Chemical Writing

By M. G. MELLON
Purdue University, Lafayette, Indiana
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That *homo sapiens* is a symbol-using animal seems to be one of the broadest generalizations which can be made concerning his activities. The particular aspect of this activity having present interest is the use of symbols as a means of recording and communicating chemical ideas and facts.

Such use of symbols marks, in part at least, our earliest historical record of man. Advance in what we usually call civilization has been accompanied by, and probably is partially the result of, increasing facility in the use of such means of communication. The current annual chemical accumulation is truly enormous, and its production and use require an appreciable fraction of chemists' working hours.

Through the ages, the use of symbols has taken many forms. The author's intention here is to consider only current practice in chemistry and chemical technology. This is adequate, even for most historical material, for probably the past two centuries. Addition of alchemistic symbols will extend the time further backward for a number of centuries.

It may be noted that, although the title is "Chemical Writing," the material is almost equally pertinent to all scientific and technical writing. Variation is necessary only in individual areas having highly specialized symbolism, such as chemists and chemical engineers have in chemical formulas.

Current Types of Writing.—The individual writing productions of chemists and chemical engineers are really innumerable. Whatever the number of distinct and separate items may be, classification according to kinds is of value to the extent that fairly uniform practices apply to different kinds.

One basis of classification is the disposal to be made of the product. There are at least three fairly distinct possibilities: (1) notes, letters, and other items intended to provide merely temporary or passing information; (2) plans of action, notes on subsequent activities, and progress reports on the projects, as generally practiced in industrial and research organizations; and (3) everything intended for public distribution, usually in published form. Anything from the first two of these classes is unlikely to be published. Perhaps because of this fact, and because their production may be hurried, the average quality is below that of most published material. Such a deficiency in class two, especially when the items constitute permanent files of organizations may be serious as the years pass.

Perhaps a more useful basis of classification is the nature of the material written. For simplicity only published items are included here. To deal with the vast collection already published, along with that being added at an annually accelerating rate, the author has found it convenient in a library course to consider these publications as primary and secondary sources. Space does not permit an elaboration of the many details of these publications, but a few items may be mentioned.

Primary sources contain our great stock of new information. The types of publications are: (1) periodicals, (2) governmental bulletins, (3) patents, and (4) dissertations and manufacturers' technical bulletins. The nature of the journal literature varies between the extremes of a passing news item to the most abstruse mathematical presentation. Most bulletins resemble journal articles, but a few approach book form. Dissertations and manufacturers' publications are not essentially different in form. Patents, of course, stand by themselves as a type of writing.

Secondary sources contain material taken largely from the primary sources and arranged in more or less definite ways to serve particular purposes. The types are: (1) periodicals, such as abstracting journals, index serials, and review serials, (2) bibliographies, (3) works of reference and textbooks, and (4) miscellaneous items, such as recipe books, catalogs, and biographical works. Here again we find great variation in writing form. Bibliographies and index serials, and often catalogs, are mere lists of entries. Abstracts and recipes are generally short summaries. Works of reference and textbooks, which include much of the collection of books on library shelves, become very comprehensive in the great treatises.

The Problem.—Anyone in contact with current chemical writing is too frequently faced with low quality and deficiency in the products. Letters from holders of the Ph.D. degree may not meet the simple standards of freshman English. Some defectively written patents are ever under fire in the courts. One research supervisor of a large concern reported that, in his group of about 50 Ph.D. research men, only two could write well. Reviewers and editors have endless difficulties because of defectively written manuscripts presented by both industrial men and college professors. Most instructors in graduate schools long to see a Ph.D. candidate who, by himself, can write a good thesis and then prepare an acceptable condensation of it for publication. Incidentally, it is doubtful that anyone should be awarded this degree until he can present his work satisfactorily.

These examples are unfortunately typical. There seems to be a twofold explanation of the causes of the difficulty. In the first place, apparently many writers do not know what should be done, as in presenting tabular material or graphs. Part of this difficulty could easily be obviated

if such individuals would examine current issues of the journal for which they are writing. As mentioned later, editors have printed instructions covering many details. In the second place, some writers know well enough what to do, but they do not do it. They resemble the automobilist who, on a dangerous curve, calmly speeds over the double yellow line to pass the car ahead. In writing, of course, there is not even a legal deterrent, unless it is the fear of invalidity in a defectively written patent.

