

# The Wide Scope of Catalysis

## FINE CHEMICALS THROUGH HETEROGENEOUS CATALYSIS

EDITED BY R. A. SHELDON AND H. VAN BEKKUM, Wiley-VCH, Weinheim, 2000, 636 pages, ISBN 3-527-29951-3, €159, £95

This book covers the application of heterogeneous catalysis to organic reactions for the synthesis of fine chemicals, and includes gas- and liquid-phase reactions (more of the latter mirroring the industrial use). The editors define fine chemicals as those costing over U.S.\$10 kg<sup>-1</sup> with volume production below 10,000 tons per annum worldwide. They describe significant developments in heterogeneous catalysis for organic synthesis and note the increasing attention paid to 'green' chemistry. Four major areas, all written by recognised authorities, are covered: acid-base catalysis, hydrogenation, oxidation and C-C bond formation.

In Chapter 2, J. W. Geus and A. J. van Dille introduce fundamental principles, preparations, characterisations and uses of different types of catalyst and reactor technologies in fixed-bed and stirred reactors. In Chapter 3, M. Campanati and A. Vaccari deal with different types of solid-acid catalyst, their preparation and uses. Clays as supports are mentioned, for example for Pt in the hydrogenation of cinnamaldehyde.

Chapters 4 to 6 discuss solid-acid catalysis. A. Kogelbauer and H. W. Kouwenhoven cover aromatic substitution: nitration, halogenation, Friedel-Crafts alkylation and acylation, and hydroxyalkylations. T. Tatsumi examines rearrangement and isomerisation reactions, such as Beckmann, epoxide, benzamine, pinacol and Fries rearrangements and isomerisation processes. T. Mallat and A. Baiker cover a collection of processes including amination (Pd catalysts for phenols amination), alkylation of carbohydrates, heterocyclic synthesis, Diels-Alder reactions and alcohol dehydration.

Solid-base catalysis is covered by A. Corma and S. Iborra (Chapter 7). Reactions include Aldol and Knoevenagel condensations over hydrotalcites, alkaline earth oxides and base-modified silicas.

Chapter 8, by S. Bailey and F. King, is extensive, covering hydrogenation and dehydrogenation, and is probably of most relevance to platinum group metals (pgms). Topics include selective hydrogenation

of acetylenes using supported Pd and doped catalysts (Pd/Pb and Pd/Ag) and the conversion of carboxylic acids to alcohols over transition metal oxides – still a challenge under mild conditions. Other sections describe aldehydes and ketones (Fe promoted Pt) and compare the selectivities of pgm catalysts for cinnamaldehyde hydrogenation. A section on carbohydrates reviews the production of several commercial materials using Ru and Ni, and a section on nitro-group hydrogenation looks at pgm costs, process problems and compares current catalytic technologies.

In Chapter 9 on oxidations, R. A. Sheldon and M. C. A. van Vliet describe epoxidation using TiO<sub>2</sub>/SiO<sub>2</sub> catalysts; the oxidation of alcohols and aldehydes over Pt and Pd catalysts and the role of Bi and Pb promoters. They give examples of catalyst preparation, processes, and a good bibliography.

C. Copéret, J. Thivolle-Cazat and J.-M. Basset (Chapter 10) cover carbon-carbon bond formation, alkene metathesis over various oxides and Heck coupling. Examples are given of the use of immobilised Pd colloids and silica-supported homogeneous complexes. Several commercial examples of the use of Pd/C catalysts are given.

Lastly, Sheldon and van Bekkum note that rapid advance is possible by high throughput screening techniques and reactive distillation, as in the integration of separate processing steps. While further understanding of catalytic processes is needed, they emphasise that research with catalysts, reaction modifiers, nanostructured materials and aqueous biphasic systems will all aid development. While more detailed texts on individual topics may exist, few will be so wide-ranging. Each topic gives an introduction and provides references for further study. The book increases awareness of the scope for catalysis in fine chemical synthesis.

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