more appropriate and more consistent term adduction[1] is recommended in place of oxidation.

Modern developments in electricity compel us to recognize that a current of electricity consists of negative electrons moving in the opposite direction to the conventionally adopted arrow; our forefathers with whom the choice of direction was one between tweedledum and tweedledee, unfortunately guessed wrong. Hence it is the negative and not the positive charge that must be considered to be the unit of reference.

CARL HERING.

PHILADELPHIA, PA.

A SYSTEM OF ORGANIC NOMENCLATURE.

BY AUSTIN M. PATTERSON AND CARLETON E. CURRAN.

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It has fallen to the lot of the authors, as part of their present work of indexing a very large number of organic compounds for the Decennial Index to *Chemical Abstracts*, to revise not only indexing methods but in many cases the names themselves in order to arrive at something like consistency. It is hoped that the following statement of the principles on which we have proceeded may be helpful to prospective users of the Index and also contribute, through discussion, to a clearer and more harmonious usage in naming organic compounds.

Ideally such a revision would be the work of an international, or at least a national, commission of organic chemists and free discussion would be of great value. Unfortunately the time allotment for preparing the Index has not permitted that exchange of opinion which the subject merits; this the authors fully realize and regret.[2]

We have not tried to invent a new system. Our aim has been to follow existing usage as far as it could be made fairly consistent, choosing what appeared to us good practices and rejecting bad, and introducing new features only when some very positive advantage was to be gained. In striving for names which would be suitable for general use, and not only for the Index, our tendency has been frankly toward compact naming and we have freely used short names for complex compounds as fresh starting points in naming derivatives of them. (This is the opposite to that of a work like Richter's "Lexikon," which reduces each compound to the derivative of as simple a parent substance as possible.) However, mere brief-

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[1] See "Inadequacy and Inconsistency of Some Chemical Terms," *Met. Chem. Eng.*, 15, 649 (1916), and "Oxidation and Reduction in Physical Chemistry, Consistency of Terms and Conceptions," *Ibid.*, 16, 507 (1917), both by Carl Hering.

[2] Although the indexing work is now far advanced, the new plan of inverting the names so as to bring them under the parent compounds enables certain kinds of changes to be made readily. The authors will welcome criticism and adopt improvements or correct weak points as far as possible.

ness is not sufficient to recommend a name if it is not consistent with general principles, and so it sometimes happens that the preferred name is not the shortest which might be chosen.

The principal departures from previous usage are: the alphabetical order of radicals, the extension of the practice of expressing the chief function of a compound in the ending of its name, and some methods of numbering.

The most striking change in indexing methods is the inversion of all names containing substituent prefixes, so that these follow the rest of the name. Chloroacetic acid, for example, is entered in the Index as Acetic acid, chloro-.[1]

This has the great advantage of bringing related compounds together to a much larger extent than is possible in the ordinary way, while yet preserving the advantages of an alphabetic arrangement. The idea was taken from the index of the *Journal of the (London) Chemical Society* but has been applied in a far more complete way.

An entirely new feature, so far as we know, is the Ring Index, by which one can ascertain quickly the name of any complex nucleus from its structural formula.

The system may be seen in practice in the 1916 Index to *Chemical Abstracts*, although some slight changes have been made in methods since it appeared.

1. The Chief Function.—The most important general principle of the system is that the chief class or function of a compound should be expressed in the main part of its name, rather than as one of the substituting radicals. This does not mean, for example, that all names of ketones should end in -one, for such accepted short names as "benzil" are freely recognized; but rather that, in general, a compound in which the ketonic group stands out as the most prominent function should *not* be named with the use of such radicals as keto- or acetyl-. This principle is almost universally followed in the case of acids. It has been clearly stated by Stelzner in his "Literatur-Register." We have applied it more extensively than heretofore, as it is of advantage in connection with our system of indexing, and also has a bearing on the numbering.

2. Order of Functions.—With compounds of mixed function there must be a definite understanding as to which is the chief one for purposes of naming. After considerable experimenting we have adopted the following order of precedence, based on existing usage:

(*"Onium" compounds*), *acid* (carboxylic first), *acid halide, amide, imide, aldehyde nitrile, ketone, alcohol, phenol, mercaptan, amine, imine, ether, sulfide* (and *sulfoxide* and *sulfone*).

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[1] In the remainder of the article names are printed as they will appear in the Index in order to familiarize the reader with the inverted forms. The inversion is for index purposes only.

If a compound possesses two or more of the above functions the one which stands highest in the list is considered the "chief" one, and the compound is named accordingly as far as feasible. Thus Benzonitrile, hydroxy- is preferred to Phenol, cyano-; Phenol, amino- to Aniline, hydroxy-; Methylamine, ethoxy- to Ether, aminomethyl ethyl; etc. By "acid" in the above list is meant such groups as CO_2H, SO_3H, AsOOH, not acidity in general as indicated by ionization. "Onium" compounds are placed in parenthesis as not very definitely fixed. The list makes no pretension to be all-inclusive but works satisfactorily in practice. It is simpler and, to us, more usable than the order formulated by Stelzner.[1]

Of course no such order could conform completely to usage since the latter is often inconsistent and also the same compound is given different names according to the standpoint from which it is viewed. This flexibility is desirable in discussions but for purposes of record there should be as far as possible one preferred name for each compound, and a fixed order (which, however, need not be applied slavishly) is of assistance in selecting it.

