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# Definitive Report of the Commission on the Reform of the Nomenclature of Organic Chemistry

### Translation with

## Comments

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## Introduction

It is possible in the domain of organic chemistry to give several names to the same compound. This state of affairs has on the one hand the great advantage of permitting clear expression of thought and of rendering it easier to bring out analogies in structure wherever this is useful. But on the other hand the multiplicity of names for the same substance constitutes a serious obstacle in the preparation of indexes.

**Translator's Note.**—This report was unanimously adopted by the Commission and by the Council of the International Union of Chemistry at the meeting of the Union, held in Liége, September 14–20, 1930, and the official French text appears in the "Comptes rendus" of that meeting. It seemed likely that some details might be modified at the meeting scheduled to be held in Madrid in April, 1932, but as that meeting was postponed the report may be considered to have reached a certain stage of completion.

The rules are based on those of the Geneva Congress of 1892,[1,2] but include many changes and additions. They are naturally compromises in some cases, but are believed to represent a distinct advance in nomenclature practice.

Many of the provisions are already being observed in the publications of the American Chemical Society. It will be the policy of *Chemical Abstracts*, which was represented on the Working Committee by the translator, to put the rules into practice in its indexing to as great an extent and within as short a time as its long-established system of nomenclature and the requirements of its decennial indexes permit. The *Journal of the American Chemical Society* follows, in general, the usages of *Chemical Abstracts*.

The translator acknowledges his indebtedness to the valuable comments of Professor P. E. Verkade,[3] some of whose examples he has used.

The text of the report is given in ordinary type; comments by the translator are in small type.

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(1) Pictet, *Arch. sci. phys. nat.*, [3] **27**, 485–520 (1892).

(2) Tiemann, *Ber.*, **26**, 1595–1631 (1893).

(3) Verkade, *Rec. trav. chim.*, **51**, 185–217 (1932).

This difficulty was experienced as long ago as 1892 and the celebrated Congress of Geneva, at which thirty-four of the best qualified chemists from nine countries of Europe created the Geneva nomenclature, attempted to remedy it by laying down as Rule 1 of its report the following: "In addition to the customary methods of nomenclature there shall be established for each organic compound an official name, which will enable it to be found under only one entry in indexes and dictionaries." As is generally known, this intent of the Geneva Congress has not been realized. The Geneva nomenclature has not been sufficiently worked out except for acyclic compounds. Even for many of these, and still more for the rest, its application gives names which are much too complicated. This is probably the reason why the commission of 1892 did not complete its work.

Today, an official nomenclature for indexes, which was desirable forty years ago, has become quite unnecessary for the following reasons: (1) In 1918 a new edition of Beilstein commenced to appear; this admirable work facilitates bibliographic researches in an extraordinary manner.

(2) The problem has been solved by the formula indexes which are now in use in a number of chemical journals, including *Chemical Abstracts* and *Chemisches Zentralblatt.*

Nevertheless, the Geneva nomenclature has been of much value to organic chemistry, for its fundamental ideas are of great importance from the systematic standpoint throughout the entire extent of the science. The classification in Beilstein is based upon it for this reason.

As has just been observed, the Geneva names are inconvenient in the majority of cases and not very practical for ordinary use. The editors of Beilstein as well as of other compilations have rightly employed them, not alone but with the addition of the names in current use.

Now, a revision of these names has become more and more pressing; for the number of compounds has increased incessantly to an extraordinary degree and their discoverers, although following usage as far as possible, have not always made a happy choice of names and have even, in some cases, adopted names manifestly incorrect.

In order to remedy this regrettable state of affairs, in 1922 the International Union of Chemistry, on the proposal of Sir William Pope, named a Working Committee (Comité de Travail) to study the reform of the nomenclature of organic chemistry, composed of delegates from the editorial staffs of important chemical journals. The following were chosen as members: Messrs. Crane, Greenaway and Marquis, representing *Chemical Abstracts*, the *Journal of the Chemical Society* of London and the *Bulletin de la Société Chimique de France.* This Committee was instructed to make a report and submit it to the Commission of the Union, which approved it. The following year this Committee was enlarged by representatives of the *Gazzetta chimica italiana* (Paternò), *Helvetica Chimica*

*Acta* (Pictet) and *Recueil des travaux chimiques des Pays-Bas* (Holleman). The last-named was chosen chairman, and M. Marquis secretary.

In the course of time this Committee underwent the following changes: Mr. Crane was replaced by Mr. Patterson, Mr. Greenaway (assisted by Mr. Gibson) retired and was replaced by Mr. Barger. M. Paternò was presently replaced by M. Peratoner, but illness prevented him from participating in the sessions. After his death, the Italian Chemical Society named M. Mario Betti, who was unable to take part in editing the report but was present at the Eighth Conference at Warsaw in 1927, the Ninth at The Hague (1928) and the Tenth at Liége (1930) in which the said report was discussed and in part modified. Herr Prager, editor of Beilstein, named by the Verband deutscher chemischer Vereine as its representative on the Committee, was also present at Liége.

During the years 1924–1928 the Committee held several meetings in Paris; the result of its work was a report which was presented at The Hague in 1928 to the Commission of the Union on the reform of the nomenclature of organic chemistry. The latter proposed certain modifications which were examined again by the Working Committee. The report as thus amended was discussed at the meeting of the Commission in 1930 at Liége and was then adopted unanimously.

This report is not intended to interfere with the editing of Beilstein or of *Chemical Abstracts*, publications which have followed for many years their own systems of nomenclature, which moreover are very similar to the rules now adopted.

The object of the Committee in its work has been rather to follow usage as nearly as possible (see rule 1 below), to record it while at the same time proposing certain simplifications and eliminating incorrect names. It hopes that the flexible system of nomenclature thus created will be used more and more by authors of articles and of treatises on organic chemistry as well as in oral instruction and that the editors of journals will recommend its use as far as possible.

## Rules

Index: I. General. II. Hydrocarbons: 1. Saturated Hydrocarbons. 2. Unsaturated Hydrocarbons. 3. Cyclic Hydrocarbons. III. Fundamental Heterocyclic Compounds. IV. Simple Functions. V. Complex Functions. VI. Radicals. VII. Numbering.

### I. General

1. As few changes as possible will be made in terminology universally adopted.

The Committee members were apparently agreed that any attempt to introduce sweeping changes in terminology, however consistent they might be, would prove impractical and undesirable in the present stage of the science. The purpose of the rules, therefore, is rather to unify existing practice as far as possible by eliminating objectionable names and guiding future naming along desirable lines. The proposal (in Geneva rule 1) of an official name for each organic compound has been abandoned.

2. For the present, only the nomenclature of compounds of known constitution will be dealt with; the question of substances of imperfectly known constitution is postponed.

It is evident that a special technique is required for naming compounds of incompletely known structure so as to denote the presence, or the removal, of certain atoms or groups, or relation to other compounds. Although there might be an advantage in regularizing nomenclature practice in this field, the Committee decided not to consider it for the present. Moreover, the classification and naming of such important natural substances as the proteins and their derivatives, the lipides or lipoids, and the carbohydrates, were already in the hands of the Committee on Biochemical Nomenclature. The wording of this rule is identical with that of Geneva rule 2.

3. The precise form of words, endings, etc., prescribed in the rules should be adapted to the genius of each language by the subcommittees.

The wisdom of this rule seems evident, otherwise chemical word elements might conflict with important grammatical or other usages. As a sample of such difficulties may be cited the fact that in German -e is a case ending and hence -ene is not appropriate as a hydrocarbon suffix; it becomes -en instead. In Spanish the same ending becomes -eno. Most such adaptations will be made readily enough; a few, because of their newness, may require some ingenuity.

## II. Hydrocarbons

4. The ending *ane* is adopted for saturated hydrocarbons. Open-chain hydrocarbons will have the generic name *alkanes*.

The name "alkane" is better and shorter than "paraffin," especially since the latter term is now so commonly applied to a solid mixture.

