A Resource File for Chemical Stereoviews

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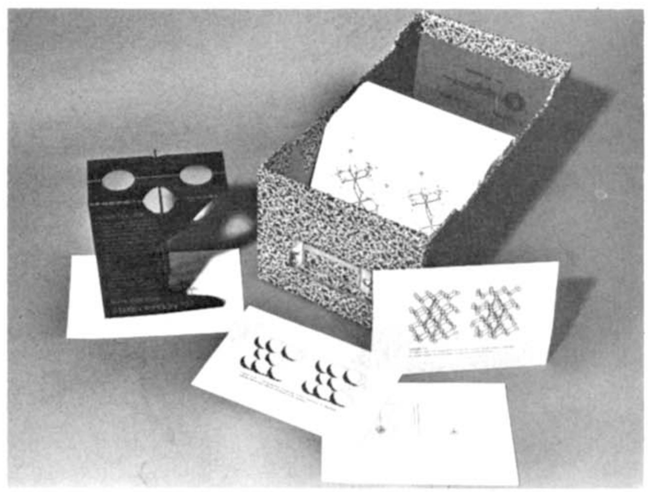
The first practical stereoscopic viewer was developed by Sir Charles Wheatstone about 1833 and the modern form of the stereoscope by Oliver Wendell Holmes in 1859. The chemist, however, appears to have been inordinately slow in bringing this standard fixture of the Victorian parlor to bear on the problems of stereochemistry. The author, at least, has been unable to find any examples of 19th century usage of the stereoscope for the illustration of stereochemical principles, even though the subject of stereochemistry had developed into an explicit discipline by the end of the century through the work of such men as van't Hoff, Le Bel, Wislicenus, Hantzsch, Werner, and Pope (*1*).

Even in the first half of this century examples of the chemical application of the stereoscope are rare. The earliest example which the author could locate was a pocket stereoscope and set of 37 stereoscopic views of various crystal structures, edited by Sir William and Lawrence Bragg and sold by A. Hilger Ltd. of London in the 1920's (*2*). These were simply stereophotographs of standard crystal models, mostly based on the early structure determinations of the Braggs themselves.

Indeed, it is not until the late 1960's and the advent of computer programs for drawing chemical stereoviews in conjunction with computerized crystal structure determinations that the chemical stereoview comes into its own. It is now not uncommon for a journal such as *Inorganic Chemistry* or *Acta Crystallographica* to carry a dozen or more stereoviews per issue, and Speakman has recently estimated that about 40 percent of all published crystal structures now make use of stereoscopic drawings (*3*). Though a few of these are slowly finding their way into the inorganic (*4*), the organic (*5*), and even the general (*6–7*) chemistry textbooks, this new wealth of chemical stereoviews represents a potentially valuable and, for the most part, still largely untapped educational resource.

The author has found that such computer drawn stereoviews may be easily photocopied without damaging their optical quality (in fact photocopying frequently improves the image). These photocopied views can then be cut out and glued on 4-in. × 6-in. index cards. Quite often the original captions can be preserved along with the stereoviews themselves. When this is not the case, the relevant information is simply printed on the back of the card. A collection of several hundred of these views, when combined with an inexpensive cardboard stereoscopic viewer (*8*), and a cardboard index card file (see figure), results in a valuable reference file for either personal use or use as a teaching resource. The cost and storage space relative to the equivalent molecular models are minimal. Many structures can be viewed and studied in the time it would take for the student to construct one or two of the structures using standard molecular models. Finally, the novelty and fun of using a stereoscope tends to motivate the student (indeed, some even express an interest in collecting their own file of stereoviews).

