

Nomenclature of Coordination Compounds: Present Status*

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I. INTRODUCTION

When Alfred Werner proposed the concept of coordination, he pointed out how prevalent is this pattern of combination among chemical compounds. The years since Werner's proposal have borne out the wisdom of his vision. Despite the vast increase in the number and variety of known compounds and the elaboration of a great amount of theory about chemical combination, the essentials of Werner's theory remain unchanged. Werner further proposed a system of nomenclature peculiarly adapted to coordination compounds. This system also continues in use although it has been extensively modified. Today, there is an increasing tendency to name new compounds according to coordination nomenclature principles. Even for older compounds with well-established names, there is a shift toward names based on the coordination pattern. It is well to take stock of the present status of the nomenclature of coordination compounds to see what has been accomplished and what remains to be done.

Several publications have reviewed the historical development of the nomenclature of coordination compounds. These reviews have pointed out the need for greater systematization and have offered specific suggestions.²¹⁻²⁴ A convenient way to assess the extent to which problems arising in the nomenclature of coordination compounds have been solved and to which agreement on solutions of these problems has been obtained is to examine critically the actions of official bodies in incorporating coordination principles into recommended nomenclature practices. The outstanding document in this connection is the 1957 Report of the Commission on the Nomenclature of Inorganic Chemistry of the International Union of Pure and Applied Chemistry (IUPAC).^{1,2,4} Another document of great importance is the statement of policy on "The Naming and Indexing of Chemical Compounds" followed by *Chemical Abstracts* (CA).⁵

The first portion of this article is concerned with an analysis of the practices recommended by the IUPAC report and of those followed by CA insofar as they concern coordination compounds. The second portion consists of a discussion of problem areas not yet covered either by the IUPAC report or the CA statement of policy. For several of these problem areas there are as yet no suggested solutions.

II. PRACTICES COVERED BY IUPAC AND CA

A previous publication²³ set forth desirable practices in the nomenclature of coordination compounds as a series of rules. These rules will be repeated here (at times in altered form) with the same numbers as in the original publication. That section of the IUPAC report relating to each rule will be given in parentheses in each instance.

*Chemical Abstracts*⁵ has accepted the IUPAC report for the naming of coordination compounds with certain exceptions. When it is necessary to refer to these exceptions, sections and pages of the CA statement of policy will be given in parentheses with the letters CA preceding the numbers of the section and page.

Note: It is always difficult to obtain agreement on matters of nomenclature. This is particularly true at the international level and between workers in the different branches of chemistry. The committees on inorganic nomenclature in this country have not found it possible to accept the IUPAC report in all details. The items of difference are made clear in the United States version of the Rules.¹ There are good working relations between the British and American workers in nomenclature matters, and the views of the latter are generally shared by the former. However, the British version of the Rules contains no comments. All versions of the Rules contain names for organic compounds and groups which are not wholly satisfactory to organic chemists. The IUPAC Commission on the Nomenclature of Inorganic Chemistry is working closely with its counterpart in Organic Chemistry to bring about a greater degree of unity in matters of nomenclature. However, the existing situation makes any discussion such as the present one difficult. In attempting to adapt the published principles to the naming of individual compounds not specifically covered by the Rules, one is often forced to make some rather arbitrary decisions. In the present instance, all such decisions have been made within the spirit of the Rules unless specific reasons for such departure are stated. Examples have been chosen so as to cover a wide variety of compounds and thus demonstrate the versatility of the system of nomenclature.

Before considering any set of rules, it is important to consider the definition of terms which must of necessity be used in those rules. Perhaps the most confusing item in discussions of coordination compounds is the use of the word "complex." Historically, the theory of coordination was advanced to explain the nature of a group of sub-

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stances which were known as "complex salts." Many chemists still like to speak of a "coordination complex" because this is a convenient way to designate a common characteristic among entities which may be either neutral or charged. Unfortunately, it is not possible to reserve a word with a general meaning for a specific use with a restricted meaning. Almost every chemist would be likely to refer to a complicated assemblage of atoms as a "complex." If, subsequently, he or someone else goes further and by association relates this "complex" to a general class known as "complexes," at least no one should be surprised. It is probably for this reason that the expression "Werner complex" is frequently encountered. The author prefers to speak of a "coordination entity" rather than a "complex" even though "complex" appears both in the IUPAC rules and the CA statement of policy.

The following terms (7.1) with the generally accepted meanings are considered suitable by the IUPAC Commission: central or nuclear atom; coordinating atom and group; ligand, chelate ligand; multidentate, unidentate, bidentate, etc.; bridging group; complex; ionic charge expressed as superior n^+ or n^- (1.31); polynuclear complex, mononuclear, dinuclear. American committees prefer *central atom* or *center of coordination* to *nuclear atom* and *polycentric* or *bridged complex* to *polynuclear complex*. The common experience of both organic and inorganic nomenclature students is that Greek-Latin hybrid terms such as *polydentate* and *monodentate* are used more than all-Latin terms such as *multidentate* and *unidentate*.

Rule 1. Order of Listing Ions.—The cation is named first, followed by the anion (2.15).

$[\text{Rh}(\text{NH}_3)_6]^{3+}$, 3NO_3^-	hexaamminerhodium(III) nitrate
3K^+ , $[\text{Al}(\text{C}_2\text{O}_4)_3]^{3-}$	potassium trioxalatoaluminate
$[\text{Co}(\text{den})_2]^{3+}$, $[\text{Cr}(\text{CN})_6]^{3-}$	bis(diethylenetriamine)cobalt(III) hexacyanochromate(III)

Rule 2. Characteristic Endings of Coordinated Groups.—These are negative, -o; neutral, none; positive, none. (It should be noted that the name of a positively charged group often has the ending -ium.)

negative, -o: CN^- , cyano-
neutral, none: NH_3 , ammine
positive, none: H_2NNH_3^+ , 4Cl^- , hydrazinium
$[\text{Pt}(\text{NH}_3)_2(\text{H}_2\text{NNH}_3)_2]^{4+}$, 4Cl^- , diamminedihydrazinium-
platinum(II) (tetra)chloride

In general, if the anion name ends in -ide, -ite, or -ate, the final -e is replaced by -o, giving -ido, -ito, and -ato, respectively (7.311). Certain exceptions are permitted (7.312) such as fluoro and chloro. Ligands derived from organic compounds not normally called acids but which function as such in complex formation by loss of a proton should be treated as anionic and given the ending -ato (7.313). Anions derived from hydrocarbons are given radical names without -o but are counted as negative when computing the oxidation number (7.324).

The name of the coordinated molecule or cation is to be used without change (7.231) except "aquo" and "ammine" (7.322). The groups NO, NS, CO, and CS, when linked directly to a metal atom, are to be treated as neutral in computing the oxidation number (7.323).

Chemical Abstracts has introduced modifications and additions to this rule. First, names for a few common

ligands (CA 57, p. 8N) are used which differ from those in the IUPAC report (see hydro, hydroxy, peroxy, mercapto, thioxo, dithio, and hydroperoxy in Table I).

Table I. List of Coordinated Groups

Note: Numbers in parentheses refer to the section of the IUPAC report where the name is given; *ions* refers to the "List of Names for Ions and Radicals" in the IUPAC report; CA indicates that the name was used in "The Introduction to the Subject Index" of CA either in the text or the lists in appendixes.

A. Negatively charged (anionic) groups

1. Inorganic

a. Singly charged groups

- amido, NH_2^- (7.311; CA)
- azido, N_3^- (7.311; CA)
- bromato, BrO_3^- (CA)
- bromo, Br^- (7.312; CA)
- chlorato, ClO_3^- (ions; CA)
- chlorito, ClO_2^- (ions)
- chloro, Cl^- (5.24; 7.311; 7.312; CA)
- cyanato, $\text{O}=\text{C}\equiv\text{N}^-$ (ions; CA)
- cyano, CN^- (5.24; 7.312; CA)
- dihydrogen phosphato, H_2PO_4^- (CA)
- fluoro, F^- (5.24; 7.312; CA)
- hydrazido, N_2H_3^- (ions)
- hydrido, H^- (7.311) (see hydro)
- hydro, H^- (CA) (see hydrido)
- hydrogen carbonato, HCO_3^- (ions)
- hydrogen peroxo, HO_2^- (ions) (see hydroperoxy)
- hydrogen sulfato, HSO_4^- (CA)
- hydrogen sulfito, HSO_3^- (7.311)
- hydroperoxy, HO_2^- (CA) (see hydrogen peroxo)
- hydroxo, OH^- (5.24; 7.312) (see hydroxy)
- hydroxy, OH^- (CA) (see hydroxo)
- hydroxylamido, NHOH^- (ions)
- hypochlorito, ClO^- (ions)
- hyponitrito, HN_2O_2^- (ions)
- hypophosphito, H_2PO_2^- (ions)
- iodato, IO_3^- (CA)
- iodo, I^- (7.312; CA)
- isocyanato, $\text{N}=\text{C}=\text{O}^-$ (CA)
- isothiocyanato, $\text{N}=\text{C}=\text{S}^-$ (7.33; CA)
- mercapto, SH^- (CA) (see thio)
- metaperiodato, IO_4^- (CA)
- metaphosphato, PO_3^- (CA)
- metavanadato(V), VO_3^- (CA)
- nitrate, NO_3^- (CA)
- nitrito, ONO^- (7.33; CA)
- nitro, NO_2^- (7.33; CA)
- perchlorato, ClO_4^- (CA)
- periodato, IO_4^- (CA) (error?, see metaperiodato)
- selenocyanato, $\text{Se}=\text{C}=\text{N}^-$ (ions; CA)
- sulfamato, H_2NSO_3^- (CA)
- tellurocyanato, $\text{Te}=\text{C}=\text{N}^-$ (ions; CA)
- thiocyanato, $\text{S}=\text{C}=\text{N}^-$ (7.311; CA)
- thio, SH^- (7.312) (see mercapto)

b. Doubly charged groups

- carbonato, CO_3^{2-} (ions; CA)
- dichromato(VI), $\text{Cr}_2\text{O}_7^{2-}$ (CA)
- dihydrogen pyrophosphato, $\text{H}_2\text{P}_2\text{O}_7^{2-}$ (CA)
- disulfido, S_2^{2-} (7.312) (see dithio)
- dithio, S_2^{2-} (CA) (see disulfido)
- hydrogen phosphato, HPO_4^{2-} (CA)
- hydrogen phosphito, HPO_3^{2-} (CA) (see phosphito)
- imido, NH^{2-} (ions; CA)
- N-nitrohydroxylaminato, $\text{N}_2\text{O}_3^{2-}$ (CA)
- oxo, O^{2-} (7.312; CA)

