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 cystallization. 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 substitutions support the authors' conclusions is both very important and encouraging for future studies. The third chapter by M. D. Bednarski is a compendium of the enzymatic reactions involving the formation of carbon-carbon bonds. It is likely to be useful for synthetic organic chemists, but unfortunately it does not provide any specifics on enzymology or on applied aspects such as rates of reaction, effects of solvents, and so on. In contrast, the contribution by K. G. Nillson is a well balanced review of the enzymatic synthesis of complex sugars. The author not only presents a comprehensive overview of the enzymatic reactions in sugar synthesis, he also provides a wealth of practical information. This chapter is accompanied by an extensive reference list and should be an excellent introduction to this increasingly important application of enzymatic catalysis. Finally, the last chapter by S. Riva discusses the biotransformation of steroids. Because of the low solubility of steroids, special emphasis is placed on processes carried out in aqueous-organic mixtures and in low water environments. This part complements the material discussed in the first two chapters.

In summary, judging from the first volume, the series *Applied Biocatalysis* is expected to be an important reference for anyone interested in enzyme technology. Several of the chapters can also be useful as reading material for advanced graduate students in biochemical engineering. Unfortunately at $99.50, the book is beyond the reach of most graduate students (and for that matter even senior investigators). One minor shortcoming is the heterogeneity in the style of the literature citations; for a book like this it is desirable to include the full titles of references as is done in the last two chapters.

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Affinity Membranes: Their Chemistry and Performance in Adsorptive Separation Processes

By Elias Klein, Wiley, New York, 152 pp., 1991

The monograph by Elias Klein on affinity membranes is an easy-to-read tutorial on the history and principles of affinity separations and membrane separations. It also presents compelling arguments of how the two may be combined to yield purification strategies which might have both high specificity and high productivity. The underlying thesis of this book is that the common tool of affinity chromatography is able to achieve biochemical separations with a high degree of purity but at a slow rate, whereas microporous membranes are able to process solutions at a relatively high rate but with relatively low selectivity. Although practical demonstration of the concept is limited to date, it is proposed that affinity membranes would offer many advantages for product recovery from gene-modified cell cultures and as membrane-bound enzyme reactors or therapeutic devices.

The book is divided into ten chapters. Chapter 1 is an introduction that covers the history of membrane separations and of affinity chromatography. The basic features and applications of each of these two subjects are discussed, and the goal of combining them to achieve large-scale biological separations with high specificity is introduced.

Chapter 2 describes the principles of affinity adsorption. An immobilized ligand is used to capture a ligate from solution to form a complex. The key to a successful separation is that the ligand must have a much higher affinity for the particular ligate molecule of interest than for other, perhaps similar, molecules that may be present in solution. Examples of affinity interactions cited include ionic forces, van der Waals attractions, and hydrogen bonding. Biological examples of ligand/ligate complexes with high affinity include an enzyme and its substrate, an antibody and its antigen, and a nucleic acid and its complementary strand.

Chapter 3 focuses on substrates, the support materials to which the ligands are bound. Common materials such as agarose, cellulose, and acrylics are described. The desired properties of these cross-linked hydrogels and polymers include the contradictory physical requirements of high porosity and sufficient mechanical strength to withstand compaction under pressure. Organic reactions used for preparing these substrates to covalently bind ligands to their pore surfaces are described in Chapter 4, whereas Chapter 5 discusses some of the more common ligands employed. Nonspecific ligands include ion-exchange resins which bind ligates of opposite charge. Group-specific ligands are those based on biological recognition parameters, but not targeted to a very specific sequence or conformation of the ligate. Examples of group-specific ligands include lectins, proteins A and G, and various coenzymes. Specific ligands, on the other hand, have a highly specific interaction with a given ligate, as characterized by a very small dissociation constant for the ligand-ligate complex. These include enzymes and their substrates or inhibitors and antibodies and their antigens.

Chapter 6 describes the concept of the capacity of affinity matrices such as used in elution chromatography. The capacity of an affinity matrix refers to the quantity of the target ligate that can be bound and later recovered. The capacity increases with the surface area of the porous matrix and with the number of active ligand sites per area. However, the increase is not necessarily proportional to these two quantities, as high surface areas may involve pores too small to be accessed by the ligand-ligate complex, and high active-site densities may also have steric constraints that prevent ligates from binding to adjacent sites. This chapter also describes frontal analysis or breakthrough curves which give the concentration of ligate leaving a sorbent bed as a function of the volume perfused when the column is continuously loaded with a fixed concentration of ligate. These calculations depend on knowledge of the diffusivity of the ligate within the porous support material and also on the kinetics of its interaction with the ligand sites.

The focus of the book then changes from concepts of affinity chromatography to a review of membranes and their applications. Chapter 7 describes the polymeric materials used in reverse osmosis, ultrafiltration, and microfiltration membranes, as well as common techniques for making these membranes. Chapter 8 then reviews various techniques for characterizing membranes. These include determination of macroscopic information such as flux and permeability, and microscopic information such as pore-size distributions. This is followed in Chapter 9 by a more detailed discussion of microfiltration, presumably because it has higher potential for affinity membrane applications