ACTA CHEMICA SCANDINAVICA 6 (1952) 73–90

Problems of an International Chemical Nomenclature

K. A. JENSEN

Chemical Laboratory of the University of Copenhagen, Copenhagen, Denmark

Interest in chemical nomenclature has been increasing in recent years. The marked activity on all fronts of chemistry has increased the demand for effective communication, for clearness and precision in information, and has thus stimulated interest in chemical nomenclature problems. International co-operation on chemical problems has at the same time emphasized the need for more conformity in the chemical nomenclature of different languages.

The Geneva conference of 1892 initiated chemical nomenclature work on an international scale, and this was later continued under the auspices of the International Union of Chemistry, but was unfortunately interrupted and severely hampered by two world wars and their depressing influence on international co-operation and confidence. Nevertheless the International Union of Chemistry succeeded in accomplishing a nomenclature work which has already exercised a far-reaching influence on chemical literature.

On several points, however, the committees of the International Union of Chemistry have refrained from attempts to create a truly international chemical nomenclature, leaving it to national committees to modify the adopted names in conformity with "the genius of each language". By doing this problems of a purely linguistic nature have been highly overestimated. Actually there is, from a modern philological point of view, no fundamental reason for not introducing a much more radical unification of chemical terms, at least among the Indo-European languages. Among these languages there is a unanimity of major pattern which in principle makes it possible to formulate an idea in much the same way. There is no real reason that the French should not say ferrochloride instead of chlorure ferreux, the Italian ferro-clorido instead of cloruro ferroso, the Czech ferro chlorid instead of chlorid železnatý, and so on. Only habit prevents the use of essentially the same name in all these languages. Similarly no rule of language forbids the Italians to write *e.g.* helio and oxido instead of elio and ossido, the Spanish to write scandio and

yttrio instead of escandio and itrio, the Germans to write Citronensäure instead of Zitronensäure. There is no more reason for some languages to continue to use names such as benzol, kolesterin, dioxyacetone *etc.*, than there was to use irrational names such as carbolic acid and spirit of wine.

In the following, some of the most stubborn obstacles for obtaining an international chemical nomenclature are considered.

I. THE ABANDONMENT OF NATIONAL NAMES

It is now commonly agreed that a scientific nomenclature should be as international as possible. Formerly, however, it was thought to be a point of national self-assertion to introduce national terms. In some languages (Finnish, Icelandic, Czech etc.) almost all foreign words have been replaced by purely national words, even such words as the names of the months, electricity, cigar, etc., which otherwise pass almost unchanged from language to language. In many languages the names hydrogen, nitrogen, oxygen and carbon have been translated (German: Wasserstoff etc.) or replaced by new-created national words, *e.g.* Danish brint (hydrogen), ilt (oxygen) and Polish tlen (oxygen). The Slavic languages also have national names for silicon, aluminium, magnesium and calcium. This again gives national names to the inorganic compounds. From Danish "ilt" (oxygen) is derived "ilte" = oxide; we thus obtain names as "brintoverilte", "kvælstofilte" and so on for compounds for which just as well the names hydrogenperoxid and nitrogenoxid could be used, as has now actually been proposed by the Danish nomenclature committee. Czech analogously has a special name for oxide, "kysličnik", and thus names as for instance kysličnik vápenatý = calcium oxide and kysličnik uhličitý = carbon dioxide are obtained.

By unification of the names of the chemical elements as mentioned under II it would in principle be possible to do away with all these inconsistencies.

In older times most of the chemical terms were taken from words of daily life and thus differed from language to language: "slaked lime", "sugar of lead", "butter of antimony", "heavy spar", "massicot", and so on. By the introduction of rational terms the old names have almost disappeared from scientific literature. In several languages, however, names of some organic compounds, particularly organic acids, still are reminiscent of the names of early chemistry. For succinic acid for instance, names such as Bernsteinsäure (German), ravsyre (Danish), yantarnaya kislota (Russian) are used. In English and French latinized names of these acids are used, and these could as well be applied in other languages, *e.g.* Succinsäure instead of Bernsteinsäure. Even if it is difficult now to change these old names, new names should at least not be

formed in the old-fashioned way. When the name folic acid had to be used in other languages some authors translated it into "Blättersäure" (German) and "bladsyre" (Danish, Norwegian). Pretty rapidly, however, the names Folinsäure and folinsyre gained ground. *It would be very important if the International Union of Chemistry would state as a principle that new chemical names should always be formed from Greek or Latin roots. When introducing new names due consideration as to their applicability in other languages should be taken.*

These rules should also apply to chemical terms that are not names of compounds. Terms as "lone pair", "shared electrons", „core", "Zwitterion", "Eigenfunktion", "Bindigkeit", "Ionen-Beziehung", "Oktett-Lücke" are particularly difficult to translate and often are taken over as such in other languages, a practice which can only be considered as make-shift. By the way "Zwitterion" is rendered in Danish as "ampho ion", a word of real international form which ought to be introduced in other languages.