- oxotrifluoroborato, BOF_3^{2-} (CA)
 peroxy, O_2^{2-} (ions) (see peroxy)
 peroxy, O_2^{2-} (CA) (see peroxy)
 phosphito, HPO_3^{2-} (ions) (see hydrogen phosphito)
 selenato, SeO_4^{2-} (ions; CA)
 selenito, SeO_3^{2-} (ions; CA)
 seleno, Se^{2-} (ions; CA)
 selenosulfato, SSeO_3^{2-} (CA)
 sulfato, SO_4^{2-} (ions; CA)
 sulfito, SO_3^{2-} (ions; CA)
 telluro, Te^{2-} (ions)
 thio, S^{2-} (7.312) (see thioxo)
 thiocarbonato, CO_3S^{2-} (CA)
 thioxo, S^{2-} (CA) (see thio)
 thiosulfato, $\text{S}_2\text{O}_3^{2-}$ (7.311; CA)
 trithiocarbonato, CS_3^{2-} (CA)
- c. Triply charged groups
 arsenato, AsO_4^{3-} (ions) (see orthoarsenato)
 hydrogen pyrophosphato, $\text{HP}_2\text{O}_7^{3-}$ (CA)
 nitrido, N^{3-} (7.311; CA)
 orthoarsenato, AsO_3^{3-} (CA) (see arsenato)
 phosphato, PO_4^{3-} (ions; CA)
 phosphido, P^{3-} (ions)
- d. Quadruply charged groups
 hydrogen triphosphato, $\text{HP}_3\text{O}_{10}^{4-}$ (CA)
 pyrophosphato, $\text{P}_2\text{O}_7^{4-}$ (CA)
 (tetrametaphosphato), $\text{P}_4\text{O}_{12}^{4-}$ (CA)
- e. Quintuply charged groups
 hydrogen orthotellurato(VI), HTeO_6^{5-} (CA)
 orthoperiodato, IO_6^{5-} (CA)
 (triphosphato), $\text{P}_3\text{O}_{10}^{5-}$ (CA)
- f. Sextuply charged groups
 orthotellurato(VI), TeO_6^{6-} (CA)
2. Organic
- a. Singly charged groups
 acetato, CH_3CO_2^- (7.412)
 acetylacetonato, $\text{CH}_3\text{COCHCOCH}_3^-$ (7.313) (see 2,4-pentanedionato)
 benzenethiolato, $\text{C}_6\text{H}_5\text{S}^-$ (CA)
 benzyloxy, $\text{C}_6\text{H}_5\text{CH}_2\text{O}^-$ (CA)
 4'-bromo-*N*-hydroxythiocarbanilidato,
 $p\text{-BrC}_6\text{H}_4\text{NHCS-N(O)C}_6\text{H}_5^-$ (CA)
 butoxy, $\text{CH}_3(\text{CH}_2)_3\text{O}^-$ (CA)
sec-butoxy, $\text{C}_2\text{H}_5\text{CH}(\text{CH}_3)\text{O}^-$ (CA)
tert-butoxy, $(\text{CH}_3)_3\text{CO}^-$ (CA)
 cinnamyloxy, $\text{C}_6\text{H}_5\text{CH}=\text{CHCH}_2\text{O}^-$ (CA)
 cyclopentadienyl, C_5H_5^- (7.324)
 decyloxy, $\text{CH}_3(\text{CH}_2)_9\text{CH}_2\text{O}^-$ (CA)
 dimethylglyoximate, $\text{HON}=\text{C}(\text{CH}_3)\text{C}(\text{CH}_3)=\text{NO}^-$ (7.313)
 dodecyloxy, $\text{CH}_3(\text{CH}_2)_{10}\text{CH}_2\text{O}^-$ (CA)
 ethanethiolato, $\text{C}_2\text{H}_5\text{S}^-$ (7.412)
 ethoxo, $\text{C}_2\text{H}_5\text{O}^-$ (ions) (see ethoxy)
 ethoxy, $\text{C}_2\text{H}_5\text{O}^-$ (CA) (see ethoxo)
 ethyl, C_2H_5^- (CA)
 ethynyl, $\text{HC}\equiv\text{C}^-$ (7.324; CA)
 formaldehyde oximate, $\text{CH}_2=\text{NO}^-$ (CA)
 furil dioximate, $\text{HON}=\text{C}(2\text{-C}_4\text{H}_7\text{O})\text{C}(2\text{-C}_4\text{H}_7\text{O})\text{NO}^-$ (CA)
 glycinate, $\text{H}_2\text{NCH}_2\text{COO}^-$ (CA)
 heptyloxy, $\text{CH}_3(\text{CH}_2)_5\text{CH}_2\text{O}^-$ (CA)
 hexyloxy, $\text{CH}_3(\text{CH}_2)_4\text{CH}_2\text{O}^-$ (CA)
 hydrogen oxalato, HC_2O_4^- (CA)
 hydrogen succinato, $\text{HOOCCH}_2\text{CH}_2\text{COO}^-$ (CA)
 hydrogen tartrato, $\text{HOOCCH}(\text{OH})\text{CH}(\text{OH})\text{COO}^-$ (CA)
 isobutoxy, $(\text{CH}_3)_2\text{CHCH}_2\text{O}^-$ (CA)
 isohexyloxy, $(\text{CH}_3)_2\text{CH}(\text{CH}_2)_3\text{CH}_2\text{O}^-$ (CA)
 isopentyloxy, $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{O}^-$ (CA)
 isopropoxy, $(\text{CH}_3)_2\text{CHO}^-$ (CA)
 methanethiolato, CH_3S^- (7.312; CA)
 methoxo, CH_3O^- (7.312) (see methoxy)
 methoxy, CH_3O^- (CA) (see methoxo)
 methyl, CH_3^- (CA)
 nonyloxy, $\text{CH}_3(\text{CH}_2)_7\text{CH}_2\text{O}^-$ (CA)
 octyloxy, $\text{CH}_3(\text{CH}_2)_6\text{CH}_2\text{O}^-$ (CA)
 2,4-pentanedionato, $\text{CH}_3\text{COCHCOCH}_3^-$ (CA) (see acetylacetonato)
 pentyloxy, $\text{CH}_3(\text{CH}_2)_4\text{CH}_2\text{O}^-$ (CA)
tert-pentyloxy, $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{O}^-$ (CA)
 phenoxy, $\text{C}_6\text{H}_5\text{O}^-$ (CA)
 phenyl, C_6H_5^- (5.24; 7.324; CA)
 phenylethynyl, $\text{C}_6\text{H}_5\text{C}\equiv\text{C}^-$ (7.324; CA)
 propoxy, $\text{CH}_3\text{CH}_2\text{CH}_2\text{O}^-$ (CA)
 propyl, $\text{CH}_3(\text{CH}_2)_2^-$ (7.412)
 8-quinolinolato, $\text{C}_8\text{H}_6\text{NO}^-$ (7.313)
 salicylaldehydato, $o\text{-OCHC}_6\text{H}_4\text{O}^-$ (7.313)
 salicylato, $o\text{-HOC}_6\text{H}_4\text{COO}^-$ (CA)
 triiodoethyl, $\text{C}_2\text{H}_5\text{I}_3^-$ (CA)
 undecyloxy, $\text{CH}_3(\text{CH}_2)_9\text{CH}_2\text{O}^-$ (CA)
- b. Doubly charged groups
 1,2-dithioöxalato, $^-\text{SOCCOS}^-$ (7.33; CA)
N,N'-ethylenebis(salicylideneiminato),
 $(o\text{-OC}_6\text{H}_4\text{CH}=\text{NCH}_2^-)_2$ (7.313)
 furil dioximate(2-), $[-\text{C}(2\text{-C}_4\text{H}_7\text{O})=\text{NO}^-]_2$ (CA)
 3-hydroxy-2-butanone oximate(2-),
 $\text{CH}_3\text{CH}(\text{O}^-)\text{C}(\text{CH}_3)=\text{NO}^-$ (CA)
 oxalato, $^-\text{OOC}\text{COO}^-$ (7.33; CA)
 phthalocyaninato, $\text{C}_{12}\text{H}_8\text{N}_4^{2-}$ (CA)
 salicylato(2-), $o\text{-OC}_6\text{H}_4\text{COO}^-$ (CA)
 succinato, $(-\text{CH}_2\text{COO}^-)_2$ (CA)
 tartrato, $[-\text{CH}(\text{OH})\text{COO}^-]_2$ (CA)
- c. Triply charged groups
 tartrato (3-), $^-\text{OOCCH}(\text{O}^-)\text{CH}(\text{OH})\text{COO}^-$ (CA)
 $[(o\text{-carboxyphenyl})\text{imino}]_3\text{diacetato}$,
 $o\text{-}^-\text{OOC}\text{C}_6\text{H}_4\text{N}(\text{CH}_2\text{COO}^-)_2$ (CA)
- B. Neutral groups
1. Inorganic
 ammine, NH_3 (7.322; CA)
 aquo, H_2O (7.322; CA)
 carbonyl, CO (7.323; CA)
 nitrosyl, NO (7.312; 7.323; CA)
 phosphorus trichloride, PCl_3 (7.7)
 thiocarbonyl, CS (7.323)
 thionitrosyl, NS (7.323) (see comment under rule 2)
2. Organic
 2,2'-bipyridine, $(\text{C}_5\text{H}_4\text{N})_2$ (CA) (see dipyriddy)
 dimethylamine, $(\text{CH}_3)_2\text{NH}$ (7.322)
 (2-dimethylaminoethyl) (2-aminoethyl) sulfide,
 $(\text{CH}_3)_2\text{NCH}_2\text{CH}_2\text{SCH}_2\text{CH}_2\text{NH}_2$ (7.33)
 dimethylglyoxime, $[\text{C}(\text{CH}_3)\text{NOH}]_2$ (7.321)
N,N'-dimethyl-2,2'-thiobis(ethylamine),
 $(\text{CH}_3\text{NHCH}_2\text{CH}_2)_2\text{S}$ (CA)
 1,4-diphenyl-1,3-butadiene, $(-\text{CH}=\text{CHC}_6\text{H}_5)_2$ (CA)
 dipyriddy, $(\text{C}_5\text{H}_4\text{N})_2$ (7.321) (see 2,2'-bipyridine)
 ethylene, $\text{H}_2\text{C}=\text{CH}_2$ (7.321; CA)
 ethylenediamine, $(-\text{CH}_2\text{NH}_2)_2$ (7.321; CA)
 methylamine, CH_3NH_2 (7.321; CA)
 methyl isocyanide, CH_3NC (5.33)
 methyl sulfide, $(\text{CH}_3)_2\text{S}$ (CA)
 phenyl isocyanide, $\text{C}_6\text{H}_5\text{NC}$ (7.321)
 1,2,3-propanetriamine, $\text{H}_2\text{NCH}(\text{CH}_2\text{NH}_2)_2$ (IUPAC Organic Comm., CA)
 pyridine, $\text{C}_5\text{H}_5\text{N}$ (7.321; CA)
 1,2,3-triaminopropane, $\text{H}_2\text{NCH}(\text{CH}_2\text{NH}_2)_2$ (7.321) (see 1,2,3-propanetriamine)
 triethylamine, $(\text{C}_2\text{H}_5)_3\text{N}$ (7.7; CA)
 triethylarsine, $(\text{C}_2\text{H}_5)_3\text{As}$ (7.412; CA)

triethylphosphine, $(C_2H_5)_3P$ (7.321)
 triethyl phosphite, $(C_2H_5O)_3P$ (7.412)
 triphenylphosphine, $(C_6H_5)_3P$ (7.323)

C. Positively charged (cationic groups)

1. Inorganic

hydrazinium, $H_2NNH_3^+$ (3.17)
 hydrazonium, $H_2NNH_3^+$ (CA 337, p. 51N)

2. Organic

2,3-diaminopropylammonium, $H_2NCH_2CH_2CH_2NH_3^+$ (7.321)

Second, the use of the termination "ato" has been modified. The "ato" ending on names of ligands derived from organic acids (CA 57, p. 8N) implies that the hydrogen has been lost from all acid groups in the molecule even though some of these groups may not be included in the parent name but rather given as substituents; *e.g.*, the ligand [(*o*-carboxyphenyl)imino]diacetato, $o-OOCCH_2N(CH_2COO^-)_2$, has a negative charge of three. For ligands derived from organic acids containing hydroxyl or other groups which have also lost hydrogen, CA designates the charge in parentheses after the name of the ligand; *e.g.*, $^-OOCCH(O^-)CH(OH)COO^-$ is tartrato(3-).