MEANS OF WRITING

In order to improve out product, we need first to recognize the means at our disposal. Work in using the chemical literature, and in helping to make some of it, has convinced the author that we employ one or more of five rather distinct means. Since a number of books have been written about each of at least two of these means, a short paper can do little more than direct attention to what is involved.

In addition to knowing what the means are, we should recognize both their merits and limitations, and the techniques of using them effectively. This includes, of course, a sense of appropriateness, or when to use each one. The competent writer knows such things and performs accordingly.

In general, high standards of practice are followed in the publications sponsored by the American Chemical Society. "Hints to Authors," a pamphlet issued by the staff of *Industrial and Engineering Chemistry*, contains very helpful advice for preparing papers destined for that office. The suggestions are rather generally applicable.

1. Words.—From the viewpoint of the extent of their use, words are undoubtedly our most important means. Many articles, books, patents, and other publications contain nothing else. For decades one professor displayed as his only office motto, "Language is our most important scientific tool; learn to use it with precision."

Introduction to words and their use is part of the child's very early conditioning. Formal education presumes to continue the process, at least to the level of college graduates. No day passes without our practicing the art. Many books are available replete with instructions and examples of approved usage of English. With such a background, how can students reach graduate school so poorly prepared in using their mother tongue that they must be assigned to freshman writing classes? The answer is left to modern educationists as they contemplate the merits of their products.

What is the remedy? Study of handbooks of English and of the writing of competent chemists will show one what to do. Then follows the long struggle and persistent attention required to achieve facility in correct and adequate verbal expression. Mere practice does not necessarily make perfect. Continued repetition of the incorrect serves rather to mire one more deeply in error.

2. Formulas and Equations.—To many a college freshman the chemical symbols, as found in formulas and equations, seem a formidable mental hazard. To the mature chemist this is a particularly effective means in modern writing. One can hardly imagine any ordinary textbook on organic chemistry being written without structural formulas. Combined with mathematical expressions, such means become a most effective kind of shorthand, especially in the hands of physical chemists. A statement such as $PV = nRT$ is probably unsurpassed as a simple, concise, and adequate means of conveying information.

3. Tables.—Perhaps the most famous table in chemical literature is the periodic arrangement of the symbols of the elements, including usually values for the atomic masses and the atomic numbers. This example illustrates the great effectiveness of a tabular form for certain situations.

Modern tabular handbooks, such as Lange's "Handbook of Chemistry," and comprehensive works, such as "International Critical Tables," show the practicality of such arrangements for all sorts of information. Research laboratories and industrial organizations must deal with a wealth of numerical data. Many articles in journals on industrial chemistry contain a variety of examples to show many ways to present such material.

Details of making a table vary with the situation. There should always be a table number and an explanatory heading at the top. The best boxed-in subheadings and their arrangement depend upon the nature of the data. General and specific explanatory notes need attention, if required. As far as can be foreseen, the arrangement should be designed for the probable page space available.

4. Drawings.—Line and other drawings are an indispensable means of writing employed by architects, engineers, and many other technical workers. Chemical engineers know this, but most chemists graduated from arts colleges and some graduate schools do not. That many writers do not know what to do with this means, or care enough to do it satisfactorily, is all too evident to one having occasion to review manuscripts presented for publication. Many drawings are simply unusable as submitted. Large publishing houses can have drawings remade; but editorial offices, such as those for the publications of the American Chemical Society, maintain no such facilities, with the result that an unsuitable manuscript sent there must be returned for revision, even though it is otherwise acceptable.

The art and method of making such drawings is discussed in detail in various books, such as French's "Engineering Drawing." Additional help may be obtained in the "ASTM Manual on the Presentation of Data." Arkin and Colton's "Graphs" is especially useful in suggesting many kinds of uses. Many good examples of effective use of graphical presentation may be found in current journals, such as *Industrial and Engineering Chemistry* and *Chemical Engineering* and in certain books issued by publishing houses which maintain their own drafting department.

5. Pictures.—According to the Chinese, an appropriate picture is worth many words, the number of thousands depending upon who quotes the proverb. In any case, no other means is as effective under certain circumstances. Examples are the debris resulting from an explosion, an oil well fire, the microstructure of suitably polished and etched alloys, and colored objects such as a sunset.