For most of the organic functional groups, terms of international character are used. This, however, is not the case with the name acid, for which very different names are used (Säure, syre, happo, kwas, kislota, kyselina etc.). It would be preferable to introduce a term of Latin origin, *e.g.* acid (as has actually been done in Turkish asid), but the difficulty is that in several languages it will not be possible to distinguish in pronunciation between acid and azid.

Words of a national character should not be connected with international names. In Polish for instance the national numerals are used instead of mono, di, tri, etc. resulting in names as dwunitrotoluen, czterohydropirano for dinitrotoluene and tetrahydropyran. The inconvenience of this is obvious, but no less inconvenient is the use of national names as iron, lead, Wasserstoff, Bernstein in connection with international terms as oxid(e), sulfat(e), amid(e) etc.

II. THE NAMES OF THE ELEMENTS

One of the most needed improvements in inorganic chemical nomenclature is the unification of the names of the chemical elements. If essentially the same names of the elements could be introduced in different languages, the names of inorganic compounds in these languages would automatically become very similar.

The problem of the unification of the names of the elements has been considered in detail elsewhere *. Here only the main points will be mentioned:

* In a memorandum presented to the committee on inorganic chemical nomenclature of The International Union of Chemistry. Copies of this paper may be obtained from the author.

The differences in the names of the elements in different languages are of the following types:

1. The elements known from antiquity (gold, silver, copper, iron, mercury, lead, tin and sulfur) have quite different names in different languages.

2. For some of the more recently discovered elements (H, C, N and O) several languages employ translations of the original names of international character.

3. In some cases two names of international form have been introduced for the same element:

beryllium and glucinium	lutecium and cassiopeium
sodium and natrium	hafnium and celtium
potassium and kalium	antimon and stibium
columbium and niobium	tungsten and wolfram

4. In several languages the spelling of the names of the elements has been changed by applying a more or less phonetical spelling. As the pronunciation of the names of the elements differs from language to language and the phonetical value of the letters is not the same in different languages, these changes have made the names look rather different not only from the latinized names but also from each other:

k replaces c: kalcium, kadmium, skandium, aktinium, kobalt (Scandinavian, German, Slavic languages).

k replaces ch: klor, krom (Scandinavian, Croatian, Hungarian, Turkish).

z replaces c or vice versa: Kalzium, Zäsium (German), cynk, cyrkon (Polish).

s replaces c or z: kalsium, sink (Norwegian, Finnish), seziyom (often in Turkish instead of cesium).

h is eliminated: litium, renium, tallium, torium, tulium, rodium, rutenium, lantan (several languages); and Italian elio (He) and afnio (Hf).

i replaces y or vice versa: berillio, kripto, itrio, iterbio (Italian and Spanish), tytan, iryd, cyrkon, cynk (Polish).

the ending -ium is altered into -io (Italian, Spanish), -iu (Roumanian) or -ij (Russian) or completely omitted: Cer, Niob, Zirkon (German), nioob (Dutch), lit, skand, gal, osm, ren, rad (Polish).

To obtain practically the same names in different languages the following changes are necessary:

ad 1. The Latin names of the elements of the first category (aurum, argentum, cuprum, ferrum, hydrargyrum, plumbum, stannum and sulfur) should be introduced as scientific names into the literature of all countries. These should not necessarily replace the national names in common usage. The use

of Latin names may be of importance in distinguishing between for example the element ferrum and common iron, but especially it will be an advantage to use these names when forming names of compounds (see below).

In English the Latin names sulfur and mercury have practically superseded the names brimstone and quicksilver even in common usage. Unfortunately, however, the name mercury is at variance with the chemical symbol.

ad 2. The names of this group are artificial names, that have not become part of every day language to the same extent as the names of the first group. It should without doubt be possible to replace the national names Wasserstoff etc. by the names hydrogen, oxygen, nitrogen and carbon.

ad 3. The problems concerning the names of this group are in some cases mingled with a conflict of priority and therefore involve national prestige. In many cases, however, the question of priority cannot be settled unambiguously. Further a chemical name should not be accepted on grounds of priority alone: its adequacy, applicability and present usage in different languages should also be considered.

At the Amsterdam meeting of the IUC (September 1949) it was decided to recommend the names beryllium, niobium, lutetium, hafnium and wolfram. The cases where there are two different names would thus be reduced to three Unfortunately opposition to the name wolfram, especially from the English side. caused the committee to leave this name optional again.

The reasons for choosing the above mentioned names are the following:

Beryllium: The name glucinium has been little used outside France and is not particularly characteristic for this element. The name beryllium was proposed by Wöhler, who first prepared metallic beryllium. The priority of Vauquelin for being the first to prove a new "earth" in beryl is not contested by this decision.

