

## VIII

# Documenting the History of Chemical Nomenclature and Symbolism

When asked by Jim Bohning to participate in this symposium, I was also specifically asked to speak, not on the history of nomenclature and symbolism *per se*, but rather on the history of previous attempts to record that history – in other words on what historians call the “historiography” of the history of chemical nomenclature and symbolism. Though many excellent articles dealing with specific aspects of the history of chemical nomenclature and symbolism have been published over the years in the journal literature, this morning I will, for reasons of time, have to restrict my coverage to a review of those more ambitious attempts found in the monograph and textbook literature (1).

### Hermann Kopp

The first detailed treatment of the history of chemical nomenclature and symbolism that I am aware of occurs in Hermann Kopp’s (figure 1) famous four-volume *Geschichte der Chemie*, which was published 57 years after the modern nomenclature reforms introduced by Lavoisier and his collaborators in their pivotal *Méth-*

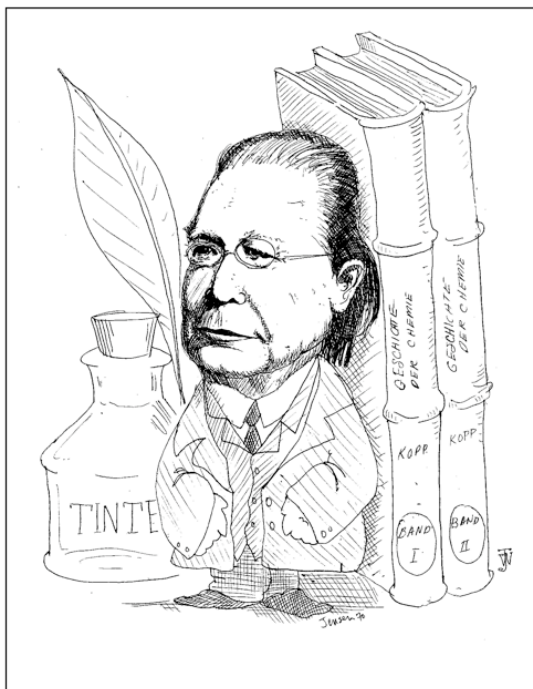


Figure 1. A caricature of Hermann Kopp (1817-1892).

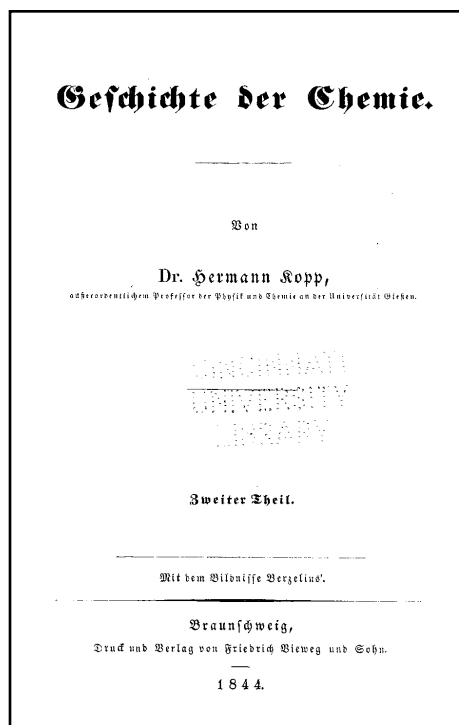


Figure 2: Title page to volume II of Kopp’s *Geschichte der Chemie*.

*ode de nomenclature chimique* of 1787 (2). The final section of Volume II of Kopp’s epic (figure 2), which first appeared in 1844, is entitled “Geschichte der chemischen Nomenclature und Zeichenlehre,” (History of Chemical Nomenclature and Symbolism) and devotes 15 pages to this subject.

