Consumer Chemistry in an Organic Course

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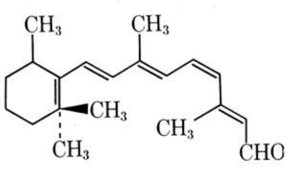
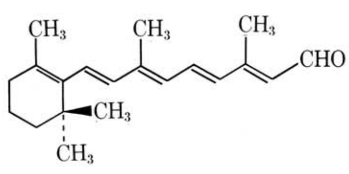
Throughout this country, colleges and universities traditionally offer a one-quarter or semester organic chemistry course for students majoring in nursing, health sciences, biology, agriculture, home economics, technology, or other science-related areas. If we examine the textbooks available for these courses, we find that most follow a function-group approach to the study of nomenclature, synthesis, and reactions of organic compounds. Any reference to consumer or applied organic chemistry is normally relegated to a few chapters at the end of the book. The result with few exceptions (*1*) is a textbook that portrays organic chemistry as a sterile, unexciting discipline involving a study of model compounds unrelated to any application of interest to the nonchemist student. Unfortunately, sterile books often lead to sterile courses due to a lack of illustrations demonstrating the use of organic chemistry in our technological world.

To recognize the value that can be realized by the study of organic chemistry the nonchemist student needs illustrations of how this knowledge aids a nurse, biologist, or understanding in other disciplines. An instructor can easily incorporate applications into the teaching of organic concepts. As an example in the study of alkanes we can discuss how the octane rating of gasoline is raised by increasing the amount of branched-chain hydrocarbons through the cracking process employed at a refinery. The significance of the geometry of double bonds is easily illustrated by examination of the chemistry of eyesight (*2*) in which 11-*cis*-retinal combines in the dark with opsin to give rhodopsin. Following the exposure to light the rhodopsin in the rods of eyes breaks down to give back opsin and *trans*-retinal. Thus black-and-white vision is a direct result of cis-to-trans isomerization of one double bond in a conjugated double-bond system.



11-*cis*-retinal

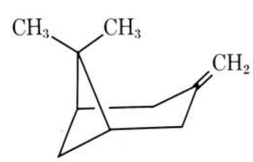


trans-retinal

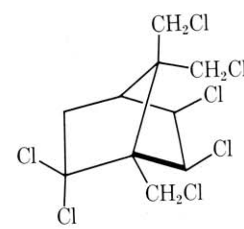
Furthermore, the importance of the double bond, and therefore of alkenes as a group, can be better shown by including a discussion of the formation of addition polymers rather than studying exclusively the traditional reactions included in most textbooks.

The aromatic hydrocarbons provide a perfect vehicle to illustrate further the importance of structural features on the physiological action of compounds in living systems. The fact that carcinogenic activity (*3*) is associated with the phenanthracene but not the anthracene ring system can be extended to considering the affect of alkyl groups, nonaromatic rings, or replacement of carbon by nitrogen atoms in a ring. This information provides the community health major or nurse with not only a fundamental knowledge of the structure of aromatic compounds but also an expanded background that provides a direct insight into the actual problems associated with these compounds whether found in the industrial work place or obtained by smoking.

Another subject, alkylhalides, lends itself to the use of consumer chemistry to teach basic concepts. The free radical substitution in which a chlorine atom replaces a hydrogen on an sp^3-hybridized carbon is illustrated in the synthesis from β-pinene of a component of the insecticide toxaphene (*4*) used on cotton crops.



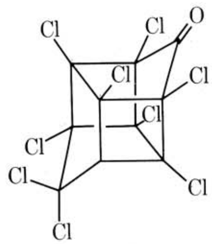
β-pinene



2,2,5-*endo*-6-*exo*-8,9,10-heptachloroborane, a component in toxaphene

The formation of another alkyhalide, 1,2-dibromo-3-chloropropane (DBC), by addition of bromine to 3-chloropropene is an example of the addition reaction being applied to synthesis of a compound used for nematode control in pineapple fields. Unfortunately DBC has caused sterility in the men who worked in the production plant.