Finally, CA (57, p. 8N) considers hydrocarbon and other organic radicals attached through carbon to be neutral organic ligands in determining the order of citation (see Rule 3 below) even though they are counted as negative when computing the oxidation number of the central atom (or atoms) of a coordination entity.

The ligand names given in Table I are compiled from the report of the Commission and from the CA statement.

A complete list of common ligands would be much larger than that of Table I. While for many of these, suitable names are obvious, for others, there is no accepted pattern for deriving a suitable name or else there is disagreement even among those actively engaged in research on the ligand in question. It would be rather pointless to compile an enlarged list of common ligands until agreement has been reached on many of the items discussed in the last section.

Comment: The present situation concerning the characteristic endings of coordinated groups requires a good deal of comment.

Although most positively charged coordinated groups are polyamines with an uncoordinated quaternary amine present, a few simple groups, notably NO, are known to coordinate as a positively charged unit. Some chemists would like to indicate this in the names when it is definitely established. The earlier suggestion of extending the termination -ium to such cases was not adopted by the Commission probably because NO^+ is neither a metal nor an "onium" type of ion.

Hydrazonium is preferred by CA (CA 337, p. 51N). Hydrazinium is given in both the inorganic (3.153) and organic³ (921.5, p. 197) reports of the IUPAC commissions.

Both IUPAC and CA use the term acid in a restricted sense. Since dissociation constants can be measured for practically all compounds which furnish negative ligands, there is no reason why they should not be "normally called acids." Similarly, OH is an "acid group" in the same sense that COOH is.

The neutral group, thionitrosyl, NS, should be removed from the Rules (7.323) and Table I. The compound which

was thought to be $Pt^0(NS)_4$ has been shown to be $Pt^{II}(S_2N_2H)_2$ and a derivative of the ligand $HNSNS^-$.^{34,44}

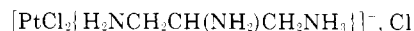
The scheme which CA has introduced for designating the charge on a ligand will avoid a good deal of confusion. Further, it is in harmony with the scheme introduced by Ewens and Bassett²⁰ and used by IUPAC for naming $N_2H_5^+$ and $N_2H_6^{2+}$ (3.17). However, the practice of citing organic radicals with neutral groups seems needlessly confusing.

The matter of deriving suitable names for anionic ligands will be discussed further in section III.

Rule 3. Order of Classes of Ligands.—In names, the central atom(s) is placed *after* the ligands (7.21). The order of citation of ligands is anionic ligands first, followed by neutral and cationic ligands (7.25) without separation by hyphens.

$[Co(NO_2)(NH_3)_5]^{2+}$	nitropentaamminecobalt(III) ion
$[PtCl_2(N_2H_4)(N_2H_5)]^+$, Cl^-	dichloro(hydrazine)hydrazinium-platinum(II) chloride
K^+ , $[Ni(CN)(CO)_3]^-$	potassium cyanotricarbonylnickelate(0)

In formulas the symbol for the central atom(s) is normally placed *first* (except in formulas which are primarily structural), followed by anionic ligands and then the neutral and cationic ligands, and the formula for the whole complex particle, ion, or molecule, is placed in square brackets (7.21). (The use of braces, {}, within brackets is recognized (7.321).)



dichloro(2,3-diaminopropylammonium)platinum(II) chloride

Comment: Good arguments have been presented for the order: positive, neutral, negative groups.^{20,23} These arguments are still valid.

Rule 4. Order within Classes of Ligands.—Anionic ligands are cited in the following order: (1) H^- ; (2) O^{2-} , OH^- ; (3) other simple anions (*i.e.*, one element only); (4) polyatomic inorganic anions; (5) organic anions in alphabetical order (7.251). Within group 3 the ions shall be cited in the order B, Si, C, Sb, As, P, N, H, Te, Se, S, At, I, Br, Cl, oxygen anions apart from O^{2-} (*i.e.*, O_2^{2-} , etc.), F (2.16; 6.332). Within group 4, anions containing the smallest number of atoms shall be cited first (*e.g.*, CO_3^{2-} precedes CrO_4^{2-}), and in the case of two ions containing the same number of atoms, they are cited in the order of decreasing atomic number of the central atoms (*e.g.*, CrO_4^{2-} precedes SO_4^{2-} (6.332)).

Neutral and cationic ligands shall be cited in the following order: (1) H_2O , NH_3 ; (2) other inorganic ligands in the sequence in which their coordinating elements appear in the list given for group 3 just above; (3) organic ligands in alphabetical order (7.252).

K^+ , $[CrO_3Cl]^-$	potassium trioxochlorochromate(VI)
$2NH_4^+$, $[OsNCl_5]^{2+}$	ammonium nitridopentachlorosmate(VI)
Na^+ , $[B(OCH_3)_3H]^-$	sodium trimethoxohydridoborate
Na^+ , $[Co(NO_2)_2(C_5H_7O_2)_2]^-$	sodium dinitrobis(2,4-pentanedionato)cobaltate(III)
$2K^+$, $[CrO_2(O_2)(CN)_2(NH_3)]^{2+}$	potassium dioxoperoxodicyanaminochromate(VI)

$[\text{PtCl}_2\text{NH}_3(\text{C}_2\text{H}_5)]$	dichloroammine(ethylene)- platinum(II)
$[\text{CoH}_2\text{O}(\text{NH}_3)_5]^{3+}, 3\text{Cl}^-$	aquopentaamminecobalt(III) chloride

Chemical Abstracts retains the classes of ligands given in the rule but uses an alphabetical order within groups 3–5 of anions and 2–3 of neutral or cationic groups (including organic radicals) (CA 57, p. 8N). Further, CA considers all ligands containing carbon (including CO, CN[−], etc.) to be organic.

Comment: No part of the IUPAC report has received as much objection, both in the United Kingdom and in the United States, as the order within classes of ligands. Some would insist on a completely alphabetical order while others prefer an alphabetical order within the various groups. The symbol H should be omitted from the order of elements (group 3, anions) because it has already been listed previously. Most U. S. chemists prefer to list H[−] last not first.

Rule 5. Use of Numerical Prefixes.—The prefixes *di-*, *tri-*, *tetra-*, etc. are used before simple expressions and the prefixes *bis-*, *tris-*, *tetrakis-*, etc. before complex expressions. All complex expressions are enclosed in parentheses, if necessary (2.251, 6.34).

$[\text{Fe}(\text{H}_2\text{NCH}_2\text{CH}_2)_2\text{NH}]^{2+}$	bis(diethylenetriamine)iron(II) ion
$[\text{Mn}(\text{C}_5\text{H}_7\text{O}_2)_3]$	tris(2,4-pentanedionato)manganese- (III)
$[\text{Mo}(\text{CO})_3(\text{C}_2\text{H}_5)_2\text{S}]_3$	tricarbonyltris(diethyl sulfide)molyb- denum(0)
$[\text{CoCl}_2(\text{HON}=\text{CCH}_3)_2]$	dichloro(dimethylglyoxime)cobalt- (II)

Whenever there is any possibility of confusion in names where the name fragments dichloro(ethylene), bis(thiocyanato), tris(thiourea), etc. are present, the use of multiplicative prefixes and parentheses will make the meaning clear.

Chemical Abstracts approaches this problem in a very different manner (CA 57, p. 9N):

"Whenever the name of a ligand is not simple like chloro, nitro, sulfato, etc., enclosing marks are used. Non-simple ligands fall into the following classes: (1) all whole molecules except water, ammonia, carbon monoxide, and nitrogen oxide (NO) (the ligand names are aquo, ammine, carbonyl and nitrosyl, respectively); (2) anionic ligands derived from organic molecules (2,4-pentanedionato, glycinate, salicylate, phthalocyaninate, etc.); (3) substituted organic radicals (as phenylethynyl); (4) ligands whose names consist of more than one word (as methyl sulfide, formaldehyde oximate, hydrogen sulfato); (5) ligands whose names contain numerical prefixes (as triphosphato); (6) most thio (and seleno and telluro) analogs of oxo anions (as thiocarbonato, thiooxalato). The parentheses around names of these non-simple ligands are required at all times, even when only one of them occurs in a complex and there is no numerical prefix preceding it. For example: $\text{Cu}(\text{P}_3\text{O}_{10})^{3-}$, (triphosphato)cuprate(II). (Without the parentheses the name 'triphosphatocuprate(II)' would represent the ion $\text{Cu}(\text{PO}_4)_3^{7-}$.) When more than one of these non-simple ligands occurs in a complex, the number occurring is designated by the numerical prefixes *bis-*, *tris-*,

tetrakis-, etc., rather than *di-*, *tri-*, *tetra-*, etc. Thio (and seleno and telluro) analogs of oxo anions are considered to be non-simple ligands unless the parent oxo anion contained only one oxygen atom and the thio analog could therefore only contain one sulfur atom. Thus, thiocyanato, isothiocyanato, selenocyanato, and tellurocyanato are considered simple. Thiosulfato is also considered simple because it is the only known thio derivative of SO_4^{2-} . Although carbonato, cyanato, cyano, isothiocyanato, oxalato, and thiocyanato (and Se and Te analogs) fall in class (2) of non-simple ligands, they are considered to be exceptions and treated as simple ligands. The contracted ligands methoxy, ethoxy, propoxy, isopropoxy, butoxy, *sec*-butoxy, *tert*-butoxy, isobutoxy, and phenoxy are considered to be simple. Unsubstituted hydrocarbon and other organic radicals attached through carbon are considered simple and not enclosed in parentheses. For example: $\text{Na}[\text{AlI}_3(\text{C}_2\text{H}_5)_3]$, Sodium triiodoethylaluminate; $\text{Na}[\text{B}(\text{C}_6\text{H}_5)_4]$, Sodium tetraphenylborate; $\text{Na}[\text{AlH}_3(\text{C}_2\text{H}_5)_3]$, Sodium trihydro(triiodoethyl)aluminate."