3. Multiple Functions.—When the chief function is multiple, as in the case of diketones, polybasic acids, etc., all should be placed on an equality and expressed together in the name whenever feasible, and not as keto—one, carboxy—acid. This is not always possible; in the case of cyclic amines, for example, attached amino and imino groups are treated as substituents.

4. Largest Parent Compound.—Other things being equal, the largest parent compound possible should be chosen in naming a given derivative, so that the substituents may be as small as possible. This is often called the principle of "the lesser a substituent of the greater." Thus, Benzene, ethyl- would be chosen in preference to Ethane, phenyl-. For convenience this rule must sometimes be waived, particularly (1) when two or more complex radicals are substituents of a simple compound (as in Methane, triphenyl-), and (2) when it is not compatible with the principle of the chief function, stated above.

The above two principles (1 and 4), both of which are desirable, may often conflict, but they can be harmonized to some extent by using "additive" names. For example in the compound $C_{10}H_7CH_2CO_2H$ naphthalene is the parent compound but the acid group is in a side chain. The name carboxymethylnaphthalene is not satisfactory; on the other hand to call it naphthylacetic acid would violate Principle 4 and, in our system of indexing, would throw the compound under acetic acid instead of with the naphthalene series. Accordingly the name Naphthaleneacetic acid is

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[1] "Literatur-Register," p. xxviii.

used, which is indexed under N. Similar names are Cyclohexanecarbinol, Chrysene-*o*-benzoic acid, Anthracenemethylamine.[1]

5. **"Index Compounds."**—The main part of the name, with its functional ending (if it has one), denotes what we have called for lack of a better term, the "index compound" because in the index to *Chemical Abstracts* this is the part which will be placed first and determine the alphabetic position of the name. Thus the name dihydroxyanthraquinone appears in the index as Anthraquinone, dihydroxy- (anthraquinone being the index compound). The name of the index compound may or may not be the complete name of the compound indexed (according to whether or not it has the names of substituting radicals attached to it) but it must in all cases be complete in itself (that is, designate a real or theoretically possible compound or class of compounds) and not be merely the detached part of a name. It may or may not be a "parent compound." In the above instance anthracene would usually be spoken of as the parent compound.

6. **Two Functions in the Index Compound.**—Many names are in use in which two different functions are expressed in the end of the name, *e. g.*, phenolsulfonic acid, anthraquinonecarboxylic acid. Such names will no doubt continue to be employed on account of their convenience and we have adopted a few of the most common ones, but it is desirable to avoid their systematic use as they can be formed to an unlimited extent and lead to uncertainty in naming. When the parent compound is a base they are unavoidable (as, *e. g.*, Pyridinecarboxylic acid).

7. **Alphabetical Order of Radicals.**—The names of the substituting radicals in an organic name should have a definite order; otherwise two persons may name the same substance in the same chemical way and yet spell the two names very differently. The simplest possible order is an alphabetic one. To our mind this is as much to be preferred to any order based on chemical considerations as an alphabetic index to a general chemistry is to one arranged according to the periodic system. The latter would be logical but exasperating. There are over two hundred radicals the names of which are in common use. When a name has been settled upon for each radical the alphabetic system gives an instant means of deciding their order, in any combination. The use of it is greatly shortening the time required for preparing the index and we believe it will be equally useful to those who consult it. According to it one writes, *e. g.*, *b*enzyl*e*thyl*m*ethyl*p*henylammonium chloride. The number of radicals of each kind present does not affect the order, that is, di-, tri-, etc., are

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[1] The same idea is seen in Stelzner's proposal to leave the name of the parent compound unchanged in attaching the names of all functions to it, as ethanediamine instead of ethylenediamine. "Literatur-Register," p. xxviii.

disregarded (mono- is not used in the index entries). But when a radical is itself substituted its entire compound name is treated as a unit and constitutes the name of a radical in the alphabetic order. Thus $(CH_3)_2N$- is called "dimethylamino," a name which (for example) follows "chloro" but precedes "ethyl." However, once the complete name has been formed it is alphabeted like any other word in the language.[1]

8. Parentheses and Brackets.—The use of parentheses, brackets and even braces, where necessary, is of great assistance in marking off complex radicals. Many names in the literature are ambiguous for lack of them, and we have found it advantageous to use them freely. Thus the name Malonic acid, chloromethyl- indicates the compound $ClC(CH_3)(CO_2H)_2$ while Malonic acid (chloromethyl)- is the name of $CH(CH_2Cl)(CO_2H)_2$.[2]

By the alphabetic plan a departure from the alphabetic order calls attention at once to a complex radical, for aminomethylbenzene is a name for toluidine, $H_2NC_6H_4CH_3$, while methylaminobenzene (aniline, *N*-methyl-) indicates the formula $C_6H_5NHCH_3$, and therefore it is not absolutely necessary to write (methylamino)benzene.

