

cages; 3) supported metal catalysts prepared from clusters (but not necessarily retaining the cluster intact); and 4) supported bimetallic clusters. The third chapter noted above has numerous subsections authored by different researchers, for the reader interested in a smaller part of the overall topic. Each of these subsections provides a self-contained discussion complete with its own list of references.

Part III contains a heavy dose of the experimental results found in the literature. Again, it provides an excellent resource for researchers since it places at one's fingertips a huge body of work on a wide range of systems, almost all of it completed in the last ten years. While the cataloging of this information is exhaustive, it does not leave the reader with a clear overall picture of the current status and future foci of research involving metal clusters. This discussion is left to the last chapter by G. Ertl and to a brief summary contributed by the three editors.

The chapter by Ertl seeks to unveil the relations between metal clusters and metal surfaces, and it ought to be required reading for all students of metal catalysis whether they are involved with cluster-chemistry or not. The chapter begins with an historical perspective about how the two disciplines developed along separate lines, clusters being viewed from a localized bonding picture while metal surfaces were conceived as having delocalized valence electrons. Although it had been recognized that "band theory" for metal catalysts does not always account for the spatially localized effects of chemisorption on individual metal atoms, the analogies between chemisorption and organometallic bonds were not enthusiastically pursued until the development of instrumental techniques such as ultraviolet photoelectron spectroscopy.

This final chapter assesses the relationships between the structural, energetic, electronic and vibrational properties of metal clusters and chemisorption on metal surfaces. In many of these respects, metal clusters can serve as models for metal-adsorbate bonds and will continue to be important in the understanding of catalytic metal chemistry. There is, however, compelling evidence of limitations inherent to this analogy. This topic is discussed both in this final chapter and in the editors' summary.

The stability of metal-metal or metal-

organic bonds is quite different for metal clusters than for chemisorption on metal surfaces. Metal clusters enjoy substantially less coordination to other metal centers than metal atoms in a surface; the metal-metal bonds of a cluster often may break as readily as the metal-organic bonds, while the extended metal surface in a metal crystallite stabilizes the bonding between metal atoms in it. Reactivity of metal clusters is also quite different from metal surfaces. Achieving unsaturation at metal centers is required for catalytic reaction, but metal clusters often are unable to provide these sites without fragmentation of the cluster.

One main conclusion to be drawn about the appropriateness of this analogy is that in terms of structure and bonding properties, metal surfaces often superbly mimic the behavior of metal clusters; however, with respect to reactivity, the analogy tends to diminish. While this conclusion still insures that study of metal cluster systems remains a valuable tool in understanding metal surfaces, it does little to encourage prospects of discovering revolutionary new catalysts from metal clusters, at least in the near future.

The editors of this book have carefully and thoroughly compiled an excellent and exhaustive reference source of research on metal cluster structure and chemistry that covers the field from its infancy not much more than one decade ago to the present state of the art. While this task alone is quite formidable, the contributors have gone far beyond this point by also providing a good overall picture of the history, development, and future focus of the field of organometallic chemistry in catalysis.

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Catalyst Supports and Supported Catalysts: Theoretical and Applied Concepts

By Alvin B. Stiles, Butterworth Publishers, Stoneham, MA, 1987, 270 pp.

In addition to Professor Stiles, this book has eleven contributors, drawn from the United States and Europe, and who are credited with eight of the eleven chapters. The presence of these twelve people allows for the inclusion of interesting viewpoints and hitherto unpublished

data, both of which improve the book's usefulness. The chapters themselves are diverse and cover both specific supports as well as general subjects. Of course, in a book of this nature, every reader can come up with a list of topics the reader considers under- or unrepresented; my list would include metal-support interactions and the newer molecular sieve materials (ALPO, SAPO, etc.).

The book is written as "a reference for those interested in preparing supported catalysts." As such, a fair number of catalyst manufacturers are listed. However, the details of preparation of catalyst and support are sketchy in many cases, and there is often an inadequate citation of the literature to fill in these holes.

The early sections are historical, and include a very nice discussion of the effect of different preparative techniques on a particular catalyst, the zinc-containing methanol synthesis catalyst. This approach is continued in the first chapter, which describes various generic techniques of catalyst support and manufacture. The chapter on alumina contains a particularly good treatment of the industrial preparation and its effect on commercial properties of the support. The authors do well to include a treatment of rare earth oxide supports in the chapter dealing with metal oxysalts and oxides other than alumina; however, the treatment of titania contains no mention of anomalous adsorption, the so-called SMSI effect. The chapter on activated carbon contains a good discussion of catalytic action and structure, but is characterized by a total absence of references. The treatment of metal supports helps to fill a void in the literature, but reviews relatively little scientific information. However, it contains a good case study of the design of a catalyst potentially to replace a "conventional" methanation catalyst. There are two chapters dealing with the use of organic polymers as supports. Both are well-referenced. The first deals extensively with pore characterization, but is more concerned with the "hows" rather than the "whys." The second chapter is a good treatment of reactions with these supports. The chapter on molecular sieve catalysts concentrates on zeolites, and contains a good discussion of the effect of the reactor on the design of the support. The final chapter on multifunctioning catalysts provides good process descriptions, but may be somewhat lacking in technical material.

