than do reverse osmosis or ultrafiltration (although this is not made clear). A review of theories for both deadend and cross-flow microfiltration is presented.

The final chapter describes possible applications and advantages of affinity microfiltration membranes. The chapter primarily is a comparison of chromatographic and membrane separations. In affinity chromatography, which is commonly used for separations of biologicals, the typical process is to perform a batch adsorption process by perfusing a ligate-containing solvent through a cylindrical column packed with ligand-containing beads, until saturation occurs. This is followed by an elution step in which the solvent conditions are changed so that the ligate desorbs from the absorbents. Although the purification achieved by affinity chromatography may be very high, it is argued that the capacity is low and the processing rate is slow. Order-of-magnitude estimates are given to indicate that the slow step is the diffusion of ligate molecules into and out of the porous adsorbent beads. The primary hypothesis of Chapter 10 is that affinity membranes have much shorter diffusion paths than do chromatography beads (on the order of 1 μm instead of 100 μm). This is because the solvent is forced to flow through the membrane pores, so that the ligate is convected to within a pore radius of the active sites. Thus, it is proposed that affinity membranes would not be limited by a slow diffusion step. Recent studies on perfusion chromatography have shown that beads having some relatively large through-pores can also experience significant internal convective flow through them as a result of the imposed pressure drop, which reduces the diffusional transport limitations of conventional chromatography, but these studies are not mentioned in the book. By extrapolating previous experimental studies using affinity chromatography or conventional membranes, the chapter concludes with the proposal that cross-flow microfiltration with ligand-containing membranes may yield both high purification and high processing rates for applications such as the recovery of enzymes from fermentation broths or cell lysates.

The book does not include homework problems or even worked example problems, and so would be of limited use as a textbook. It better serves the role of an introductory monograph of both affinity chromatography and membrane separations. It is disappointing that no data or actual demonstration of affinity membrane systems are presented. Even the limited work on affinity membranes mentioned in the introduction chapter is not elaborated on in subsequent chapters. Thus, the reader is left with a sense that this is a book written before its time. I look forward to reading a sequel in a few years, when the conjecture is hopefully replaced by laboratory demonstrations and practical applications of affinity membrane systems.

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Active Carbon

By H. Jankowska, A. Swiatkowski, and J. Choma, Ellis Horwood, West Sussex, England, and Prentice-Hall, Englewood Cliffs, NJ, 1991, 280 pp.

The term "active carbon" appeared in the old literature and is still seen occasionally in European literature. Since the term "activated carbon" is more common and is the only term used in the U.S., it will be used in this review.

The book was first published in Polish in 1985 by the three authors, all of whom were from the Military Technical Academy in Warsaw. The English translation was published in 1991. Through no fault of the authors, it is already outdated in many places.

The activated carbon used today had a noble origin—it was developed as a sorbent during World War I for the protection of human lives against chemical agents. It remains the most useful sorbent, due to its large surface area (around 1,000 m^2/g) and hydrophobicity. Because adsorption is the main application for activated carbon, it is also the main subject of the book. The book contains ten chapters (in my abbreviated terms): (1) Introduction, (2) How to Make Activated Carbon, (3) Structure and Surface Chemistry, (4) Adsorption Isotherms, (5) Micropore Filling Theories, (6) Heat of Adsorption, (7) Adsorption from Liquid Solution, (8) How to Measure Adsorption and Pore Structure, (9) Applications, and (10) Regeneration.

The literature discussed in the book is heavily drawn, understandably, from the Russian and Polish literature. Chapter 2 addresses the principles and processes for making activated carbon. It is a good chapter; however, the vast amount of U.S. patent literature is hardly mentioned. Chapter 5 gives an excellent account of the potential theory of micropore filling. Two of the authors of the book are accomplished researchers on this subject. Because of the microporosity and nonuniform pore-size distribution of activated carbon, the potential theory is particularly useful for this sorbent. Chapter 9 contains an authoritative discussion on the impregnated carbon that is used for the retention of chemical agents in chemical warfare. The carbon is impregnated with metal oxides which react with the different agents to form harmless gaseous products. The complex chemical reactions involved are effectively summarized. Most of the other chapters, however, are inviting criticism because of their obvious weaknesses. For example, adsorption from binary solutions is discussed in two places (in Chapters 3 and 7). Yet, the important theories and models for predicting mixture adsorption from pure-component isotherms, from both gas and liquid phases, are missed. Hysteresis is an important phenomenon occurring in activated carbon, but is overlooked. Molecular sieve carbon, a relatively new and useful form of activated carbon, is also overlooked. The main portion of Chapter 8 describes old experimental techniques for measuring adsorption and pore structure, employing glass vacuum manostats with McLeod gauges. It is quite outdated: in fact, it resembles a similar chapter in Young and Crowell's 1962 book on adsorption. The weaknesses mentioned above are partly attributable to the author's very limited access to the Western literature in 1985, the time the book was written.

Despite the weaknesses, the book does contain a wealth of information and should be a useful reference for scientists and engineers who deal with activated carbon and adsorption.

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