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Book review

GREEN ORGANIC CHEMISTRY
Strategies, Tools, and Laboratory Experiments

Kenneth M. Doxsee, James E. Hutchison
Thomson-Brooks/Cole Publishing Co., London
ISBN: 0-534-38851-5, 2004, 244 pages

This unique laboratory workbook for students has the blending concept of green chemistry and preparative organic chemistry. Even though a variety of excellent laboratory textbooks are now available, this brand-new one provides timely and state-of-the-art examples of experiments in organic chemistry relating to green chemistry, which distinguish the book markedly from others. The book consists of two sections: **Strategies and Tools** and **Laboratory Experiments**.

The **Strategies and Tools** section may be envisaged as a concise textbook on green organic chemistry describing the tools and strategies used in its implementation and hence readers can easily learn from the section the scopes and perspectives of the chemistry. The material is considered to be an essential complement to the following experimental section, thus allowing investigation of green organic chemical concepts in the laboratory setting.

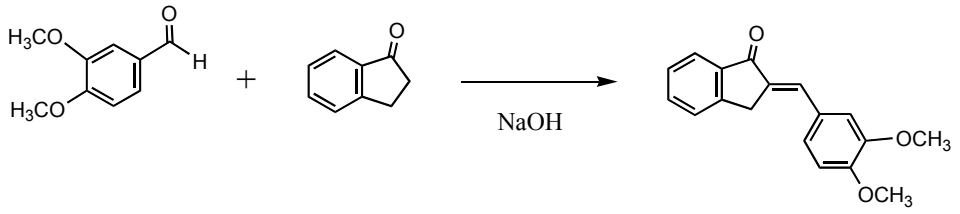
In the introduction chapter of this section, the authors describes at first the impact of organic chemistry on our lives, that is, the many benefits of organic chemistry to follow the need for sustainable chemistry and new approaches to important problems, now being popularly called as green chemistry.

The following chapters are discussed about the identification and evaluation of chemical hazard, chemical exposure and environmental contamination, sources of information about chemical hazards including reference books and websites, and introduction to green chemistry.

An overview of the common solvents used in the course of laboratory experiments and the problems associated with their use are given in the next chapter following the examples of alternative solvents. Similarly, safer and alternative reagents are presented in another chapter and the reaction design and efficiency together with alternative feedstocks (starting materials) and products are briefly described to conclude the big picture and green chemistry metrics for the **Strategies and Tools** section of this book.

The second section **Laboratory Experiments** provides actual 19 examples of laboratory experiments guided with green methodologies. After preface to the experimental section including general safety issues, working with chemicals, waste disposal/recycling and so forth, the first experiment (Experiment 1) starts with solventless reaction of an aldol condensation (Scheme 1).

1. SOLVENTLESS REACTIONS: THE ALDOL CONDENSATION (p. 115-119)



Concepts/techniques:
Carbonyl chemistry; the aldol reaction; melting points of solids and mixtures; recrystallization.
Green cemistry messages:
Solventless reactions between solids, atom economy.

Scheme 1. An example of Graphical Abstracts for the Experiments

In general, chemical concepts, green lessons, estimated lab time, introduction and pre-lab preparation are provided in each experiment before the experimental procedure to learn the aim and content of the experiment and the students can easily understand what is required to carry out the experiments. In the experimental procedure is noted SAFETY PRECAUTIONS followed by the reaction, workup and purification, characterization, post-lab questions and exercises, and experimental development note.

The next two experiments (Experiment 2 and 3) are dealt with bromination of stilbene, the former one by using pyridinum tribromide and the greener latter one by in situ formation by oxidation of hydrobromic acid with hydrogen peroxide. Then follows cyclohexene synthesis by mild phosphoric acid-catalyzed elimination in Experiment 4 and oxidative cleavage of cyclohexene to adipic acid by using a catalyst and an alternative reaction media together with reuse of reagents in Experiment 5.

A green oxidative coupling of an alkyne by a Glaser-Eglinton-Hay method is exemplified in the next Experiment 6 and a couple of solvent-free synthesis of 5,10,15,20-tetraphenylporphrin is outlined in the following two experiments (Experiment 7 and 8); one by gas-phase reaction and another by solid-supported/microwave one. The metallation of the porphirin in a safer solvent system is successively described in Experiment 9.

In Experiment 10 and 11, typical physical organic methods are allocated; kinetics of *tert*-butyl chloride for the recognition of solvent choice on reaction rate as measuring solvent effect and molecular mechanics modeling for the design of safer product and synthetic efficiency.

Two examples of electrophilic aromatic substitution are exhibited in Experiment 12 (electrophilic aromatic iodation) and Experiment 18 (acetylation of ferrocene, a Friedel-Crafts reaction) by using safer reagents and solvents. Use

of water as a solvent is another possible approach for green organic chemistry and it is exemplified as palladium-catalyzed alkyne coupling/intramolecular alkyne addition in Experiment 13. While resin-based oxidation chemistry is outlined as a nontraditional and recyclable reagent in Experiment 14, an example of the usage of safer and easier to handle reagents and solvents in carbonyl chemistry is shown in Experiment 15 as thiamine-mediated benzoin condensation of furfural.

A solid-phase photochemistry is of interest for the usage of alternative and clean energy source in green condition and the [2+2] cycloaddition of *trans*-cinnamic acid is exemplified in Experiment 16. The experiment cited in Experiment 17 is the method used mainly in materials chemistry, namely, patterning surfaces with molecular films by self-assembled monolayer (SAM) as a design of high-efficiency processes requiring less material with benign solvents. An example of combinatorial chemistry is indicated in the last experiment (Experiment 19) for antibiotic drug discovery with green lessons of synthetic efficiency, design of safer product and waste minimization.

Thus, the experiments consist of solvent-free reactions (Experiments 1, 7, 8, 16), modified reactions of ordinary ones by the usage of catalyst, safer and easier to solvents (Experiment 2, 3, 4, 5, 6, 9, 12, 13, 15, 18), resin- or surface-based chemistry (Experiment 14, 17), modified kinetics and molecular modeling (Experiment 10, 11), or even combinatorial chemistry (Experiment 19). Finally, an appendix (Appendix A) is given in the last part to summarize the twelve principles of green chemistry along with the index of the whole text.

This laboratory textbook has originally been developed from the green organic chemistry program at the University of Oregon, where the authors are now teaching, based on the view of an urgent need and rapidly growing demand for green chemistry laboratory materials and the experiments contained in this laboratory manual have already been performed safely by students in college laboratories under the supervision of the present authors.

The experiments have been well selected and designed to support and complement the content of the typical undergraduate organic chemistry sequence, illustrating the principles and strategies of green organic chemistry. Moreover, it is very convenient to see and check the content of experiments with the aid of their Graphical Abstracts attached before the text-body.

In summary, this textbook will undoubtedly be useful not only to university students and instructors but also to those interested in learning about the green organic chemistry in general.

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