9. Numbering.—Common usage has been followed in numbering aliphatic acids and the corresponding amides, aldehydes, nitriles, etc., with Greek letters, denoting the carbon atom next to the functional group by α, the next by β, and so on. For iso compounds primes may be used; *e. g.*, the three positions in isobutyric acid are called α, β, and β'. Greek letters are also used for numbering open-chain hydrocarbon radicals, α denoting the chain atom at the point of attachment. We have not found it necessary or even of advantage to use Greek letters with the Geneva names of aliphatic compounds as is the practice of some. The numbers cause less trouble in writing and counting.

Benzene and other simple carbocyclic compounds are numbered around the ring in the usual way and the symbols *o*, *m* and *p* are also employed for disubstituted benzene derivatives.

For complex cyclic compounds requiring fixed numberings, those given in the Richter "Lexikon" (3rd edition) have been adopted, the only exceptions being cases of manifest inconsistency. Of course many new ring

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[1] The one objection to the alphabetical order, namely, that it would vary slightly in different languages, we do not believe to be a serious one in view of its advantages. The proper transpositions would be a part of the translation.

[2] That there should be different names of like sound and spelling which must be distinguished to the eye by enclosing marks is not ideal, yet they are scarcely to be avoided in naming organic compounds. Attempts to do this often result in making the name unintelligible. As our chemical language is largely a written one a clear message to the eye is of first importance. The use of bis- and tris- instead of di- and tri- before complex radical names is a help to the ear and we accordingly favor it.

complexes are being described continually, and those not numbered in the Lexikon are given numberings in harmony with Richter methods.[1]

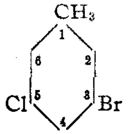
Side chains are numbered with Greek letters. If the side chain contains the chief function, α denotes the position next to it; if not, the position next to the ring. Thus, $C_6H_5CH_2CHClOH$ is Phenethyl alcohol, α-chloro-; $C_6H_5CH : CHCl$ is Styrene, β-chloro-. This numbering may even be extended to side chains attached to the ring by oxygen, sulfur, or the like, provided none directly attached by carbon is present. Thus, $C_6H_5OCH_2Cl$ may be called Anisole, α-chloro-.

10. Chief Function First.—When two or more numberings are possible for a given compound, that one is chosen which gives the smallest number or numbers for the *chief function* if one is present, then for double bonds if these must be taken into account, then for triple bonds, then for point of attachment if the molecule is a doubled one, and finally for substituents. (In the case of substituting radicals the point of attachment takes the smallest possible number, as is customary.) In doubtful cases the smallest numbering is considered to be that in which the figures concerned yield the smallest sum, or if the sums are equal, the set which has the lowest single figure. If there are two possible lowest numberings for substituents that one is chosen which best follows the alphabetic order of the radicals. These may seem very fine points, yet it is of some importance to have definite rules for numbering a compound so that index entries may come absolutely together. The precedence given the chief function we believe to be valuable, even where some other usage is more common (as, for example, the practice of numbering toluene derivatives from the methyl group even when hydroxyl, amidogen or some other functional group is present). Terpene names, being given a fixed numbering, form an exception (see TERPENES, p. 1637). Examples illustrating the above rules:[2]

$\overset{1}{CH_3}.\overset{2}{CHBr}.\overset{3}{CH_2}.\overset{4}{CH}(CH_3).\overset{5}{CH_3}$

Pentane, 2-bromo-4-methyl-

Bromo- precedes *methyl-* in alphabetic order.



The methyl group, being expressed in the index name, has position 1. *Bromo-* precedes *chloro-*.

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[1] The Richter system, which is only in a measure consistent, may best be understood from a study of the graphic formulas in the Introduction. Typically, the formula is drawn so that a characteristic part (hetero atom or atoms, five-membered ring or the like) comes on the right rather than the left; and especially so that the formula, if irregular in outline, turns *upward to the right*. The numbering then commences at a convenient point at the upper right and continues clockwise around the formula.

[2] The rules for numbering resemble those of Stelzner, but in the latter system the *point of attachment* is given first place, then the chief function; also, secondary functions affect the numbering. The differences in naming may be seen by comparing the examples here given with Stelzner, "Literatur-Register," pp. xxxi–xxxiii.

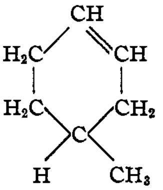
Toluene, 3-bromo-5-chloro-

$\overset{1}{CH_3}.\overset{2}{CH} : \overset{3}{CH}.\overset{4}{C}(CH_3)_2.\overset{5}{CH_3}$
2-Pentene, 4,4-dimethyl-

The double bond takes the lowest possible number (2 instead of 3) and so fixes the numbering.

$CH_2 : CH.CH_2.CH(CH_3).C \vdots CH$
1-Hexen-5-ine, 4-methyl-

The double bond takes precedence over the triple.

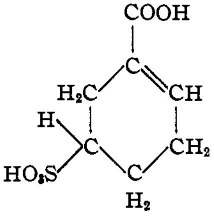


Cyclohexene, 4-methyl-

The double bond takes the lowest possible position (1–2) and fixes the numbering.

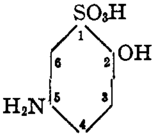
$\overset{\epsilon}{CH_3}.\overset{\delta}{CH} : \overset{\gamma}{CH}.\overset{\beta}{C}(CH_3)_2\overset{\alpha}{CH_2}CO_2H$
γ-Hexenic acid, β,β-dimethyl-

Hexenic acid is chosen as the index compound, being the largest available.



