

was made to the extensive modeling and performance optimization studies of Lipis at the University of Missouri, Rolla. Lyophilizer components and related temperature, pressure, and process monitoring techniques are presented, as well as a case study for the lyophilization of a generic protein formulation. Yet, information or references concerning the critical issues of the selection of excipients and their impact on freeze drying conditions were scant.

Solid introductory and affinity chromatography chapters compose the balance of the book. The first chapter provides an overview of purification process considerations including typical facilities and equipment, current good manufacturing practices (cGMP), teams, process synthesis, and scaleup. The number of topics necessarily limits the discussion to a cursory level. I particularly appreciated a brief introduction of cGMP and the associated literature. Regulatory issues often delimit the design and operating parameter space available to the purification process development team; for a team to proceed in ignorance of cGMP will result in costly delays in bringing product to the market. Process synthesis is of major importance, but this book adds little beyond a recounting of the heuristics that Asenjo of the University of Reading has enunciated; this topic would have been much more effective if expanded into a summary chapter.

The chapter on affinity chromatography offers an extensive listing of available affinity resins and modes of operation. The discussion is slanted toward the materials of Pharmacia Corporation, even though it is a major player in the field. The myriad potential affinity ligands including dyes, immobilized metals, antibodies, receptors, lectins, and thiophilic interactions as well as a directory to the available immobilization chemistries are provided with numerous examples of the use of affinity chromatography at the bench scale. The available descriptions of process-scale applications are, however, few in number. This perhaps reflects the reluctance of the biotech industry to use unconventional separations techniques or to divulge details of the successful application of such techniques. The discussions of the economics of using often expensive affinity resins, the development of both elution and eluent removal strategies, and the consequences of ligand leaching were limited. However, the incredible referencing more than compensates for any slight these issues may have been dealt in this chapter.

This book, as the genesis of a handbook in many respects on bioseparations unit operations provides a centralized resource for introductory material and a guide to the literature for all of the major unit operations of protein purification. As such, *Protein Purification Process Engineering* should be an important reference for those involved with protein purification process development. The book is touted as being useful for "... all upper-level undergraduate, graduate, and continuing-education courses in biochemical engineering, bioseparations, and biochemical separations," in addition to industrial practitioners. I suspect that this book will not gather any dust on the library shelf.

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Biotreatment of Industrial and Hazardous Waste

Edited by Morris A. Levin and Michael A. Gealt, McGraw-Hill, New York, 1993, 331 pp.

This is yet another volume edited for a comprehensive overview of this high-profile subject area, but leaves chemical engineers anxious about the lack of useful technical details. At bare minimum, process analysis or design requires information on product characterization, stoichiometry, and kinetics. This book has none of this, and unfortunately that is keeping within the norm for literature in this field.

The editors intend the book to approach biodegradation of hazardous wastes in a holistic fashion. Issues of science, engineering and regulation are all addressed. Chapter authorship or titles do not reveal a clear indication of the balance among these issues, but they are not presented evenly. Chapters 2 and 3 deal with the microbiology of biodegradative activities as effected by augmentation of nutrient concentrations, molecular oxygen, redox potential, or moisture, or genetic manipulation. These chapters are rich in scientific content, but are not very well illustrated. Chapter 2 contains not a single table or figure, and the figures of Chapter 3 do not add much to the written communication.

Chapters 4 and 5 address engineering aspects of bioremediation. Chapter 4 is an encyclopedic treatment of bioreactor

configurations and design relationships. Analysis of bioreactor performance is restricted to conventional wastewater applications and therefore is limited in its applicability to the subject of bioremediation. Chapter 5 strives to present conceptual foundations for modeling biodegradation of hazardous organic compounds by classifying microbial substrates as primary or secondary, and as electron donor or acceptor. The hazardous compound targeted for degradation may be any of these. Unfortunately, the quantitative aspects of the models are incomplete or unnecessarily complicated, and the utility of this framework is never illustrated by modeling actual data. Unsteady mass balances of perfectly mixed bioreactors are presented with no application in mind. Rate equations for electron acceptor and donor lack stoichiometric coefficients. Real biodegradation systems will contain multiple compounds, and each one may have multiple roles (electron acceptors, donors).

Chapter 6 presents the federal statutes and regulations which apply to the use of bioremediation. The chapter stands alone, and its relevance to the subjects covered in other chapters of the book is not described.

Chapter 7 describes experiences with *in-situ* bioremediation. Conditions which favor or disfavor this method of site renovation are described. Engineering aspects, such as oxygen or nutrient delivery, are illustrated through specific examples of petrochemical remediation. These examples and the 15 case studies summarized in tabular form provide the best backdrop for thinking about engineering details as can be found anywhere in the book.

Four of the remaining six chapters are further illustrations or examples of practices previously described. Chapter 8 on the use of altered microorganisms adds little new information to what has already been described in Chapter 3 and should have been incorporated into the previous chapter. Chapter 9 on the biotreatment of phthalate-laden soils near the site of a train derailment is a very interesting tale about a specific bioremediation success story wherein the effects of background environmental variables had to be carefully assessed to find the optimum remediation strategy. Chapter 10 deals with the anaerobic bioremediation of the nitroaromatic herbicide Dinoseb (2-sec-butyl-4,6-dinitrophenol). Biocatalytic pathways for degrading these compounds are reviewed, and bench- and pilot-scale data presented on the kinetics of degradation by anaerobic incuba-

tions of contaminated soils pretreated to encourage microbial enrichment. Chapter 11 on the biological treatment of industrial and hazardous wastes goes over much of the same material covered by Chapter 4. The lack of relevant data in Chapter 4 is rectified here, but much descriptive redundancy could have been avoided if these two chapters had been combined. Chapter 12 deals with the actual application of bioaugmentation to clean up the Exxon Valdez Oil Spill. The design strategies, data and regulatory concerns described here are inter-

esting, but the effectiveness of both Chapter 2 and this chapter could have been improved, had there been some integration and cross-referencing between the two chapters.

Chapter 13 on future directions contains a few additional items about the microbiology and regulatory aspects of bioremediation, but ignores the engineering aspects which are in such great need of attention to make this technology more widely usable and economical.

The readership for this book is hard

to define. The specialist will know more than is presented in any single area; however, the novice trying to get an introduction to bioremediation will be frustrated by unevenness of details presented in the individual chapters.

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