In some cases, then, there is really no substitute for a good picture for recording and/or transmitting information. In many other cases, however, their use for such

purposes range from the questionable to the inappropriate. Occasionally, one even sees a picture having no apparent relevancy to the subject of the publication. Frequently the original print was not good, its reproduction was unsatisfactory, or one cannot determine what was intended to be shown. Pictures of equipment, especially those showing a mess of irrelevant background objects, are often much less revealing than a dimensioned line drawing showing a vertical or horizontal cross section of the apparatus.

REQUIREMENTS OF WRITING

The general requirement of good technical writing is that the writer should present his story as effectively as possible. In order to analyze what is involved if one is to achieve this highly desirable goal, attention is directed briefly to some of the specific items which must receive the attention of successful performers.

1. Accuracy.—The requirement of accuracy is imperative, of course, if the writing is to be reliable. Every detail which can be correct or not is involved. Examples of such items are names, spelling, experimental data, abbreviations, calculations, formulas, equations, reference citations, and others. Typographical errors are a common occurrence.

The author knows only too well how easily such errors creep in and are overlooked. Vigilant and meticulous checking of every detail, not only in the original manuscript but also in the proof-reading stages, is necessary to approach 100% accuracy. The perfectly reliable scientific textbook is probably yet to be written. However, this is no excuse for a writer's being so careless that errors occur every few pages of his book.

In patents accuracy is critical. Thus, if a claim specifies a two-cylinder engine, the statement can hardly be extended to multicylinder coverage on the occasion of an infringement suit.

2. Clarity.—Considering clarity in this sequence does not imply that it is in any way less important than accuracy as a requirement of good writing. In fact, the two really belong side by side.

Probably the ultimate test of clarity is that the reader cannot misunderstand the writer. Obviously, one must assume that this reader has adequate intelligence and training to understand the material.

Failure to achieve the height of clarity is common. Unpublished examples are professors' examination questions and students' answers thereto. For letter writing one chemical executive has estimated that 30% of his letters need not be sent if those reaching him were clear and accurate. Common published examples are the working details in organic preparative papers, in physical manipulative directions, and in analytical operative procedures. Second only to writing a fool-proof patent specification comes writing an analytical method with such clarity that a beginning student cannot do the wrong thing, or the right thing in the wrong way.

Lack of clarity may result from the omission of incomplete specification of various details. There are many familiar examples. In most of the working details for laboratory procedures one skilled in the art of the specialty concerned can probably surmount the uncertainty. His experience enables him to read between the lines. But even an analyst could hardly know which of several possible equivalent weights is involved if the writer states only that the concentration of a potassium cyanide solution is normal. A more difficult type of the defect is found in the general structure of many sentences.

Here, as with accuracy, the writer must exercise every precaution. He himself can check inaccuracies. To achieve clarity, however, he must in effect put himself in the position of reader. Some help in this direction may come from reading one's product aloud. In addition to his self-criticism, the judgement of others competent in the field is invaluable.

3. Brevity.—Brevity is a highly desirable characteristic rather than a strict requirement. Two developments have led to this situation. The first item is economic difficulty of publishing the ever-increasing mass of material being submitted each year. Reviewers and editors must insist upon condensation to essentials. The second item is the increasing temporal load upon the reader. Biochemistry, for example, is concerned with some 20% of the more than 9,000 periodicals being covered by *Chemical Abstracts*. One in this field has no time for the irrelevant and the inconsequential.

Achievement of effective brevity, without the sacrifice of scientific accuracy and clarity, is a real art. The Bible and Shakespeare's plays are superb examples of concise and effective word usage. If one does not possess the sense for effective brevity, its cultivation will probably require a long, persistent struggle. That the task is not easy, even for the scientifically great, seems evident from Pascal's apology, "I have made this letter longer than usual because I lack the time to make it shorter."

4. Consistency.—This requirement is formal, in the sense of usage, and esthetic, in the sense of appearance. It concerns policies and practices of writing and printing established largely by the best editors and publishers. Involved also are the definitions and usages recommended by committees and societies. So many details are concerned that only typical items can be cited as examples.

General appearance, or external consistency, is very important from the viewpoint of a publisher. As far as possible, the printed page (or a typed letter, as an unpublished example) should both please the reader and facilitate his use of it. Style of type, different sizes of type for different kinds of material, appropriate use of center and side headings, and related details all contribute to the desired result when used consistently. An experienced writer is able to make the major recommendations in this category.