5. The present names of the first four normal saturated hydrocarbons (methane, ethane, propane, butane) are retained. Names derived from the Greek or Latin numerals will be used for those having more than four atoms of carbon.

The words "or Latin" have been added to the Geneva rule (no. 4) because *nonane* is almost universally used for $C_9H_{20}$ instead of the Greek derivative *enneane* (as also is *nona-* instead of *ennea-* in combination, as in *nonadecane*); and because *undecane* appears oftener than *hendecane,* although the latter has a respectable standing. For most of the alkanes, however, names of Greek derivation are customary.

6. Branched-chain hydrocarbons are regarded as derivatives of the normal hydrocarbons; their names will be referred to the longest normal chain present in the formula by adding to it the designations of the side chains. In case of ambiguity, or if a simpler name would result, that chain which admits of the maximum of substitutions will be selected as the fundamental chain.

This rule may require further interpretation. The version published by the Journal of the Chemical Society[4] is quite different. It reads: "Branched-chain hydrocarbons

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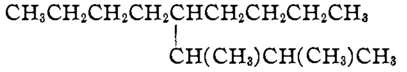
(4) *J. Chem. Soc.*, 1607–1616 (1931).

are regarded as derivatives of normal hydrocarbons; their names will be determined by the longest chain containing the maximum number of double or triple linkings (preference being given to the double linking where ambiguity arises), or, in the case of saturated hydrocarbons, by the longest chain in the formula. In cases where there might be doubt as to the choice of the longest chain, that one will be selected which admits of the maximum of substitution." It was the impression of the writer that this version, which he considers preferable, was adopted at Liége, but he has followed the French version of the "Comptes rendus" of the meeting.

If the French version is accepted, then it seems best to interpret it as referring to *saturated* hydrocarbons only, unsaturated hydrocarbons being treated in rules 8–10. The phrase "or if a simpler name would result" ("ou si cela donne un nom plus simple" in the French version) is of doubtful value as there may be differences of opinion as to which name is "simpler." In saturated branched-chain hydrocarbons, in the writer's opinion the longest chain present should be chosen as the fundamental one, and if there are two or more choices for the longest chain, then that one should be chosen in which there is the greatest number of substitutions (the reason being that the substituting radicals, while more numerous, will be of simpler structure).

Example:



$$\underset{\displaystyle CH(CH_3)CH(CH_3)CH_3}{CH_3CH_2CH_2CH_2\overset{}{C}HCH_2CH_2CH_2CH_3}$$

By the principle of the "longest chain" the name would be 5-(1,2-dimethylpropyl)-nonane; but according to the rule the name 4-butyl-2,3-dimethyloctane (which avoids a branched side chain) is the one to be chosen if it seems simpler.

7. In case there are several side chains, the order in which such chains are named will correspond to the order of their complexity. The chain having the greatest number of secondary and tertiary atoms will be considered the most complex. The alphabetic order may also be followed in such cases.

The Committee members were divided in their preferences between an order of radical names based on structure (for example, one based on increasing weight, as methyl, ethyl, butyl) and an alphabetic order as used, for example, in *Chemical Abstracts*. The two possibilities were hence left side by side, not only in this rule but also more generally in rule 63.

The advocates of the structural basis for such an order did not formulate any complete rule, and the wording of rule 7 is not very clear. In the writer's opinion it means that the name of the hydrocarbon radical of lowest weight is to be announced first, then that of the next highest weight, and so on, and that as between isomers the normal radical comes first, then the ones of branched structure, *e. g.*, methyl, ethyl, propyl, isopropyl, butyl, isobutyl. The rule does not decide completely between branched isomers, and neither this rule nor rule 63 prescribes any structural order for the host of substituting groups which are not hydrocarbon radicals (such orders have been constructed, however).[5]

The beauty of the alphabetic order is that it furnishes a means of arranging in order, almost instantly, substituents of any kind. Its only difficulty is that a few radical names differ substantially in spelling in certain languages (*e. g.*, ethyl, Äthyl). In such cases a transposition would be necessary in the translation. Fortunately, the exact order of prefixes in an organic name is not of great importance except in indexes. Example of the alphabetic order: butyl, ethyl, isobutyl, isopropyl, methyl, propyl.

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(5) See for instance Stelzner, *Literatur-Register der organischen Chemie*, **1**, xxiv–xxxiii (1913); **2**, xxii–xl (1919).

(Or, if *iso*- is italicized, butyl, *iso*-butyl, ethyl, methyl, propyl, *iso*-propyl.) For further illustrations the indexes to *Chemical Abstracts* may be consulted.

8. In the names of open-chain unsaturated hydrocarbons having one double bond the ending *ane* of the corresponding saturated hydrocarbon will be replaced by the ending *ene;* if there are two double bonds, the ending will be *diene,* etc. These hydrocarbons will bear the generic names *alkenes, alkadienes, alkatrienes,* etc. Examples: propene, hexene, etc.

This rule follows the Geneva system and in addition introduces the generic names *alkene,* etc., corresponding to *alkane.* Strictly interpreted, it calls for the replacement of *ethylene* by *ethene.* The writer doubts if this change will ever become general but the higher names, as propene, butene, etc., seem to be slowly supplanting the older propylene, butylene, etc. Examples: $\overset{1}{C}H_2{=}\overset{2}{C}H\overset{3}{C}H_3$, propene; $\overset{1}{C}H_2{=}\overset{2}{C}H\overset{3}{C}H_2\overset{4}{C}H_3$, 1-butene; $\overset{1}{C}H_3\overset{2}{C}H{=}\overset{3}{C}H\overset{4}{C}H{=}\overset{5}{C}H\overset{6}{C}H_3$, 2,4-hexadiene. The double bond receives its number from the lowest-numbered carbon atom to which it is attached. The principle of "lowest numbers" (see rule 64) is always applied; for instance, 1-butene might also be called 3-butene, but the lower number is selected.

For the naming of branched unsaturated hydrocarbons see the comments on rule 10.

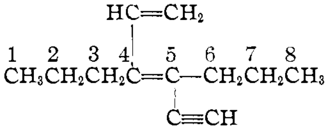
9. The names of triple-bond hydrocarbons will end in *yne, diyne,* etc. They will bear the generic name *alkynes.* Examples: propyne, heptyne, etc.

The Geneva ending *-ine* for these hydrocarbons has been replaced by *-yne* because -ine is reserved for names of organic bases (see rule 33). The English pronunciation of -yne is like that of -ine in "wine." It seems unlikely that the time-honored "acetylene" will be replaced by "ethyne" but the names for the higher members, such as propyne, ($\overset{1}{C}H{\equiv}\overset{2}{C}{-}\overset{3}{C}H_3$), 1-butyne ($\overset{1}{C}H{\equiv}\overset{2}{C}{-}\overset{3}{C}H_2\overset{4}{C}H_3$) and 2,4-hexadiyne ($\overset{1}{C}H_3\overset{2}{C}{\equiv}\overset{3}{C}{-}\overset{4}{C}{\equiv}\overset{5}{C}\overset{6}{C}H_3$) will probably be increasingly used.

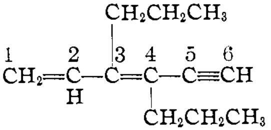
10. If there are both double and triple bonds in the fundamental chain the endings *enyne, dienyne,* etc., will be used. The generic names of these hydrocarbons will be *alkenynes, alkadienynes,* etc.

The endings *-enyne* and *-dienyne* given in the rule indicate that the double bonds are always to be expressed first, then the triple bonds. *E. g.,* $\overset{1}{C}H{\equiv}\overset{2}{C}{-}\overset{3}{C}H{=}\overset{4}{C}H\overset{5}{C}H{=}\overset{6}{C}H\overset{7}{C}{\equiv}\overset{8}{C}H$, octa-3,5-diene-1,7-diyne.

