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Book Reviews *

Microreactors - New Technology for Modern Chemistry. Wolfgang Ehrfeld Volker Hessel Holger Löwe Wiley-VCH: Weinheim. 2000. 288 pp. Price £80. ISBN3-527-29590-9.

Microreaction technology is a hot topic at the moment as the demand for miniaturisation in chemical production increases and the potential of the new methods is explored. The use of small, inexpensive, independent, and versatile microreactors promises to achieve better control, selectivity, and safety in hazardous chemical processes, with lower cost investment in equipment and minimum waste, yet with the versatility to meet changing production demands, as in batch processes.

The book outlines the progress achieved in the past few years and is written by a group of engineers from the Institute für Microtechnik Mainz in Germany, where much of the innovative work has occurred.

Small microfabricated reactors have proven to provide excellent mass- and heat-transfer properties as well as uniform flow patterns and resistance flow distribution. The devices are now available commercially and are being tested by a number of chemical companies all over the world, but with more emphasis in Germany than anywhere else.

The advantages of microreactors in production are seen as flexibility, where a numbering-up approach (more reactors) is used rather than, as now, a scaling-up (bigger reactors). This guarantees that the desired features of the small system are not lost (particularly surface-to-volume ratio) when more material is needed.

Additional advantages are:

- Faster transfer of research into production
- Earlier start of production at lower costs
- Easier scale up
- Smaller plant size
- Lower costs (transportation, materials, and energy)
- Flexible response to market needs
- Safety (lower inventory of hazardous materials).

The book summarises the state of the art, including microfabrication techniques, micromixers, microheat exchangers, separation systems, and microreactors. The use for liquid-phase reactions, gas-phase reactions, and gas−liquid systems is covered. The final chapter discusses the disposable miniplant concept and the future of chemical production using microreactors.

The book is extremely well written and is highly recommended. Of most interest to process chemists is the chapter on liquid-phase reactions, where specific examples are discussed in detail. The most informative is on a process involving reaction of a ketone with a Grignard reagent to produce a tertiary alcohol by Merck AG, Germany. They studied this process in a microreactor, using statistical optimisation methods and found conditions where the yield was 92−95% (lab yield 88%, production yield 72% in a semi-batch process). The very fast continuous contact, and the low residence time (10 s) account for the increased yield. Merck were so impressed with the results when a yield of 92% was obtained, that a production plant has been constructed comprising five minireactors of 10^{-3} M^3 size. A further increase in volume results in a considerable reduction in performance.

Other processes carried out in these reactors include Suzuki coupling, Wittig and Horner-Emmons reactions, hydrogenations, and electrochemical oxidations (e.g., synthesis of anisaldehyde from 4-methoxytoluene).

In conclusion, this volume usefully summarises the state of the art on this revolutionary field and should be of value to both chemists and chemical engineers in industry.

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Chemical Risk Analysis -A Practical Handbook. Bernard Martel. Penton Press/Kogan: London, UK. 2000. 528 pp. £80. ISBN 1-8571-8028-3.

The handbook includes the principal methodological tools and data required to evaluate and assess chemical risk analysis in practical working situations. It has been translated from the French 1997 edition by the same author. It not only includes theoretical treatments on flammability, stability, and toxicity of chemicals but also discussion of dangerous reactions. A large part of the handbook is a list of dangerous reactions (approximately 200 pp) and table of compounds listing physical properties and safety data from various sources.

The style is not just factual, but also includes a great deal of discussion on key issues. For example, an in-depth understanding of flash point, auto-ignition temperature, and exposure limits is presented in relation to European and U.S. legislation, including the anomalies of the systems. The section on stability includes detailed discussion of the principles behind the CHETAH programme and reproduces Benson's Tables for estimation of heat of formation of organic compounds. The toxicity chapter emphasis the difficulty in analysing toxicity risks, with the different values used (LC50. LVE/STEL, MVE/TWA) with no apparent logic between the systems.

