BOOK REVIEWS

Turbulence and Random Processes in Fluid Mechanics

By M. T. Landahl and E. Mollo-Christensen, Cambridge University Press, 154 + vi pp., 1986, $34.00 cloth.

This little book does not do justice to the subject of turbulence, but it is very different from other turbulence texts and deserves to be read. It evolved from a set of class notes for an introductory turbulence course given at MIT to graduate students from such diverse areas as engineering, applied math, oceanography, and physiology. It is not a comprehensive treatment but instead reflects the interests of the authors: MTL in waves and transition, and EMC (well known for his NCFMF film on "Flow Instabilities") in surface waves and sound. In a course or even with self study, it is necessary to supplement the text with a more substantial one such as Hinze, Tennekes & Lumley, or Davies, and also with the area's literature. Because the text is so short, maybe enough engineers will look at the figures in Chapter 8 to learn once and for all that the laminar sublayer is a fiction; for this alone the text is worth reading.

A list of the chapter titles gives an idea of the content: Chapter 1. Introduction with Historical Notes, Chapter 2. Characteristic Scales and Nondimensional Parameters, Chapter 3. Basic Equations, Chapter 4. Statistical Tools for Description of Turbulence, Chapter 5. Examples of Homogeneous Turbulent Flows, Chapter 6. Waves, Chapter 7. Instability and Transition to Turbulence, Chapter 8. Shear Flow Turbulence Structure, Chapter 9. Turbulence Modeling and Closure Schemes, Chapter 10. Aerodynamic Noise, and Chapter 11. Convective Transport. Included in the book are several concepts arising from geophysical fluid dynamics, e.g. density stratification, thermal convection, and gravity waves. Because the text is short, most topics are really just sketches done in an attractive and readable manner. In this respect one might think of the book as a child's guide to the subject of turbulence and transition to turbulence. Such topics as statistical closure theory and coherent structures, certainly central to any modern treatment of turbulence, are hardly developed in this introductory text.

The best feature of the book is the inclusion of or at least mention of a number of modern concepts that appear in the literature but not in most other introductory texts. These include solitons, bifurcation theory, and Runstadler streaks. The worst feature, aside from the light treatment of statistical theory and coherent structures, is the classification of turbulent boundary layers and fully developed channel flows as examples of homogeneous turbulent flows.

In summary, although the text cannot stand alone, its different point of view renders it a welcome addition to my bookshelf.

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Metal Clusters in Catalysis

By B. C. Gates, L. Guzci, and H. Knoezinger, Eds., ("Studies in Surface Science and Catalysis," **29**), Elsevier Science Publishers, 648 pp., $84.75.

This book provides an excellent and thorough review of the state of the art in molecular and supported metal cluster chemistry. Research in this area has expanded quite rapidly over the past decade, spurred on by advances in instrumentation and by the compelling analogy that can be drawn between adsorbate-metal crystallite systems and organometallic clusters. Indeed, the authors suggest that information gained from relating organometallic-cluster chemistry to metal-surface chemistry will contribute to a better fundamental understanding of the links between the areas of catalysis, organometallic chemistry, and surface science.

The book is divided into three parts. Part 1 concerns synthesis, structure and characterization, thermochemical properties and reactivity of metal clusters. The book is quite exhaustive in its review of the literature, from simple to complex systems. Excellent descriptive discussions provide the reader with not only a general understanding of these topics but also a thorough list of references for consultation. This part of the book is an excellent resource for anyone just entering this field of research since one is able to draw on the considerable experience of the work cited.

The last chapter of Part I deals specifically with particular metal clusters and the homogeneous catalytic processes in which they participate, presented by examples categorized by type of transition metal. While the fragility of the complex is always a concern, these studies are inspired by the hope that a metal cluster will be found with sites that can form products not normally found on catalytic metal surfaces.

The fragmentation of metal clusters under reaction conditions has encouraged the development of ways to stabilize the clusters. Part II of this book describes materials derived from metal clusters in or on supports including metal oxides, functionalized metal oxides, and polymeric materials. The section begins with an overview of experimental techniques useful in characterizing these cluster-support systems. The importance of this chapter can be appreciated when one pauses to realize that most of the instrumental methods discussed were unknown or were available only in a less sophisticated fashion as little as twenty years ago.

The application of these techniques to explore metal cluster chemistry highlights once more the analogy between metal clusters and adsorbate-metal systems. For example, much of the current understanding of carbon monoxide adsorption on metal crystallites as studied by vibrational spectroscopies draws directly on work done with metal carbonyl clusters.

Sectioned off as separate topics in Part II of this book are four distinct areas dealing with metal clusters and supports. These are: 1) metal clusters from vapor chemistry, which includes metal complexes with and without ligands studied using matrix isolation techniques as well as metal clusters evaporated onto supports; 2) metal clusters within zeolite

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 cataloguing 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.