Commercial Heterogeneous Catalysis

HANDBOOK OF COMMERCIAL CATALYSTS – HETEROGENEOUS CATALYSTS

BY HOWARD F. RASE, CRC Press LLC, Boca Raton, 2000, 488 pages, ISBN 0-8493-9417-1, U.S. $139.95, £94

In this book, Professor Rase has set about the gargantuan task of describing many of the commercial processes which employ a heterogeneous catalyst. His main aim has been to enable chemists or chemical engineers to gain background information quickly on a particular process. In the main he has been very successful in the compilation of a concise and highly readable book which addresses reactions as diverse as hydrogenation, oxidation, dehydrogenation, alkylation, epoxidation, isomerisation, petroleum refining and synthesis gas chemistry.

The book is divided up into 19 chapters, each of which describes a particular type of reaction and contains a comprehensive reference section to direct the interested reader to pertinent review articles. The chapters are subdivided into sections dealing with the overall reaction chemistry including any thermodynamic constraints associated with it. Subsequent sections deal with the favoured catalysts for the reaction, the sources of deactivation and methods for regeneration of these materials as well as their suppliers and licensors of the processes. Details of the catalytic reactors used are considered as are the reaction kinetics. Some quite detailed drawings of the various reactors for these industrial-scale processes are given in a final appendix. This is possibly more beneficial for a chemist than an engineer! The index is arranged so that the reader can search for the relevant section by reactant or product.

The book shows clearly the wide range of reactions, which are catalysed efficiently by supported platinum group metals (pgms) materials. In many cases the supported pgm is not unique in its ability to catalyse the reaction, but its superior activity and selectivity is sufficient to outweigh the cost considerations. For example, many exothermic hydrogenation reactions can be catalysed by nickel but operation of a more active supported platinum or palladium catalyst at lower reaction temperature will bring obvious thermodynamic benefits.

This can be illustrated by a reaction such as the hydrogenation of benzene to cyclohexane where the supported pgm catalyst has sufficient activity to allow short contact time between the reactant and the catalyst. This minimises the extent to which the thermodynamically favoured but kinetically slow hydroisomerisation reaction occurs. This reaction produces the unwanted methylcyclopentane side-product.

Operating this process at low temperature also helps avoid the highly exothermic cyclohexane hydrocracking reaction, which can cause thermal runaway in the reactor. Temperature excursions can be minimised using three or four adiabatic fixed bed reactors with interstage cooling. Temperature can be further controlled by the use of a lower activity catalyst in initial beds. Alternatively, non-adiabatic multitubular reactors where the heat of reaction is absorbed by a cooling fluid in the shell side of the reactor can be used.

The half century experience of the author is evident in his astute treatment of the kinetics of these processes. The benzene hydrogenation reaction is very suited to kinetic analysis as it is dominated by a single reaction and has been shown to be zero order in benzene. However, in high temperature reactions such as the dehydrogenation of ethylbenzene or lower alkanes where rapid coke formation results in catalyst deactivation, the author stresses that basing an industrial model on intrinsic kinetics of the desired reaction is 'futile'. He suggests that an empirical rate expression as a function of time-on-stream, which includes a deactivation term, would be more appropriate.

This book is a very useful reference tool for any chemist or engineer working in the area of heterogeneous process catalysis and Professor Rase is to be commended for succinctly compiling so much information.

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