Kopp first provides a straight-forward chronological account of the history of chemical nomenclature which focuses on four topics: 1) ancient and alchemical terminology; 2) the early and sporadic 18th-century reforms of Macquer, Baumé, Bergmann, and Guyton de Morveau; 3) the 1787 *Méthode* of Lavoisier *et al.*; and 4) early 19th-century amendments of Lavoisier’s proposals by Thomson and Berzelius.

Kopp then proceeds to outline the history of chemical symbolism, following the same chronological sequence: 1) ancient and alchemical symbols; 2) early modifications of these symbols by Geoffroy and Bergman; 3) the geometrical symbolism of Adet and Has-

senfratz; 4) the circle symbolism of Dalton; and 5) a very brief mention of the alphabetic symbols of Berzelius. For obvious reasons there is no coverage of the history of either systematic organic nomenclature or of structural formulas, since these subjects did not exist at the time of Kopp's writing.

### Robert M. Caven and John A. Cranston

While Kopp's contribution has the honor of being the first full textbook account of the history of chemical nomenclature and symbolism, another 84 years would have to pass before the first monograph-length (220 pages) account would appear – an account which would deal only with the history of chemical symbolism, and thus have little to say about the companion subject of chemical nomenclature. The monograph in question was entitled *Symbols and Formulae in Chemistry: An Historical Study* (figure 3), and was published in 1928 by the Scottish chemists Robert Caven and John Cranston (3). Caven (figure 4) was an inorganic chemist who had authored numerous textbooks on inorganic and analytical chemistry with a decidedly historical emphasis, whereas Cranston (figure 5) was a radiochemist who had played a role in the discovery of the element protactinium.

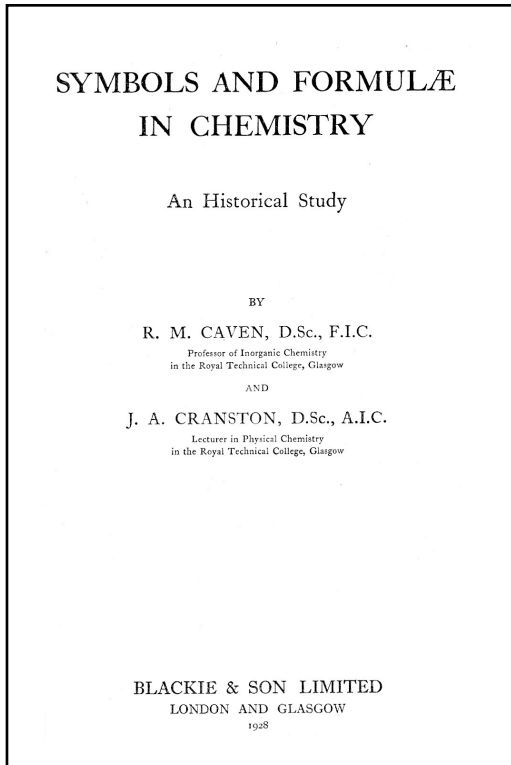


Figure 3. Title page of the first monograph to deal with the history of chemical symbolism.



Figure 4. Robert Martin Caven (1870-1934).

Their monograph is divided into eight chapters having the following titles: 1) "Beginnings of Symbolism," 2) "Appearance and Development of Modern Symbols," 3) "The Theory of Structure," 4) "The Development of Stereochemistry," 5) "Special Theories of Valence," 6) "The Electron in Chemistry," 7) "Extreme Dualistic Theories of Valency," and 8) "Symbols in Physical Chemistry." The first of these chapters covers developments from ancient symbolism through the circle symbolism of Dalton; the second covers developments from the alphabetic compositional formulas of Berzelius through the topological formulas of Frankland; the third deals largely with attempts, from Kekulé through Thiele, to symbolize the structure of benzene; the fourth with the introduction of organic stereochemical formulas from Pasteur through von Baeyer; the fifth with inorganic structural formulas from Werner through Abegg; the sixth with electronic formulas from the polar theory of J. J. Thomson through the shared electron-pair bond of Lewis and Langmuir; the seventh with symbolism related to the electronic theory of organic reactivity from Fry through Ingold; and the eighth with special symbolism related to the rise of physical chemistry, including thermochemical symbolism, equilibrium symbolism, pH, etc.

