Heterogeneous Catalytic Hydrogenation

HANDBOOK OF HETEROGENEOUS CATALYTIC HYDROGENATION FOR ORGANIC SYNTHESIS

BY SHIGEO NISHIMURA, John Wiley & Sons, New York, 2001, 700 pages, ISBN 0-471-39698-2, U.S. $185, €217.70, £137

Catalytic hydrogenation is widely applied for the reduction of a variety of functional groups. It has been and will continue to be a very substantial market for platinum group metal (pgm) catalysts as they tend to be more active for a given transformation than their base metal equivalents. This permits the use of less severe reaction conditions. In the main, though not exclusively, the reactions are carried out over a heterogeneous catalyst. Unsupported catalysts have found application in small-scale laboratory use, though on an industrial scale use of a supported catalyst is usually advantageous. The rather difficult-to-handle Raney Ni catalyst is one of the few unsupported materials which has been utilised industrially.

A diversity of materials can be used as a support to the hydrogenation catalyst and numerous techniques are used to deposit and anchor the active metal on this material. This results in a vast array of catalysts, each of which may be optimal for a given reaction operating under appropriate conditions. Correlating this data to produce a reference book, to enable a researcher to ascertain quickly the favoured catalyst and reaction conditions for the hydrogenation step of a particular functional group is an ambitious and highly laudable endeavour. This is exactly what Professor Nishimura has attempted to do with this book.

The book is divided into thirteen chapters. The first chapter gives an overview of hydrogenation catalysts, subdivided into sections on base metal catalysts and one on pgm catalysts. Details are given of methods by which both supported and unsupported catalysts can be prepared. The recipes provide a useful starting point for preparation of an optimised catalyst. The second chapter deals briefly with reactors, then with catalyst inhibitors and poisons, the judicious use of which is seen in the subsequent chapters on hydrogenation chemistries to be a good control of catalyst selectivity.

For example, in Chapter 4 on the hydrogenation of alkynes we see that Pb-doped $CaCO_3$-supported Pd (the Lindlar catalyst) is active in the selective hydrogenation of alkynes to alkenes. The catalyst can be further modified for this reaction by addition of a nitrogen base such as quinoline or pyridine. This inhibition of the catalyst prevents further hydrogenation of the alkene product and results in an increase in selectivity. It is important, however, to adjust the concentration of the inhibitor to avoid complete poisoning of the catalyst. Another example of selective poisoning is described in Chapter 13 where a $BaSO_4$-supported Pd catalyst when treated with a sulfur-containing poison, such as thioquinanthrene, becomes selective in the hydrogenation of acid chlorides to give aldehydes (the Rosenmund reduction). Addition of the inhibitor prevents further hydrogenation of the labile aldehyde product.

The specialist nature of this book is reflected not only in the price (an eye-watering £137) but also in the fact that technical terms (explanations being beyond its scope) are used liberally throughout. The reference lists for each chapter, while not meant to be comprehensive, could perhaps benefit from an update as they tend to be biased towards earlier work, sometimes even towards unsupported catalysts.

In conclusion, this book is easy to use to find information quickly on the hydrogenation of a given functional group. In conjunction with other texts (1, 2) it adds to a useful armoury for dealing with most queries on hydrogenation. It is therefore good value for the specialist practitioner.

References

1 R. L. Augustine, "Heterogeneous Catalysis for the Synthetic Chemist", Marcel Dekker, New York, 1995

2 "Fine Chemicals through Heterogeneous Catalysis" ed. R. A. Sheldon and H. Van Bekkum, Wiley-VCH, Weinheim, 2000

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