If we interpret rule 6 as applying to saturated hydrocarbons only (see the comments on rule 6), then the Committee has made no rule for the naming of *branched unsaturated* hydrocarbons. Two alternatives seem to be open: (1) to follow the Geneva system and choose the longest chain in the molecule as the fundamental one, even if it does not contain the double or triple bonds. (2) To consider the unsaturated linkages as functions (they are so listed in rule 52) and, guided by rule 18, to select as the fundamental chain that one which contains the maximum of double and triple bonds (even if it is not the longest present in the molecule). Example:


$$\overset{1}{C}H_3\overset{2}{C}H_2\overset{3}{C}H_2\overset{\substack{HC=CH_2\\|\\4}}{C}=\underset{\substack{|\\C\equiv CH}}{\overset{5}{C}}-\overset{6}{C}H_2\overset{7}{C}H_2\overset{8}{C}H_3$$

1


$$\overset{1}{C}H_2=\underset{H}{\overset{2}{C}}-\overset{\substack{CH_2CH_2CH_3\\|\\3}}{C}=\underset{\substack{|\\CH_2CH_2CH_3}}{\overset{4}{C}}-\overset{5}{C}\equiv\overset{6}{C}H$$

2

By method (1): 4-ethenyl-5-ethynyl-4-octene. By method (2): 3,4-dipropyl-hexa-1,3-dien-5-yne. (As to beginning the numbering with the double instead of the triple bond, see rule 64.) For general use the writer favors method (2) as being in accordance with the treatment of other functions, and also as better expressing the nature of the hydrocarbon in the ending of the name.

11. Saturated monocyclic hydrocarbons will take the names of the corresponding open-chain saturated hydrocarbons, preceded by the prefix *cyclo*. They will bear the generic name *cycloalkanes*.

The Geneva names *cyclopropane, cyclobutane*, etc., have won general acceptance, replacing the older names trimethylene, tetramethylene, etc. The latter names have a better use as applied to bivalent radicals (recognized in rule 57).

12. When they are unsaturated, rules 8–10 will be applied. However, in the case of partially saturated polycyclic aromatic compounds the prefix *hydro*, preceded by *di-*, *tetra-*, etc., will be used. Example: dihydroanthracene.

Further examples: cyclobutadiene, cyclohexene (not tetrahydrobenzene), 1,2-dihydronaphthalene. For completely saturated polycyclic aromatic hydrocarbons it was at one time proposed in the Committee to use the ending -ane; *e. g.*, naphthalane. This provision was later rejected, however. In so doing the Committee no doubt intended that "decahydronaphthalene" be used instead of "naphthalane," and so for other cases. It was therefore probably an oversight that the words "or wholly" were not added after "partially" in revising the rule.

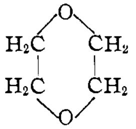
13. Aromatic hydrocarbons will be denoted by the ending *ene* and will otherwise retain their customary names. However, the name *phene* may be used instead of *benzene*.

The best usage in English already conforms to this rule, which will help to hasten the disuse of such names as benzol, toluol and xylol for chemical individuals. "Phene," while logically related to "phenol," is not likely to replace "benzene."

## III. Fundamental Heterocyclic Compounds

14. The endings of customary names, endings which do not correspond to the function of the substance, will undergo the following modifications, so far as they are in accord with the genius of each language: (a) The ending *ol* will be changed to *ole*. Example: pyrrole. (b) The ending *ane* will be changed to *an*. Example: pyran.

The change from *-ol* to *-ole* is obviously for the purpose of reserving -ol as an ending for the names of alcohols and phenols; similarly, the change from *-ane* to *-an* is made in order to reserve -ane for saturated parent compounds. The rule does not state whether names of fully saturated heterocyclic parent compounds such as are to be spelled -ane or -an (*Chemical Abstracts* calls the above 1,4-dioxane), or whether -ane is to be used for saturated hydrocarbons only. It is clear, however, that -ane should *not* be used for any substance not completely saturated. The above changes are not possible in German, since *e* is the sign of the plural (*cf.* rule 3).

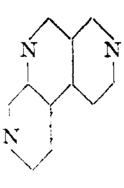


15. When nitrogenous heterocycles not having the ending *ine* give basic compounds on progressive hydrogenation, such derivation will be indicated by the successive endings *ine, idine*. Examples: pyrrole, pyrroline, pyrrolidine; oxazole, oxazoline.

This rule merely recognizes and extends a well-established practice.

16. The ending *a* is adopted for hetero atoms occurring in a ring. Oxygen will accordingly be indicated by *oxa*, sulfur by *thia*, nitrogen by *aza*, etc. The letter *a* may be elided before a vowel. Examples: thiadiazole, oxadiazole, thiazine, oxazine.

While the universally accepted names of heterocyclic compounds are retained, the names of other heterocyclic compounds are derived from that of the corresponding homocyclic compound by adding to it the names of the hetero atoms ending in *a*. Example: 2,7,9-triazaphenanthrene.



The use of *a* in such prefixes as oxa-, thia- and aza- distinguishes these forms clearly from oxy-, thio-, azo-, etc., which have other meanings. The "a" prefixes may be used either (1) to form such names as *thiadiazole*, or (2) to denote the replacement of a carbon atom or hydrocarbon grouping by a hetero atom or grouping, as stated in the second paragraph of the rule. This latter method is a very useful one, especially in naming bridged heterocyclic compounds, but there are objections to making it the sole method for naming new forms. Among these objections are (1) that in certain cases the hetero atom would be given a different numbering in two tautomeric compounds, thus making it appear that the hetero atom has shifted instead of a hydrogen atom;[6] (2) that in some cases the corresponding homocyclic compounds are not known and that the known heterocyclic compound is more readily named from its own component rings; and (3) that in the case of nitrogen bases the method yields names that do not end in -ine.

The writer therefore sought to have this rule modified so as to make it clear that the use of the "a" nomenclature is permissive only. His impression is that it was the intention of the Committee to so modify the rule at Liége, but the modification does not appear in the final version. The Committee surely cannot have intended to abrogate the well-established practice of forming such names as anthrapyrrole and naphthopyridine, in which the prefix denotes a form which is "fused" with the form whose name follows it. Both practices should be permitted, in the writer's opinion. The older practice can be preserved along with the new if, in accordance with rule 1, a broad interpretation is given to the words, "The names of heterocyclic compounds which are universally adopted will be retained." It is interesting to note that the German version reads: "Wo ein solcher Name fehlt, *kann* der Name," etc., and accordingly makes the use of the "a" nomenclature in such cases permissive only.

## IV. Simple Functions

17. Substances of simple function are defined as those containing a function of one kind only, which may be repeated several times in the same molecule.

That is to say, a compound which is an acid, an alcohol or an aldehyde and only that, is defined as a substance of simple function, while one which is at the same time an alcohol and an acid, or an acid and an aldehyde, is said to be a substance of complex function.

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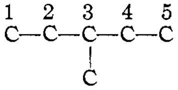
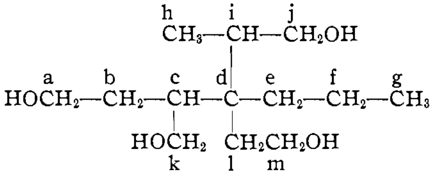
(6) For an example see Patterson, This Journal, **50**, 3084 (1928).

(7) *Ber.*, **65A**, 11-20 (1932).

18. When there is only one functional group, the fundamental chain will be selected so as to contain this group. When there are several functional groups the fundamental chain will be selected so as to contain the maximum number of these groups.