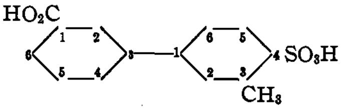
Δ¹-Cyclohexenecarboxylic acid, 5-sulfo-

Here the order of precedence is CO_2H (chief function), double bond, SO_3H (substituent). If carboxyl were eliminated, SO_3H would become the function and the compound would be named Δ³-Cyclohexenesulfonic acid.



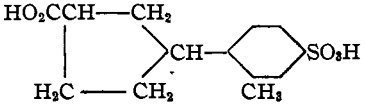
Benzenesulfonic acid, 5-amino-2-hydroxy

The numbering 5-amino-2-hydroxy- is lower than 3-amino-6-hydroxy-. If the mixed-function name, phenolsulfonic acid, which is very common, is accepted, the compound would be called *o*-Phenolsulfonic acid, 5-amino-, and the index compound, $C_6H_4(OH)SO_3H$, would acquire a fixed numbering.



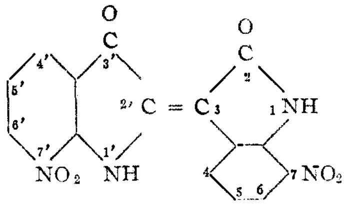
Benzoic acid, *m*-(4-sulfo-*m*-tolyl)-

Benzoic acid is made the index compound since such names as Biphenylcarboxylic acid have been found to lead to difficulties. The position of the methyl group, 2, fixes the numbering of the tolyl radical. It is not necessary to use primes for the tolyl numbers.



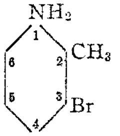
Cyclopentanecarboxylic acid, 3-(4-sulfo-*o*-tolyl)-

The Stelzner name for this compound is methyl-2′-[*cyclo*-pentyl-phenyl]-1,1′-carboxylic acid-3-sulfonic acid-4′, each nucleus being numbered from the point of attachment.



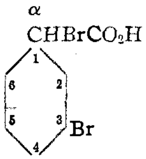
2,3'-$\Delta^{3,2'}$-Biindolinedione, 7,7'-dinitro-

The fixed numbering of indole is used for this and all other indole derivatives.



o-Toluidine, 3-bromo-

The numbering is from the functional group (NH_2), not from the methyl group.

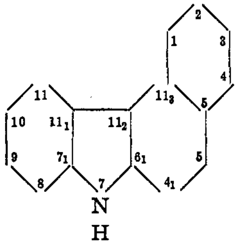


α-Toluic acid, *α*,3-dibromo-

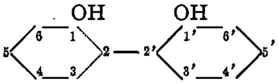
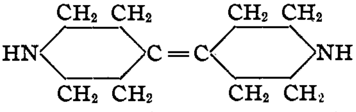
11. Numbers Understood.—By the application of the above principles many compounds receive a fixed numbering and this need not be expressed in naming their derivatives. For example, in cyclohexenol the hydroxyl group is in position 1; in cyclohexene the double bond is between positions 1 and 2; in resorcinol the hydroxyl groups are in positions 1, 3; and *m*-cresol is 1-hydroxy-3-methylbenzene. Consequently the following names completely describe derivatives: Δ^1-Cyclohexenol, 3-methyl-; Cyclohexene, 3-methyl-; Resorcinol, 2-chloro-; *m*-Cresol, 2-chloro-.

12. Numbering of Hydro Derivatives.—It frequently happens that functional derivatives, particularly ketones, of cyclic compounds must be regarded as formed by substitution, not of the parent compounds themselves, but of hydro derivatives of them; and yet it is very convenient to form names for such functional derivatives from the parent name. Quinoline, for instance, cannot itself have a ketonic derivative, yet the name quinolone is in use as a short name for dihydroketoquinoline. In our system it is not only convenient but very desirable to form such names. This offers no difficulties if (1) it be understood that only so many pairs of hydrogen atoms are added as are sufficient to form the compound in question, and if (2) the position of the entering hydrogen is fully indicated. In simple nuclei the latter can be done by indicating the positions of the remaining double bonds present; *e. g.*, $\Delta^{3,5}$-2-pyridone is equivalent to 1,2-dihydro-2-ketopyridine. For the more complex nuclei, however, this method becomes impracticable and we have adopted the simple plan, which is of general application, of indicating the positions of the extra hydrogen atoms in a parenthesis immediately following the figures for the position of the functional group. Thus, 4(3)-quinolone is equivalent to 3,4-dihydro-4-ketoquinoline, and 1(2)-quinolinesulfonic acid to 1,2-dihydroquinoline-1-sulfonic acid.