Niobium: The name columbium has only been used by American and some British authors. The name niobium, proposed by H. Rose who was the first to give definite proof of the existence of this element, is used in all other languages. On grounds of priority there is no reason for preferring the name columbium (*cf.* A. Larsson [1]).

Lutetium: The name cassiopeium is only used in German and (in part) Dutch. Both for this reason and because the name is difficult to adapt to some languages the name lutetium is preferred. It is not intended to settle the question of priority (*cf.* Paneth [2]) by this decision. The hitherto used spelling lutecium should be replaced by lutetium, because the name should be derived from the Latin form Lutetia rather than from its French equivalent Lutèce.

Hafnium: The name hafnium is used in all other languages than French. It is also to be preferred on grounds of priority.

Wolfram: Wolfram is the name proposed by the discoverers of this element, the brothers de Elhuyar, it is in accordance with the chemical symbol and is used in 12—13 languages out of 17 considered. On ground of his historical studies Moles [3] has strongly advocated the general introduction of the name wolfram, and even in England this name has been

recommended (Hadfield[4]). Further tungsten in Scandinavian languages means "heavy stone" and could not well be applied to an element; it is the original and still used name for the wolfram mineral scheelite, $CaWO_4$. Thus the arguments for abandoning the name tungsten for the element are certainly very strong.

In the remaining cases where there are two names for the same element consideration of the accepted symbols favours the names natrium, kalium and stibium instead of sodium, potassium and antimony.

ad. 4. The spelling should be regulated on the lines mentioned under VI. In the main languages only minor changes in spelling are necessary:

The spelling baryum is only used in French and Czech, where it should be changed to barium. In English sulfur should not be spelled with *ph*. In American aluminum should be replaced by aluminium.

In recent German there has been a tendency to use *k* and *z* instead of *c* (as for instance Kalzium, Zäsium, Kadmium). After the war, however, the Latin forms are gaining ground again. Vanadin should be changed into Vanadium, Cer into Cerium, Niob into Niobium and Wismut into Bismuth.

In other languages rather more extensive changes in the spelling are necessary to arrive at true international names (*cf.* VI).

The introduction of the names mentioned under 1 and 2 would bring us a major step forwards toward an international chemical nomenclature. Thus sulfurtrioxid(e) would replace Schwefeltrioxyd, zwaveltrioxyd, svovltrioxyd, kysličnik sirový, trekh-okis sery. Hydrogenperoxid(e) would replace Wasserstoffperoxyd, brintoverilte, vätesuperoxid, perekis vodoroda. Nitrogenoxid(e) would replace Stickstoffoxyd, kväveoxid, oxyde d'azote, kvælstofilte, kysličnik dusnatý, and so on. Other examples are to be found under III.

III. THE STOCK NOMENCLATURE

According to the IUC rules for naming inorganic compounds »indication of the electrochemical valency in the names of compounds should be made only by Stock's method» and »the system of valency indication by terminations such as -ous, -ic .... should now be avoided not only in scientific but also in technical writing».

This report was published in 1940, when work in the International Union was suspended because of the war, and could not therefore be thoroughly discussed and criticized before an international forum. In the following years the Stock system became rather widespread, especially in Germany and the United States.

From an international point of view, however, the Stock nomenclature suffers from the serious drawback of being much more national in character than the older nomenclature. This may be sufficiently substantiated by giving the names of $FeSO_4$ in different languages according to the older nomenclature and the Stock system:

	Older name	Stock name
Danish	Ferrosulfat	Jern-to-sulfat
Dutch	Ferrosulfaat	Ijzer-twee-sulfaat
English	Ferrous sulfate	Iron-two-sulfate
Finnish	Ferrosulfaatti	Rauta-kaksi-sulfaatti
French	Sulfate ferreux	Sulfate de fer-deux
German	Ferrosulfat	Eisen-zwei-sulfat
Hungarian	Ferroszulfát	Vas-kettö-szulfát
Italian	Solfato ferroso	Solfato di ferro-due
Spanish	Sulfato ferroso	Sulfato de hierro-dos
Swedish	Ferrosulfat	Järn-två-sulfat
Turkish	Ferrosulfat	Demir-ikki-sulfat

Accordingly the failure of the Stock system is that it uses the national names of the elements and, in spoken language, the national numerals. In written language the numerals will be designated by Roman figures, but even then the Stock nomenclature is much more national than the one hitherto used. The joint Scandinavian (Danish, Finnish, Norwegian and Swedish) nomenclature committee writes on this matter to the International Union of Chemistry: "We find this objection so significant that we question the advisability of recommending the Stock nomenclature without radical alteration of it. At any rate we find it objectionable that the international rules mention Stock's system as the only one allowed for indicating the electrochemical valency."