Although there is no problem, given the hundreds which are printed each year in the research journals, in collecting stereoviews of complex and often rather arcane molecules,



The stereoview resource file.

there is a problem in locating stereoviews illustrating simpler structures and many of the principles and concepts covered in the standard general, inorganic, and organic textbooks. A complete collection of stereoviews for the hydrogenic atomic orbitals has been published by Cromer (*9*). These are based on the "electron smear" picture and use dots to indicate variations in electron density. Alternative stereoviews of the *p* and *d* orbitals using 90% probability envelopes are given by Brady and Humiston (*7*). The text by these authors also contains stereoviews relating to hybrid orbitals, the VSEPR rules, metal and ligand orbital orientations for octahedral crystal-field splittings, geometrical and optical isomerism among d-block coordination complexes, and the structures of a large number of simple inorganic molecules. The books by Hall (*10*) and by Bernal et al. (*11*) contain stereoviews illustrating chemical applications of symmetry and the point group classification; the text by Streitwieser and Heathcock (*5*) contains stereoviews of a large number of simple organic molecules and their conformers, several illustrating the geometries of simple reaction mechanisms (e.g., the Walden inversion), and at least one example relating to optical isomerism; and, finally, both the book by Ladd (*12*) and the text by Brady and Humiston (*7*) contain stereoviews relating to elementary solid-state chemistry, including closest-packing of spheres and the unit cells of a number of simple lattices, such as sodium chloride, diamond, and graphite.

Nevertheless, there are still a large number of topics of interest to the teacher for which easily accessible stereoviews are not yet available. A few topics which immediately come to mind include:

(1) Molecular orbitals for simple molecules
(2) Tangent-sphere molecular models
(3) Linnett double-quartet structures
(4) Metal and ligand orbital orientations for crystal field splittings other than octahedral (e.g., tetrahedral and square planar)
(5) Wade's rules for cluster polyhedra
(6) Further examples of optical isomerism drawn from both the fields of organic and coordination chemistry
(7) Various three-dimensional data plots, such as ternary phase diagrams, reaction surfaces, etc.

In this regard the JOURNAL OF CHEMICAL EDUCATION could play a valuable role by encouraging the publication of educationally relevant chemical stereoviews, perhaps even as a monthly feature, thereby making them available to a large audience of chemical educators at both the university and high school levels.

Literature Cited

(1) See, for example, Werner, A., "Lehrbuch der Stereochemie," Fischer, Jena, 1904, and Stewart, A. W., "Stereochemistry," Longmans, Green & Co., London, **1907**.
(2) *Sci. Amer.*, **139(7),** 64 (1928). Other early examples may be found in Pouleur, A. L., J. CHEM. EDUC., **9,** 301 (1932) and Lipson, H., and Beevers, C. A., *Proc. Royal Soc. London*, **148A,** 664 (1935). Again, both of these involve stereophotographs of molecular models.
(3) Speakman, J. C., *New Scientist*, **78,** 827 (1978), also Johnstone, A. H., Letton, K. M., and Speakman, J. C., *Educ. Chem.*, **17,** 172 (1980).
(4) Huheey, J. E., "Inorganic Chemistry," 2nd Ed., Harper & Row, New York, **1978**.
(5) Streitwieser, A., and Heathcock, C. H., "Introduction to Organic Chemistry," Macmillan, New York, **1976**.
(6) Pauling, L., and Pauling, P., "Chemistry," Freeman, San Francisco, Calif., **1975**.
(7) Brady, J. E., and Humiston, G. E., "General Chemistry: Principles and Structure," Wiley, New York, **1975**.
(8) Cardboard stereoscopes for under $2.00 can be obtained from Taylor-Merchant Corporation, 25 West 45th Street, New York, N.Y., 10036. A variety of more expensive stereoscopic viewers is available from C. F. Casella and Co., Ltd., Regent House, Britannia Walk, London, N1 7ND. The articles in ref. (*3*) consider the possibility of attaining stereopsis with the naked eye.
(9) Cromer, D. T., J. CHEM. EDUC., **45,** 626 (1968).
(10) Hall, L. H., "Group Theory and Symmetry in Chemistry," McGraw-Hill, New York, **1969**.
(11) Bernal, I., Hamilton, W. C., and Ricci, J. S, "Symmetry: A Stereoscopic Guide for Chemists," Freeman, San Francisco, Calif., **1972**.
(12) Ladd, M. F. C., "Structure and Bonding in Solid State Chemistry," Wiley, New York, **1979**. Stereophotographs of solid-state models are also given in Wells, A. F., "The Third Dimension in Chemistry," Oxford, **1956,** and Wells, A. F., "Structural Inorganic Chemistry," 4th Ed., Clarendon Press, Oxford, **1975**. However, such photographs do not preserve their quality upon being photocopied and are generally much less effective than the line drawings of the computer-generated stereoviews.