Experiments in Green and Sustainable Chemistry

The concept of "green chemistry" has become generally accepted for the design of new syntheses and chemical processes that are environmentally benign and sustainable. Such procedures generally involve the use of less hazardous chemicals and solvents, minimization of the number of reaction steps, stoichiometric reagents and by-products ("atom economy"), and the reduction of waste generation and energy use. The popularity of these principles is reflected in the increasing frequency of original research papers and reviews, as well as textbooks and journals covering this research area. Nevertheless, most chemistry students learn about these important concepts only rather late during their education, not least because many introductory chemistry courses depend on reliable laboratory experiments using conventional and well-established procedures and equipment to teach the basic principles of chemistry.

The collection of 46 experiments in this book, compiled by Herbert Roesky and Dietmar Kennepohl, is therefore a valuable and unique addition to the vast number of previously published laboratory courses, because it represents the first attempt to teach the basic concepts of green chemistry to students at the introductory university level as part of their everyday laboratory experience.

The procedures described in this book include examples from a variety of disciplines within chemistry, and cover the most important principles of sustainable and green chemistry. Although the primary objective of the book is clearly to present procedures that are reliable and easy to carry out, it is a little unfortunate that the introductory and explanatory sections of the individual experiments differ considerably in the extent of background information that is given, so that in some cases students might find it difficult to grasp their relevance. In this context, an introductory chapter might have been useful for readers who are not familiar with all aspects of green chemistry.

However, the strength of the book lies in the very thorough and detailed description of the experiments, which often includes schematic drawings or pictures of the required experimental setup in addition to a description of the actual procedure, although in some cases additional reaction schemes would have been helpful. Nevertheless, all the experiments should be easily reproducible within a typical academic laboratory setting, and some of the procedures could also serve as school experiments.

The experiments are divided into five groups based on different aspects of the guiding principle of green and sustainable chemistry that was the impetus for the development of the methodology described. The first section (Part I) focuses on the use of catalytic methods, and provides instructive procedures that involve the use of recyclable solid-phase acid and base catalysts and environmentally benign reagents, as well as microwave-induced and "on-water" reactions and catalytic oxidations using air as the stoichiometric oxidant. The topic of Part II is the use of water and ionic liquids as "green" solvents, as well as solvent-free preparations. This includes examples from organic chemistry (disulfide synthesis and Heck coupling reactions, cross-metathesis) as well as from polymer chemistry and electrochemistry (polypyrroles and ammonia-sensing coordination polymers). Part III provides examples of atom-economic and one-pot syntheses, including a domino reaction, a dendrimer synthesis using click chemistry, and a multistep synthesis of various nickel complexes. Issues related to the limitation of waste generation are covered in Part IV. The experiments in this part consist of a simple method for the disposal of small quantities of alkali metals using a flower pot filled with sand, an environmentally friendly recycling of sodium metal, a one-step synthesis of juglone, and the synthesis of copper oxalate complexes for copper deposition. Finally, Part V contains a collection of miscellaneous experiments, some of which cover additional aspects of the topic; these include, for example, simple experimental setups for the production of biogas and for illustrating the greenhouse effect, and the use of semiconductor photocatalysts for the removal of pollutants from air and water.

The most instructive experiments compiled in this book are those for which a comparison with established methods is possible, because then a student can easily grasp both the benefits and the present limitations of the methodologies that they exemplify. The implementation of such experiments as a part of introductory laboratory courses will help to raise a generation of chemists that is familiar with the concepts of green chemistry from an early stage, which in turn should be of great benefit for the whole of society.

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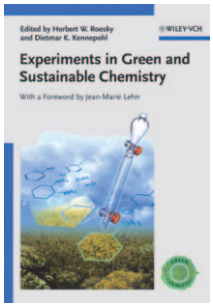

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