In the written language the designation by Stock's method can be made international by the use of the Latin names of the elements, *e. g.*: ferrum(II)-sulfate, cuprum(I)-chloride, stannum(IV)-chloride, aurum(III)-chloride. Contrary to the English version of the international rules it is considered advisable to use a hyphen after the parenthesis.

Fernelius [5] says that there is a definite tendency to shift to English names throughout; for example to use silver(I) ion instead of argentous ion and iron(II) ion instead of ferrous ion. This is certainly a step backward. According to Fernelius: "the percentage of such names is so small that any benefit a foreign reader may be expected to gain is negligible". In a chemical text, however, the chemical terms are so important that often little more than the

understanding of the chemical terms is necessary to get the meaning of a chemical text in a foreign language. Furthermore it is an advantage to the chemists of the small countries, who are compelled to *write* in a main language that the chemical terms look similar in different languages.

The proposal to use the Latin names of the elements seems to be the only satisfactory solution of this intricate matter. It is true that it does not do away with the difficulty that the national numerals have to be used, but as chemical knowledge is mainly communicated in written language this objection is of minor importance.

The names ferrum(II)-chloride etc. resemble very much the hitherto used names, and indeed the endings *-ous* and *-ic* may be used when they leave no uncertainty as to the valence. The circumstance that the ending -ous sometimes refers to a univalent, sometimes to a bivalent and sometimes to a tervalent state is no serious objection. But often it is necessary to indicate more than two valencies, and there the ous-ic system fails. As is well known Alfred Werner proposed an alteration and extension of the *o-i*-system, using the endings *a-o-i-e-an-on-in-en*, thereby being able to indicate 8 different valencies. This ingenious system failed because the vowels in some languages, particularly English, are not pronounced distinctly enough. In Czechoslovakia a system is in use in which the name of the metal is used in adjective form with different endings, indicating different valencies. Thus the oxides MnO, Mn_2O_3, MnO_2, MnO_3 and Mn_2O_7 in Czech are called kysličnik manganatý, manganitý, manganičitý, manganový and manganistý. This nomenclature represents a purely national solution of the problem and indeed is an example of the way in which a scientific nomenclature should not be developed.

Thus it seems to be most satisfactory to use the Latin names of the elements with the Stock numbering system.

IV. THE NAMES OF SALTS

In the Stock nomenclature the acid residue is indicated in the same way as in the *o-i*-system. The terminations *-at*(-e, -o) and *-it* (*-e*, *-o*) are now universally adopted and the names formed in this way have almost completely superseded the names of the types "schwefelsaures Magnesium" or "schwefelsaures Magnesia", formerly used in German, Russian and Scandinavian languages. The termination *-id*(*-e*, *-o*), however, is not universally adopted. The Romance languages (and Turkish) use instead the termination *-ur*(*-e*, *-o*). This was formerly also used in English and German, where it, however, was used to designate a lower oxidation state (Eisenchlorür=$FeCl_2$; Eisenchlorid=$FeCl_3$). When by the introduction of the o-i-system the valency state was

indicated by terminations of the name of the metal, one of the terminations -ur and -id became superfluous, and unfortunately in most languages the termination *-id(-e, -o)* was chosen. Actually it is difficult to distinguish in pronunciation between *-id(-e, -o)* and *it(-e, -o)*. When the d is not followed by a vowel it is generally pronounced as t and recourse has therefore to be taken to modify the length of the *i* to distinguish between -id and -it. In some languages, however, a certain vowel can have only one length, and in these languages it is absolutely impossible to distinguish between chlorid and chlorit, sulfid and sulfit etc. Even when the d is followed by a vowel (as in English) the difference between *-ide(-o)* and *-ite(-o)* is not very distinct.

Therefore the re-introduction of the termination *-ur(-e, -o)* would offer certain advantages. Unfortunately, however, the termination *-id(-e, -o)* is much more widespread and even in the Romance languages the name oxyde(-o), not oxure(-o), is used.

Perhaps the best solution of this problem would be to choose a new termination. By analogy with the name oxyd(e), which is used in French, German and some other languages one might write chloryde, sulfyde etc. In the languages where the above mentioned difficulty of distinguishing arises, the termination *-yd* could be pronounced, and perhaps written (although this would violate the principles set forth under VI) as *-üd*.

It would of course be an advantage if all compounds of this type were designated in an uniform manner in all languages. But the difficulty in attaining this is unusually great, since the changes will be great, whatever decision be taken:

a. If the termination *id(-e, -o)* is retained the termination *ur(-e, -o)* in Romance languages should be changed and oxyd(e) should be changed into oxid(e). The problem of distinguishing clearly between *-id* and *-it* is not solved in this manner.

b. The introduction of the termination *-ur(-e, -o)* means a change in all other languages than the Romance ones, and also for these oxur*(-e, -o)* is a a new name.

c. The introduction of the termination *-yd(-e, -o)* means a change in all languages, but this termination is not very different from *-id(-e, -o)* and may be pronounced as this. In the languages where a different pronunciation is desirable it may be pronounced as -üd.