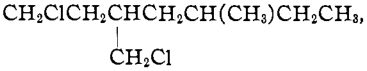
This is an important modification of the Geneva system. The central idea of the latter, so far as aliphatic compounds are concerned, is a fixed carbon skeleton with a fixed numbering, analogous to the fixed scheme for parent cyclic compounds, such as anthracene or quinoline. Hence the longest carbon chain in the molecule and the length and position of the side chains attached to it become of first importance—functional groups such as OH or COOH may come where they will. An example of such a skeleton is  $\overset{1}{C}-\overset{2}{C}-\underset{\displaystyle C}{\underset{|}{\overset{3}{C}}}-\overset{4}{C}-\overset{5}{C}$ and the saturated hydrocarbon corresponding to it is 3-methylpentane. Suppose carbon atom number 1 and the carbon atom of the side chain in 3-methylpentane to be oxidized to carboxyl groups. According to the Geneva system the original numbering is retained and the compound is called pentanoic-3-methyloic acid. But chemists commonly call this substance ethylsuccinic acid and thereby choose as the fundamental chain the one containing the two carboxyl groups. These groups have a far greater influence upon the properties of the compound than an extra methyl or ethyl group, so it seems natural to treat the compound as a derivative of the corresponding straight-chain diacid rather than as a modified 3-methylpentane. The Committee has recognized this very common principle of nomenclature in rule 18. The functional groups, and not the complete skeleton, are given the place of first importance. By rules 18 and 29 the systematic name of ethylsuccinic acid becomes 2-ethyl-butanedioic acid.

If there are two or more choices for the chain containing the maximum of functional groups, then the principle of rule 6 should be applied (although rule 18 does not so state). That is, the longest chain should be chosen as the fundamental one and if there is still a choice to be made, then the one involving a maximum of substitutions. Example:



In this compound the maximum of functional groups in any straight chain is two. The longest chain in the molecule is abcdefg = 7, but it contains only one OH group. Those containing two OH groups are: abck = 4, kcdlm = 5, jidlm = 5, abcdij = 6 and abcdlm = 6. The choice therefore lies between the two 6-membered chains. Of these, abcdij has one more substitution than the other and therefore becomes the fundamental chain. The compound accordingly receives the name (numbering j = 1, i = 2, d = 3, c = 4, b = 5 and a = 6): 3-(2-hydroxyethyl)-4-(hydroxymethyl)-2-methyl-3-propyl-1,6-hexanediol.

Should rule 18 be applied to halogen substitution products of the hydrocarbons? At first glance one would infer so, since "halogenide" is listed as a function in rule 52. The real purpose for rule 18, however, in the writer's opinion, is to ensure that all, or as many as possible, of the groups of the principal function (see rule 51) may be expressed in the ending of the name. Rule 18, although it occurs under the heading "Simple Functions" is therefore to be regarded as a complement to rule 51; it should be understood to apply to the principal function (and to it only) when other functions are present. Now, according to rules 19 and 52, halogen functions are to be expressed by prefixes only and there is no utility in applying rule 18 to them *or to any other function when it is expressed as a prefix.* The nitro and nitroso functions are other instances of functions which are expressed as prefixes only. It seems better, and more in accord with present usage, to allow chloro, bromo, nitro, etc., derivatives to be named as derivatives of the longest chain present in the molecule. Example:



$CH_2ClCH_2\underset{\underset{\displaystyle CH_2Cl}{|}}{C}HCH_2CH(CH_3)CH_2CH_3$,

1-chloro-3-chloromethyl-5-methylheptane and not 1,4-dichloro-2-(2-methylbutyl)-butane.

19. Halogen derivatives will be designated by the name of the hydrocarbon from which they are derived, preceded by a prefix indicating the nature and number of the halogen atoms.

Examination of text-books shows a prevailing use of such names as ethyl chloride, amyl iodide, hexyl bromide. These compounds are usually, however, of very simple structure. A perusal of the journals will show that the more complex halogen derivatives cannot be conveniently named in this manner and as a matter of fact are nearly always named with the use of prefixes. Rule 19 recommends that prefixes be employed in all cases and we have therefore chloromethane instead of methyl chloride, 1-chlorobutane instead of *n*-butyl chloride, 1,2-dichloroethane instead of ethylene chloride, and so on, although by rule 1 the older names may still be used.

20. Alcohols and phenols will be given the name of the hydrocarbon from which they are derived, followed by the suffix *ol.* In accordance with rule 1 names universally adopted will be retained, as: phenol, cresol, naphthol, etc.

This nomenclature may also be applied to heterocycles. Example: quinolinol.

This is the Geneva nomenclature, with an extension to heterocyclic compounds. Examples: $CH_3CH_2OH$, ethanol; $CH_3CHOHCH_3$, 2-propanol; cyclohexanol; fluorenol (for hydroxyfluorene); quinolinol (for hydroxyquinoline), etc.

By rule 14, names ending in -ol for substances which are not alcohols or phenols are to be spelled -ole. Similarly, trivial names of alcohols and phenols should end in -ol (as, mannitol instead of mannite, resorcinol instead of resorcin).

21. In naming polyhydric alcohols or phenols, one of the forms *di, tri, tetra,* etc., will be inserted between the name of the parent hydrocarbon and the suffix *ol.*

Examples: $CH_2OHCH_2OH$, 1,2-ethanediol; $CH_2OHCHOHCH_2OH$, 1,2,3-propanetriol; $C_6H_4(OH)_2$, benzenediol; $C_{10}H_4(OH)_4$, naphthalenetetrol.

22. The name *mercaptan* as a suffix is abandoned; this function will be denoted by the suffix *thiol.*

Examples: $CH_3SH$, methanethiol; $C_6H_5SH$, benzenethiol; $CH_2SHCH_2SH$, 1,2-ethanedithiol.

23. Ethers are considered as hydrocarbons in which one or several hydrogen atoms are replaced by alkoxy groups. However, for symmetrical ethers the present nomenclature may be retained. Examples: $CH_3OC_2H_5$, methoxyethane; $CH_3OCH_3$, methoxymethane or methyl ether.

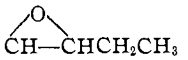
The ether function is treated as a relatively unimportant one, in naming, probably because it is so slightly reactive. Also, like all functions involving a bivalent radical, it causes some difficulties in nomenclature. In this rule the Committee subordinates it to the hydrocarbon and provides that it be expressed in a prefix rather than in the ending of the name. A concession is made to usage in recognizing also the usual names of the simple ethers. In naming by the alkoxy method the larger radical should be chosen for the parent compound. The method is to be extended, presumably, to cyclic compounds. Examples: $CH_3OCH_3$, methoxymethane or methyl ether; $CH_3OC_2H_5$, methoxyethane; $CH_3OC_4H_3O$, methoxyfuran; $C_6H_5OC_{10}H_7$, phenoxynaphthalene; $CH_3OCH_2CH_2OCH_3$, 1,2-dimethoxyethane.

24. Oxygen linked, in a chain of carbon atoms, to two of these atoms will be denoted by the prefix *epoxy* in all cases where it would be unprofitable to name the substance as a cyclic compound. Examples: ethylene oxide = epoxyethane; epichlorohydrin = 3-chloro-1,2-epoxypropane; tetramethylene oxide = 1,4-epoxybutane.

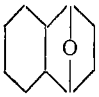
Rule 24 was no doubt given this position because it refers to a special case of the ether function. The prefix *epoxy* is not intended to supplant the regular cyclic names but to be used only where the latter are inconvenient. It will probably find its most common use in cases where a double bond has been oxidized and it is desired to bring out this relationship. Example:

$CH_2{=}CHCH_2CH_3$
1-butene

$CH_2OHCHOHCH_2CH_3$
1,2-butanediol


$\overset{O}{CH{-}CHCH_2CH_3}$
1,2-epoxybutane

Another opportunity for its use will be found in bridged compounds; as, 1,4-epoxynaphthalene:



25. Sulfides, disulfides, sulfoxides and sulfones will be named like the ethers, *oxy* being replaced by *thio, dithio, sulfinyl* and *sulfonyl*, respectively. Examples: $CH_3SO_2C_2H_5$, methylsulfonylethane; $CH_3SC_3H_7$, methylthiopropane; $CH_3CH_2CH_2SOCH_2CH_2CH_2CH_3$, 1-(propylsulfinyl)butane.