A second difficulty sometimes arises with complex nuclei of fixed numbering when hydrogen is added to tertiary carbon atoms which have not been numbered. There should be some general method of numbering such atoms without altering in any way the original numbering of the nucleus. We propose to do this by adding an inferior 1 to the number of the position just before it in order. If two or more tertiary atoms occur in succession, the second would take inferior 2, and so on. To illustrate:



The interpolated numbers 4_1, 6_1, 7_1, 11_1, 11_2, 11_3 would of course be used only when necessary.[1]

13. Doubled Molecules.—A molecule that has been doubled by the elimination of hydrogen is named by prefixing *bi-* to the original name, with figures to indicate the point of attachment, and the original numbering is retained, the two halves being distinguished by simple numbers and primes. Thus  is 2,2′-biphenol or *o,o′*-biphenol. If the attachment is by a double bond that fact is indicated by the use of the delta. Thus  would be called $\Delta^{4,4'}$-bipiperidine. Doubled radicals are also named with bi-; as, biphenyl.

If two like molecules are united, not directly, but by a bivalent radical the name of the radical followed by *bis-* is used; thus $HOC_6H_4CH_2C_6H_4OH$ is called Phenol, methylenebis-; $H_2NC_6H_4N : NC_6H_4NH_2$ is Aniline, azobis-. The use of bi- instead of di- for doubled molecules avoids confusion. Thus, by accepted usage diacetamide is $(CH_3CO)_2NH$, while $(CH_3CONH)_2$ could be called *N,N′*-biacetamide if desired (in this instance it is customary to name as a hydrazide or hydrazine derivative).

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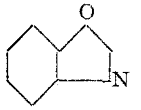
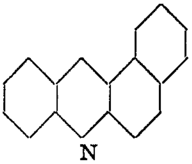
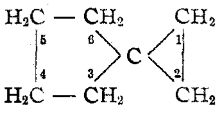
[1] This device covers all cases except the interior tertiary atoms in such compounds as pyrene, and these can, if the necessity arises, be cared for by an extension of the regular numbers (for pyrene, 11 and 12).

14. Naming New Complexes.—Ring complexes are often named from their component parts, and here two different methods are in vogue: (1) The name is formed from the names of the nuclei which may be regarded as combined together (with some atoms in common) to form it, as in benzoxazole, 

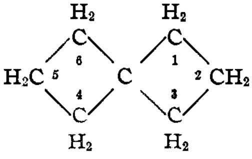
which may be considered as formed by the union of a benzene nucleus and an oxazole nucleus. (2) The compound is named from different nuclei that may be regarded as existing in it, notwithstanding the fact that these nuclei may have one or more entire rings in common. For example, the compound 

has been named naphthacridine. It is obvious, we think, that the second method finds itself in difficulties sooner than the first and also does not give as clear an indication for numbering isomers. We have therefore chosen to favor the first method systematically in naming new complexes. According to it the second compound would be called benzacridine and the structures of the isomers would be clearly indicated by prefixing 1,2- or 2,3- or 3,4- as the case might be, the figures referring to the original numbering of acridine. It will be noticed that in this instance the principle of "the lesser a substituent of the greater" has been followed in forming the name, and it would appear to be a useful one to apply in cases of doubt. By any method such compounding is likely to lead to long names and it seems to us advisable for authors to invent short names for totally new parent compounds.

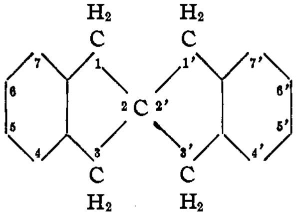
15. Spiro Compounds.—These contain rings united by a *single* common atom, and in forming the names of the parent compounds the prefix *spiro* has been used by us in two ways: (1) as in spiroheptane and (2) as in 2,2′-spirobiindan (see the formulas). The latter denotes a union of two indan rings with one common atom in the 2 position; simple numbers and primes are used just as in biphenyl or biindan. A union of dissimilar nuclei may be named as follows: Spiro [1-cyclohexane-4′-piperidine].



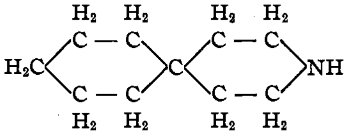
as-Spiroheptane.



s-Spiroheptane.



2,2'-Spirobiindan.



Spiro[1-cyclohexane-4'-piperidine].

The following paragraphs indicate the way in which particular classes of compounds are handled. In what is said regarding alcohols, amines, etc., it is of course assumed that no functional group of higher order is present or that if such group is present it is for some reason advisable not to recognize it as the chief function but to treat it as a substituent.

Acids.—The simple names in common use (acetic, isobutyric, acrylic, glutaric, cinnamic, gallic, etc.) are employed, both for these compounds and in naming their derivatives. Polybasic acids should conform to the rule for multiple functions (see 3, p. 1625); as 1,2,4-Butanetricarboxylic acid (not Succinic acid, (β-carboxyethyl)-), $CH_2(CO_2H)CH(CO_2H)CH_2CH_2CO_2H$. Unsaturated open-chain acids not having a common name may be named from the hydrocarbon of the same number of carbon atoms; as, β-Pentenic acid (not 1-Butenecarboxylic acid or Propionic acid, β-ethylidene-), $CH_3CH : CHCH_2CO_2H$.