The names indicating the anion can be combined with the name of the metal in two ways, illustrated by magnesium sulfate and sulfate of magnesium. In French exclusively names of the latter type are used (sulfate de magnesium). The names of the first type are most convenient when the acid has a short name, and they could well be employed in French also. When, however, the acid has a very long name the distance between the name of the metal and the ending -ate becomes unduly long, and in such cases it seems more con-

venient to use names of the French type, *e.g.* 3,5-dinitro-4-dimethylaminobenzoate of sodium(in German Natriumsalz der 3,5-Dinitro-4-dimethylaminobenzoesäure or 3,5-dinitro-4-dimethylaminobenzoesaures Natrium).

The same applies to esters where names of the type benzoic ethylester (in German: Benzoesäureäthylester) are to be preferred to names of the type ethyl benzoate when the acid has a long name.

V. THE TERMINATIONS OF NAMES OF ORGANIC COMPOUNDS

Building on the famous Geneva rules the International Union of Chemistry in its Definitive Report of the Commission on the Reform of the Nomenclature of Organic Chemistry (the "Liége Report") has created a consistent system of terminations expressing the functions of organic compounds. This system was first adopted in the English literature and was then also introduced in French and (in part) in Dutch, Spanish and Polish. Quite recently it is also being introduced (as far as possible) in the Scandinavian languages. Although the Geneva rules were created also on the initiative of German chemists German literature continues to use the names benzol, toluol, carotin, cholesterin, glycerin, resorcin *etc.* It is true that the Liége rules cannot be applied so consistently to the German language as to English, but the names mentioned could at least be altered as proposed already in the Geneva rules. The difficulty of a consistent application of the Liége rules is connected with the termination *-e*, which in German indicates the plural. Therefore it is not possible to use the endings *-an* and *-ane*, *-in* and *-ine*, *-ol* and *-ole* as designation of different functions. Oxazole in German is simply the plural form of Oxazol. Similar difficulties, however, are encountered in Scandinavian and other languages, where one nevertheless has found it advantageous to introduce the system as far as possible.

One of the most urgent problems for the creation of an international chemical nomenclature is the universal adoption of the endings *-en*(*-e*, *-o*) for unsaturated hydrocarbons (benzen, toluen, styren, caroten etc.) and the ending *-ol*(*-o*) for hydroxy compounds (glycerol, resorcinol, cholesterol *etc.*). On the other hand it is not possible in several languages to avoid giving heterocyclic compounds the same ending as hydroxy compounds (pyrrol-glycerol) or saturated hydrocarbons (pyran-methan) or to give some non-nitrogeneous compounds the same ending as nitrogen bases (dextrin-pyridin). Even with this limitation the Liége rules offer such great advantages that it is unwise to neglect them.

In this connection it may be pointed out that the prefix hydroxy- should be universally adopted to express the alcohol- or phenol-function. In German

and several other languages (presumably under the influence of the Beilstein nomenclature) the prefix oxy- is used (Oxysäuren = hydroxyacids, Oxybenzole = hydroxybenzenes). This is a relic of the old addition nomenclature, *oxy-* meaning an oxygen atom (*cf.* trioxymethylene, phosphorus oxychloride), but organic chemical nomenclature now generally follows the principle of substitution.

The prefix hydroxy- (oxy-) should be spelled thus and not hydroxi- (oxi-).

VI. THE SPELLING OF CHEMICAL TERMS

a. Importance of agreement on spelling of the beginning of words

The international committees of chemical nomenclature have hitherto concentrated their efforts on attaining uniformity in the endings of chemical names. In this respect they have been quite successful. The beginnings of the names on the contrary have been left aside as a problem of orthography which cannot be dealt with by chemists, at least on an international level. For the perception of the names, however, the beginnings of the words are as least as significant as the endings, simply because we read the words from left to right. When we read the words there is certainly as much difference between cholesterol and kolesterol as between cholesterol and cholesterin, between caroten and karoten as between carotene and carotin, between phloroglucinol and floroglucinol as between phloroglucinol and phloroglucin. It is particularly inconvenient, both as to recognizability and to mnemonics, when chemical names of plant substances are spelled in another way than the botanical names from which they are derived. In some languages for instance the names of compounds isolated from *Colchicum*, *Crocus*, *Coca*, *Citrus*, *Rhamnus*, *Rheum*, *Quercus*, *Physalis*, *Thymus*, *Haematoxylon*, *Hedera*, *Chelidonium etc.* are spelled: Kolkicin, krozetin, kokain, zitral or sitral, ramnose, rein, kversetin, fysalien, tymol, ematossilina, ederagenina, kelidonin. For chymosine one finds the spellings chimosina, quimosina, kymosin, for chlorophyll the spellings clorofilla, klorofyl, and so on.