Further examples: $CH_3SSC_6H_5$, methyldithiobenzene; $C_6H_5SOC_{10}H_7$, phenylsulfinylnaphthalene; $CH_3SO_2C_4H_3O$, methylsulfonylfuran. Presumably the provision about symmetrical compounds in rule 23 applies here also, according to which $CH_3SCH_3$ could be called methylthiomethane or methyl sulfide; $C_2H_5SOC_2H_5$, ethylsulfinylethane or ethyl sulfoxide, etc.

26. Aldehydes are characterized by the suffix *al* added to the name of the hydrocarbon from which they are derived; thioaldehydes, by the suffix *thial*. Acetals will be named as 1,1-dialkoxyalkanes.

Aliphatic aldehydes and thioaldehydes are named in the above manner in the Geneva system. Examples: $CH_3CHO$, ethanal; CHOCHO, ethanedial; $CH_3CH_2CHS$, propanethial; $CH_3C(OC_2H_5)_2$, 1,1-diethoxyethane. No provision is made in the rules for aldehydes in which the CHO group is attached directly to a ring (compare rule 49). By analogy with the suffixes -carbonamide, -carbonitrile, etc., the suffix for a substituting CHO group would be *-carbonal*, and $C_6H_5CHO$, for example, would be named benzenecarbonal (naturally, by rule 1, the common name benzaldehyde would also be recognized). Similarly, $C_5H_3N(CHO)_2$ would be named pyridinedicarbonal.

27. Ketones will receive the ending *one*. Diketones, triketones, thioketones will be designated by the suffixes *dione*, *trione*, *thione*.

This is a Geneva rule which has justified itself in practice for aliphatic compounds. Examples: $CH_3COCH_3$, propanone; $CH_3CSCH_3$, propanethione; $CH_3COCOCH_3$, 2,3-butanedione. So, also, cyclohexanone, 1,4-cyclohexanedione, etc. The rules make no provision for ketone groups in side chains in the cyclic series (compare rule 49).

28. The name *ketene* is retained.

"Ketene" (or, as spelled by some, "keten") is accordingly recognized as a name for the parent compound $CH_2{=}CO$. It was at one time proposed to call this compound "ethenone" or "ketenone" but the Committee finally decided not to disturb already established usage. Example: $(CH_3)_2C{=}CO$, dimethylketene.

29. For acids the rule of the Geneva nomenclature is retained. However, in cases where the use of that nomenclature would not be convenient the carboxyl group will be considered as a substituting group and the name of the acid will be formed by adding to the name of the hydrocarbon the suffix *carbonique* or *carboxylic*, according to the language.

This rule on the naming of acids is a frank compromise between two conflicting ideas, whose advantages and disadvantages led to much discussion both in the Geneva Congress and in the International Committee. By the Geneva rules aliphatic acids are regarded as derived from hydrocarbons of the same number of carbon atoms ($CH_3$ being replaced by COOH). The acid name is formed from the hydrocarbon name by adding to it *-oic acid*, *-dioic acid*, etc. Such names are convenient for simple monoacids and diacids, but become less so as the structure grows more complicated. In the latter case most chemists will probably prefer the "carboxylic" nomenclature. Examples of both systems are given below, with their respective numberings. By rule 1, the familiar names of acids, as butyric, succinic, may also be used.

| | |
|---|---|
| 4 3 2 1<br>$CH_3CH_2CH_2CO_2H$<br>butanoic acid | 3 2 1<br>$CH_3CH_2CH_2CO_2H$<br>1-propanecarboxylic acid |
| 1 2 3 4<br>$HO_2CCH_2CH_2CO_2H$<br>butanedioic acid | 1 2<br>$HO_2CCH_2CH_2CO_2H$<br>1,2-ethanedicarboxylic acid |
| 4 3 2 1<br>$CH_3CH(CH_3)CH_2CO_2H$<br>3-methylbutanoic acid | 3 2 1<br>$CH_3CH(CH_3)CH_2CO_2H$<br>2-methyl-1-propanecarboxylic acid |
| 1 2 3 4 5<br>$CH_3CH_2CH(CO_2H)CH_2CH_3$<br>pentane-3-methyloic acid | 1 2 3 4 5<br>$CH_3CH_2CH(CO_2H)CH_2CH_3$<br>3-pentanecarboxylic acid<br>(or 1-ethyl-1-propanecarboxylic acid) |
| 1 2 3 4 5<br>$HO_2CCH_2CH(CO_2H)CH_2CO_2H$<br>pentanedioic-3-methyloic acid | 1 2 3<br>$HO_2CCH_2CH(CO_2H)CH_2CO_2H$<br>1,2,3-propanetricarboxylic acid |
| 4 3 2 1<br>$CH_2{=}CHCH_2CO_2H$<br>3-butenoic acid | 3 2 1<br>$CH_2{=}CHCH_2CO_2H$<br>2-propene-1-carboxylic acid (*cf.* rule 64) |

In the original Geneva system side chains and double bonds take precedence over the carboxyl groups in determining the numbering. Such numberings are contrary to rule 64 and hence in the examples above they have been revised to give carboxyl low numbers. In most of the carboxylic numberings the figures 1, 2, 3 correspond to the familiar $\alpha$, $\beta$, $\gamma$. The Geneva rules refer to aliphatic acids only, hence where the carboxyl group is directly attached to a ring the "carboxylic" nomenclature is to be followed. Example: $C_6H_5COOH$, benzene-carboxylic acid (or benzoic acid).

It will be noted that in the Geneva names of acids a side chain containing a carboxyl group is expressed as "methyloic" ($-COOH$), "ethyloic" ($-CH_2COOH$), etc. (see examples 4 and 5, above). In the "carboxylic" nomenclature, presumably any carboxyl group which is not attached to the fundamental chain is to be expressed by the prefix "carboxy;" as, $HOOCCH_2C(CH_2COOH)(COOH)CH_2COOH$, pentanedioic-3-methyloic-3-ethyloic acid (Geneva name) or 2-(carboxymethyl)-1,2,3-propanetricarboxylic acid ("carboxylic" name).

30. Acids in which an atom of sulfur replaces an atom of oxygen will be named according to the Geneva nomenclature. Example: ethanethioic, -thiolic, -thionic, -thionothiolic. If the carboxyl is considered as a substituent the compounds will be named *carbothioic* acids. The suffix *carbothiolic* will be used if it is certain that the oxygen of the OH group is replaced by sulfur; the suffix *carbothionic* if it is the oxygen of the CO group; the suffix *carbodithioic* will be used if both oxygen atoms are replaced.

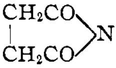
Examples of the two systems of names: $CH_3COSH$ or $CH_3CSOH$ (either one), ethanethioic acid, methanecarbothioic acid; $CH_3COSH$, ethanethiolic acid, methanecarbothiolic acid; $CH_3CSOH$, ethanethionic acid, methanecarbothionic acid; $CH_3CSSH$, ethanethionothiolic acid, methanecarbodithioic acid.

31. The existing conventions will be retained for salts and esters.

Examples: Sodium butanoate or sodium salt of butanoic acid; diethyl 1,2-ethanedicarboxylate or diethyl ester of 1,2-ethanedicarboxylic acid; sodium acetate; methyl succinate.

32. Acid anhydrides will retain their present mode of designation according to the names of the corresponding acids. For names formed in accordance with the Geneva nomenclature, the amides, amidoximes, amidines, imides and nitriles will be named like the acids by adding to the name of the corresponding hydrocarbon the endings *amide, amidine, amidoxime, imide* and *nitrile,* respectively, while the halides will be named by combining *chloride,* etc., with the name of the radical. Examples: $C_3H_7COCl$, butanoyl chloride; $C_3H_7CONH_2$, butanamide; etc.

If the carboxyl is considered as a substituent the endings *carbonamide, carbonamidine, carbonamidoxime, carbonimide, carbonitrile* will be used. Examples: $C_3H_7COCl$, propanecarbonyl chloride; $C_3H_7CONH_2$, propanecarbonamide; etc.