The organization of the book is obviously driven as much by the history of chemical theory as it is by purely chronological considerations, the implicit premise being that theory drives symbolism, and at times it appears to be more a popular history of these theories



Figure 5. John Arnold Cranston (? - 1972).

than a strict history of chemical symbolism *per se*. Given its subject matter, it also comes as no surprise that the monograph is heavily illustrated and, because



Figure 6. Maurice Crosland (b. 1931).

of its date of publication, that it is also lacking coverage of both resonance and orbital symbolism.

### Maurice Crosland

Perhaps the most famous monograph (406 pages) on the history of both chemical nomenclature and symbolism is Maurice Crosland's (figure 7) *Historical Studies in the Language of Chemistry*, published simultaneously in 1962 by Heinemann in England and by Harvard University Press in the United States, and available since 1978 as a Dover reprint (4).

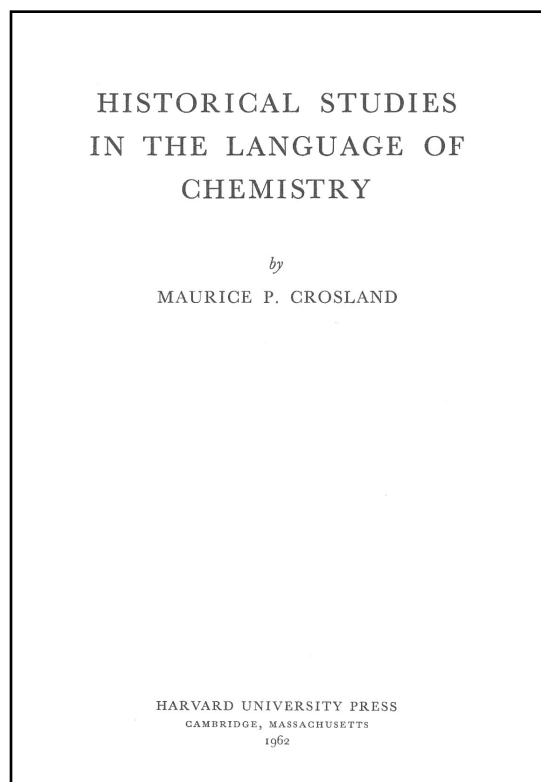


Figure 7. Title page of the first American edition of Crosland's history of chemical nomenclature and symbolism.

This monograph (figure 7) is divided into five sections: 1) "The Language of Alchemy" (three chapters), 2) "Early Chemical Terminology" (four chapters), 3) "The Introduction of Systematic Nomenclature into Chemistry and the Acceptance of the 1787 Reform" (nine chapters), 4) "Chemical Symbolism" (four chapters), 5) "The Language of Organic Chemistry" (four chapters). The first four sections essentially cover the same time period and cast of characters as did Kopp's brief survey of 1844 but obviously do so in far greater detail, with the greatest emphasis being on the impact of the reforms of Lavoisier and his collaborators. This



means that there is no coverage of developments in either inorganic nomenclature or inorganic symbolism after about 1820. Part 5 provides the history of organic nomenclature and symbolism which was missing from Kopp's original account, but does so only through the Geneva Convention of 1892. These limitations also mean that, unlike the Caven and Cranston book, there is no coverage of electronic formulas. Despite these limitations, the Crosland monograph was and still remains the single most definitive source for the history of early chemical nomenclature and symbolism.

### Aaron J. Ihde

Most general histories of chemistry published after Kopp devoted a paragraph or a page to the *Méthode* of 1787 and to the symbols of Berzelius, as well as providing some coverage of the development of structural formulas in the later chapters dealing with the rise of valence and stereochemistry. However, little or nothing was said of the subsequent evolution of inorganic nomenclature and symbolism, of the origins of systematic organic nomenclature, or of the rise of electronic and orbital symbolism.