These sections are well set out and make valuable reading. The section on dangerous reactions, however, seemed jumbled—one was never certain whether laboratory reactions or large-scale work was being discussed (for example, accumulation is not really discussed in detail). In a section

*Unsigned book reviews are by the Editor.

entitled “Quantitative estimation of dangerous character of a reaction”, only calculations were discussed; calormetric determinations are not covered. Thus, the word “Practical” in the book title seems inappropriate.

The main section on dangerous reactions of chemicals, particularly the organic section, was also rather jumbled, being a collection of two- or three-line statements with often little to connect them together. The data are presented with no primary references, only general references to other texts (for example, Bretherick), and thus it is difficult to trace back the incidents, which are mentioned and discussed. When compared to Bretherick, (from which, I suspect, much of the data came), it is much less easy to use when trying to find specific reactions or compounds. The index is quite comprehensive so this does help with locating data, but there are some annoying traits; hydrogen azide (which many people would refer to as hydrazoic acid) is listed as hydrogen nitrate in the index; ethyl oxide and isopropyl oxide are used in the text, ethylene oxide and propylene oxide in the index; malonitrile in the text, malononitrile in the index.

The tables assemble data from diverse sources in a unified manner, providing physical constraints, flammability data, toxicity and legislative classifications—this section will inevitably be compared to Sax, which contains more compounds, but less detail on each compound. This section is a relatively useful source of data on inorganic and relatively simple organic compounds, mostly aliphatic (for example, benzoic acid is the only aromatic monocarboxylic acid listed—heterocyclic compounds are hardly included).

The Handbook suffers from poor editing, with annoying translations (bycompound for byproduct) and amusing new words (toxicityology!). The Translator could have compared the style and changed words and abbreviations which clearly derive from the French (E_b for boiling point, security for safety).

In conclusion, the book is recommended reading for the early discussion chapters but not for the sections on dangerous reactions, which do not add to existing texts such as “Bretherick”.

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Handbook of Hazardous Chemical Properties. Nicholas P. Cheremisinoff. Butterworth-Heinemann: Oxford, UK. 2000. 433 pp. £60, $90. ISBN 0-7506-7209-9.

The *Handbook of Hazardous Chemical Properties* contains information on over 1000 industrial and consumer chemicals. Each entry contains data subdivided into Chemical Designation, Observable Characteristics, Physical and Chemical Properties, Health Hazards, Fire Hazards, and Chemical Reactivity. This includes standard information such as name, synonym(s) and chemical formula, physical state, colour, odour, molecular weight, boiling point, melting point, specific gravity, vapour density, various thermodynamic properties and ignition temperature, and in addition information such as recommended personal protective equipment, typical symptoms of exposure, general first aid treatment, and various toxicological information, list of fire extinguishing agents to be used, list of fire extinguishing agents not to be used, special by-products of combustion, electrical hazard rating, burning rate, reactivity with water, and common materials such as plastics, organic matter, stainless steel, and whether the compound polymerises and recommended polymerisation inhibitors.

As such, this book provides a useful set of information which is designed to assist chemical handling specialists, emergency responders, health and safety engineers, and technicians in the safe handling and shipping practices of chemicals. It will undoubtedly be of great assistance to people involved in chemical packing, shipping, emergency response, health and safety, and similar activities, but practising chemists will be far better served by *Bretherick’s Handbook of Reactive Chemical Hazards*. Most common reagents such as sodium borohydride and lithium aluminium hydride are included, but surprisingly butyllithium is not included although triethylaluminum is.

To have all the information for each compound collected together is very useful, particularly for those engaged in compiling Safety Data Sheets, although for practising chemists the relatively small number of entries (compared to almost 5000 entries in Bretherick) limits the book’s value for practising chemists. For the main target “audience”—those involved in handling chemicals (as opposed to those who use chemicals) or dealing with emergencies involving chemicals—it should prove to be a very useful reference book.

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