Hydroxamic, *imidic*, *nitrolic* and *nitrosolic acids* are named after the corresponding carboxylic acids, as: Benzohydroxamic acid, $C_6H_5C(: NOH)OH$; acetimidic acid, $CH_3C(: NH)OH$; acetonitrolic acid, $CH_3C(: NOH)NO_2$; acetonitrosolic acid, $CH_3C(: NOH)NO$. *Phosphinic*, *phosphonic* and *sulfonic acids* are named from the parent compounds as follows: C_6H_5HPOOH, benzenephosphinic acid; $(C_6H_5)_2POOH$, benzenephosphinic acid, *P*-phenyl-; $C_6H_5PO(OH)_2$, benzenephosphonic acid; $CH_3PO(OH)_2$, methanephosphonic acid; $C_6H_5SO_3H$, benzenesulfonic acid; $C_6H_4(SO_3H)_2$, benzenedisulfonic acid. *Arsinic*, *arsonic*, etc., *acids* are named in the same manner. For *amic acids* and *anilic acids* see *Amides*, p. 1634.

Alcohols.—The common names ethyl alcohol, isobutyl alcohol, benzyl alcohol, benzohydrol, piperonyl alcohol, cyclohexanol, etc., are employed; however, aliphatic alcohols having no such simple name are not named as derivatives of ethyl alcohol, isobutyl alcohol, etc., but are given Geneva names (carbinol being used instead of methanol). Many aromatic alcohols which might be named as derivatives of carbinol are referred to benzyl alcohol and benzohydrol as being larger index compounds, but where three nuclei are concerned (as in $(C_6H_5)_3CH$, Carbinol, triphenyl-) the carbinol nomenclature is retained. Phenethyl alcohol, $C_6H_5CH_2CH_2OH$, is the logical index compound for many derivatives but for longer chains Geneva names are used (example, $C_6H_5(CH_2)_3OH$, 1-Propanol, 3-phenyl-). When other nuclei than benzene have a side chain containing the alcohol group as chief function, an additive name is given to the index compound (see 4); as, 1(or 2)-Naphthaleneëthanol, $C_{10}H_7CH_2CH_2OH$.

Aldehydes are given names corresponding to those of the acids, in the usual way, but the replacement of acid by aldehyde groups must be complete; thus, succinaldehyde is $(CH_2CHO)_2$, the monoaldehyde $OHCCH_2CH_2CO_2H$ being called Propionic acid, β-formyl-. When the name of the acid has the ending "-carboxylic acid" this is replaced by "-aldehyde" (not carboxaldehyde) in naming the corresponding aldehyde. In all cases the addition of -aldehyde to the name of a parent compound signifies the replacement of hydrogen by the group CHO and not the conversion of CH_3 into CHO.

Compounds having the hydrogen of the CHO group substituted are no longer aldehydes and should not be named as aldehyde derivatives.

Amides are named in the usual way from the corresponding acids, when the acid groups are completely replaced by amide groups. Monoamides of dibasic acids are named as *amic acids* (as, succinnamic acid, $H_2NOCCH_2CH_2CO_2H$). *N*-Phenyl derivatives of amides are named as *anilides* (as, acetanilide) or, in the case of monoanilides of dibasic acids, as *anilic acids* (as, succinanilic acid, $C_6H_5NHOCCH_2CH_2CO_2H$). *N*-Tolyl, *N*-anisyl, *N*-phenetyl and *N*-xylyl derivatives are named, respectively, as *toluides*, *anisides*, *phenetides* and *xylides;* as, *o*-butyrotoluide, $C_3H_7CONHC_7H_7$. When the numbering of such compounds offers too great difficulties they may be named as derivatives of the amides. When the name of the acid ends in "-carboxylic acid" the name of the amide is formed by replacing this with "-carboxamide." Di- and triamides are numbered by using primes and seconds in addition to the ordinary characters; thus Dibenzamide, p,p'-dichloro- has the formula $(C_6H_4ClCO)_2NH$ and $(CH_2ClCO)_3N$ would be called Triacetamide, $\alpha,\alpha,'\alpha''$ -trichloro-. Mixed amides are referred to the amide of largest molecular weight; thus, $C_6H_5CONHCOCH_3$ is Benzamide, N-acetyl-.

Amidines are named from the corresponding carboxylic acids; for example, benzamidine, $C_6H_5C(:NH)NH_2$, corresponds to benzoic acid. If derivatives of simple amidines cannot be readily named they are treated as derivatives of the corresponding primary amine (in the above case benzylamine, $C_6H_5CH_2NH_2$).

Amines.—The common names ethylamine, diethylamine, trimethylamine, benzylamine, cyclohexylamine, etc., are used as index names. Aliphatic amines are numbered α, β, etc., away from the amino group, and primes and seconds are employed in the case of secondary and tertiary amines just as in the case of amides. Mixed amines are referred to the largest simple amine present; as, $CH_3CH_2NHCH_3$ is called Ethylamine, *N*-methyl-. Amino groups attached to cyclic amines are treated as substituents, not as functions; thus, Quinoline, amino- (not quinolylamine). When there is no suitable radical name to which to attach the ending "-amine" the name of the parent compound may be used; thus, $C_6H_3(NH_2)_3$ is called benzenetriamine.

