii) loss of H <sup>•</sup> -ylumyl
(d) Loss of e <sup>-</sup>	(i) addition of H <sup>+</sup> -ium -onium	(ii) loss of H <sup>•</sup> -iumyl -oniumyl
(e) Addition of e <sup>-</sup>	(i) addition of H <sup>-</sup> -uide	(ii) loss of H <sup>•</sup> -uidyl

<sup>a</sup>The starting point is the parent hydride. Operation = (i) + (ii)

Dioxidaniumyl ( $\text{H}_2\text{O}_2^{\bullet+}$ ) is created in a similar fashion from dioxidane by first adding a hydron, and then removing a hydrogen atom. Note that dioxidaniumyl,  $\text{H}_2\text{O}_2^{\bullet+}$ , is a radical, but dioxidanylium,  $\text{HO}_2^+$ , is not.

*Examples:*

<b>Substitutive nomenclature</b>		<b>Coordination nomenclature</b>
1. $\text{H}_2\text{S}^{\bullet+}$	sulfaniumyl	dihydrosulfur( $\bullet 1+$ )
2. $\text{HO}^\bullet$	oxidanyl	hydridoxygen( $\bullet$ )
3. $\text{O}_2^{\bullet+}$	dioxidanyliumyl	dioxygen( $\bullet 1+$ )
4. $\text{S}^{\bullet-}$	sulfanidyl	sulfide( $\bullet 1-$ )
5. $\text{BH}_3^{\bullet-}$	boranuidyl	trihydroboride( $\bullet 1-$ )
6. $\text{CH}_3\text{C}^\bullet\text{HOH}$	1-hydroxyethyl	hydridohydroxidomethanidocarbon( $\bullet$ )
7. $\text{CO}_2^{\bullet-}$	oxidooxomethyl	dioxidocarbonate( $\bullet 1-$ )
8. $\text{NO}_3^\bullet$	nitrooxidanyl	trioxidonitrogen( $\bullet$ )

## REFERENCES AND NOTES

1. IUPAC. *Nomenclature of Inorganic Chemistry, Recommendations 1990*, G. J. Leigh (Ed.) Blackwell Scientific Publications, Oxford, 1990 (The Red Book).
2. J. G. Traynham. A short guide to nomenclature of radicals, radical ions, iron-oxygen complexes and polycyclic aromatic hydrocarbons. *Adv. Free Radical Biol. Med.* **2**, 191 (1986).
3. IUPAC. Revised nomenclature for radicals, ions, radical ions and related species, Recommendations 1993, W. H. Powell (Ed.), *Pure Appl. Chem.* **65**, 1357 (1993).
4. It has been suggested that: 'Radicals are promiscuous molecules that react with anything that passes by' (*Newsweek*, 1993).
5. The word 'free' in front of 'radical' is obsolete and should not be used [1,3].
6. In the description of solid state compounds the superscript dot indicates positive charge on ions, see section I-6.4.4 of Ref. 1, which is an unfortunate conflict.
7. W. H. Koppenol. NO comments. *Nature* **367**, 28 (1994).
8. The term 'oxo' in the nomenclature of organic chemistry refers strictly to an oxygen attached to a carbon with a double bond; in inorganic chemical nomenclature the term 'oxo' refers to a single oxygen atom attached to the central atom regardless of the bond order, as in 'ihydrogen tetraoxosulfate'.