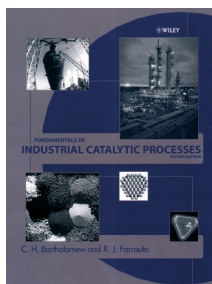




Fundamentals of Industrial Catalytic Processes



2nd Ed. By Calvin H. Bartholomew and Robert J. Farrauto. Wiley-Interscience, New York 2005. 992 pp., hardcover
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Following the first edition of this work, which named the authors in the opposite order (Farrauto/Bartholomew) and came from a different publisher, we now have this second, enlarged, edition. With a total of 966 pages in a single volume, it describes the essential features of industrial catalytic processes. Catalysis is certainly a massive and unwieldy subject, and accordingly this volume weighs over 3 kg, and in its 29 × 22 cm format (approximately A4) it is by no means easy to handle—certainly not with one hand or as bedside reading—it would probably be best to use it in conjunction with a high desk as in the time of Berzelius.

However, as regards the contents, the book is easier to open up. It is arranged in two main parts—"Introduction and Fundamentals" and "Industrial Practice"—although it is somewhat illogical that Chapter 12, on homogeneous, enzymatic, and polymerization catalysis, is not similarly divided into two parts with a separate treatment of the fundamentals, but is lumped together under industrial processes. This is consistent, autocatalytically as one might say, with the fact that "Catalytic Processes" in the book's title is not quite correct, because it is oversimpli-

fied. It would be more honest to insert the prefix "Heterogeneous", since more than 90 % of the pages deal with heterogeneous catalysis, whereas homogeneous catalysis occupies less than 10 %, an asymmetrical imbalance that certainly does not reflect the relative importance.

The first main part is devoted to the fundamentals of heterogeneous catalysis, and consists of five chapters with altogether 331 pages. With chapters on catalytic phenomena (Chap. 1), catalytic materials, preparations, and manufacturing processes (Chap. 2), choosing and characterizing catalysts (Chap. 3), reactors for catalytic processes (Chap. 4), and information about activity and deactivation (Chap. 5), this part gives a survey of the present state of knowledge about heterogeneous (but, as noted, not homogeneous) catalysis, which covers practically every aspect and treats some aspects in greater depth. The literature references are well chosen, and earlier work is included where necessary. Certain sections also include references to material "for further studies", usually for reading in greater depth.

As already mentioned, the subjects of homogeneous, enzymatic, and polymerization catalysis (the latter being treated, unusually, as a separate type of catalysis), including the fundamentals, are not covered in the first part of the volume but as sections within the "Industrial Practice" part. One can only speculate about the reasons for this very unusual and unsystematic decision. Organic catalysts, which are becoming increasingly important, are not even mentioned, nor do they appear in the glossary or the (rather meager) index.

The second main part, "Industrial Practice", consists of 600 pages describing the catalytic production of hydrogen and synthesis gas reactions (including the syntheses of ammonia and methanol and the Fischer-Tropsch process, Chap. 6), hydrogenation and dehydrogenation processes (Chap. 7), catalytic oxidations (including sulfuric acid and nitric acid processes, ammoxidations, and partial oxidations, Chap. 8), and reactions involved in the processing of crude oil (the very long Chap. 9). The second part ends with two chapters about environmental catalytic processes—one on the treatment of

mobile gas sources (motor vehicles and the depletion of ozone by commercial aircraft at high altitudes, Chap. 10), and the other on stationary sources (power stations, and effluent gases from industrial processes, Chap. 11)—and a section on fuel cells (included under "Industrial Practice", in a separate chapter on "Catalyst Technology"). This chapter also contains valuable information about large-scale applications of catalytic processes, and details about important reactions and prototype processes, information that otherwise could only be found by a detailed study of widely scattered literature. Thus, an astonishing wealth of information is collected together in both parts of the book—a remarkable achievement for only two authors!