Another important point is that conformity in spelling gives the same alphabetical order of chemical terms irrespective of the language. Each chemist frequently uses compilations of chemical data and subject indices of journals and books of reference in other languages than his own. It is inconvenient to search quinoline under *q* in an English journal, but under *ch* (Chinolin) in a German and under *k* (kinolin) in a Scandinavian journal. Even such small differences as between thorium and torium, rhodium and rodium,

rhamnose and ramnose etc. are inconvenient and may even cause one to miss important references.

Finally the chemists of the small countries, who are obliged to write their papers in a main language are hampered by their national spelling. The Scandinavian Chemical literature, written in English, sometimes contain such misspellings as bensoic acid, bensyl, styfninic acid, tiazole, metyl *etc.*, and even if such errors are corrected in the proofs great care is necessary to avoid them. Influenced by the chemical symbols and by papers written in foreign languages Scandinavian students of chemistry are inclined to use spellings such as calcium, chlor, chrom, phenthiazin *etc.*; but hitherto these have been corrected to kalcium, klor, krom, fentiazin *etc.* When these spellings finally have been impressed on the students, they add to confusing when the students have to read or write in a foreign language. From the point of view of mental effort the unification of the names of the chemical compounds accordingly offers great advantages. Because the chemical symbols are international, the efforts should primarily aim at introducing names of the elements which are in accordance with their symbols.

b. Etymological versus phonetical spelling

The divergent spellings are particularly numerous in the smaller European languages where the written language has no old tradition, but has mainly been established in the 19th century. At that time the predominant opinion of philologists was that a written language should, as far as possible, be a phonetic rendition of the spoken language. But as the pronunciation differs from language to language, and the phonetical value of a certain letter is not the same in different languages (*c* is *e. g.* pronounced as *s* or *k* in western languages, but as *ts* in Slavic languages; *z* is pronounced as *ts* in German, but as voiced *s* in Slavic languages) the introduction of phonetic spelling has isolated these languages from each other and from the classical languages. The newer theory of language, however, considers the spoken and written language as two different coordinated modes of expression and does not approve of efforts to bring them as close together as possible. Moreover the process of reading is not, as was formerly thought, simply a process of spelling. In reading we do not spell the words but perceive them as entities, as symbols. It is not absolutely necessary that these symbols have any connection at all with the sounds for which they stand — as is well known, for instance, from the Chinese ideographs and from the chemical symbols or the numeral figures. A certain approach to a phonetical rendition has some value as to mnemonics, but an exact phonetical rendition of the spoken language is impossible because the

pronunciation of a certain word may vary with place, time and even the connection, in which it is used. Because we read the words as symbols it is of great importance that the same thing is always described by the same symbol whenever we come across it. A written language has as a rule only one accepted spelling of each word even if there may be several pronunciations. The advantage of this is uncontested when a single language is concerned, but it also applies to international words occurring in different languages. The pronunciation of "lieutenant" for example is quite different in French and English, but it is obviously an advantage to understanding that the "symbol" is the same. Nevertheless many languages have nationalized the spelling of such international words. An alternative to the phonetical spelling of words is an etymological spelling, in accordance with the derivation from the parent language *. The phonetical spelling will vary from language to language, the etymological spelling may be constant. Accordingly an etymological spelling is the only spelling on which there is the possibility of an international agreement. A difficulty, however, arises with terms derived from languages that are not written with the Latin alphabet: Arabic, Chinese, Greek, Russian. The etymological spelling of words derived from these languages will only be constant if there is agreement concerning their transliteration. Now the foundation of the sciences was laid in a literature written in Latin and in this literature words of Greek (and Arabic) origin were transcribed by a consistent and universally accepted system. As will be discussed in more detail below it is the most rational to continue to use this system, even if it in some cases does not give the simplest spelling possible.

Fortunately English and French have to a large extent retained the classic spelling of words of Latin and Greek origin, even if the pronunciation has changed much from the original one. Also German had formerly mainly the classic spelling of words of Latin and Greek origin, but in more recent times the spelling has been nationalized by introducing *z* and *k* instead of *c*, for instance Krozetin, Kalzium, Zäsium, Kapronsäure, Karbazol, Karboxyl, Kozymase, Kumarin, Zellobiose, Zetylalkohol, Zitronensäure, Zitral, Zyan, Zyklohexan, Zystein. This spelling has also spread to a great extent in Swiss literature. The big German handbooks, Beilstein, Gmelin and Richter-Anschütz, however, use the older spelling and it seems that after the war this spelling is gaining ground again, so there should be a fair chance of bringing the German spelling of chemical terms very close to the English and French one.

