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Book Review

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Green chemistry and catalysis

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Environmental legislation is driving the fine and speciality chemicals industries to consider alternative processes that avoid the use of hazardous reagents and chemicals. Green chemistry addresses the sustainability and environmental impact of chemical processes by seeking means to eliminate the use of toxic reagents, reduce waste and promote the use of renewable resources. Catalytic technologies have played a key role in the economic development and growth of the chemicals industry. The development of new catalytic routes for the manufacture of fine, speciality and pharmaceutical chemicals is one of the main recognized solutions to these problems. *Green Chemistry and Catalysis* provides a detailed and critical overview of the various catalytic systems developed specifically for use in organic synthesis.

Since the introduction of the green chemistry concept there has been rapid development of new catalytic systems and a review of the state of the art will prove to be a great resource for researchers and graduate students working in the field. This book begins with an introduction to the principles of green chemistry, explaining how catalysis can play a major role in reducing the environmental impact of some common chemical transformations. The authors then give a brief overview of the advantages of using heterogeneous, homogeneous and enzymatic catalysts in synthesis and also explain how the use of alternative solvents and renewable resources can also help reduce pollution.

The first detailed chapter covers acid and base initiated reactions. These are widely used in the chemical industry, and are an area where the availability of new catalyst systems would have a significant impact. The following review of the application of solid acids and bases in synthetic chemistry explains the advantages over conventional soluble reagents. The focus of this chapter is on the application of acidic zeolites in selective organic transformations; however clays, mesoporous sulfonic acids and heteropoly acid clusters are also covered. The section on solid bases is less extensive but covers the application of basic zeolites, hydrotalcites and organically functionalized mesoporous materials in base-catalysed reactions.

The next two chapters focus on heterogeneous catalysts for reduction and selective oxidation chemistry. The discussion of catalytic reduction encompasses supported noble metals, transfer hydrogenation over zeolites and chiral hydrogenation systems. An overview of homogeneous and biocatalytic reductive alternatives is also given. The review of the pros and cons of alternative catalysts and more environmentally friendly systems for hydrocarbon selective oxidation is quite detailed, touching upon a range of heterogeneous, homogeneous and enzymatic catalysts for reactions including alkene epoxidation, and alkyl-aryl alcohol conversion to aldehydes/ketones and carboxylic acids via O_2 or H_2O_2 routes. Catalysts for asymmetric oxidation are also introduced.

Carbon–carbon bond formation is another area of huge importance to the chemical industry, and is the subject of Chapter 5. Enzymatic catalysts for the synthesis of cyanohydrins, aldols, α-hydroxyl acids and α-hydroxy ketones are discussed along with transition metal based structures for carbonylation, Heck-, Suzuki- and Sonogashira-type reactions, as well as versatile metathesis processes.

The application of biocatalysts is discussed in more detail in Chapter 6 with systems capable of replacing concentrated acids or bases in hydrolysis reactions discussed. Biocatalysts are shown to effectively facilitate mild enantioselective hydrolysis of esters, amides and nitriles.

Chapter 7 considers how alternative solvents can also be employed to make processes greener. The authors first address the roles of solvents in aiding diffusion, heat transfer and solubility (polarity control) of the reaction media. The use of alternative systems such as aqueous or fluorous biphasic catalysts is discussed as a means of improving separation of homogeneous catalysts. An overview of the application of supercritical CO_2 and ionic liquids in cleaner synthesis is also given.

Dwindling petrochemical resources is also a major concern to the chemical industry. To address the sustainability issues of green chemistry the authors also look to the future to consider whether renewable resources can be employed in chemical syntheses and how catalysis can contribute to their utilization. A discussion of the concept of the 'biorefinery' based chemical industry is introduced with possible limitations highlighted. The authors also address the impact of the number of processing steps on the efficiency of a synthesis. In the final chapter they consider the viability of cascade reactions where several catalytic steps are performed in a single reactor without the need for individual separations.

Overall this text provides an essential reference for any research laboratory interested in clean chemical synthesis, and would serve as excellent recommended reading for advanced undergraduate and graduate courses on green chemistry. One of the most important messages communicated is that there is no unique catalyst system for all problems, and individual processes may require homo-, hetero- or enzymatic catalytic solutions. This book also highlights the importance of academic research efforts in the development and optimization of new catalytic processes for a green and sustainable chemical industry.

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