For some reason, the chapters dealing with a general treatment of catalyst supports are interspersed between chapters dealing with specific supports. The advantages of this approach are not quite clear to me. An interesting contribution discusses the interrelationships between granule strength, pore size, pore volume, and density, and ways of controlling these parameters; however, few quantitative details are given, and there are few references cited to help the reader in this regard. The chapter on spillover contains a good treatment of the behavior of different oxides with respect to this phenomenon. It also deals with SMSI as a subset of this phenomenon. In the concluding section of this chapter, partial oxidation is treated as an example of oxygen spillover: an interesting approach, which could stand further elaboration in the text.

The book suffers from a number of small annoyances to be expected in multi-contributor texts. References are inconsistent from chapter to chapter, there are minor inconsistencies in separate chapters, and often opportunities are lost in not cross-referencing material from one chapter to an earlier or later one. Nevertheless, Professor Stiles and his contributors are to be congratulated on attempting a book of this breadth and scope. To a significant extent, it may be said that they have succeeded.

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Filtration

By Michael J. Matterson and Clyde Orr,
Eds., Marcel Dekker, Inc., 1987, 760 pp.,
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other countries)

As a revision of an earlier publication first out in 1977 about various aspects of filtration; this present volume incorporates significant changes and additions. It follows a format used earlier, which is a compilation of a number of chapters written by experts dealing with various filtra-

tion topics. The editors selected the topics generically (for example, air filtration, liquid filtration, etc.) and according to the nature of the application (for example, filtration in the chemical industry, filtration in the mineral industry, etc.). While this format may be an easy way to meet the needs of practical filtration engineers and those interested in more fundamental aspects of filtration, subject coverage in certain instances becomes repetitive. For example, flow through porous media and the Carmen-Kozeny equation are considered in no fewer than six places, with slightly different notations used each time. While this approach may not be a serious flaw in itself, the result is annoying and may represent a waste of useful space.

Further, the chapter on liquid filtration is very sketchy and lacks depth. Theoretical discussions are limited to cake filtration; there is hardly any mention of deep-bed filtration. With cake filtration, the level of discussion has not gone beyond what appears in any introductory unit operation text (for example, see McCabe, Smith and Harriott, *Unit Operations of Chemical Engineering*, 4th Ed., McGraw-Hill).

The chapter on air filtration is also disappointing. It is heavily biased in favor of fibrous filtration with only a perfunctory discussion of fabric or granular filtration. This emphasis is understandable since earlier work in aerosol filtration originated from World War I gas-warfare experiences. The need in those early days was for developing fail-proof masks. This limited view, however, no longer corresponds to the present where fabric filtration (baghouse filters, for example) and, to a lesser degree, granular filtration are increasingly applied to industrial processes.

More important than the bias, though, is the fact that the chapter on air filtration suffers from certain omissions and factual errors. Since the work was purported to be extensively revised, one ex-

pects it to include a substantial amount of recent research results. A casual check indicates that of the four hundred references cited, fewer than thirty appeared in the literature after 1977. This imbalance is rather surprising if one considers the popularity of aerosol filtration during the past decade. In the area of collection efficiency resulting from diffusion in fibrous filtration there are omissions and errors. The author devotes considerable space to its discussion but nowhere mentions the work of Lee and Liu (*Aerosol Sci. & Technol.*, 1, 35, 147, 1982), which is now regarded as the definitive work on fibrous filtration at least in this country. Another example concerns the discussions of granular filtration (p. 103). True, a number of references were cited (*AIChE J.*, 19, 58, 1973; 20, 889, 900, 1974; *J. Colloid Interface Sci.*, 43, 350, 1973; 49, 320, 1974). But all these references deal with hydrosol filtration, not air filtration.

The two chapters on industrial air filtration and filtration in the chemical industry (which is concerned only with liquid filtration) are very good. Both chapters are well-balanced between theory and practice. They provide useful information in both areas. The latter chapter is particularly strong, so strong, that it makes Chapter V superfluous. The compilation and tabulation of the porosities and specific cake resistance of various systems studied so far (Tables 6, 7, 8, on pages 330-333, 338-339) should prove extremely useful to design engineers.

The remaining chapters provide useful data on current practices related to various aspects of filtration operation, including filter media, high-efficiency air filtration, analytical application, etc.

This volume is a useful reference on filtration, but not the invaluable work one is led to expect after reading the publisher's press release.

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