* As a matter of principle scientific terms should as far as possible be derived directly from the classic languages and not from modern languages (*cf.* I). In some instances terms have been formed from words of modern languages and should retain the spelling of the language of origin (*e. g.* ytterbium, named after the Swedish town Ytterby).

The main difference between the English-French and older German spelling is the rendition of Greek *kappa*, which will be discussed in more detail below, and the spelling of names related to quinine (quinoline, quinic acid, quinone, quinhydrone, quinuclidine, quinoxaline, *inter alia*), which in German are spelled with ch. The common origin of these words is a Peruvian word *kina-* (bark), but as this has come into European languages via Spanish, where it is spelled *quina*, it seems most logical to use the spelling with *qu* and not that with *ch*.

c. The problem of transliteration of words of Greek origin

The peculiarities of the different spellings of chemical terms are in most cases connected with a different transliteration of words of Greek origin. Thus *zeta* may be reproduced as *z*, *s* or *c; theta* as *th* or *t; kappa* as *c*, *k*, *s* or *z; ksi* as *x* or *ks; rho* as *r* or *rh; upsilon* as *y* or *i; phi* as *ph* or *f;* and *chi* as *ch* or *k*. Further in words of Latin origin *c* may be reproduced as *k* and *qu* as *kv*.

It would be of great importance if the International Chemical Union could recommend only one system to be used, when forming chemical names from Greek roots. Without doubt the most rational would be only to use the Latin transliteration, *i. e. kappa* = *c*, *phi* = *ph*, *chi* = *ch* etc.

German, in contrast to English and French, often reproduce *kappa* as *k*, when it is pronounced as *k:* Pikrinsäure, Kresol, Kakodyl, often also Galaktose, Oktan etc. There is certainly something to be said in favour of this practice, but the following reasons make it difficult for the Greek *kappa* to be generally reproduced as *k:*

α. In chemical names introduced in older times the Latin transliteration of Greek words was used exclusively, and accordingly the pronunciation of *kappa* before front vowels (*e*, *i*, *y*) changed to *s (ts)*, for instance cetyl, decyl, cinnabar, glycin, cyan, cyclo-, cystin, cytochrom. It certainly does not seem advisable to change these spellings to ketyl, dekyl, kinnabar, glykin, kyan, kyklo-, kystin, kytokhrom. In the words where *c* is pronounced as *k* the spelling could in many cases be changed, as has been done in German and several other languages, but in some words the *c* has been stabilized by becoming part of a chemical symbol. It is unwise to introduce spellings as Kadmium and Aktinium as long as their chemical symbols are Cd and Ac.

β. In the international, latinized names of zoological and botanical species the Latin transliteration for Greek names are, of course, still used. When the name of a chemical compound is derived from these names it is important

that the spelling should not be altered. For instance crocetin should be spelled thus, because its name is derived from the botanical name *Crocus*, although this again is derived from Greek κρόκος. The same argument applies to colchicin, coniin, corydalin and many others.

Thus it is not possible to reproduce *kappa* as *k* consistently. Therefore the most rational procedure is undoubtly to use the classic Latin transliteration of Greek words, *i.e.* practically not to use the letter *k* in chemical names. This is in accordance with French, other Romance languages and, for the most part, with English. In modern English chemical nomenclature there is, however, a tendency to reproduce *kappa* as *k*, for instance katalase, hexokinase, kathepsin, keratin, kynurenine, kyanmethine, kephalin. *To avoid further confusion it is very important that a rule should be established concerning the formation of chemical names from Greek roots.*

Something might also be said in favour of the simplified reproduction of *phi* as *f*. However *ph* will presumably be used for ever in the names of botanical and zoological species and in medical terms, and it is desirable that chemical names derived from these terms should conserve the same spelling (*e. g.* physostigmine, physaliene, phthiocol). Further it is unwise to spell phosphorus with *f* as long as the chemical symbol is P. It therefore seems most rational to adhere strictly to the Latin transliteration of Greek words and to spell words of Latin origin in the same way as the words from which they are derived.

It should, however, be emphasized that a system of transliteration should not be considered as an end but as a means, and exceptions to it may therefore be admitted, if they are agreed to internationally. For instance the spellings krypton, barium, ethyl, kynurenin are found in more languages than the more orthodox spellings crypton, baryum, aethyl, cynurenin, and it would therefore be easier to obtain international agreement concerning the first spellings. Such exceptions should, however, not be too numerous.

d. Languages with phonetical spelling

Next to English, French and German the languages of greatest importance to chemistry are Czech, Dutch, Italian, Polish Russian and Spanish. Russian need not be considered here, because the use of another alphabet makes almost any approach to an international spelling impossible. In Dutch almost no changes are necessary. Polish has strictly phonetical spelling with *k* instead of *c*, *ks* instead of *x* (even when initial sound: ksenon, ksantogen) and *f* instead of *ph*. A peculiarity of Polish is that *i* has been replaced by *y* and vice versa; thus pyridine for instance becomes pirydyna. Thus rather extensive changes are

necessary. Czech on the other hand has a spelling of international words which is to a great extent in accordance with the international spelling, though for many compounds purely national names have been introduced (see under I).