Comment: The purpose of this rule is to obtain such clarity that each name signifies one, and only one, substance. It was so written that whenever there was any possibility of ambiguity, one was free to use parentheses to avoid it. The important question is whether CA has simplified the rule or made it more complicated.

Rule 6. Terminations for Anions.—The characteristic termination for an anionic coordination entity is *-ate*, or *-ic* if named as an acid. There are no characteristic terminations for cationic or neutral coordination entities (7.24).

$3\text{K}^+, [\text{Co}(\text{NO}_2)_6]^{3-}$	potassium hexanitrocobaltate(III)
$\text{H}_4[\text{Fe}(\text{CN})_6]$	hydrogen hexacyanoferrate(II) or hexacyanoferric(II) acid
$\text{H}_3[\text{Mn}(\text{CN})_6]$	hexacyanomanganic(III) acid or hydrogen hexacyanomanganate- (III)

Rule 7. Designation of Oxidation Number.—The oxidation number of the central element is designated by a Roman numeral in parentheses: for a cationic or neutral coordination entity, after the name of the central element; for an anionic entity, after the termination *-ate* (7.22); for an acid, after the termination *-ic*. The oxidation numbers 0, *−I*, and *−II* are recognized in addition to the more common ones (7.323, 7.324).

Note: The arabic 0 is used for zero; mention of the oxidation number is permissive but *not necessary* (1) when the number of ionized atoms or groups is given in the name or (2) when naming a neutral coordination entity.

$[\text{Rh}(\text{C}_2\text{H}_5\text{N}_3)_3]^{3+}, 3\text{NO}_3^-$	tris(ethylenediamine)rhodium(III) nitrate
or	tris(ethylenediamine)rhodium tri- nitrate
$\text{K}^+, [\text{SbCl}_5\text{C}_6\text{H}_5]^-$	potassium pentachloro(phenyl)- antimonate(V)
$4\text{K}^+, [\text{Mo}(\text{CN})_8]^{4-}$	potassium octacyanomolybdate(IV)
or	tetrapotassium octacyano- molybdate
$4\text{K}^+, [\text{Ni}(\text{C}_2\text{C}_6\text{H}_5)_4]^{4+}$	potassium tetrakis(phenylethynyl)- nickelate(0)

$[\text{Co}(\text{NO}_2)_3(\text{NH}_3)_3]$ trinitrotriamminecobalt(III) (the indication of oxidation state may be omitted)

Rule 8. Bridging Groups.—A bridging group is indicated by adding the Greek letter μ immediately before its name and separating this from the rest of the name by a hyphen. Two or more bridging groups of the same kind are indicated by di- μ -, etc. (7.411).

If the number of central atoms bound by one bridging group exceeds two, the number is indicated by adding a subscript numeral to the μ (7.412) (see "basic beryllium acetate" in list of examples).

Note: The order of listing bridging groups cannot always follow that given in Rule 3.

$[(\text{NH}_3)_5\text{Cr}-\text{OH}-\text{Cr}(\text{NH}_3)_5]^{3+}, 5\text{Cl}^-$
 μ -hydroxo-bis{pentaamminechromium(III)} chloride

$\text{AuBrPr}_2-\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2-\text{AuBrPr}_2$
 μ -ethylenediamine-bis{bromodi-*n*-propylgold(III)}

$[(\text{CN})_5\text{Co}-\text{CN}-\text{Fe}(\text{NH}_3)_5]$
 pentacyanocobalt(III)- μ -cyano-pentaammineiron(III)

$[(\text{CO})_5\text{Fe}(\text{SEt})_2\text{Fe}(\text{CO})_5]$
 di- μ -ethanethiolato-bis{tricarbonyl-iron(I)}

$[(\text{en})_2\text{Co} \begin{array}{c} \text{NH}_2 \\ \diagup \quad \diagdown \\ \text{O}_2 \end{array} \text{Co}(\text{en})_2]^{4+}, 2\text{SO}_4^{2-}$
 μ -amido- μ -peroxo-tetrakis(ethylenediamine)dicobalt(III,IV) sulfate

$[(\text{NH}_3)_2\text{Co} \begin{array}{c} \text{HO} \quad \text{HO} \\ \diagdown \quad \diagup \\ \text{HO} \quad \text{HO} \end{array} \text{Co} \begin{array}{c} \text{HO} \quad \text{HO} \\ \diagup \quad \diagdown \\ \text{HO} \quad \text{HO} \end{array} \text{Co}(\text{NH}_3)_2]^{3+}$
 bis{tri- μ -hydroxo-triamminecobalt(III)} cobalt(III) ion

$[\text{Au}(\text{CN})(\text{C}_3\text{H}_7)_2]_4$ cyclo-tetra- μ -cyano-tetrakis(diisopropyl gold) (the structure is a square with an Au at each corner and a CN group along each side).

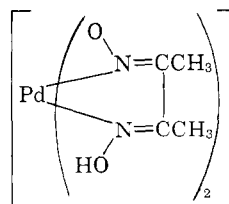
$[\text{CuI}(\text{Et.As})_4]$ tetra- μ_3 -iodo-tetrakis{triethylarsinecopper(I)} (the structure is a tetrahedron with a Cu at each apex and an I above the center of each triangular face)

$[\text{Be}_4\text{O}(\text{CH}_3\text{COO})_6]$ μ_4 -oxo-hexa- μ -acetato-tetraberyllium (the structure of "basic beryllium acetate" is a tetrahedron with a Be at each apex and an O in the center with $\text{O}=\text{C}(\text{CH}_3)-\text{O}$ along each side)

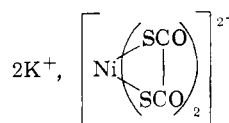
Comment: The IUPAC Commission did not consider the case where more than one kind of bridging group is present in the coordination entity. The previous suggestion²³ was that the letter μ be repeated before the name of each bridging group.

There are many other facets to the matter of bridging groups. Some of these are discussed in section III.

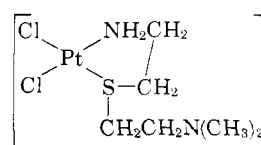
Rule 9. Designation of the Point of Attachment.—For ligands which are capable of attachment by different atoms, the point of attachment may be denoted by adding at the end of the name of the ligand the symbol for the atom by which attachment occurs (7.33).



bis(dimethylglyoximate-*N,N'*)-palladium(II)



potassium bis(dithiooxalato-*S,S'*)-nickelate(II)



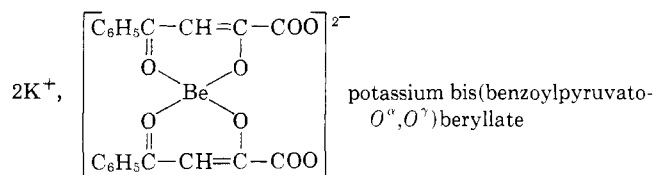
dichloro{*N,N*-dimethyl-2,2'-thiobis(ethylamine)-*N',S*}platinum(II)

Note: The name for the thio-diamine is taken from CA and not the IUPAC report.

CA (CA 57, p. 9N) has not extended its adoption of the IUPAC report to the designation of the points of attachment to central atoms.

Comment: Although it is recognized that some groups, like the ions of cysteine and dithizone, have alternate modes of attachment to a center of coordination, there has been no extensive study of the conditions determining which of two or more sets of sites are involved in coordination. As such studies are conducted there will be great need for this rule.

In some cases, it will even be desirable to designate which of several of the same kind of atoms are active in coordination. One way of handling this situation is to use Greek letters to designate the position on the carbon chain of the elements through which coordination occurs.



potassium bis(benzoylpyruvato- $\text{O}^\alpha, \text{O}^\gamma$)beryllate

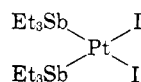
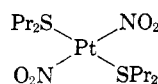
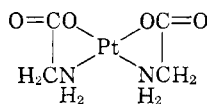
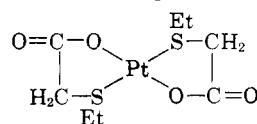
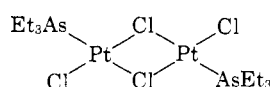
(The Greek letters are used here just as they are used to designate α -amino acids and β -keto esters.)

The sense of this rule will also be useful in designating which of alternate sites are involved in bridging (see section III).

Rule 10. Designation of Structural Isomerism in the Ligand.—Structural isomerism in the ligand is designated by the use of different terms for the stoichiometrically equivalent groups. Recognized terms are: thiocyanato ($-\text{SCN}$) and isothiocyanato ($-\text{NCS}$); nitro ($-\text{NO}_2$) and nitrito ($-\text{ONO}$) (7.33). Alternatively, the atom or atoms through which the ligand is attached to the center of coordination may be designated by adding the symbol for that atom as in Rule 9 above.

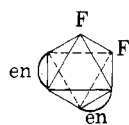
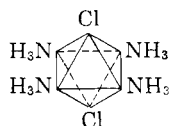
Rule 11. Designation of Geometrical Isomerism in the Coordination Sphere.—Geometrical isomerism is designated alternatively by the prefixes *cis*-, *trans*-, *asym*-, or *sym*- (2.19, 7.23, 7.412) or by numbers.

Planar configuration

*cis*-diiodobis(triethylstibine)-platinum(II)*trans*-dinitrobis(di-*n*-propyl sulfide)-platinum(II)*cis*-diglycinatoplatinum(II) or *cis*-bis(aminoacetato)platinum(II)*trans*-bis(ethylthio)acetato-platinum(II)*sym-trans*-di- μ -chloro-bis(chloro(triethylarsine)diplatinum(II) }

Note: The other two isomers of the last example are *asym*- and *sym-cis*-.

Octahedral configuration

*cis*-difluorobis(ethylenediamine)-cobalt(III) ion*trans*-dichlorotetraamminechromium-(III) ion

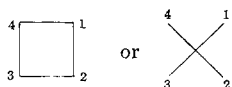
Similarly, one might use *cis*- (or facial) and *trans*- (meridial or peripheral) to distinguish between



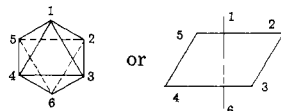
Although this latter kind of isomerism was recognized by Werner, there was no authentic example of it until very recently, *i.e.*, $[\text{Rh}(\text{py})_3\text{Cl}_3]$, yellow and orange brown forms.¹⁷

Comment: Although the IUPAC Commission made no recommendation on the use of numbers to designate coordination positions, such systems are often used. They are usually based on the following patterns.