What might be called internal consistency is important from the viewpoint of an editor or a research supervisor. In a given manuscript or report, the writer must not indulge in all possibilities for handling details. Such items include nomenclature, use of words for chemical formulas (or the reverse), definitions, plotting data, arrangement of tables, place and method of citing references, and others.

Editors of journals, and of company reports, are likely to differ in the style adopted for some of these details. The writer may have some choice. In any case, he should

determine what is required, or settle himself upon some consistent practice, and then stick to it.

5. Interest.—Perhaps intrinsically every published item has some interest for someone. Otherwise justification for publication is questionable. Probably the interest of an instability constant of some complex, for example, might better be designated as its utility, either to enable one to predict analytical applications or to interpret activity theoretically.

The connotation of interest in mind here is not entertainment in the sense that modern novels are supposed to entertain. It is difficult to conceive of anyone's reading an involved chemical patent or the procedure for the analysis of a silicate rock because of its entertainment value. But even in writing of this type, where accuracy and clarity are paramount, one should try to acquire a satisfying style—one not repetitious, monotonous, and dull. Undoubtedly, little current chemical writing can be cited for its noteworthy literary quality.

In publications intended for lay readers, interest becomes of prime importance. Without it the product will not be sold or read. With it most of our productions would have enhanced reading appeal. The "it" may lie partly in the selection and the arrangement of material, and in the appropriateness of the writing means employed. Principally the secret is the quality of the style.

WHAT CAN BE DONE?

Since probably all editors of chemical publications and most supervisors of academic, governmental, and industrial research would agree that the quality of our writing needs improvement, the concerned producer faces the question of how to do it. Lack of space precludes anything but mention of a method.

The problem of the prospective writer, of course, is to use his raw materials to produce something. Such writing resources consist of facts or knowledge gained from conversation, from the literature, and from observation and experience. The end products range from mere notebook entries and short letters to the most comprehensive treatise. Our general means for writing have been summarized as words, formulas and equations, tables, drawings, and pictures. For the sake of the reader, and perhaps also for himself, the writer should aim for productions having accuracy, clarity, brevity, consistency, and interest.

In brief, then, we have the following sequence for our writing operations: (1) collecting and arranging for use the materials for a given projected product; (2) determining the kind of writing form to be used—such as a letter, an abstract, a research report, a journal article, a patent application, or a textbook; (3) selecting the means, or combination of means, of expression deemed the most suitable for the production in mind; (4) writing something, in tentative form by following the instructions of editors, the recommendations of research supervisors, or the practices of writers of recognized accomplishment; and (5) criticizing, revising, and rewriting until satisfied that the achievable maximum has been attained toward meeting the general requirements discussed.

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Practical Aspects Concerning the Development and Use of ASTIA's Thesaurus in Information Retrieval*

By J. F. CAPONIO and T. L. GILLUM
Defense Documentation Center for Scientific and Technical Information,
Cameron Station, Alexandria, Virginia
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One of the most crucial problem areas in the process of research, development, testing, and evaluation is science information communication. It is quiet obvious that before the results of research can be exploited effectively they must first be put under bibliographic control and made available to everyone who can use them. As the research and development spectrum expands, with increasing allocations of resources involved, the time gap between scientific and technological discovery and reporting and application tends to lengthen.

In the scientific and industrial community, journal publications, meetings, and symposia have been the chief means of keeping abreast of the constantly accumulating mass of new findings elucidated by scientific research. In the Department of Defense (DOD), the largest research sponsor, responsibility for collecting, analyzing, and disseminating the results of research and development is centered primarily in the Armed Services Technical Information Agency (ASTIA).

In the years since its inception, ASTIA has accumulated a vast and comprehensive collection of more than 700,000 technical reports in virtually all fields of science, technology, and medicine. ASTIA currently receives, abstracts, and indexes 30,000 reports each year. These are announced in a semimonthly abstract journal, the *Technical Abstract Bulletin* (TAB). In the next two years the total accessions are expected to reach 300,000 reports annually as a result of ASTIA's new acquisition policy.

ASTIA makes available to DOD contractors and military organizations full-size copies of reports and, upon request, supplies bibliographies of its holdings on any given subject. At present, requests for more than 3500 reports and 25 literature searches are received per day from among 4,000 users. These figures are expected to rise in proportion to the increase in accessions.

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