Organic Chemistry Supplement

Context

Carbon-based molecules are central to a host of chemical and biological processes because of their broad range of structure and reactivity. The millions of organic compounds alone, ranging from polymers to pharmaceuticals, make the field important for study. Yet organic chemistry is also a highly integrated discipline that impacts and is impacted by the other branches of chemistry and other sciences. Indeed organic chemistry enables a molecular understanding of physicochemical phenomena in materials science, the environment, biology, and medicine. Because the field has reached a high level of integration with these areas, progress in organic chemistry continues at a fast pace and much more remains to be discovered.

An introductory sequence should drive the student to appreciate the breadth of organic chemistry by facilitating an understanding of the principles, and the practice of applying them, to gain a working knowledge and appreciation of organic structure and reactivity.

Conceptual Topics

- the understanding that our only way to molecular knowledge is through experimentation; correlating structure with reactivity and function through wet chemical methods, spectroscopy, (notably nuclear magnetic resonance and infrared spectroscopy and X-ray crystallography) and use of computational simulations
- bonding and its consequences on molecular structure and reactivity
- interplay between electronic, steric, and orbital interactions in the behavior and properties of molecules
- the dependence of structure and reactivity on context, particularly solvent effects and other non-covalent interactions
- Lewis and Brønsted acid-base chemistry
- stereochemistry and conformational analysis
- addition, elimination, substitution and rearrangement mechanisms, and reactive intermediates
- functional groups and their interconversions, particularly redox transformations
- organic synthesis, including retrosynthetic analysis of target molecules
- synthesis and behavior of macromolecular species, including biomolecules such as proteins and polysaccharides, and synthetic polymers
- methods of activation, including Brønsted or Lewis acid/base, free radical chemistry, and organometallic catalysis

Practical Topics

The laboratory portion of the organic chemistry experience should demonstrate how organic chemical knowledge is acquired through experimentation. Laboratory skills and techniques are important, as are the skills of asking questions that can be formulated into chemical experiments, and then answering them by the analysis of experimental data. Working in teams can be useful in the laboratory learning environment, and mirrors the team-oriented problem solving that occurs in professional laboratories.

- developing a feel for the logic of organic experimental procedures: the logic of glassware design, selecting the optimum equipment for a particular reaction or operation, why particular solvents and reaction conditions are used for a specific transformation planning and carrying out a variety of organic reactions, including safety considerations
- keeping a laboratory notebook as a record of what is done and when it was completed
- monitoring the process of a reaction
- isolation and purification of products
- spectroscopic analysis of starting materials and products; deducing structures by interpretation of modern
- spectroscopic and computational data, and its use to answer the formulated hypothesis
- analysis sis of experimental data using statistical analysis
- the value and limitations of computational methods

Illustrative Modes of Coverage

The foundation experience in organic chemistry is generally presented as a two-semester (or equivalent) sequence of courses and associated laboratories. While it is usually taught in the second year, some institutions teach it with success in the first year. Where a one-semester foundation course is used to support other course work such as biochemistry, the topics in that course must be carefully chosen. Some topics appropriate for the foundation course that supports biochemistry include:

- carbonyl chemistry, including nucleophilic addition, alkylation and condensation reactions
- oxidation and reduction
- nucleophilic substitution reactions
- addition and elimination
- acidity and basicity of organic compounds
- stereochemistry, as applied to the previous topics
- concepts and consequences of resonance and aromaticity
- spectroscopy at a basic level as applied to the previous topics

Since this may be the only course in organic chemistry a student may see, the lecture and laboratory must reinforce each other. It is appropriate for the primary treatment of spectroscopy, including NMR and IR spectroscopy, to be done in the laboratory setting.