Planar configuration



Octahedral configuration



Hence the names for the first two examples under planar configurations are:

- 1,2-diiodo-3,4-bis(triethylstibine)platinum(II)
1,3-dinitro-2,4-bis(di-*n*-propyl sulfide)platinum(II)

The third and fourth examples are more easily named by the use of *cis*- and *trans*-. However, a numbering system readily distinguishes the three isomers of $[\text{Pt}(\text{NO}_2)(\text{NH}_3)(\text{H}_2\text{NOH})(\text{C}_5\text{H}_5\text{N})]^-$, Cl^- :

1-nitro-2-hydroxylamine-3-pyridine-

4-ammineplatinum(II) chloride

1-nitro-2-hydroxylamine-3-ammine-

4-pyridineplatinum(II) chloride

1-nitro-2-ammine-3-hydroxylamine-

4-pyridineplatinum(II) chloride

No numbering system has yet been proposed for bridged structures such as the fifth example (bridged platinum compound) above.

For octahedral configurations, the *cis* isomer of Ma_2b_4 becomes 1,2- and the *trans* isomer 1,6-. The isomers of Ma_3b_3 become 1,2,3- or *cis*- and 1,2,6- or *trans*-. Once again structures with more than two different ligands require a numbering system.

Note: Chernyaev's method for describing coordination formulas by designating the constituents which are at opposite ends of the coordination axes²⁷ has been little used outside of the Russian literature. While the system has considerable versatility, it cannot compare in general usefulness with a numbering system.

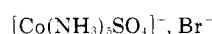
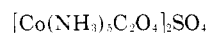
The question of numbering systems is discussed more fully in section III.

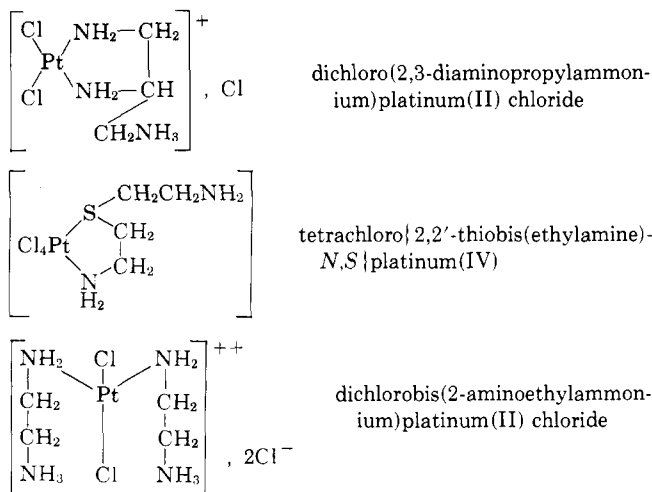
Note: The IUPAC Commission made no comment to cover the practice in the area of the following rule.

Rule 12. Designation of Optical Isomerism.—Where optical isomerism can occur the optically active compound is designated by (+) or (−) depending upon the sign of rotation; alternatively, *d*- or *l*- may be used. The racemic mixture is designated by (±) or *dl*- and the inactive form by *meso*-.

It is evident that the situation is more complex than is indicated by such a simple rule. Actually, there are three distinct kinds of asymmetry that may contribute to the rotatory power of a coordination entity: (1) that due to the arrangement of ligands around a center of coordination; (2) that present in the ligands themselves; and (3) that arising through the coordination of a ligand. It is often desirable to distinguish among these. Often times *D* and *L* have been used to designate the first type of asymmetry, and *d* and *l*, the second. However, *D* and *L* have already been pre-empted for another use in naming strictly organic optically active compounds. Further, the property of rotatory dispersion among coordination compounds is normally more complicated than among strictly organic compounds. It is not uncommon to find that the sign of rotation actually reverses within the visible spectrum so that not only the magnitude of the rotation, but the designation (+) or (−) often requires that the wave length of the light used in the measurement be specified. The entire question of nomenclature related to optical isomerism needs thorough study.

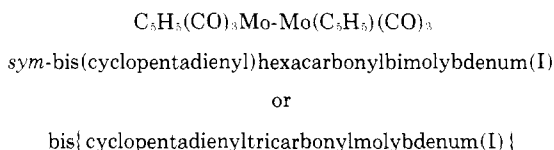
Rule 13. Coordination of Groups in Lower Functionality than Usual.—The nomenclature of compounds involving monocoordination of bifunctional groups and the dicoordination of polyfunctional groups, etc., usually can be handled according to the rules previously given (7.33) if the usual coordination number of the central atom is kept in mind.

sulfatopentaamminecobalt(III)
bromideoxalatopentaamminecobalt(III)
sulfate



Note: The names for the thiodiamine in the next to last example above is taken from CA and not the IUPAC report.

Rule 14. Direct Linkage of Coordination Centers.—The direct linking of two centers of coordination is designated by the prefix *bi-* before the name of the coordination centers.



Comment: Neither IUPAC (7.323) nor CA recognizes the difference between the situations in which two centers of coordination are linked *through* bridging groups and two centers *directly* linked.

Recently a significant number of compounds with direct linking of coordination centers has been prepared. Because it is important that such linkages be indicated in the names, this problem is discussed in section III.

Rule 15. Coordinated Oxide Ions.—Since oxide ions are best regarded as occupying specific coordination positions, they should be designated in the name rather than to use *-yl* to designate oxy ions as centers in coordination compounds. Example: $\text{UO}_2(\text{C}_5\text{H}_7\text{O}_2)_2$ is dioxobis(2,4-pentanedionato)uranium(VI) instead of uranyl acetylacetonate.

Comment: Although the IUPAC report makes no mention of this rule, its acceptance is implied in the report (3.13; 7.312). It is gratifying to note that the practice of this rule is being followed in much of the current literature.

Note: The IUPAC Commission made no comment to offer guidance for practice in the area of the following rule.

Rule 16. Abbreviations in Formulas.—In writing the formulas of coordination compounds, simple abbreviations for complicated molecules are often used. Agreement on abbreviations is needed because practices are varied.

Among the examples given in the 1957 IUPAC Report, the following abbreviations are used: *en*, *dipy*. The Report expresses preference for $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ instead of $[\text{Co} \cdot 6\text{NH}_3]\text{Cl}_3$ (2.18), and uses two different practices for abbreviations: $[\text{Fe}(\text{dipy})_3]\text{Cl}_2$ and $[\text{Co} \text{ en}_3]_2(\text{SO}_4)_3$. The first is unlikely ever to lead to confusion whereas the omission of the spacing in the last could easily do so.

Comment: There are many other aspects of the use of abbreviations which deserve attention. These are discussed in section III.

The following rule was initiated by the IUPAC Commission.

Rule 17. Extended Structures.—Where bridging causes an indefinite extension of the structure, it is best to name compounds primarily on the basis of their over-all composition (7.42). Examples: $(\text{Cs}^+)_n[(\text{CuCl}_3)_n]^{n-}$, cesium catena- μ -chloro-dichlorocuprate(II); $(2\text{K}^+)_n[(\text{HgCl}_4)_n]^{2n-}$, potassium catena-di- μ -chlorodichloromercurate(II); $(\text{Mg}^{++})_n[\text{SiO}_3]_n^{2n-}$, magnesium catena- μ -oxo-dioxosilicate (a pyroxene).

Comment: This rule does not include all types of extended structures for which good nomenclature practices are desired. In addition to the simple chains, there are ladders as represented by Sb_2O_3 and the amphiboles, complex bands such as NH_4CdCl_3 , layers such as the micas, and three-dimensional networks such as the feldspars. Presumably it should be possible to develop a nomenclature system which would indicate the structural features of each of these classes.

The current activity in this field of coordination polymers highlights the importance of a suitable means for designating various types of extended structures. The matter is discussed in section III.

III. AREAS FOR FUTURE DEVELOPMENT

Considering the many items involved in the nomenclature of coordination compounds, it is gratifying that the IUPAC commission has gone so far in reaching agreement on desirable practices. The adoption by CA for indexing purposes of most of the practices of the IUPAC commission will make users of CA much more aware of the principles of nomenclature in this field. There remains, however, the need for agreement on several minor items and a few major ones. Comments on several of the former have been included in the comments under individual rules. Those items requiring more extensive discussion are included in this section.

1. Endings for Organic Ligands.—While practically all anionic ligands are given the ending *-o*, the letters immediately preceeding the *-o* usually reflect the ending of the free anion: *amide*, *amido*; *chlorite*, *chlorito*; and *carbonate*, *carbonato*. However, in several cases, the *-ido* has been shortened to *-o*: *bromide*, *bromo-*; *cyanide*, *cyano*; *oxide*, *oxo*; etc. Metal salts of weak organic acids are often named with a terminal *-ate*: acetylacetonate (2,4-pentanedione), sodium acetylacetonate; 8-hydroxyquinoline (8-quinolinol), 8-hydroxyquinolinato (or oxinate); dimethylglyoxime, dimethylglyoximate; etc. Very likely it was this practice which led the IUPAC Commission to recommend (7.313): "Ligands derived from organic compounds not normally called acids but which function as such in complex formation by loss of a proton should be treated as anionic and given the ending *-ato*" (see Rule 2 above). However, the practice in naming anions of weak organic acids is by no means universally that of giving a terminal *-ate*: triphenylmethide, dimethylamide, acetylde, etc. Strict adherence to the *-ato* ending leads to some peculiar and, at times, misleading names: methanethiolato- certainly doesn't indicate the similarity of CH_3S^- to CH_3O^- .

or methoxo- (although both are recommended by the IUPAC Inorganic Commission); 8-quinolinolato leads to an odd piling up of vowels which doesn't occur to the same extent in 8-quinolinolo; salicylaldehydato is misleading because the *ato* seems to imply that the proton was lost from the aldehyde group; etc. Perhaps it would be better to let the terminal letters reflect the parent protonated neutral species or corresponding anion as is true for inorganic ligands (dimethylamido, methanethiolo, dithiosemicarbazido, etc.) and, unless there are compelling reasons for doing otherwise, use the simple -o in all other cases: 2,4-pentanediono, 8-quinolinolo, dimethylglyoximo, etc.

2. Agreement of Ligand Names with Organic Nomenclature Practices.—One does not need to have much experience with nomenclature problems to become aware of the wide divergence between the practices in the naming of inorganic and organic compounds. Many of those who have attempted to reconcile the two basically different patterns of nomenclature have been driven in despair to conclude that, perhaps, there must be two, rather than one, systems of nomenclature. Such a situation would be most unfortunate for an area of chemistry like coordination compounds where one is frequently dealing with substances that are simultaneously both organic and inorganic. A big step toward a uniform system of nomenclature would be accomplished if, in the names of coordination compounds, one made certain that the names for organic ligands were those which harmonize with good organic nomenclature practices. However, even this apparently simple matter will not be accomplished easily.

