Activation, Deactivation, and Poisoning of Catalysts

By John B. Butt and Eugene E. Petersen, Academic Press Inc., San Diego, 1988, 495 pp., $95.00

This book deals with the phenomena associated with the mortality of heterogeneous catalysts. The book is described as being written for "the catalytic chemist, the researcher, the reactor designer and the student. . . ." Each of these will find at least something of value. The book is divided into three parts, incorporating increasing magnitudes of scale. The first part deals with individual phenomena on active sites, the second with processes on a single catalyst pellet, and the third with processes at the scale of the reactor. Individual chapters begin with a quote (often apocryphal) from the nontechnical literature, and end with a "summary and evaluation," affording opportunity for an editorial which is often the most meaningful section of the chapter. Since the symbols used occasionally vary from one chapter to another, a nomenclature section would have been helpful.

Chapters 1 and 2 are generalized and descriptive. They make the valuable distinction between the activity, i.e., the reaction rate compared with the initial value, and the fraction of catalytic sites which are no longer active; the two parameters are, of course, related but not identical. Chapter 3 deals with the laydown of unsaturated carbonaceous matter, or coke, and its relation to catalyst deactivation. However, the statements by the authors that "there is no cause-and-effect relationship between the activity and the coke level of . . . certain . . . catalysts," and that "coke is not the culprit but an innocent bystander," are perhaps a trifle strong. In many of these cases, the results can be explained by simultaneous coking and poisoning. Poisoning is the subject of the following chapter. Here we have an excellent attempt to relate a variety of surface science results to reactor observations at much higher pressures. Chapter 5 correctly bemoans the lack of experimental data relating activity/selectivity to the sintering phenomenon. This chapter also contains a good attempt at bringing out the essence of the various mathematical models without being mired in the details.

Chapters 6 through 9 deal with diffusion-and-reaction effects on the scale of a single catalyst pellet. Much of the treatment of Chapter 6 is available in earlier books, but is rightly included here for completeness. In addition, Chapter 7 contains an excellent section on the deactivation of hydrodesulfurization catalysts, one I wish could have been expanded into a case study similar to one in a later chapter. Unfortunately, the treatment of nonuniform distribution of catalysts is restricted to supported metals. There is a good review of single-pellet experiments and interpretations in Chapter 8, in which are pointed out both the shortfalls and the advantages of modeling based on this type of experiment. The regeneration of coked pellets, treated in Chapter 9, complements the treatment of Chapter 3 very well.

The final three chapters deal with what the authors term "global processes," on the scale of a reactor. In my opinion, the highlight of Chapter 10 is the discussion of numerical techniques for modeling deactivating reactors—a mundane subject which does not often get the attention it deserves. Chapter 11 deals with regenerating a coked reactor, which could be extended to detoxification of a poisoned reactor, and perhaps to redispersion of sintered catalyst in a reactor. The final chapter is an excellent case study involving the effect of different reactors and feedstocks on the rapid deactivation found with hydrocarbon cracking catalysts.

Both authors are accomplished wordsmiths, and form a good team because of their complementary research interests and backgrounds. The result is a book which is informative and comprehensive.

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