In Italian the most serious deviations from the international spelling are the disuse of the letter *h* and the replacement of *x* by *s* or *ss* and of *y* by *i*. Thus names as esaossicicloesane (hexahydroxycyclohexane) arise. *H* is not pronounced in Italian, but nevertheless is retained in some purely Italian words (*ho*, *ha*), so it should be possible to replace names such as elio, afnio, emina, emoglobina, eptacosano by helio, hafnio, hemina, hemoglobina, heptacosano. By reintroducing *x* and *y* such names as esaidropirano, esosi, ossiemoglobina, ialuronidasi would be hexahydropyrano, hexosi, oxyhemoglobina, hyaluronidasi and thus much more easily recognizable.

In Spanish the most serious deviations from international spelling are caused by the use of *i* instead of *y*, by insertion of an *e* before *s* followed by another consonant, and by sometimes reproducing *ch* as *qu*. Thus names as itrio (yttrium), escandio, estroncio, escopolamina and quimosina (chymosine) arise.

In the languages having a phonetical spelling the introduction of an etymological spelling is often rejected with the argument, that it is not in accordance with the "genius of each language". This argument has, however, been grossly abused in discussions of chemical nomenclature. The latinized botanical and zoological names are used unchanged in different languages. In Italian for example the botanical names Oxalis and Helenium are accepted unhesitatingly; why, then, not oxigeno and helio? In all languages proper names exist which do not conform with a phonetical spelling. But the names of the chemical elements and compounds are in some sense to be considered as proper names.

To introduce the changes necessary to obtain an international spelling of chemical terms it is necessary to consider these as latinized scientific terms similar to the names of botanical and zoological species. From this point of view it should be possible to change the spelling of chemical terms without changing the spelling of words of every day life of Greek or Latin origin, and conversely, when first established the international spelling of chemical terms should not follow changes in the spelling of common words.

VII. PRONUNCIATION

A real unification of the pronunciation of chemical terms is not attainable, nor is it of any great importance because most chemical communication is given in written language. A few words should, however, be said about English as a congress language. French or German are in some sense better suited as

international languages because they are pronounced more distinctly. Without doubt, however, English is becoming more and more important as a congress language, and if this is to be for the good, English and American chemists should make efforts to articulate more distinctly.

The importance of English as an international language is also severely hampered by the fact that often international words which are pronounced in much the same way in several languages are pronounced quite different in English. Names as amid(e, -o), methyl, cyanid(-e) etc. sound very similar in French, German, Italian, Russian, Danish *etc.*, but quite different in English. The cause of this is that *i* and *y* in English may be pronounced as *ai*, a pronunciation which is different from that of all other languages, and by the way from the original Anglo-Saxon one. From this point of view the American pronunciation of methyl, phenyl *etc.* is much to be preferred to the English one. The American Chemical Society has issued a list of recommended pronunciations, and in many cases two possible pronunciations have been placed in order of preference. *In almost all cases, from an international point of view, the order of preference should be reversed,* because the specific English pronunciation has been placed first. Further some pronunciations have been described as Germanisms. As a matter of fact these pronunciations resemble not only the German pronunciation, but also that of other languages and therefore their use should be encouraged rather than discouraged. A term particularly difficult to understand for foreigners is thio-. It would be an advantage if it could be decided to pronounce it teeo- as in most other languages.

CONCLUSION

Above some of the difficulties encountered in the establishment of an international chemical nomenclature have been discussed. These difficulties will perhaps appear insuperable to those who are strongly dependent on habit and to those who consider the language as a growing organism which cannot be influenced arbitrarily. The latter opinion is quite erroneous. Which word should be used for a certain notion is almost exclusively a question of convention, but it must be admitted that habit will strongly oppose all attempts at radical changes of the language. Notwithstanding this difficulty the nomenclature committees of the International Union of Chemistry should seriously consider the possibilities of unification of chemical terms. Otherwise their influence will be mainly limited to a few languages only.

I wish to acknowledge the valuable assistance of Dr. Vincent E. Price and Dr. G. H. Cheesman in reading and criticizing the manuscript.

REFERENCES

1. Larsson, A. *Z. anorg. Chem.* **12** (1896) 193.
2. Paneth, F. *Nature* **159** (1947) 8.
3. Moles, E. *Anales soc. españ. fís. y quím.* [3] **26** (1928) 234; *El momento científico español 1775—1825* (1934). Madrid.
4. Hadfield, R. A. *J. Iron Steel Inst. (London)* **64** (1903) 69.
5. Fernelius, W. C. *et al. Chem. Eng. News* **26** (1948) 521.

Received June 16, 1951.