In general, coordination chemists use trivial names for organic ligands to a greater extent than would an organic chemist. Perhaps this is because the state of complexity requiring careful attention to nomenclature, came about at a much earlier time in organic than in inorganic chemistry. Such unacceptable (to the organic chemist) names as acetylacetone, dipyridyl, etc., and such trivial names as cupferron, oxine, dithizone, etc. have been used widely in the literature of coordination compounds.^a The names in the first group are easily replaced by the accepted names: 2,4-pentanedione, 2,2'-bipyridine, etc. While the latter or trivial group will continue in common parlance, it should be recognized that they are trivial names and the accepted name should be used for titles, indexes, etc. In general, for coordinated neutral units there is no problem because the accepted name for the ligand can be incorporated directly into the name for the coordination entity. However, there is a problem in many cases for the coordination of organic anions.

The IUPAC Commission on the Nomenclature of Organic Chemistry³ (Rules C-10.1-10.5) recognizes groups to be designated by compulsory prefixes (chloro-, nitro-, methoxy-, methylthio-, etc.) and other groups which may be cited either as suffixes or prefixes to the name of the parent compound. Of the latter groups, one kind must be cited as suffix (the principal group) but only one kind. This practice necessitates an order of priority for citation as suffix: -onium groups, acids, aldehydes and ketones, alcohols and phenols, amines, ethers in decreasing priority

with S analogs immediately following the corresponding O compounds. Other rules (C-206.1-206.2, C-511.3-511.4) govern the names for salts of alcohols and thiols: CH_3ONa , sodium methanolate or methoxide; $\text{C}_6\text{H}_5\text{CH}_2\text{ONa}$, sodium benzyl alcoholate or oxide; $\text{C}_2\text{H}_5\text{SNa}$, sodium ethanethiolate or ethyl sulfide; $\text{NaSC}_6\text{H}_4\text{SO}_2\text{ONa}$, disodium *p*-sulfidobenzenesulfonate but not *p*-mercaptobenzenesulfonate.

The construction of names for coordination compounds calls for a terminal -o on all group names for coordinated anions. Thus, the -ate of an anion name becomes -ato, and -ide becomes -ido (frequently -ide becomes -o as in chloro-) (see 1.2 above). Hence, the order of priority for groups becoming suffixes presents no problems for amino acids (acids over amines), aminoacetato for $\text{H}_2\text{NCH}_2\text{COO}^-$, and for amino thiols (alcohols over amines), 2-aminoethanethiolato or -thiolo for $\text{H}_2\text{NCH}_2\text{CH}_2\text{S}^-$. For the ligand (*o*- $\text{OC}_6\text{H}_4\text{CH}=\text{N}-\text{CH}_2$)₂, the Inorganic Commission of IUPAC used the name *N,N'*-ethylenebis-(salicylideneiminato). This produces a problem. Although aldehydes have priority over phenols, as the name indicates, it is the phenol which has lost a proton, but the name does not clearly indicate this. The name, α,α' -(ethylenedinitrilo)di-*o*-cresolato which has the approval of the Organic Commission and is used by *Chemical Abstracts*, leaves no doubt as to the place from which the proton was lost. Similarly, the ligand ($-\text{CMe}=\text{NCH}_2\text{CH}_2\text{S}^-$)₂ has been designated dimethylethanediylidenedinitrilobis(2-ethanethiolo)³³ which once again avoids difficulty. It is significant to note in the above cases that the coordination chemist runs into difficulty in exactly those cases where the organic chemist has difficulty naming an anion.

However, there will continue to be many places where the practices of coordination compound nomenclature conflict directly with the principles of strictly organic nomenclature. Already the IUPAC Inorganic Rules have endorsed the organic radical names phenyl, ethynyl, cyclopentadienyl, etc. in designating compounds such as $\text{K}[\text{B}(\text{C}_6\text{H}_5)_4]$, $\text{K}_2[\text{Cu}(\text{C}_2\text{H})_4]$, and $\text{Fe}(\text{C}_5\text{H}_5)_2$ as opposed to the names phenylo, ethyno, cyclopentadieno (or -dienido), etc. which are logical extensions of accepted practices for the nomenclature of coordination compounds. Further concessions undoubtedly will be necessary.

There remain still other cases where, in order to indicate the coordinated character of the ligand, it is necessary to depart quite definitely from accepted practices in organic nomenclature or to develop practices to meet situations which do not arise in organic nomenclature. The problems arising in naming metal derivatives of dyes and of ligands with variable patterns of coordination such as the amino polyacids were discussed in an earlier publication.²³

In the effort to reach uniformity between inorganic and organic nomenclature practices, much has been said in this presentation for acceptance on the part of inorganic chemists of the well-established practices of organic nomenclature. However, it should not be assumed that all concessions must come from one side. If organic chemists will only familiarize themselves with the simplicity of the coordination pattern of nomenclature and with its capability for expansion to include so many varieties of compounds, they will come to realize that items like peroxy- for peroxo- which appear on first sight to be

^a The incorporation of such a trademark as "Versenate" into names for coordination compounds (which has been done) is not only undesirable from the point of view of nomenclature but violates legal restrictions on the use of trademarks.

tremendously important, become relatively insignificant as compared to forcing a break in a uniform practice of the final -o for all negatively charged groups.

3. Use of Double Vowels.—Because some of the numerical prefixes end in vowels and many of the names for ligands begin with vowels, it is inevitable that there are many cases where there will be two vowels together if one follows the rules strictly. In practice, some authors write hexammine and others hexammine. It is desirable that some rule be established which states under what conditions vowels will be repeated or one of them dropped (elided). In *Chemical Abstracts*¹² the elision of a vowel before another vowel is the exception rather than the rule. It is done systematically only before functional suffixes, as in the names acenaphthenol, naphthalenetetrol, chrysene-tetrone, and butanetetramine, and in fusion names of cyclic compounds only with carbocyclic prefixes such as benz(o), acenaphth(o), naphth(o), and cyclopent(a). Hence, *Chemical Abstracts* uses monooxalate, diiodo, tetraammine, hexamino (when used as a suffix, -hexamine is the custom). From this analysis one recommends against elision of a vowel unless the nature of the organic ligand naturally calls for it.^b

4. Agreement of Abbreviations and Their Use.—If there is confusion over suitable names for organic ligands, there is absolute chaos in the use of abbreviations. At least three distinct patterns are discernible:

a. The long established use of uncapitalized abbreviations begun by Werner with *en* for ethylenediamine and continued by other early writers in the field:

en	ethylenediamine
pn	propylenediamine (1,2-propanediamine)
py	pyridine
dipy	dipyridyl (2,2'-bipyridine) - also dip
phen	<i>o</i> -phenanthroline (1, 10-phenanthroline)
trpy	tripyridyl (2,2':6', 2''-terpyridine)
acac	acetylacetonato (2,4-pentanedione or -ato)

Perhaps the most recent additions to this list to become widely accepted are those due to Schwarzenbach⁴⁷:

den	diethylenetriamine (dien has also been used)
ptn	1,2,3-propanetriamine
tren	tris(2-aminoethyl)amine
trien	triethylenetetramine

b. The use of capitalized abbreviations (also long established but not as extensively used) after the pattern of abbreviations for organic radicals (Me, Et, etc.):

Ox	oxalato
Cy	cyano
Ac	acetylacetonato (2,4-pentanedione)- also AcAc
Ac	acetato (not for acetyl, as used by <i>Chemical Abstracts</i>)

c. The use of several capitals (wide spread but of more recent origin):

EDTA	ethylenediaminetetraacetic acid
HEDTA	<i>N</i> -(2-hydroxyethyl)ethylenediaminetriacetic acid
NTA	nitriolotriacetic acid
TTA	2-thienyltrifluoroacetone

^b Anyone who consults the American version of IUPAC rules¹ will declare that this discussion is pointless because the recommended practices have already been adopted. However, the original version of these rules² elides the vowels in such cases as tetraoxo and pentaammine almost consistently. The British version,¹ on the other hand, shows many cases where vowels have been elided and even more where a hyphen has been used (penta-ammine, etc.).

These abbreviations arise from a general current practice in the chemical literature and in industry of representing long names by capitalizing the beginning letters of key units making up the name. Sometimes this practice results in long abbreviations like CHENTA for cyclohexane-1,2-diaminotetraacetic acid, which raises the question of how long an abbreviation should be.

Finally, there are abbreviations for group names:

Ch ⁵² or Ke ¹¹	chelate
L	ligand
M or Me	metal

The use of L seems to produce no difficulties but Me is widely used as a symbol for the methyl group. A choice should be made between Ch and Ke for chelate group.

The use of abbreviations is much too convenient for one ever to think that they will be abolished. Further, each of these systems has advantages and areas where its use is well established. However, one can still hope that it will be possible to enunciate some general principles covering the use of abbreviations. A few principles might be adopted now which would prevent the situation from becoming more confused than it is already.

1. Use abbreviations which conform to accepted organic names rather than to trivial names. Thus *bipy* would be preferable to *dipy*.

2. Do not use a widely recognized abbreviation as evidenced by the practice of *Chemical Abstracts* and other major reference works (*e.g.*, Me or Ac), to represent a species other than that normally represented by the abbreviation.

3. Instead of using little-known abbreviations, represent the structure of the ligands when possible by well-established abbreviations whenever no significantly larger number of characters is required. There is little justification for using Cy instead of CN. The use of HCAC₂ (Ac = acetyl) for the anion from 2,4-pentanedione is only one character longer than AcAc and leaves no doubt as to the structure of the coordinated species. This general pattern can be used for methylene substitution products, CMeAc₂, and a variety of other β -diketone anions, HCBzAc, HCBz₂, etc. Such practice has the additional advantage of permitting the use of R, R', etc. to write general formulas for general classes of compounds.

4. With any but a select few abbreviations, be sure that the meaning of the abbreviation is given where it is first used. A corollary would be to never use an abbreviation in a title.

Perhaps it is even possible to go a step farther and agree on some other aspects of the use of abbreviations. Non-capitalized abbreviations like *en* could be reserved for neutral ligands whereas the capitalized abbreviations could refer to groups as is already the practice with Me, Ph, Bz, etc. Within a coordination entity there is no need to show a charge but, when used to indicate a simple anion, the charge could be added.

In addition to the simple abbreviations, there are a number of what might be called derived abbreviations. If one is dealing with the protonated form of an anionic ligand, it is easy to represent the neutral (or less highly charged) species by adding H to the abbreviation:

Big ⁴⁵ = biguanido	HBig = biguanide
Dmg = dimethylglyoximo	HDmg = dimethylglyoxime

Similarly, if one has an alkyl or aryl substituted ligand and the common abbreviation is for the unsubstituted ligand, it is easy to add the abbreviation for the hydrocarbon radical to that for the unsubstituted ligand.