Azo and Azoxy Compounds.—Very common names such as azobenzene and azoxybenzene are used as index names without change. In general, however, the azo group —N : N—, and the azoxy group $-\overline{N-O-N}-$, should be made to follow the rule for bivalent radicals with the use of "bis-" to show that two like molecules are united by it, where this is the case. Thus $HOC_6H_4\overline{NON}C_6H_4OH$ is called Phenol, azoxybis- (not Azoxybenzene, dihydroxy- or Azoxyphenol). When the index compound cannot be named in this way the azo or azoxy group becomes part of a substituting group, as in the compound $C_6H_5N : NC_6H_4OH$, which is called Phenol, phenylazo- (not Azobenzene, hydroxy-).

Condensation Products.—A substance must be called simply a condensation product of certain compounds when its structure is unknown, otherwise it may be named on its own merits. It is convenient to describe certain classes, *e. g.*, semicarbazones and acetals, as derivatives of the corresponding aldehydes, ketones, etc., as the case may be. For doubled molecules see 13.

Cyano Derivatives are named as nitriles from the name of the corresponding acid in case the nitrile group is the chief function present; as, butyronitrile, $CH_3CH_2CH_2CN$ (not propyl cyanide or cyanopropane). Otherwise the group becomes a substituent; as, Acetic acid, cyano-. When the name of the acid ends in "-carboxylic acid" the name of the nitrile is formed by replacing this with "-nitrile;" as Cyclohexanenitrile, $C_6H_{11}CN$. In all cases the addition of "-nitrile" to the name of a parent compound means the replacement of hydrogen by the group CN and not the conversion of CH_3 into CN, *e. g.*, 1,8-octanedinitrile, $NC(CH_2)_8CN$ (not $NC(CH_2)_6CN$).

Acyl cyanides are named in the usual way; as, benzoyl cyanide, C_6H_5COCN.

Ethers.—The ether function is low in the order of precedence and even where no function of higher rank is present it is treated with a considerable amount of liberty to avoid awkward naming. For example, alkoxy derivatives of complex hydrocarbons are more conveniently so named than as ethers, and when two or more ether groupings are present the difficulties of naming as an ether are increased. Simple ethers, as ethyl ether, phenyl ether, etc., retain these common names (not diethyl ether, diphenyl ether). The names anisole, phenetole, etc., are adopted for naming these compounds and their derivatives. Other ethers (when named as ethers) are given a three-part name (as, Ether, ethyl methyl; Ether, chlorophenyl phenyl) in which the alphabetic order of radicals is followed.

Ethers of alcohols and phenols are named independently; for example, $C_6H_4(OMe)OH$ (*m*) is called Phenol, *m*-methoxy- and not Resorcinol, monomethyl ether.

Hydrazine Derivatives.—Hydrazine may be an index compound and many of its derivatives are named as follows: Hydrazine, phenyl-; Hydrazine, α-ethyl-β-phenyl-. But when a function of higher order than amidogen is present the group H_2NNH— becomes a substituent and is called hydrazino-.

Hydrazides are treated as derivatives of the corresponding acids, and *hydrazones* as derivatives of the aldehydes and ketones.

Ketones.—(1) The Geneva system is used for ketones having *no ring* directly attached to the group. (2) *Mono*ketones having a ring attached to *one side* of the ketone group are named as acetophenone, butyrophenone, etc., or acrylophenone ($CH_2 : CHCOC_6H_5$) or as derivatives of these when that is possible; if not, by the Geneva system, the names 1-propanone, 1-butanone, etc. (not propanal, butanal) being used as index names. Acetyl compounds are exceptions in this last case: they are named (for example) Ketone, indyl methyl, or where this proves to be inconvenient, as acetyl derivatives. (3) *Mono*ketones with rings directly attached to *both sides* of the carbonyl group are, if symmetrical and simple, named as - - - - - yl ketones; *e. g.*, 1-Naphthyl ketone, $(C_{10}H_7)_2CO$; if not, they are given such names as the following, Ketone, *o*-chlorophenyl 2-naphthyl; Ketone, bis (3-bromo-2-pyrryl); Benzophenone, *p,p'*-dibromo-. (4) *Poly*ketones in which the carbonyl groups are in the same straight chain are named by the Geneva system; otherwise the compound must be referred to the largest index compound available, preferably itself a ketone. (5) *Cyclic* ketones (in which the carbon of the carbonyl group is a ring member) are referred to index names which are formed from the name of the parent substance and the -one ending; as, 2,5-Pyrroledione. (For use of the parenthesis see 12.) (6) Simple names such as acetone, biacetyl, acetophenone, benzil, etc., are adopted, it being understood, however, that aliphatic ketones are not named as *derivatives* of acetone, biacetyl or similar compounds but by the Geneva system.

Mercaptans.—Mercaptans of simple radicals are given index names commencing with that of the radical; as, Ethyl mercaptan, C_2H_5SH. Those not easily named in this way are named directly from the parent compound; as, Acenaphthenemercaptan. When a function of higher order is present the group –SH becomes a substituent, called mercapto-.

Nitriles.—See *Cyano Derivatives*.

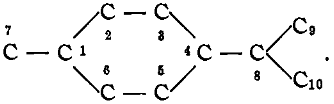
Oximes are ordinarily treated as derivatives of the corresponding aldehydes and ketones (as, benzaldehyde oxime or benzaldoxime). But sometimes this is very inconvenient and the group : NOH is then treated as a substituent (replacing H_2, not O) under the name isonitroso-.

