JOURNAL OF CATALYSIS 3, 299–300 (1964)

BOOK REVIEW

The Role of Diffusion in Catalysis. By CHARLES N. SATTERFIELD and THOMAS K. SHERWOOD. Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, 1963. ix + 118 pp. Price $4.75.

The effect of mass transport on catalysis was known as long ago as Nernst, but has received little attention from chemists until recent years. It has been estimated that the experiments in 30% of all papers given at the 1960 Congress of Catalysis were not free from diffusion effects. In the last few years, an awareness of the importance of diffusion effects has steadily increased so that it is no longer prudent to perform a catalysis study without consulting a standard reference on diffusion.

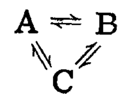
Unfortunately, awareness does not always imply understanding. One often hears remarks such as: "We have only 5% conversion, consequently there are no diffusion effects," or "The activation energy is 40 kcal/mole, so there are no diffusion effects"—both false. This book discusses the principles involved together with an extensive list of formulas and tables of diffusivities; it contains what every catalysis investigator should know.

The role of diffusion in catalysis is twofold: (1) It changes the speed of reaction, thereby changing the apparent reaction orders and activation energies. (2) It changes product distribution, thereby changing the apparent kinetics and mechanisms. The importance of role (1) can be seen in Table 3-1 where 25 experimental studies are discussed. The effectiveness factors range from 1 to 0.0009, i.e. some reactions are slowed down to less than one-tenth of a per cent of the natural speed by diffusion. This should convince anyone that diffusion effects need not be small, and are not invented by ogres just to frighten already over-worked catalysis investigators.

The importance of role (2) is mentioned in this book, but unfortunately not emphasized enough. A chemist may not be too concerned when diffusion effects slow down a reaction by 40%, especially since catalyst activities are so hard to reproduce. But he will be concerned when diffusion effects change the product distribution to the point of disguising the true mechanism. Consider a consecutive reaction

$$A \rightleftharpoons B \rightleftharpoons C$$

If pure A is led into a reactor, molecule A enters a catalyst particle and is converted into B. Before B can diffuse out to the surrounding gaseous stream, it may meet another site and be converted to C. Thus, even the "initial" product distribution will consist of C as well as B in abundance. The measured kinetics will appear as if there is direct conversion from A to C.



To discover the true consecutive mechanism, one must reduce diffusion effects to negligible proportions, such as by reducing the dimension of the catalyst particles.

This book is intended to be an up-to-date bibliography, and as a text for upper undergraduate or graduate level course. It is very useful as a reference book, but the subject matter is probably too narrow for an entire course. One may argue that the first two chapters are only preparatory and are already well covered by such standard texts as Bird, Stewart, and Lightfoot and by Sherwood and Pigford. But it is very handy to have all the formulas and tables of diffusivities bound in one volume.

The really important chapter is the third one, which justifies the title of this book. The authors have done a very useful service by compiling a nearly complete list of papers on the subject published in recent years. It is invaluable to anyone about to start a research project. All the principal and peripheral results are here, and regrettably, they are given almost equal coverage. The narrative therefore, lacks the authority and coherence necessary for a critical review.

Research papers on the diffusion effects in catalysis employ an amazing profusion of notations. For the fundamental Thiele modulus, Sherwood and Satterfield use φ, Aris uses Λ, Weisz and Prater use ϕ, Carberry uses ψ, Wheeler uses h, Tinkler and Metzner use $\sqrt{\alpha}$. This book, being the first text in this field, should go a long way in unifying the notation.

In summary, this book should be very useful for any chemist who wishes to check whether he is in diffusion trouble. It is remarkably easy to use the criteria for negligible diffusion difficulties on p. 86 and p. 91. He can also find out whether he can stay out of trouble by reducing particle sizes, by lowering the temperature, etc. For chemical engineers who are interested in more quantitative information on catalyst performance, this book serves as an excellent introduction.

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