Further examples: $(CH_3CO)_2O$, ethanoic anhydride or methanecarboxylic anhydride (also acetic anhydride); $CH_3CONH_2$, ethanamide or methanecarbonamide; $CH_3C(=NH)NH_2$, ethanamidine or methanecarbonamidine; $CH_3C(=NOH)NH_2$, ethanamidoxime or methanecarbonamidoxime;  $\begin{matrix}CH_2CO\\ |\\ CH_2CO\end{matrix}{>}NH$, butamide or 1,2-ethanedicarbonimide; $CH_3CN$, ethanenitrile or methanecarbonitrile; $CH_3COCl$, ethanoyl chloride or methanecarbonyl chloride (*cf.* rule 58).

English-speaking chemists may, if they desire, use *-carboxamide* or *-carboxylamide* instead of -carbonamide, and so on (*cf.* rules 3 and 29) but it is well not to introduce any more such language differences than are necessary.

33. The ending *ine* is reserved exclusively for nitrogenous bases. The present nomenclature of monoamines is retained. For polyamines, the name of the hydrocarbon will be followed by the suffixes *diamine, triamine,* etc.

For aliphatic compounds containing quinquevalent nitrogen the ending *ine* will be changed to *onium.* For cyclic substances containing quinquevalent nitrogen in the ring the ending *ine* will be changed to *inium;* for those with the ending *ole,* this will be changed to *olium.* Examples: pyridine, pyridinium; imidazole, imidazolium.

In accordance with the first sentence of this rule the spelling of names of non-bases ending in -ine should be changed; thus glycerine becomes glycerol, dextrine becomes dextrin, propine becomes propyne (see rule 9). Examples of names of amines: $CH_3NH_2$, methylamine; $(CH_3)_2NH$, dimethylamine; $(CH_3)_3N$, trimethylamine; $H_2NCH_2CH_2NH_2$, 1,2-ethanediamine; $C_6H_4(NH_2)_2$, benzenediamine.

34. The nomenclature of the derivatives of phosphorus, arsenic, antimony and bismuth, being very complicated, will be considered later.

Usage in this field needs systematizing but the Committee could not agree upon a plan. The scheme proposed by the American Committee for the acids of phosphorus, arsenic and antimony was as follows (with "phosph" and "stib" corresponding to "ars"):

| Formula | Prefix | Suffix |
|---|---|---|
| RR'AsOH | Arsinoso | Arsinous |
| $RAs(OH)_2$ | Arsonoso | Arsonous |
| RR'AsO.OH | Arsino | Arsinic |
| $RAsO(OH)_2$ | Arsono | Arsonic |

35. Compounds derived from hydroxylamine by replacement of the hydrogen of the hydroxyl will be regarded as alkoxy derivatives; those in which an atom of hydrogen of the $NH_2$ group is replaced, as alkylhydroxylamines. Oximes will be named by adding the suffix *oxime* to the name of the corresponding aldehyde, ketone or quinone. Examples: $C_2H_5ONH_2$, ethoxyamine; $C_2H_5NHOH$, ethylhydroxylamine.

Further examples: $CH_3CH_2CH{=}NOH$, propanal oxime; $CH_3C({=}NOH)CH_3$, propanone oxime.

36. The generic term *urea* is retained; it will be used as a suffix for the alkyl and acyl derivatives of urea. Examples: butylurea, $C_4H_9NHCONH_2$; butyrylurea, $C_3H_7CONHCONH_2$. The bivalent radical —NHCONH— will be named *ureylene.*

Butyrylurea may also be called butanoylurea or propanecarbonylurea. Nothing is said about polysubstituted ureas.

37. The generic name *guanidine* is retained.

38. The name *carbylamine* is retained.

In earlier drafts the terms *isonitrile* and *isocarbonitrile* were favored and *carbylamine* was rejected. The latter was apparently restored at the instance of Professor Grignard, who believed there should be more of a distinction from nitriles than the prefix "iso" gives. No examples are given but the form favored by custom seems to be: ethylcarbylamine, $C_2H_5NC$. No objection seems to have been raised to *isocyanide*, a term also in use for these compounds (as, ethyl isocyanide).

39. Isocyanic and isothiocyanic esters (RNCO, RNCS) will be named *isocyanates* and *isothiocyanates*.

Examples: ethyl isocyanate, $C_2H_5NCO$; ethyl isothiocyanate, $C_2H_5NCS$.

40. The name *cyanate* is reserved for true esters which on saponification yield cyanic acid or its hydration products. The name *sulfocyanate* will be replaced by *thiocyanate*.

This is Geneva rule 44 with slightly altered wording. Examples: $C_2H_5CNO$, ethyl cyanate; $C_2H_5CNS$, ethyl thiocyanate.

41. Nitro derivatives: no change in the present nomenclature.

That is, the group $NO_2$ is always indicated by the prefix *nitro*, never by a suffix. Nitroso compounds are treated similarly (see rule 52). Examples: nitrosobenzene, 2,4,6-trinitrophenol.

42. Azo derivatives: the forms *azo*, *azoxy* are retained.

This rule is rather non-committal, as it does not state how the azo and azoxy names are to be formed. By rule 1 familiar terms like azobenzene, $C_6H_5N_2C_6H_5$, would be retained. The Geneva name for this substance is benzeneazobenzene. In treating the group $C_6H_5N_2$ as a substituent the Committee does not indicate whether it should be called "benzeneazo" or "phenylazo" (the latter would seem to accord best with rules 23 and 25). The same considerations apply to azoxy compounds. Hydrazo compounds are treated as hydrazine derivatives (rule 44).

43. (a) Diazonium compounds, $RN_2X$, are named by addition of the suffix *diazonium* to the name of the parent substance (benzenediazonium chloride).

(b) Compounds having the same empirical formula but containing trivalent nitrogen will be named by replacing diazonium with *diazo* (benzenediazohydroxide).

(c) Substances of the type $RN_2OM$ will be named *diazoates*.

(d) Compounds in which the two nitrogen atoms are united to a single carbon atom will be designated by the prefix *diazo* (diazomethane, diazoacetic acid).

(e) The term *diazoamino* is retained; however, these compounds may also be regarded as derivatives of triazene.

(f) Derivatives of the substances $H_2NNHNHNH_2$; $NH{=}NNHNH_2$; $NH{=}NNHN{=}NH$ will be named *tetrazanes*, *tetrazenes*, *pentazdienes*, etc.

Examples: (a) $C_6H_5N({\equiv}N)Cl$, benzenediazonium chloride; (b) $C_6H_5N{=}NOH$, benzenediazohydroxide; (c) $C_6H_5N{=}NONa$, sodium benzenediazoate; (d) $N_2CH_2$, diazomethane; $N_2CH_2COOH$, diazoacetic acid, diazoethanoic acid or diazomethanecarboxylic acid; (e) $C_6H_5N{=}NNHC_6H_5$, diazoaminobenzene or 1,3-diphenyltriazene; (f) $C_6H_5NHNHNHNHC_6H_5$, 1,4-diphenyltetrazane; $C_6H_5N{=}NNHNH_2$, 1-phenyl-1-tetrazene. (The numberings are the writer's.)

44. Hydrazines are designated by the name of the alkyl radicals from

which they are derived, followed by the suffix *hydrazine*. In cases where the amino group of carbonamides is replaced by the hydrazino group, the suffix *hydrazide* will be used. Hydrazo derivatives are regarded as derivatives of hydrazine. Examples: $CH_3NHNH_2$, methylhydrazine; $C_2H_5NHNHC_3H_7$, 1-ethyl-2-propylhydrazine; $C_3H_7CONHNH_2$, butyrohydrazide or propanecarbohydrazide.