Phenols.—The common names phenol, resorcinol, guaiacol, naphthol, etc., are employed, both for these compounds and for naming their derivatives. When no such common name exists and hydroxyl is the chief function a name is formed by attaching -ol to the name of the parent substance; as, quinolinol, naphthalenetriol.

Silicon Compounds.—The form "silico-" may be used to denote replacement of carbon by silicon just as "thio-" denotes replacement of oxygen by sulfur. For example, Si_2H_6 is disilicoethane. The following short names are also used: silicane, SiH_4; silicol, SiH_3OH; silicyl, H_3Si-; and silicone, corresponding to ketone (RSiOR′).

Sulfides are treated similarly to ethers. So, for instance, Ethyl sulfide (not diethyl sulfide); Sulfide, ethyl methyl. When a compound is referred to a different class the group CH_3S– is called methylmercapto-, C_6H_5S- phenylmercapto-, and so on. The compound $HO_2CC_6H_4SC_6H_4CO_2H$ would be named Benzoic acid, thiobis- (not Phenyl sulfide, dicarboxy- or Benzoic acid, carboxyphenylmercapto-).

Terpene Series.—The commonly accepted fixed numbering herewith shown is used for all terpene names, whether of the *o*-, *m*- or *p*-series. But any compound named as a derivative of cyclohexane or benzene—even if it happens to be a terpene—would conform to the general rules of the system. Thus menthol as a derivative of menthane is 3-*p*-menthanol; as a derivative of cyclohexanol it would be called Cyclohexanol, 2-isopropyl-5-methyl-. The terpene names and numbers are used by preference.



Thio Compounds.—The combining form "thio" (denoting -S-) is used in two slightly different senses which need not be confusing; first and usually, to denote the replacement of oxygen by sulfur in ketones, alcohols, acids, etc.; and second, with "bis," to denote the replacement of hydrogen by sulfur in such names as Acetic acid, thiobis-, $S(CH_2CO_2H)_2$. When it is necessary to distinguish between carbonyl oxygen and hydroxylic oxygen in replacements the forms thiono- and thiol- are used instead of thio-. Thus: Carbonic acid, thiol-, HSCOOH; Carbonic acid, dithiol-, HSCOSH; Carbonic acid, thiono-, HOCSOH; Carbonic acid, thiolthiono-, HOCSSH; Carbonic acid, trithio-, HSCSSH. When "thio" is used in naming ring compounds having the sulfur in the ring, it is not the name of a substituent but a part of the index name; as, Thiopyran, methyl- (not Pyran, methylthio-).

COLUMBUS, OHIO.

[CONTRIBUTION FROM THE KENT CHEMICAL LABORATORY OF THE UNIVERSITY OF CHICAGO.]

THE METHOD OF OXIDATION AND THE OXIDATION PRODUCTS OF *l*-ARABINOSE AND OF *l*-XYLOSE IN ALKALINE SOLUTIONS WITH AIR AND WITH CUPRIC HYDROXIDE.[1]

BY J. U. NEF, OSCAR F. HEDENBURG AND J. W. E. GLATTFELD.

Received June 6, 1917.

Nef published his first work on the oxidation of sugars by Fehling's solution, or, more correctly, by a suspension of cupric hydroxide in an alkaline sugar solution, in Liebig's *Annalen* in 1907.[2] The sugars studied were *l*-arabinose, *d*-glucose, *d*-mannose and *d*-fructose. Thereafter a series of investigations was undertaken by Nef, in part in collaboration with his students.[3]

The present work was undertaken in order to obtain more complete information with regard to the amounts of the oxidation products. Experimental proof of the production of certain acids, such as ribonic acid, was sought for.

When *l*-arabinose was oxidized in alkaline solutions by air, *l*-erythronic, *d*-threonic, *d*- and *l*-glyceric, glycollic, formic and carbonic acids were produced. When oxidation was accomplished by cupric hydroxide, *l*-arabonic, *l*-glyceric, glycollic, oxalic, formic and carbonic acids were found among the oxidation products. *l*-Ribonic acid was not found, although it was presumably produced, for *d*-lyxonic acid was found among the oxidation products of *l*-xylose. Other products of oxidation of *l*-arabinose were obtained by Nef in former experiments.[4]

When *l*-xylose was oxidized in alkaline solutions by air, *l*-threonic, *d*-erythronic, *l*-glyceric, glycollic, formic and carbonic acids were found to be present among the products. When oxidation was accomplished

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[1] The experimental work described in this paper was done by Dr. Nef during the two years previous to his death on August 13, 1915, with the assistance of Dr. Glattfeld and myself. I have undertaken to prepare the results of the work of this period for publication. Dr. Glattfeld has assisted in the preparation of this paper.—Oscar F. Hedenburg.

[2] *Ann.*, **357**, 214 (1907).

[3] Anderson, *Am. Chem. J.*, **42**, 401 (1909); Spoehr, *Ibid.*, **43**, 327 (1910); Glattfeld, *Ibid.*, **50**, 137 (1913); Nef, *Ann.*, **403**, 282 (1913); C. C. Todd, dissertation published by the University of Chicago Press.

[4] *Ann.*, **357**, 251 (1907).