BOOK REVIEWS

Bioreactor Design Fundamentals

By N. G. McDuffie, Butterworth-Heinemann, Stoneham, MA, 1991, 137 pp., $42.95

Several books on biochemical engineering topics have recently emerged. Among these McDuffie's text is unique in terms of the succinctness with which the broad topic of bioreactor design is presented. The goal of this monograph, according to the author, was to provide a unified coverage and condensation of applications of biological kinetics and thermodynamics related to biological reactor design. The need for such coverage evolved from the author's experience in teaching courses in bioengineering.

The material is divided into seven chapters. The introductory chapter gives a brief overview of models that are used for describing the kinetics in bioreactors. Chapter 2 gives an overview of thermodynamics and stoichiometry as foundation to discuss material and energy balances, and phase and reaction equilibria. Enzyme kinetics in the next section describes some fundamental rate laws, the classical enzyme inhibition models, and the effect of pH and temperature on the reaction rates. The section concludes with a brief excursion into the kinetics of polymer hydrolysis. After a brief chapter on fundamentals of mass transfer, the kinetics of cellular multiplication is illustrated. Typical growth phases of a cell culture are described. The Monod kinetics is explained, and yield coefficients are introduced to relate cell growth to substrate consumption and product formation. Some examples of how inhibitory effects can be treated are given before concluding with a classification of mixed cultures. The design equations for plug-flow and stirred-tank bioreactors are introduced in the chapter on enzyme reactors, which also shows how concepts of heterogeneous catalysis are applicable to immobilized enzyme systems. The book concludes with a chapter on cell culture bioreactors that illustrates the application of the developed rate equations in designing the basic reactor types. Concepts used for scaling up bioreactors are described at the end.

The presentation of the material is very clear and simplified to the backbone of essential concepts. Details are deliberately omitted, but helpful references can be found throughout the text so that interested readers can quickly find more comprehensive treatments of the presented topics. I found reading the book very enjoyable, as it gives a quick overview of the subject and impressively shows how much simplification can be afforded in presenting the topic without losing essential concepts. This is certainly a reflection of the author's extensive experience in teaching the material. The book should be useful as an introductory text for both biologists and engineers. It can show biologists that an engineering analysis of growth phenomena is not essentially complicated. And for chemical engineers it illustrates that bioreactors are just another type of reactors that can be approached with the common engineering tools.

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Crystal Growth from Melts: Applications to Growth of Groups 1 and 2 Crystals

By B. N. Roy, Wiley, New York, 1992, 322 pp.

This is not a book on the general aspects of melt crystallization; rather, it addresses the crystallization of specific classes of substances from melts of metal salts. The objectives of the book are "..... to present the major ideas and the important principles of high-temperature crystal growth."

The book attempts a general overview of phenomena important in crystallization and coverage of results specific to the crystallization of alkaline-earth metal salts from melts. The overview of general principles is too brief to be of significant value. On the other hand, the treatment of alkaline-earth metal salts is superb, and anyone interested in these substances would do well to have this book; coverage is complete and there is extensive documentation of the presented material. Below are my reasons for the disparate views of the two thrusts of the text.

Crystallization Phenomena. Chapters 1 through 8 address fundamentals of crystallization; in almost every instance, the coverage is skimpy and the order in which some material is presented is less than optimal. For example, not until an overview of crystallization methods is presented, is crystal growth divided into growth from the gas phase, from solutions, and from the molten state; earlier subdivision would seem more appropriate. The material in the early chapters is overly repetitive—for example, much of the introductory material from Chapter 1 is repeated in Chapter 2—and the sparse use of graphics makes following the descriptive material more difficult than it should be. For a book that focuses on experimental results, there are surprisingly few illustrations of apparatus, as is done with the schematic representation of a Czochralski crystal-pulling furnace.

Chapter 3 is an exception to the format of the first eight chapters: it provides an excellent compilation of solubility data for alkaline-earth salts. Even here, however, the descriptive material is overly sparse as fundamental thermodynamic relationships involving solute-solvent behavior are insufficiently illustrated. The section intended to accomplish that, "Thermochemical Calculations," is slightly less than one page in length.

Crystallization of Alkaline-Earth Metal Salts. Beginning with Chapter 9, the focus shifts to specifics associated with crystallization of alkaline-earth salts from different melts. It is with this material that the *raison d'être* for the book becomes apparent. Here and in subse-

quent chapters, experimental results and conclusions from experimental data are treated thoroughly. Special consideration is given to crystallization of alkaline-earth metal tungstates, molybdates, chromates, sulfates, and titanates from the following melts: lithium chloride, alkaline-earth metal chlorides, and sodium tungstate. Considered are variations of crystal size and structure (morphology) with the metal salt, the rate of cooling, and initial crystallization temperature. Differences in behavior of the various systems are highlighted.