The name for $C_3H_7CONHNH_2$ which corresponds to the Geneva name for the acid would probably be butanohydrazide, although neither the Geneva rules nor the present rules say so explicitly. The cases of *poly*substituted hydrazines in which one or more substituents are acid radicals are not covered by the rule. If there is more than one acyl substituent the compound is possibly best named by analogy with rule 36; example: $CH_3CONHNHCOCH_3$, 1,2-diacetylhydrazine, 1,2-diethanoylhydrazine, or 1,2-bis(methanecarbonyl)hydrazine. If there is only one acyl substituent it might be named by analogy with rule 36 (example, $CH_3CONHNHC_2H_5$ 1-acetyl-2-ethylhydrazine) or as a substituted hydrazide (in the latter case, however, the two nitrogen atoms would have to be distinguished in some way). By rule 1, $C_6H_5NHNHC_6H_5$ may still be called hydrazobenzene as well as 1,2-diphenylhydrazine.

45. Hydrazones and semicarbazones are named like the oximes. The term *osazone* is retained.

Examples: $CH_3CH{=}NNHC_6H_5$, ethanal (or acetaldehyde) phenylhydrazone; $(CH_3)_2C{=}NNHCONH_2$, propanone (or acetone) semicarbazone.

46. The name *quinone* is retained.

Examples: *p*-benzoquinone or *p*-quinone, 1,2-naphthoquinone or 1,2-naphthaquinone, phenanthrenequinone or phenanthraquinone.

47. Sulfonic and sulfinic acids will be designated by adding the suffixes *sulfonic* and *sulfinic* to the name of the hydrocarbon.

The analogous acids of selenium and tellurium will bear the names *alkaneselenonic* and *-seleninic* acids; *alkanetelluronic* and *-tellurinic* acids.

Examples: $C_2H_5SO_3H$, ethanesulfonic acid; $C_{10}H_6(SO_2H)_2$, naphthalenedisulfinic acid; $CH_3SeO_3H$, methaneselenonic acid; $C_6H_5TeO_2H$, benzenetellurinic acid. The radicals of these acids would presumably be named by replacing "ic acid" by *yl;* as, $CH_3SO_2Cl$, methanesulfonyl chloride (but meth*yl*sulfonylethane; *cf.* rule 25). The amides would presumably be named by replacing "ic acid" by *amide* (as, $C_6H_5SO_2NH_2$, benzenesulfonamide), etc. *Cf.* rule 32.

48. Organometallic compounds will be designated by the names of the organic radicals united to the metal which they contain, followed by the name of the metal. Examples: dimethylzinc, tetraethyllead, methylmagnesium chloride.

However, if the metal is united in a complex manner it may be considered as a substituent. Example: $ClHgC_6H_4CO_2H$, chloromercuribenzoic acid.

The rule gives no examples for compounds in which a second metal is present, but the name "methylmagnesium chloride" suggests the principle that organic radicals may be denoted by prefixes attached to one part of a binary inorganic name. Hence, we might risk as a further example: $(C_6H_5)_3SnNa$, sodium triphenylstannide.

49. The nomenclature of cyclic derivatives having side chains will be considered later.

An earlier draft attempted to treat, in two paragraphs, cyclic derivatives with one and with more than one side chain but it became evident that much further study was needed.

50. If it is necessary to avoid ambiguity, the names of complex radicals will be placed in parentheses. Examples: (dimethylphenyl)amine = $(CH_3)_2C_6H_3NH_2$; dimethylphenylamine = $C_6H_5N(CH_3)_2$.

## V. Complex Functions

51. For compounds of complex function, that is to say, for compounds possessing different functions, only one kind of function (the principal function) will be expressed by the ending of the name. The other functions will be designated by appropriate prefixes.

This is a definite departure from the Geneva system, since the latter permits functional suffixes to pile up in the names of mixed compounds (as, pentanaloloic acid). The Committee's decision is in accord with usage. The writer, in a study of the names of compounds of complex function in journal and book literature,[8] found 2557 instances in which only one of the functions present was expressed in the ending, as contrasted with 251 names in which two or more were so expressed. In certain cases it seems unavoidable that more than one function be expressed in the ending; as, butenyne, butenol, quinolinesulfonic (*-ene*, *-yne* and *-ine* have no corresponding prefixes).

52. The following prefixes and suffixes will be used for designating the functions.

| Function | Prefix | Suffix |
|---|---|---|
| Acid and derivatives | carboxy | carboxylic, carbonyl, carbonamide, etc., or oic, oyl, etc. |
| Alcohol | hydroxy | ol |
| Aldehyde | oxo, aldo (for aldehyde O) or formyl (for CHO) | al |
| Amine | amino | **amine** |
| Azo derivative | azo | .... |
| Azoxy derivative | azoxy | .... |
| Carbonitrile (nitrile) | cyano | carbonitrile or nitrile |
| Double bond | .... | ene |
| Ether | alkoxy | .... |
| Ethylene oxide, etc. | epoxy | .... |
| Halide | halogeno [halo] | .... |
| Hydrazine | hydrazino | hydrazine |
| Ketone | oxo or keto | one |
| Mercaptan | mercapto | thiol |
| Nitro derivative | nitro | .... |

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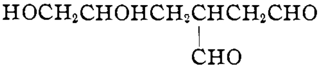
(8) Patterson, *Rec. trav. chim.*, **48**, 1016 (1929).

| Function | Prefix | Suffix |
|---|---|---|
| Nitroso derivative | nitroso | .... |
| Quinquevalent nitrogen | .... | onium, inium [olium] |
| Sulfide | alkylthio | .... |
| Sulfinic derivative | sulfino | sulfinic |
| Sulfone | sulfonyl | .... |
| Sulfonic derivative | sulfo | sulfonic |
| Sulfoxide | sulfinyl | .... |
| Triple bond | .... | yne |
| Urea | ureido | urea |

The order of functions in the French version is alphabetic and has no significance. The entries have been transposed in the translation in order to give an alphabetic arrangement in English also. The Committee intended at one time to establish an *order of precedence of functions* (to determine which should be the principal function in a compound containing two or more different functions), but later gave up the idea. The study of the writer already referred to under rule 51 indicates that it will be difficult to construct any order that will agree closely with general usage.[9]

As to the choice of the fundamental chain in compounds of complex function, the writer's opinion is, that by analogy with rule 18 (which treats of simple functions) the fundamental chain should be so chosen as to contain as many of the principal functional groups as possible, even if this is not the longest chain in the molecule or the chain which contains the most functional groups of all kinds. A correct name for the compound  $HOCH_2CHOHCH_2\underset{\substack{|\\ CHO}}{C}HCH_2CHO$ would therefore be 2-(2,3-dihydroxypropyl)butanedial, rather than 3-formyl-5,6-dihydroxyhexanal. This is in accord with common usage, which would certainly regard the compound as a derivative of succinaldehyde.

53. The names of derivatives of fundamental heterocyclic substances will be formed according to the preceding rules.

Example: Hydroxyquinolinecarbonamide, not quinolinolcarbonamide.

## VI. Radicals

54. Univalent radicals derived from saturated aliphatic hydrocarbons by removal of one atom of hydrogen will be named by replacing the ending *ane* of the hydrocarbon by the ending *yl*.

Examples: methyl, ethyl, pentyl (or amyl), etc. Since isopropylidene is recognized (rule 56) it was no doubt the intention of the Committee to recognize isopropyl similarly.

55. The names of univalent radicals derived from unsaturated aliphatic hydrocarbons will have the endings *enyl*, *ynyl*, *dienyl*, etc., the positions of the double or triple bonds being indicated by numerals or letters where necessary

Examples: $CH_2{=}CH{-}$, ethenyl (or vinyl); $CH{\equiv}C{-}$, ethynyl; $CH_3{-}CH{=}CH{-}CH_2{-}$, 2-butenyl; $CH_2{=}CH{-}CH{=}CH{-}$, 1,3-butadienyl.

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[9] For the order used in the *Chemical Abstracts* indexes, see Patterson and Curran, THIS JOURNAL, **39**, 1624 (1917).

56. Bivalent or trivalent radicals derived from saturated hydrocarbons by removal of 2 or 3 hydrogen atoms from the same carbon atom will be named by replacing the ending *ane* of the hydrocarbon by the endings *ylidene* or *ylidyne*. For radicals derived from unsaturated hydrocarbons, these endings will be added to the name of the hydrocarbon. The names isopropylidene and methylene are retained.