An exception is Aaron Ihde's (figure 8) 1964 textbook, *The Development of Modern Chemistry*, also available since 1984 as a Dover reprint (5). Ihde's book (figure 9) contains three brief sections devoted to the history of nomenclature – one each for the 18th, 19th



Figure 8. Aaron J. Ihde (1909-2000).

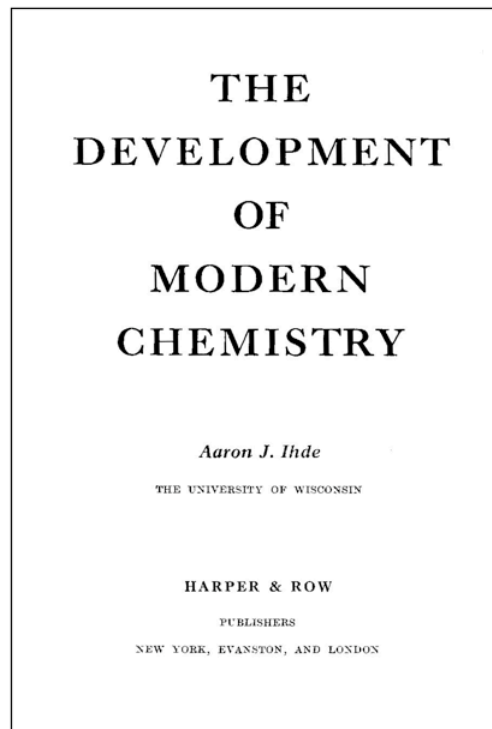


Figure 9. The title page of Aaron Ihde's history of chemistry.

and 20th centuries. That for the 18th century provides a one-page summary of the proposals found in the *Méthode* of 1787, whereas that for the 19th century provides a two-page summary of organic nomenclature through the Geneva Convention of 1892, both accounts being based on Crosland. It is, however, Ihde's two-page account of 20th-century developments, including the origins of IUPAC and the proposals of Brauner (1902), Rosenheim and Koppel (1909), and Stock (1919) for the revision of inorganic naming practices, as well as the more specialized proposals of Fernelius *et al* with respect to coordination complexes (1948), which set his account apart from those found in most other general histories of chemistry.

### Pieter Eduard Verkade

The year 1985 finally saw the publication of a detailed (507 pages) monographic account of the long-missing history of the development of systematic organic nomenclature since the Geneva Convention of 1892 (6). The monograph in question was an English language translation of 13 articles on the history of organic nomenclature written in French for the *Bulletin de la société chimique de France* between 1966 and 1979 by the Dutch chemist, Pieter Eduard Verkade (figure 10), and published posthumously (Verkade died in 1979) as *A History of Organic Nomenclature* by Reidel as part



Figure 10. Pieter Eduard Verkade (1891-1979).

of its ill-fated *Chemists and Chemistry* history series (figure 11). This is very much an insider's account as Verkade was a member of IUPAC's Commission on the Nomenclature of Organic Chemistry from 1927-1971 and served as its chair from 1934-1971. Drawing on this background he provides the reader with a very detailed account of events from, as already noted, the Geneva Convention of 1892 through the work of Section D of IUPAC in 1973. As such, it meshes perfectly with Crosland's account of earlier developments up to 1892.