Chapters 10, 11, 12 and 13 describe observations from the studies of the systems cited in the above paragraph, and chapter titles ("Crystallization at Constant Temperatures," "Crystallization by Continuous Cooling from Lithium Chloride Melts in alumina Crucibles," "Crystallization by Continuous Cooling from Sodium Tungstate Melts in Alumina Crucibles," and "Crystallization by Differential Thermal Analysis") identify the conditions of alkaline-earth crystallization. Each chapter presents experimental results showing how processing conditions affect crystal sizes, shapes, and nucleation and growth kinetics of the alkaline-earth materials.

The author concludes the book with a chapter that attempts to generalize reported experimental observations by developing and then applying mathematical models to describe kinetic parameters for the subject systems. The model allows determination of the energies, enthalpies, entropies, and free energies of activation for crystal growth, as well as a pre-exponential factor for use in Arrhenius expressions for crystal growth. Tabulations of these quantities determined from experimental data on various systems are an excellent feature of this chapter.

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Slurry Flow: Principles and Practice

By C. A. Shook and M. C. Roco, Butterworth-Heinemann, Stoneham, MA, 1991, 324 pp., $75.00

This book is a comprehensive monograph on slurry transport written by two leading researchers in the field. It is intended for use by plant engineers and designers dealing with slurry transport. The goal of the book is to enable the designer or plant engineer to derive the maximum benefit from a limited amount of test data and to generalize operating experience to new situations. Design procedures are described in detail and are accompanied by illustrative examples. The book is hardly a textbook or a handbook, but most chapters have aspects of both functions. Practitioners will find it a useful reference, while teachers will want to assign particular chapters as collateral reading for undergraduate and graduate courses in fluid mechanics and related areas.

The book consists of 11 chapters and five appendices. Chapters 1 to 3 cover the basic concepts of fluid, particle and slurry behavior. The discussions are well presented, and a wealth of references are provided. These chapters give the reader a good background on the underlying principles of fluid-particle systems. Chapter 4 provides a brief background in slurry rheology with emphasis on pipeline design for homogeneous slurries. Chapters 5 to 7 give a fairly complete account of the correlations and models available for predicting deposit velocities and frictional headlosses for nonhomogeneous slurries. The remaining chapters deal with wear mechanisms, pumping equipment, instrumentation, and operating aspects. Throughout the book, the authors guide the reader toward more comprehensive sources of information, and the reference list is excellent and up-to-date. The book is also infused with many practical examples which should enhance the reader's understanding of the material.

In summary, this is a book that provides a balanced overview of slurry flow. The contents of the book constitute a trove of information that will be relished by practitioners of slurry transport.

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Review: "Applied Biocatalysis: Volume 1"

Edited by H. W. Blanch and D. S. Clark, Marcel Dekker, Englewood Cliffs, NJ, 1991, 248 pp., $97.75 (U.S. and Canada)

In the last ten years, a series of exciting scientific and technical developments have revolutionized the use of biological catalysts for analytical and preparative purposes. Advances such as the ability to substitute specific residues in proteins with natural or unnatural amino acids, the application of enzymes in "exotic," that is, nonaqueous solvents and the discovery of new synthetic processes that benefit from the use of biocatalysts, have stimulated great commercial and scientific interest. The increasing importance of enzymatic biocatalysis is underlined by the proliferation of patents and research articles in the area. However, since enzyme technology is highly interdisciplinary, the relevant scientific literature is dispersed in more than a dozen journals in disciplines ranging from biochemical engineering to protein chemistry and applied microbiology. As a result, it has become increasingly difficult to keep abreast of new developments and research breakthroughs. The need for a comprehensive treatise that provides an in-depth overview of the status of biocatalysis has been apparent for many years. Finally, the series *Applied Biocatalysis*, whose first volume appeared in print recently, promises to fulfill this role.

The volume consists of five chapters written by internationally known experts. The rationale for the chapter selection is not immediately apparent, since the first two deal with general aspects of enzyme engineering in organic solvents whereas the remainder focus on synthetic applications. The first chapter by J. S. Dordick presents an overview of how enzymes perform in nearly anhydrous organic solvents and a survey of related applications. Written in a simple, easy-to-follow manner and with an extensive reference list, this chapter represents an excellent introduction to this increasingly important area. In the second chapter, Hwang and Arnold review the effect of water on enzyme function. Based on a thoughtful consideration of the factors that contribute to the protein folding in aqueous solutions, they propose a set of rules for guiding the engineering of enzymes, that is, the replacement of specific amino acids in the protein sequence, to achieve higher stability in organic solvents. Admittedly, this is a very difficult task given that there is no experimental information on the molecular mechanism of enzyme deactivation in organic solvents. However, the fact that the limited data on the effects of amino acid