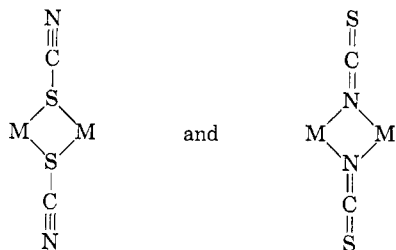
Big = biguanido

Ph₂Big⁴⁶ = diphenylbiguanido

It is evident that in one case Big = C₂H₅N₃ whereas in the other Big = C₂H₄N₃. Since the abbreviation does not always represent the same group, there is some chance of confusion. The use of bipyO₂²³ for bipyridine *N,N'*-dioxide is less objectionable because bipy stands for the same group alone and in bipyO₂.

Recently another need has arisen and has been solved in a logical manner which, however, introduces a totally new practice. Under extreme conditions it becomes possible to remove a proton from a normally neutral ligand for which there is a well-recognized abbreviation. What is easier than writing (en-H)?^{8,54} Yet even here one must be careful not to confuse the minus sign with the dash indicating a bond. Further, the symbol (en-2H) gives no indication as to whether the ligand is symmetrical or unsymmetrical. Finally, for many amines like trien the protons may be lost from one or more nonequivalent positions.

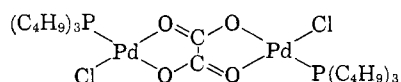
5. Bridging Groups.—Aside from the problems mentioned under Rule 8, it is conceivable that a case may arise where it will be necessary to designate through which of two possible atoms the bridging takes place. This can be done by the usual practice of designating the point of attachment. Just suppose that the thiocyanate ion could serve as a bridging group in two ways.



The first could be designated as di- μ -thiocyanato-*S*- or thiocyanato and the second as di- μ -thiocyanato-*N*- or isothiocyanato.

Some interesting compounds have been prepared recently in which R₂P⁻ is a bridging group³⁰ and as such would be called μ -dialkylphosphido. However, a problem will arise if, at some future time, RP²⁻ should be found to be a bridging group (both NH₂⁻ and NH²⁻^{15,55} are known to be bridging groups). The name μ -alkylphosphido does not distinguish RP²⁻ from RHP⁻ nor reflect the double negative charge on the group. Perhaps μ -alkylphosphido-(2-) and μ -alkylphosphido(1-) or μ -alkylphosphido(-2H) and μ -alkylphosphido(-H) would clearly distinguish between bridging by RP²⁻ and RHP⁻.¹⁰

Not only may a bridging group link more than two centers of coordination but also the same bridging group may be attached to the same center by more than one linkage. Consider the substance of the structure³⁷



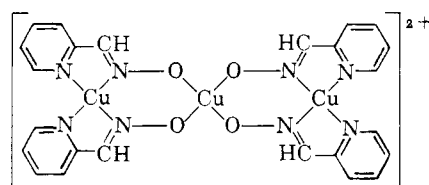
The structure would not be evident unless the functionality of the bridging group is indicated in some manner. Since a subscript numeral is used to designate the number (in excess of two) of central atoms bound by one bridging group, a superscript numeral or a numeral in parentheses immediately after μ might indicate the functionality of the bridging group.^c

dichlorobis(tributylphosphine)- μ^4 -oxalato-dipalladium(II)

or

$\mu(4)$ -oxalato-bis[chloro(tributylphosphine)palladium(II)]

Normally, one thinks of a ligand forming a bridge between two centers of coordination but there are several instances where a center of coordination forms a bridge between two coordination systems. This takes place by a further reaction of reactive sites on already coordinated ligands; e.g.,³⁵



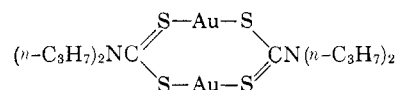
tetrakis(pyridine-2-carboxaldoximo)tricopper(II) ion

or

bis[bis(pyridine-2-carboxaldoxime-H)copper(II)]copper(II) ion

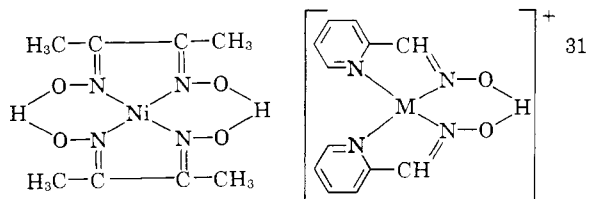
However, the naming of such polycentric coordination entities is best treated as part of a separate general heading (see Rule 7 below).

A type of coordination closely akin to bridging in some ways yet distinctly different in others is illustrated by³¹



The linear configuration of gold(I) in two-coordination prevents the coordination of the two sulfur atoms in R₂NCS₂⁻ to the same gold atom but does not interfere in the dimer where each gold atom is coordinated to two sulfur atoms each in a different dithiocarbamate ion. To call this "*N,N*-di-*n*-propyldithiocarbamatogold(I) dimer" gives no hint as to the actual structure. The corresponding copper and silver compounds are even more complicated: [R₂NCS₂Cu]₄ and [R₂NCS₂Ag]₆.

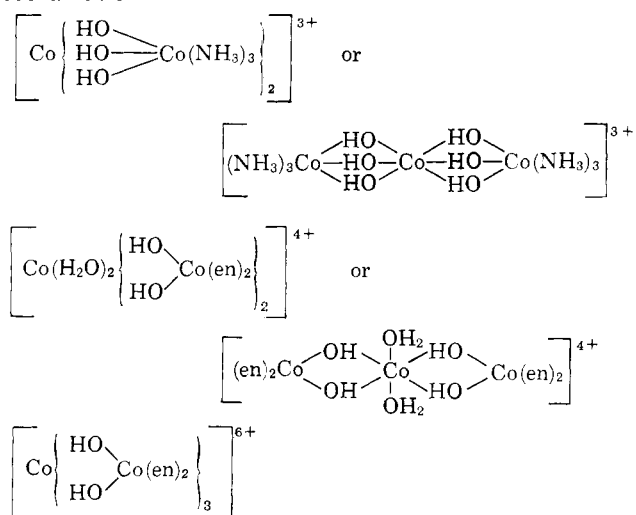
6. Designation of the Presence of Hydrogen Bonds.—In some compounds, the presence of hydrogen bonds contributes significantly to the stability and other properties of the coordination entity. It is often desirable to indicate in the name the presence of these hydrogen bonds.



^c Although one is tempted to suggest the use of true Arabic numerals for this purpose, their use would not only confuse the uninitiated but put a burden on printers for additional characters in type.

This problem is closely related to the one immediately following.

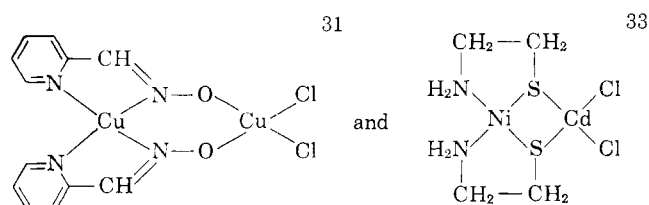
7. Coordination of Ligands Which in Themselves Are Coordinated Units.—The following formulas represent compounds which are examples of the coordination to a common center of groups containing another center of coordination.



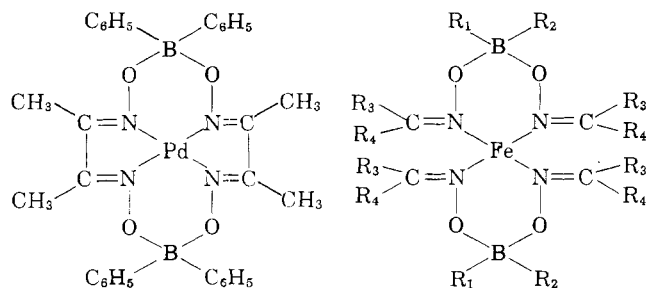
These were previously named,²³ respectively, according to the pattern prescribed for simple bridging:

bis| triamine-tri- μ -hydroxo-cobalt(III) {cobalt(III) ion or triamminecobalt(III)-tri- μ -hydroxo-cobalt(III)-tri- μ -hydroxotriamminecobalt(III) ion
 bis| bis(ethylenediamine)-di- μ -hydroxo-cobalt(III) {diaquo-cobalt(III) ion
 tris| bis(ethylenediamine)-di- μ -hydroxo-cobalt(III) {cobalt(III) ion

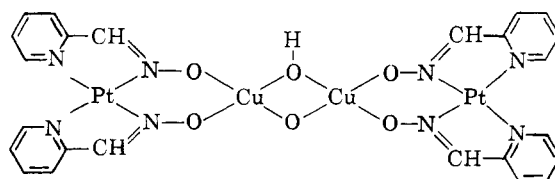
However, this pattern is not readily extended to



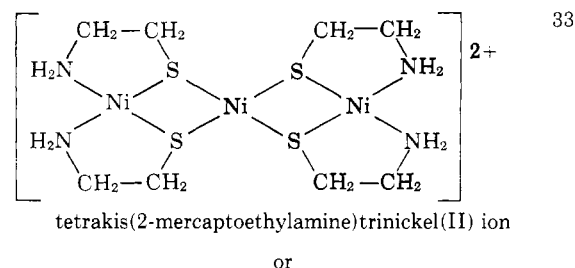
The second compound may be called dichloro|bis(2-aminoethanethiolato)nickel(II)-S,S'|cadmium(II), but the name does not indicate that the bridging is through the sulfur atoms. Additional troublesome compounds⁵¹ are



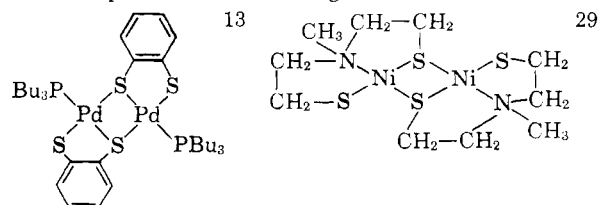
The problem arises because the ligands which are coordinated to the metal ions are simultaneously parts of another coordination system involving boron. The pyridine-2-carboxaldoximo example given in section 5 above involves three centers of coordination and the following formula involves four centers.³¹



A further variation on the formation of polycentric complexes is represented by the following example.

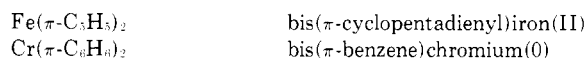


Whatever pattern of nomenclature is adopted for the above compound will depend to some extent upon the pattern adopted for the following.