Examples: $CH_2<$, methylene; $CH_3CH<$, ethylidene; $CH_3CH_2CH<$, propylidene; $(CH_3)_2C<$, (1-methylethylidene) or isopropylidene; $CH_3C\equiv$, ethylidyne; $CH_2{=}CH{-}CH_2CH<$, 3-butenylidene. In the last example the number must be changed from 1 (in the name of the hydrocarbon, 1-butene) to 3 in order to indicate the position of the double bond correctly. The new ending *ylidyne*, formed by analogy with "ylidene," should prove useful.

57. The names of bivalent radicals derived from aliphatic hydrocarbons by removal of a hydrogen atom from each of the two terminal carbon atoms of the chain will be ethylene, trimethylene, tetramethylene, etc.

Only saturated radicals are provided for: $-CH_2CH_2-$, ethylene; $-CH_2CH_2CH_2-$, trimethylene, etc. (In an earlier draft the ending *ylene* was employed, thus: $-CH_2CH_2CH_2CH_2-$, butylene; $-CH_2CH{=}CHCH_2-$, 2-butenylene.)

58. Radicals derived from acids by removal of OH will be named by changing the ending carboxylic to *carbonyl* or, if the Geneva nomenclature is used, oic to *oyl*.

Examples: $CH_3CO$, ethanoyl or methanecarbonyl (or acetyl).

59. Univalent radicals derived from aromatic hydrocarbons by removal of a hydrogen atom from the ring will in principle be named by changing the ending *ene* to *yl*. However, the radicals $C_6H_5$ and $C_6H_5CH_2$ will continue provisionally to be named phenyl and benzyl, respectively. Moreover, certain abbreviations sanctioned by usage are authorized, as *naphthyl* instead of *naphthalyl*.

Examples: $CH_3C_6H_4-$, tolyl (instead of toluyl), anthryl (instead of anthracyl), phenanthryl, fluoryl.

60. Univalent radicals derived from heterocyclic compounds by removal of hydrogen from the ring will be named by changing their endings to *yl*. In cases where this would give rise to ambiguity, merely the final *e* will be changed to *yl*. Examples: pyridine, pyridyl; indole, indolyl; pyrroline, pyrrolinyl; triazole, triazolyl; triazine, triazinyl.

In this rule the Committee recognizes such accepted short names as pyridyl, quinolyl and furyl but at the same time recommends the longer forms where confusion could arise; thus, indolyl (instead of indyl, which might suggest indene), pyrrolinyl (instead of pyrrolyl, which might suggest pyrrole), triazolyl (instead of triazyl, which might suggest triazine).

61. Radicals formed by removal of a hydrogen atom from a side chain of a cyclic compound will be regarded as substituted aliphatic radicals.

Examples: $C_6H_5CH_2CH_2-$, (2-phenylethyl); $C_6H_5CH{=}CHCH_2-$, (3-phenyl-2-propenyl).

62. In general, special names will not be given to multivalent radicals derived from cyclic compounds by removal of several hydrogen atoms from the ring. In this case prefixes or suffixes will be used. Examples: triaminobenzene or benzenetriamine; dihydroxypyrrole or pyrrolediol.

Comparison with rules 21, 33 and 51 will show that of the names given as examples, "benzenetriamine" and "pyrrolediol" are the ones ordinarily to be preferred (according to the rule of expressing the principal function in the ending of the name where there is a suffix denoting it.)

63. The order in which prefixes or radicals are stated (alphabetic order or conventional order) remains optional.

See the comments on rule 7. There is no generally accepted "conventional order" for all prefixes.

## VII. Numbering

64. In aliphatic compounds the carbon atoms of the fundamental chain will be numbered from one end to the other with the use of arabic numerals. In case of ambiguity the lowest numbers will be given (1) to the principal function, (2) to double bonds, (3) to triple bonds, (4) to atoms or radicals designated by prefixes. The expression "lowest numbers" signifies those that include the lowest individual number or numbers. Thus, 1,3,5 is lower than 2,4,6; 1,5,5 lower than 2,6,6; 1,2,5 lower than 1,4,5; 1,1,3,4 lower than 1,2,2,4.

Examples: $CH_2{=}CHCH_2CH_3$, 1-butene (not 3-butene); $CH_2{=}CHC{\equiv}CH$, 1-propen-3-yne (not 3-propen-1-yne); $CH_2{=}CH{-}CH_2OH$, 3-propen-1-ol (not 1-propen-3-ol; the name allyl alcohol may also be used); $CHCl_2CH_2CH{=}CH_2$, 4,4-dichloro-1-butene.

The last example illustrates a difficulty of interpretation which might arise; it might be thought that, the numbers 1,1,3 being lower than 1,4,4, the compound should be named 1,1-dichloro-3-butene. This, however, was apparently not the intention of the Committee, for 1-butene is the parent compound. The British version makes this interpretation clearer by translating the French "En cas d'ambiguité" rather freely as "To avoid ambiguity."

The principle of "low numbers" also applies to cyclic compounds, with due regard to their different structure (*e. g.*, bridges and hetero atoms are usually given preferred positions). Examples: 1,3-cyclohexadiene; 3-cyclohexen-1-one or simply 3-cyclohexenone; 4,4-dichlorocyclohexene.

**Position of Numbers.**—Where shall position numbers be placed, *before* or *after* the parts of the name to which they refer? Usage varies; some chemists place them before, some place them after, some use a combination. The Committee has left full latitude on this point. The examples in the French version usually show the numbers placed after; the examples in these comments follow the practice of *Chemical Abstracts* in being placed before. Each method has certain advantages. In Beilstein numbers placed after are in parentheses, those placed before are not, *e. g.*, "2-methyl-butanol-(4)."

65. Positions in a side chain will be designated by numerals or letters, starting from the point of attachment. The numerals or letters will be in parentheses with the name of the chain.

Examples: $(CH_3)_2CH{-}$, (1-methylethyl) or isopropyl; $CH_3CHClCH_2{-}$, (2-chloropropyl). The rule equally permits Greek letters, ordinary letters, primed numbers (1′, 2′), numbers with indices ($4^1$, $4^2$) or other designations. Although the original Geneva nomenclature prescribed numbers with indices for side chains they have not been generally used and the present rules do not mention them. Plain numbers or letters usually suffice. The writer prefers to reserve primed numbers for special cases (as for doubled molecules, or for numbering the branched position in isopropyl).

66. In case of ambiguity in the numbering of atoms or radicals designated by prefixes, the order will be that chosen for the prefixes before the name of the fundamental compound or side chain of which they are substituents.

Example: $CH_2BrCH_2CH_2Cl$, 1-bromo-3-chloropropane (alphabetic order), or 1-chloro-3-bromopropane (order of increasing radical weight). The purpose of the rule is to decide which prefixes shall have which numbers, when the set of numbers (in the above example 1,3) for the prefixes has been determined.

67. The prefixes, *di, tri, tetra*, etc., will be used before simple expressions (for example, diethylbutanetriol) and the prefixes *bis, tris, tetrakis*, etc., before complex expressions. Examples: bis(methylamino)propane: $CH_3NH(CH_2)_3NHCH_3$; bis(dimethylamino)ethane, $(CH_3)_2NCH_2CH_2N(CH_3)_2$. The prefix *bi* will be used only to denote the doubling of a radical or compound; for example, biphenyl.

Additional example of the use of *bi:* *p*-$(C_6H_4CO_2H)_2$, 4,4′-bibenzoic acid or biphenyl-4,4′-dicarboxylic acid.

68. A catalog of cyclic systems, with their numberings according both to the existing system and to that of Mr. Patterson, is in preparation under the auspices of the National Research Council of the United States and of the American Chemical Society.

Work on this project is now in abeyance pending better financial conditions for publication.

In order to avoid all confusion the Commission recommends placing a scheme of numbering at the head of each article.

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