We have all heard of the pollution problem associated with DDT but few students know the relationship between a bimolecular elimination (E2) of an alkyhalide treated with KOH in alcohol to give an alkene and the formation of DDE in an insect by the enzyme DDT dehydrochlorinase (*5*). Further studies concerning the parameters controlling E2 reactions can easily be related to the problem of destroying chlordane or other chlorinated hydrocarbons. Still another example of basic concepts integrated with consumer chemistry is the synthesis and destruction of kepone (*6*), an S_N2 substitution reaction, in which a hydroxyl group replaces a chlorine. Kepone is the compound responsible for the 1976 Charles River disaster that caused severe nerve damage to many people.



kepone

Greater use of special topics would further broaden a student's background. Introduction of the topics of steroids, birth control pills, and vitamin D provides nursing students with a more useful background than that which is offered by a traditional study of alcohols. Likewise a study of oxidation–reduction reactions in the synthesis of aldehydes or ketones from alcohols or the reverse reaction can be readily related to the biochemical process that occurs naturally in our bodies. The role of NADH or NADPH in cells is analogous to the reduction of an aldehyde by lithium aluminum hydride to give a primary alcohol. One such example is the formation of lactate anion in our muscles during strenuous exercise.

Most organic textbooks contain a chapter on carbohydrates and usually one in which the study of carboxylic acids and esters includes some discussion of fatty acids and glycerides. Another logical, though seldom included, example of special topics should be the extension of amines to include the naturally occurring bases called alkaloids (*7*). Since alkaloids and their analogs are the bases of many medicinal drugs (*8*), an omission of this topic is unfortunate for a class filled with nursing or other health science students who will eventually enroll in a pharmacodynamics course. These students have heard of nicotine but seldom know that the even more poisonous drug, curacurine, is valuable for treating pancreatitis. Likewise, few students know that cocaine can be used as a local analgesic or that there are over 100 analogous synthetic drugs, several of which are used by dentists and surgeons as local analgesics. In addition, a discussion of the fact that these drugs are normally administered as a salt rather than as the free base can be used to illustrate the fact that amines react with acids to form salts. Still other information concerning the structural relationship of morphine to demerol (*9*) or to naloxone (Nar-Can) and to a drug that can be used to induce Parkinson's disease (*10*) will greatly enhance a student's background of the relationship between structure, chemical reactivity, and physiological action.

This limited discussion illustrates the ease with which an instructor can integrate consumer or applied chemistry into the teaching of basic organic concepts. With the incredible number of applications of organic chemistry in our world there is no basic organic topic that one can conceivably teach in a one-quarter organic course for which one cannot find illustrative, practical applications. If we seek to include at least one application in the teaching of each basic concept, the resulting course will not only provide the student with a solid background in basic fundamentals, but also will reveal the significant role the knowledge of organic chemistry plays in other areas of study. Thus organic chemistry becomes an exciting adventure into the study of the unknown, not a sterile recitation of facts.

Literature Cited

1. Miller, J. A.; Neuzil, E. F. *Organic Chemistry Concepts and Applications*; Heath: Lexington, MA, 1979.
2. Hubbard, R.; Kropf, A. *Sci. Am.* **1967,** *216* (6) 64–76.
3. Fieser, L. F.; Fieser, M. *Topics in Organic Chemistry*; Reinhold: New York, 1963.
4. Matsumura, F. *Toxicology of Insecticides*; Plenum: New York, 1975.
5. Keller, E. *Chemistry* **1970,** *43* (2), 8–12.
6. Livingston, J.; Matsumura, F.; Williams, G. A.; Nisbet, I. C. T. *Kepone/Mirex/Hexachlorocyclopentadiene: An Environmental Assessment*; National Academy of Sciences: Washington, DC, 1978
7. Swan, G. A. *An Introduction to the Alkaloids*; Wiley: New York, 1967.
8. Goth, A. *Medical Pharmacology*, 10th ed.; Mosby: St. Louis, MO, 1981.
9. Cochin, J.; Harris, L. *Synthetic Substitutes for Opiate Alkaloids*; Drug Abuse Council: Washington, DC, 1975.
10. Baum, R. M. *Chem. Eng. News* **1985,** *63* (36), 7–16.