To properly evaluate this book, one must take into account its rather unusual aim: according to their foreword, the authors have set out to produce a combined "textbook and handbook", by which we are apparently to understand that the textbook covers the fundamentals of heterogeneous catalysis, while the handbook covers the industrial applications. In accordance with this aim, the authors expect that the volume will be read by students, chemical engineers, and "professional scientists". That is an unusually broad anticipated readership, and it is in fact taken into account by the widely differing levels of the exercises given at the end of each chapter, by the very instructive numerical examples (which even include details of mass and heat transfer problems), and by theoretical discussions, sometimes in considerable depth. That probably also explains the wide variations in the depth of the exercises and examples: for example, one exercise cites an "e-mail from Nancy McFadden, Plant Manager" to a presumably better-informed colleague, Jeff, pleading "please help" (Example 8.6). Apparently his advice was not followed quickly enough, because in Example 8.8 Nancy, who has been rather slow to grasp the point, is asking again for help (p. 627). However, the exercises are divided into "easy questions" and "problems", and a few are even described as "relatively difficult". Rather unhelpfully, the solutions to the questions and problems are not given;

instead it is stated that “An answer book will be made available to professors upon request”.

I assume that this (for Germans) rather unusual style of presentation is common American practice (Calvin H. Bartholomew is Professor of Chemical Engineering at Brigham-Young University). Commendably, and especially worth mentioning in the case of American authors, metric units are used throughout, although they do not entirely follow the most up-to-date recommendations. For example, although pascal is given as the unit of pressure, it is not actually used: in the book the authors generally use atmospheres, bar, or even torr, and also kcals have not been converted into joules—however, that is also the case in some currently used European textbooks. Often only annual production figures for the USA are given, rather than worldwide figures, and here again, for consistency, that part of the book's title should be changed to “Industrial Catalytic Processes in the USA”. On the other hand, the rest of the book's help resources are of an exemplary standard: a very detailed list of common abbreviations and explanations of nomenclature, and the comprehensive and highly informative glossary, which is appropriate for the book's heterogeneous contents. However, the index, as already mentioned, is mediocre. The glossary is inadequate with regard to homogeneous catalysis: important concepts such as ligands, central atoms, and complexes are not even mentioned, let alone explained.

The printing errors are rather disturbing, and some are annoying for a catalyst chemist—for example, 1908 is given as the year of the first hydro-

formylation (Table 12.8). However, it is really disappointing to come across factual errors, such as that on page 400. There, in discussing the history of the Fischer-Tropsch synthesis (which has again become a very important process), it is stated that in 1934 Ruhrchemie operated its experimental plant for several months with a nickel catalyst (which, of course, would have given disappointing results). In 1934 it was already known that nickel catalysts with synthesis gas yield only methane, and in particular that must have been very well known to Otto Reulen, who was in charge of the Ruhrchemie experimental plant at the time and had previously led the semitechnical-scale experiments at the Kaiser Wilhelm Institute in nearby Mülheim. To imply that he could have made such a mistake is very unfair! Some distortions of the truth have also slipped into several statements about products from homogeneous catalysis. Thus, in Table 12.6 it is claimed that in 1980 in the USA no acetic acid was being produced from methanol, in other words by the Monsanto process. That statement is incorrect, as indeed one can read a few pages later (p. 843). Moreover, this process, which is also very important in the development of homogeneous catalysis, as it was the first application of rhodium catalysts, is not mentioned by name. More generally, the shortness of the chapter on homogeneous catalysis is largely due to the fact that the “Examples of Industrial Processes” in this chapter are limited to hydroformylation and methanol carbonylation (and even these are treated as being of minor importance compared with heterogeneous processes). As a consequence of this, some important

homogeneously catalyzed processes such as those for polymers, propylene dimers, and dichloroethane, and especially the developmentally important and large-tonnage processes for terephthalic acid, terephthalic esters, and polyesters, unaccountably fail to get their appropriate share of attention. That there is a systematic intention in this parsimonious treatment is also shown elsewhere: for example, the section on “Reactors and process design for homogeneous catalysis” consists of only ten lines, even though the authors themselves admit that the catalytic metals and ligands involved in homogeneous catalysis must often allow for complicated process variants so that the two can have separate recirculation cycles—there is not a word here about the challenges and interesting possibilities of chemical engineering!

Because of these annoying inconsistencies, the verdict on this book by Bartholomew and Farrauto must definitely be ambivalent: it is extremely informative about heterogeneous catalysis, but its treatment of homogeneous catalytic processes is inadequate. A third edition of the work should incorporate some substantial changes, if only because of the authors' claim in their foreword that it is “designed to address the needs of both students and practising professionals”. Those needs include the duty of university teachers to provide equally good information about the two types of catalysis (not to mention also covering enzymatic catalysis).

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