Chemistry and Sustainability

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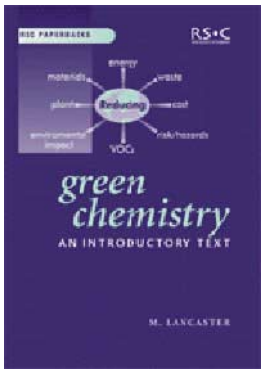

Green Chemistry: An Introductory Text

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Royal Society of Chemistry,
Cambridge, U.K.
2002, 310 pp.
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Softcover, 25 GBP.

Green chemistry is an important emerging interdisciplinary field, with links into engineering, biochemistry, physics, materials science, and other areas. The 310 page book is an attempt to cover most of the areas, a difficult task as acknowledged by the author, and it is thus by no means comprehensive. Rather it is an attempt to introduce the area, without over simplification or bias, and at the same time without complication. The target audience is chemists who are attempting to develop new processes and products, which meet the demands of society, and have lower financial and environmental impact. The book will also make an excellent advanced undergraduate textbook, with review questions at the end of each chapter, along with key reference material.

It is an excellent book to get a flavour for the practical applications and important industrial processes, and what the main challenges are. The need for green chemistry is put forward with balanced arguments. Every practising chemist should be aware of this important field, and the book is a good starting point, although unfortunately reference to primary literature is limited. This is a deficiency for a rapidly developing field. Another deficiency is the emphasis on synthetic chemistry, especially relating to chemicals and the pharmaceutical industry. There is very little reference to other areas such as the green chemistry of materials science. In addition, the industrial case studies, by the author's own admission, are drawn mainly from his own experiences, and are rather focussed.

Chapter 1 deals with green chemistry in the context of sustainable development, defined as 'meeting the needs of the present without compromising the ability of future generations to meet their own needs'. Also covered are perceptions of the community towards the chemical industry, and the 12 principles of green chemistry using mainly examples from organic synthesis, with an emphasis on atom economy and reducing toxicity of reagents, for example replacing neurotoxic organotin compounds.

More thought-provoking issues are developed in Chapter 2, which focus on the vexing issue of waste—covering historical events (for example mercury poisoning, Minamata Bay, 1965), quantifying waste using the Sheldon E-factor, the importance of 'Right First Time', the so called triple bottom line (environmental, economic, social), waste minimization techniques, recycling, and designing for biodegradability. This also includes how to critically assess a process incorporating chemistry, risk reduction, and engineering.

Chapter 3 deals with measuring the 'greenness' of a system, namely green chemistry metrics and life cycle analysis, which is becoming increasing important, perhaps even controversial. Again the arguments are balanced, with examples drawn mainly form the chemical industry. Also included is environmental management and legislation.

Chapter 4 is devoted exclusively to catalysis in green chemistry (heterogeneous, homogeneous, photo-, and biocatalysis), starting with background chemistry, which is a feature of other topics covered elsewhere. This tends to enhance the text as a more stand-alone book.

Chapter 5 launches into issues associated with using alternative reaction media, or avoiding the use of solvents. The arguments are balanced, and the approach is systematic, albeit with a bias towards detailed examples in organic chemistry, with occasional terse reference to other applications such as ionic liquids in separation technology.

Chapter 6 covers renewable resources, including energy (from biomass, solar power, and fuel cells), chemicals and polymers from renewable resources, and associated costs of production barriers. This sets the scene for Chapter 7 which deals with energy efficiencies in the chemical industry, covering photochemical reactions and associated engineering challenges, and non-conventional energy sources, notably microwaves and sonic energy. The author correctly highlights that this area is not usually regarded as important to researchers, although this can apply to green chemistry overall. This serves to highlight the importance of the book in the need to bring the average researcher up to speed.

Chapter 8 delves into engineering considerations, starting out with the conventional batch reactor which has scale-up problems, through to process intensification. This includes spinning disc, rotating fixed bed, and catalytic membrane reactors, and on-line monitoring.

Chapter 9 covers case studies of green chemistry in the market place and Chapter 10, as the concluding chapter, takes a pragmatic look at the barriers to adoption green chemistry, as well as the drivers of green chemistry, and the role of legislation and associated difficulties. Perhaps this would have been best dealt with earlier with an emphasis on futuristic benign technologies in a concluding chapter.

Overall, it is a timely book, covering the challenges and excitement of green chemistry, attracting even the practicing green chemist to read on. It is a compelling introductory text, and is destined to be an important starting point for researchers. It can be argued that there is a moral obligation for researchers to embrace the concepts of green chemistry if we are serious about sustainable development.

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