### What is Still Missing?

There are still many important developments in the history of chemical nomenclature and symbolism for which proper accounts are missing in the monograph literature. The most obvious of these is a detailed history, similar to that of Verkade, of developments in inorganic nomenclature after 1820 which would amplify on Ihde's brief pioneering account of 1964. An idea of just what this would entail may be illustrated using the example of the compounds  $\text{FeO}$  vs  $\text{Fe}_2\text{O}_3$  and a brief overview of the various systems which have been proposed over time for naming them:

*Color System (Lavoisier et al, 1787):*  
red oxide of iron vs black oxide of iron

*Saturation System (Thomson, 1807):*  
protoxide of iron vs peroxide of iron

*Suffix system (Berzelius, 1811):*  
ferrous oxide vs ferric oxide

*Condensed Suffix System (Werner & Brauner, 1902):*  
ferrooxide vs ferrioxide

*Coefficient System (Rosenheim & Koppel 1909):*  
iron oxide vs 2-iron 3-oxide

*Oxidation Number System (Stock, 1919):*  
iron(II) oxide vs iron(III) oxide

*Prefix System (IUPAC, 1940):*  
iron oxide vs diiron trioxide

Also missing is an account of the special nomenclature systems which have been developed for certain classes of inorganic compounds, such as those of hydrogen (silanes, boranes, etc.), or those involving special structural features, such as cluster compounds (*closo-*, *nido-*, *arachno-* etc.) and solid-state polymorphs.

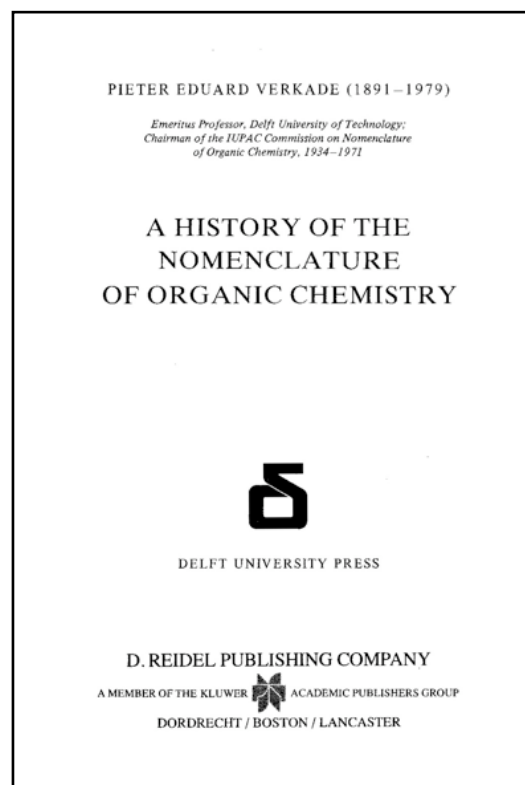


Figure 10. The title page of Verkade's account of the development of systematic organic nomenclature from 1892-1973.

Many of the topics covered in the monograph by Caven and Cranston also require updating, such as their coverage of the special symbolism of physical chemistry, and of electronic formulas so as to include both resonance and orbital notation.

### Also Rans and What Ifs

There are several ways of stimulating the interest of an audience of chemists when discussing the history of chemical nomenclature and symbolism. One of these is to mention various “Also Rans” – proposals, both good and bad, which never gained widespread acceptance. When it comes to symbols and formulas, most of the above books do a good job of mentioning these. Indeed, the proposals of Hassenfratz and Adet and of Dalton really belong in this category as neither were ever widely adopted. In the case of nomenclature, however, the coverage is far more spotty. Thus no mention is made, for example, in the above books of the ill-fated nomenclature proposals of Laurent (1854), of Griffin (1858), or of Werner (1905), to name but a few.

These “Also Rans” almost always strike a modern chemist as bizarre, but, it is important to point out that this reaction is largely an issue of lack of familiarity rather than one of logic and self-consistency. This point can be further driven home by mentioning a few “What Ifs.” Thus, for example, what if the concept of homologous series had been discovered earlier so that the first four members were given numerically self-consistent names like the later members, rather than their current trivial names?

*monane* ( $CH_4$ ), *diane* ( $C_2H_6$ ), *triane* ( $C_3H_8$ ), *tetrane* ( $C_4H_{10}$ ), *pentane* ( $C_5H_{12}$ ), etc.

Or what if the hydrocarbons were made to conform to the same naming rules for hydrogen compounds as the silanes and boranes?

