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Book review

GREEN CHEMISTRY AND CATALYSIS

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Wiley-VCH Verlag GmbH& Co. KGaA, Weinheim, Germany
ISBN-13: 978-3-527-30715-9; ISBN-10: 3-527-30715-X, XIV + 434 pages.

This book addresses the application of some catalytic methodologies to industrial organic chemistry, in the general context of green chemistry.

The book is initially aimed at scientists involved in developing processes for the production of different organic chemicals. It could be also used for advanced undergraduate or post-graduate level courses in green chemistry, and for researchers working in catalysis, interested in discovering new applications for different catalytic materials.

The volume is organized based on the type of transformation rather than on the type of catalyst. This approach provides a direct comparison of different catalytic routes (homogeneous, heterogeneous, bio-catalysis) for a particular process.

Chapter 1 consists in a general introduction to the overall theme of green chemistry and catalysis, highlighting the importance of several concepts (atom efficiency and E-factor) for assessing the environmental impact of chemical process. Further on, all the topics that will be presented in detail, in the following chapters of the book, are summarized and discussed from a general point of view. Several well-known examples of some recently developed catalytic processes illustrate this introductory chapter.

Chapter 2 deals with the acid-base catalyzed processes, with the aim on replacing traditional acids and bases with their solid, recyclable counterparts. The first part covers the solid acid catalysis: after a short presentation of the main classes of solid acids (acidic clays, zeolites and zeotypes), pertinent examples of zeolite-catalyzed reactions are presented. Subsequently, ion-exchange resisns, mesoporous silicas (with SO_3H acidic functionality) and heteropolyacids, together with some applications in organic synthesis are reviewed. The second part deals with solid base catalysts such as anionic clays, basic zeolites and mesoporous silicas grafted with pendant organic bases.

Chapter 3 covers the application of catalytic methodologies to reduction reactions. If chirality in not required, heterogeneous supported catalysts could be efficiently used, in combination with hydrogen. In addition to classical reductions, the Pd-catalyzed reductive alkylation of alcohols and amines with aldehydes, producing ethers and amines via a green synthesis route is particularly discussed. For chiral synthesis the use of homogeneous catalysts is an important option, as proved by some mature technologies based on chiral Ru, Rh and Ir catalysts. Biocatalysis, a rapidly increasing area of research, is presented as the method of choice for ketone reduction, due to the high purities of the reaction product.

Catalytic oxidation, a central process in organic synthesis, is discussed in Chapter 4. Homogeneous and heterogeneous catalysts in combination with green oxidants, such as O_2 and H_2O_2, are presented as an alternative to the heavily polluting stoichiometric oxidants. For exemple, the use of gold nanoparticles appears to be especially promising for the oxidation of alcohols and carbohydrates. In the area of asymmetric epoxidations, hydrogen peroxide can be activated by catalysis, to give good results, comparable with more established methods based on alkylhydroperoxide or hypochlorite oxidants. Several comparative results show that, homogeneous catalysts perform better that the heterogeneous ones, where the leaching of metals in solution in an additional complication of the process.

On the other hand, chemical methods are considered less efficient than biochemical ones, especially for some selected processes such as Bayer-Villiger oxidation. However, despite the huge effort in this research area, the applications of the green catalytic methods in fine chemical synthesis are still limited.

Chapter 5 is concerned with C-C bond forming reactions where the organocatalysis plays a pivotal role. The use of the amino acid proline, able to selectively catalyze almost every reaction of the aldehyde/keto group is presented in detail.

Biocatalysis is shown as the answer to many problems in the hydrolysis reactions in Chapter 6. It enables the mild, selective and often enentioselective hydrolysis of many esters, amides and nitriles. The clean and green production of acrylamide, a bulk chemical, based on the high selectivity of hydrolases is a significant example.

The use of water and supercritical carbon dioxide as the reaction medium holds much promise for the development of a sustainable organic chemical industry, as presented in Chapter 7. After an introductory part on solvents and alternative reaction media, various reactions occurring in aqueous biphasic and fluorous catalysis are exposed.

Hydrogenation, oxidation and biocatalysis are the main examples illustrating the use of supercritical carbon dioxide as green solvent. Finally, ionic liquids and biphasic systems with supercritical carbon dioxide are discussed through some selected processes.

The most important classes of renewable raw materials and the catalytic methodologies to convert them into more valuable chemicals are addressed in Chapter 8.

Chapter 9 is concerned with the integration of the catalytic steps into a catalytic cascade process, having the multi-enzyme processes occurring in the living cells as model. The downstream processes are equally discussed.

Chapter 10 gives the general conclusions and future prospects.

The principal literature has been covered up to 2006, and an extensive list of references is included in each chapter. The index is cross-referenced, the reader being encouraged to seek the various topics under more than one entry. Finally, each chapter contains a large number of reaction schemes and tables, making the reading more easy and enjoyable.

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