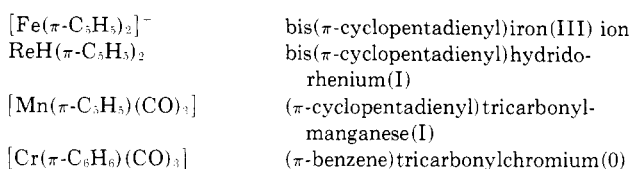


For the first of these, the name bis(tri-*n*-butylphosphine)- μ -bis(*o*-phenylenedithiolato)dipalladium(II) does not indicate that bridging is through sulfur. However, one may argue: where else could it be? Further, one hopes for a system of nomenclature which will designate the different isomers that would arise from a substituted *o*-phenylenedithiol.

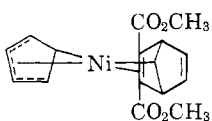
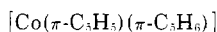
8. Designation of π -Bonded Structures.—The concept of π -bonding has brought order to an area of coordination chemistry which seemed quite mysterious before the concept was enunciated. Bonds may have partial or complete π -bond character. It is only the later type that have presented any nomenclature problem and for convenience such bonds are termed π -bonds here. Whenever it is desirable to indicate the presence of a π -bond either in formulas or in names the practice begun by Piper and Wilkinson⁴³ of using the letter π ,⁴ is now widely used. The simplest compounds of this type are:



One may argue that the π -designation is hardly necessary in the above cases since the compounds could not exist unless there was such a thing as π -bonding. However, there are many more complicated cases:



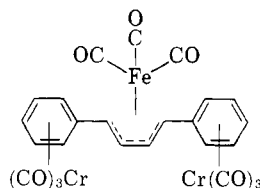
⁴ The letter π has had another usage in the organic literature. The older literature used π as a locant on the camphor molecule. However, *d*- π -bromocamphor- π -sulfonate is better referred to as *d*-3-bromo-8-camphorsulfonate.¹²



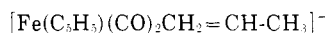
π -cyclopentadienyl- π -cyclopentadienecobalt(I)²⁶

{2,3-bis(methoxycarbonyl)-2 π ,5-norbornadien-6-yl}(π -cyclopentadienyl)nickel(II)¹⁹

Note that the positions of the π -bonds in the norbornadienyl moiety is designated by the number preceding the π . Some of these compounds are so complicated that satisfactory names will require the enunciation of new principles of nomenclature.⁴⁰



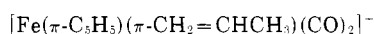
There may be occasions when it is desirable to emphasize in a name that a linkage is a σ - and not a π -bond. Consider the reaction⁷



The first compound would be written



and named π -cyclopentadienyl- σ -allyl-dicarbonyliron(II) while the second would be written



and named π -cyclopentadienyl- π -1-propenedicarbonyliron(II) ion.

9. Number Systems for Designating Structures.—In connection with the conventional numbering systems for square planar and octahedral structures (see Rule 11 above), some further comments are desirable. First, however, it is essential that the true nature of the problem be recognized. The need is not for an alternate to the *cis*, *trans*, etc. designations recognized by the IUPAC, but rather, for a system which is all inclusive and which provides a designation for all types of coordination position isomerism. A numbering system is the most satisfactory method.⁹

Instead of continuous numbering around a square planar configuration, Chatt¹⁴ has suggested the numbering system



so that the sum of the numbers designating a *trans* configuration will always be five and the sum of those designating a *cis* configuration will always be some value other than five. Similarly, for the octahedral configuration, the apexes would be numbered in the same manner as the sides of the cubes in dice so that similarly the sum of the numbers of the *trans* positions is always seven whereas the sum for *cis* positions is never seven.¹

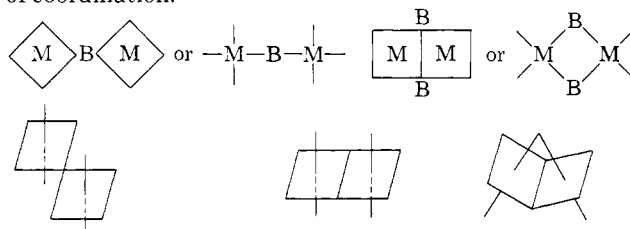
⁹ By introducing the prefixes *fac* (facial) and *mer* (meridional) for the relationships of three groups and designating which coordinating atoms were *cis* and *trans*. Trimble³⁰ was able to designate the isomers of the octahedral configuration with nonbranching ligands. This scheme is probably the limit of any simple prefix system and is certainly no simpler than a numerical system.

¹ It is interesting to note that this method was used on at least one previous occasion.⁴⁰

Detailed study will determine whether the advantages of this system over the present one outweigh the disadvantages.

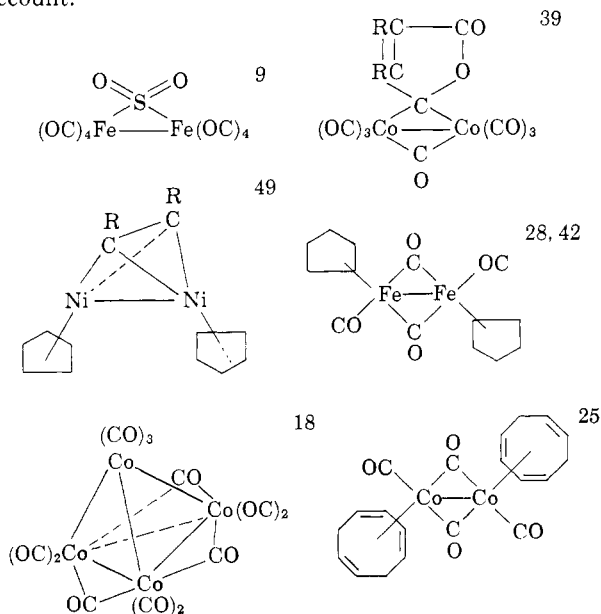
For those chemists who have occasion to consider transformation from square planar to octahedral configurations it may be preferable to use the same numbering scheme around the square as around the equator of the octahedral configuration so that individual fixed ligands retain the same numbers before and after the reaction. The question, once again, is one of relative advantages and disadvantages.

Whatever numbering scheme is adopted for compounds with only one center of coordination, the same one must then be extended to compounds with more than one center of coordination.



Here one may number the positions around each coordination center separately and designate those referring to the second center with a prime, etc. Or one may follow the practice used with fused ring organic systems where the positions common to two rings have the highest numbers since they are referred to least often. It is also necessary to consider bridging between planar and tetrahedral configurations and between octahedral and both planar and tetrahedral configurations. Also it may become necessary to designate the individual isomers of various configurations for coordination numbers 5, 7, and 8.

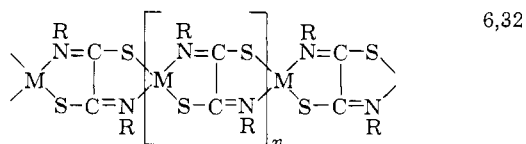
10. Direct Linkage of Coordination Centers.—When the method of naming compounds with a direct linking of coordination centers was first suggested, there was no thought that a direct linkage might exist between two centers and that are also bound together by bridging groups. Examples of this situation are now so numerous that nomenclature patterns must take the problem into account.



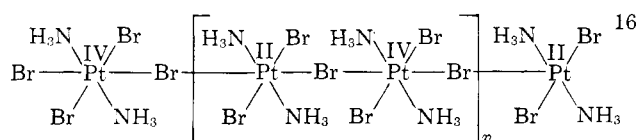
The direct linking of two different kinds of metal atoms, $\text{Ph}_3\text{PAu-Co(CO)}_4$,⁴¹ gives rise to a still further complication.

11. Nomenclature of Extended Structures Including Coordination Polymers.—The problems in the nomenclature of coordination polymers are related to those for which Rule 17 is designed. However, most of the cases encountered are much more complex than indicated by the example given by the IUPAC Commission. At least three general types are recognizable:

1. The repeating unit involves only one center of coordination.

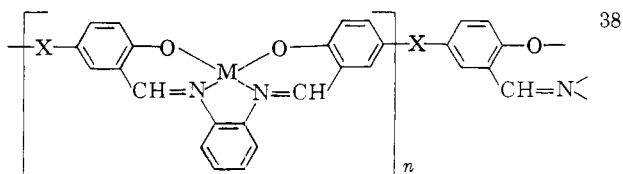


2. The repeating unit involves two centers of coordination.



catena-dibromodiammineplatinum(II)- μ -bromotribromodiammineplatinum(IV)

3. The repeating unit is completely organic and the metal is merely attached in regular fashion to the polymer.



It would also be helpful to have some means of designating the terminal groups in a polymer chain.

12. Molecular Addition Compounds.—The IUPAC Rules (7.7) state: "If it needs to be shown that added molecules form part of a complex, the names are given according to [the rules for coordination compounds]." Undoubtedly there will be more occasion to employ this rule in the future. It will certainly be true for at least two areas of chemical investigation: (a) the transition in a series of compounds or in a single compound under varying conditions from a neutral molecular addition compound to an ionized salt⁴² and (b) the formation of second-order complexes by the addition of neutral molecules to coordination entities.

13. Clathrates.—Papers on clathrates or other inclusion compounds are often included in symposia, conferences, and treatises on coordination compounds. Further, there is a tendency for many chemists to consider clathrates as a special type of coordination complex. However, clathrates are not built up on a pattern of coordinating centers with surrounding groups chemically linked to the central atom and occupying regular geometrical positions. Hence, there can be no extension to these interesting substances of nomenclature patterns designed for coordination compounds.

CONCLUSION

Even the most casual glance at the current journals indicates the rapid rate at which the chemistry of the coordination compounds is developing and expanding. It is to be expected that this evolving field of chemistry will continue to bring new nomenclature problems. The study of nomenclature must keep pace with the new developments. For that reason, it is essential that broad patterns capable of extension be followed so that the new problems can be solved without breaking so completely with previous practices as to render the earlier literature not readily understandable.

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⁴² A very good summary of a large portion of this field has recently been published.⁴³

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Nomenclature of Phosphorus Compounds*

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Aside from carbon, probably a greater number and variety of compounds have been described for phosphorus than for any other element. Furthermore, the study of phosphorus compounds is a very active branch of present-day chemistry, and our knowledge of phosphorus chemistry is ever-widening. Although the chemistry of phosphorus has been reasonably well systematized,¹ the present-day nomenclature is most inadequate and often confusing. Indeed, when one is writing about any organic phosphorus compound except a few of the more common

ones, it is wise to have a structural formula accompany the name when it is first stated. Furthermore, phosphorus chemistry during the past decade or so has been extended to include whole families² of compounds in which phosphorus atoms appear repeatedly in the molecular backbone, and there must be names not only for individual compounds but also for families.

NOMENCLATURE HERITAGE IN PHOSPHORUS CHEMISTRY

Peculiarities in Inorganic Naming.—In the early days of chemistry, study of phosphorus compounds was very

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