*carbane* ( $CH_4$ ), *dicarbane* ( $C_2H_6$ ), *tricarbane* ( $C_3H_8$ ), *tetracarbane* ( $C_4H_{10}$ ), *pentacarbane* ( $C_5H_{10}$ ), etc.

Of course such proposals do not have a hope in hell of ever being accepted and I am sure that such names as monane and tricarbane strike you as impossibly strange and unmelodious, yet they are perfectly logical and systematic. More importantly, they perfectly illustrate, not just how conservative chemists are when it comes to nomenclature, but the overwhelming role played by “familiarity” in such considerations. No subject better illustrates how much arbitrary historical baggage modern chemists unknowingly carry around than does the history of chemical nomenclature.

### Some Pedagogical Considerations

In closing I cannot resist commenting on how badly the concepts of systematic chemical nomenclature and symbolism are taught to chemistry majors. While some effort is made to explain the elementary principles of organic nomenclature and symbolism, nothing of the sort is done with respect to inorganic nomenclature and symbolism in either the introductory or advanced courses. Instead, it is assumed to be so self-evident that the student will somehow automatically absorb the requisite knowledge through constant exposure or by reading a special appendix in the back of the textbook.

Our information concerning a molecule can be logically broken into five stages:

1. Its relative or stoichiometric composition.
2. Its absolute or molecular composition.
3. Its 2D bonding connectivity or topology.
4. Its 3D shape or geometry.
5. The presence or absence of chirality.

The first two of these stages are compositional in nature and the last three are structural. This hierarchy should be reflected in the kinds of formulas and names which we assign to molecules and in how we teach these subjects to students. Yet few books explicitly point out that the names and formulas assigned to inorganic compounds are largely compositional, whereas those assigned to organic compounds are largely structural or why this distinction works in practice. Likewise, most textbooks continue to describe 2D topological formulas as “structural” when, in fact, the term structure logically encompasses geometry and chirality as well. And, of course, no attempt is made to notationally distinguish between stoichiometric versus molecular compositional formulas, thus forcing the students to guess which kind they are dealing with from the context.

Even more tragically, in direct contradiction to the IUPAC guidelines, most general chemistry textbooks incorrectly state that the prefix system is used only to name covalent inorganic compounds, whereas the Stock system is used only to name ionic inorganic compounds, and the simple logic of the prefix system continues to be subverted by the many exceptions allowed by IUPAC and demanded by most textbook authors, such as carbon monoxide instead of carbon oxide and calcium chloride instead of calcium dichloride, thus requiring generations of students to need-

lessly memorize special rules, exceptions, and tables of common oxidation states.

And, lastly. I cannot resist pointing out that many chemists continue to exhibit what can only be described as a schizophrenic attitude toward the subject of chemical nomenclature. On the one hand, they celebrate the great advance made by Lavoisier and his collaborators in the *Méthode* of 1787 in introducing a logical and systematic naming system based on chemical composition and often point to the mishmash of earlier alchemical names with derision, yet, on the other hand, as will become apparent from some of the talks later in this symposium, organic and natural products chemists in particular continue to glory in the practice of inventing wildly irregular names for their complex compounds based on puns, metaphors, and personal trivia.

## References and Notes

1. An invited lecture given as part of the symposium on the history of chemical nomenclature sponsored by the Bolton Society at the 238th National ACS Meeting, Washington, DC, 16 August 2009.
2. H. Kopp, *Geschichte der Chemie*, Vol. 2, Vieweg: Braunschweig, 1844, pp. 412-426.
3. R. M. Caven, J. A. Cranston, *Symbols and Formulae in Chemistry: An Historical Study*, Blackie: London, 1928.
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5. A. J. Ihde, *The Development of Modern Chemistry*, Harper and Row: New York, NY, 1964, pp. 77, 338-340, 587-588.
6. P. E. Verkade, *A History of the Nomenclature of Organic Chemistry*, Reidel: Dordrecht, 1985.