

## BOOK REVIEW

**Mass Transfer in Heterogeneous Catalysis.**  
By CHARLES N. SATTERFIELD, M.I.T. Press,  
Cambridge, Massachusetts, and London, 1970.  
xvi + 267 pp. \$14.25.

"The observed rate of a catalytic reaction and the nature of the products formed can be profoundly affected by the rate of mass transfer—by how fast reactant molecules are transported to the catalyst surface and product molecules removed." The quote from the paper jacket tells the basic reason for writing this monograph. It covers the theory and reviews the experimental and computational work that has been done in the field of mass transfer between reacting fluids and solid catalysts.

In these days, persons trying to become current with the state of the art of an area find themselves inundated by a Brobdingnagian tidal wave of articles of varying quality, and the monograph has become the lifeline to sanity. A good monograph will digest and evaluate the material published prior to the monograph's appearance; it also will probably bring to a researcher's attention literature that has escaped him, and present a critical evaluation of it.

Professor Satterfield's latest book is such a monograph. It is a thorough revision and extension of "The Role of Diffusion in Catalysis," which he coauthored with Professor T. K. Sherwood. This new effort is most welcome, because of the large amount of work in this field during the 7 years since the publication of the older book.

The present work is divided into five chapters. Chapter 1 starts with some groundwork by first giving a brief discussion of diffusion both in normal circumstances and in minute pores. Next, since the internal structure of porous catalysts has a significant effect on intraparticle transport rates, the pore structure of catalysts is treated. The last part of the chapter (somewhat over half) is devoted to mass transport in porous catalysts, presenting an extensive review of both theory and experiment in this area. Intraparticle heat transport, for some reason, is left to Chapter 4.

The second chapter deals with mass and heat transfer external to catalyst particles. It discusses these transport effects for fixed beds, fluidized beds, trickle reactors, and slurries. Both two- and three-phase systems are considered. The coverage

of types of catalytic reacting systems thus is quite broad, and brings together in one handy reference a summary of the transport investigations in this area.

The remaining three chapters treat simultaneous reaction and transport of mass and heat within porous catalysts. The third chapter presents the elementary theory and describes simple situations concerning these coupled phenomena. A large amount of experimental work is covered in this chapter. The fourth chapter extends the theory to more complex situations where temperature gradients within the catalyst particles, complicated kinetic rate expressions, and variable volume reactions exist. The thermal conductivity of porous catalysts is also covered in this chapter. In the area covered here, experimental work is rather sparse, and most of the work has been computational. A large amount of the latter is reviewed.

Chapter 5 shows how the interaction between diffusion and reaction can complicate the phenomena of catalyst poisoning, reaction selectivity, and catalyst regeneration. Although these are rather complex situations, a surprising amount of experimental confirmation of the theoretical work has been accomplished and is reviewed here.

The book is of high quality throughout; the writing is lucid, the organization is reasonably logical, and the literature coverage is extensive. Misprints are blessedly few—the reviewer noticed but one, and that completely trivial. A good subject index allows the reader to pick and choose his topics.

Two portions of the book are outstanding. The coverage of diffusion in porous catalysts in the first chapter and the three chapters which treat the different aspects of simultaneous transport and reaction in porous catalysts present a synthesis of the available information that is not even approached anywhere else. The only mild criticism that the reviewer has of the latter part is that he feels the asymptotic solutions approach to complex situations has some real attractions, and deserves a little kinder treatment than it received. But viewed generally, these parts of the book present valuable and significant contributions to the practicing catalytic kineticist.

The prospective reader deserves some minor caveats concerning other portions of the book. The section on the structure of porous catalysts

does not cover the available research in this area at all extensively. For the purpose of the book, this is quite justifiable, since the recent research in catalyst structure has not yet been applied to transport within the porous catalysts. So this portion should not be regarded as the last word on catalyst structure—merely the investigations concerning structure that have been used in transport situations.

The chapter treating mass and heat transport external to the catalyst particles deals primarily with transport through the boundary layer. Dispersion within the various reactor types is treated in a rather cursory fashion. Also, while an admirable summary of the transport effects through the boundary layer is presented, the coupling of these effects with chemical reactions is not developed to any large degree. Admittedly, a thorough treatment of these aspects could easily have doubled the size of the book. Nevertheless, the interested reader will have to use other sources, such as the texts of Petersen, Astarita, Kunii and Levenspiel, and the article by Olson and Stout in Uhl and Gary's second volume on mixing, for extensive studies of the effects of coupling transport external to the catalyst particle with chemical reaction.

The book appears to be written for use by the practicing kineticist, who can look up a particular topic in the index and find that area and associated areas covered in the immediate vicinity. The organization does not seem ideal for use as a basic text for a university course, although it should be very good for use in supplementary reading assignments.

The coverage of the literature available in English appears excellent. The coverage of articles in other languages may be much less complete; only about 8% of the 398 references are originally from non-English journals, and the book notes that many of these references are available in translation.

But the quibbles are not serious. Professor Satterfield is owed a vote of thanks for the high quality job he has done in collecting and codifying the huge amount of work in this area. The book well deserves the wide readership and use it will undoubtedly attain.

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