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Book review

Green techniques for organic synthesis and medicinal chemistry

Wei Zhang and Berkeley W. Cue (Eds.)
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Green chemistry, as opposed to synthetic chemistry, is the term we use for a new approach to chemistry in an attempt to reduce or eliminate the use or generation of hazardous substances. This book is primarily meant for the academic or the professional in the pharmaceutical industry. Examples in green chemistry encompass the period from the early development of new drugs to the manufacture of active pharmaceutical ingredients (APIs). This book is divided into four parts: Introduction (three chapters), Green Catalysis (four chapters), Green Synthetic Techniques (ten chapters) and Green Techniques in Pharmaceutical Industry (seven chapters).

Part I contains three chapters, which introduce different aspects of green chemistry. Green toxicology is an extension of the principles and practice of toxicology, which is used to minimize the risks to human health and the environment from exposure to chemicals. The implementation and adoption of green chemistry earns special attention regarding myths and trends.

Working on green chemistry does not involve sacrifices in performance and cost. Several examples of green chemistry in the pharmaceutical industry, resulting in reduced manufacturing costs as a result of a reduction in solvent use, reduced disposal costs, energy efficiency and other direct or indirect benefits, are presented.

Descriptions of chemical control laws from countries such as China, the United States and the European Union, are introduced. There is also information relating to the use and innovation possibilities of environmental science and green chemistry, and market forces.

Part II describes the green catalysis approach. Chapters 4–7 contain an extensive description of organic chemistry reactions, such as green catalytic C-H bond activation reactions, employing homogeneous and heterogeneous catalytic reactions with metal complexes, organocatalysis, and also the use of enzymatic reactions. Green asymmetric organocatalysis is related using supports, including polymers, solid acids, ionic liquids, magnetic nanoparticles and silica type materials.

The use of fluorous solvents in catalytic transformations, by immobilizing catalysts in the fluorous phase, is described in several applications including: hydrogenation, Stille and Suziki coupling, Heck reaction and others. Also, the impact of solid-phase organic synthesis (SOPS) on green chemistry and applications in preparing several classes of chemical compounds, in both the small bench chemist and industrial scale, are shown. Chapter 8 relates biocatalysis, which focuses on the application of enzymatic synthesis in the manufacture of pharmaceuticals, with emphasis on synthetic and semi-synthetic chiral molecules.

Part III describes synthetic techniques which have recently been used in green chemistry, and focuses on applications in the pharmaceutical industry. Examples cover early development in a small scale to scale-up for the manufacture of APIs. Advantages and disadvantages are related for each technique, and an extensive and detailed overview of recent literature is provided. In 10 chapters, the authors inform us how innovative solvents, supports and techniques have been increasing in the green process.

In chapters 9–11, the reader will find a useful literature study regarding solvents. New and specific green solvents have been developed for application in different chemical reactions. The use of water as an organic synthesis solvent has become more common, as well as the improvement of usual chemical transformations in this new, greener environment. Methods to obtain solvent-free synthesis are also related, such as ball milling, melts, mortar and pestle and microwave reactions. These methods will allow a decrease in terms of energy used by distillation sites to supply the chemical and refining industry.

Chapters 12–14 cover the use of alternative energy sources as tools to obtain chemical reactions and greener sustainable processes. For example, microwave reactions have wide implementations and applications nowadays. Chemists can count on equipment and procedures to obtain different organic scaffolds; furthermore, microwaves fit very well with green chemistry outlook, since they

prevent waste and operate safely. Ultrasonic reactions are described as a complementary green technique for promoting chemical reactions, reducing the amount of undesired hazardous chemicals and solvents, decreasing energy demands and increasing the selectivity toward the furnished product. Less common than the previous examples, photochemical synthesis cannot operate at all scale levels of organic preparations which makes this process rare in industry. Photochemical synthesis, in some instances furnishes natural products or operates in specific rearrangement or ring formation reactions.

Chapters 15–17 relate the use of different techniques as tools for increasing the synthetic efficiency, as well as for working in green chemistry. Solid-supported synthesis is a green alternative method to conventional synthetic methods. How this technique works is demonstrated step by step, from the initial step of the process, to the workup process, improving important factors in green chemistry.

In fluorous chemistry, there are advances in catalysts, reactants, linkers and scavengers. In particular, a light fluorous type is addressed with regards to the reaction, separation and analytical issues in organic synthesis. Ionic liquids are not just used as solvents in organic reactions. They can also be used in other processes, such as crystallization, separation, extraction, delivery systems, detection and as active ingredients.

Chapter 18 covers multicomponent reactions (MCR), in which more than two starting materials react to furnish a product. MCR operate on principles of green chemistry. MCR furnish sustainable synthesis technology and their use can even be performed in solvent-free conditions, or using water as the solvent. They also work with atomic economy. New possibilities for MCR might include the use of microreactors in the exploration of novel chemical routes.

Chapter 19 discusses the recent progress in chemical engineering, focusing on miniaturized and process intensification in flow reactors, which are alternative ways for the preparation of organic compounds in batches or flasks. Because works looking forward of mass and energy transfer issues, as well as open novel process windows using different conditions from classical.

Part IV is dedicated to green techniques in the pharmaceutical industry, dealing with problems addressing waste generation, business opportunities obtaining innovation needs and case studies in the manufacture of APIs for drugs used in tropical diseases. The importance of implementation and barriers within green chemistry, are also covered, at the first stage of drug discovery.

Chapter 22 presents several examples of the use of chromatography as a green technique at the manufacturing level, which has a significant impact on efficiency, decreasing the number of process steps, increasing the usage of the raw materials, improving the economics of the process, and working with solvent recycling and waste generation. A related issue is covered in chapter 25 regarding green analytical techniques, which act in the procedure to decrease waste and hazardous chemicals, and to increase renewable feedstocks and energy efficiency.

Chapter 23 presents the chance to operate in a green manner, reducing waste and expanding therapeutic opportunities to develop new drug delivery formulations, operating on spray-dried dispersions as a tool for drugs with low aqueous solubility and increasing the range of compounds in preclinical evaluations. As yet, this technique operates in small scale equipment.

In summary, the book covers new advances in green chemistry, which are applied in the pharmaceutical industry. It also shows ways of introducing innovation in a more holistic manner, through the development of smart equipment, techniques, or innovative chemicals. The book makes it clear that green pharmaceutical manufacturing has a large future, with potential for growth. The important issue of regulatory matters is discussed, which are decisive in drug development and have less relevance in the classical green chemistry field. Both newcomers and experts in medicinal chemistry will enjoy reading the developments in green manufacturing. A large number of bibliographic references is provided, among which are several major compilations such as books and chapters; however, some issues could be condensed in fewer chapters. Industrial applications are interestingly and well described, showing the value of green chemistry in trying to decrease waste generation disposal and energy consumption, and to improve other sustainability indicators. Industrial experts can use these special chapters as a guide, motivation and justification to implement the green idea into the daily manufacturing business of their companies.

Patricia Tambarussi Baraldi
Department of Chemical Engineering and Chemistry –
Micro Flow Chemistry and Process Technology Group
Eindhoven University of Technology
Den Dolech 2
5612 AZ Eindhoven
The Netherlands
E-mail: patricia.baraldi@institutovitanova.org.br