Book Reviews

Aqueous Two-Phase Partitioning. Physical Chemistry and Bioanalytical Applications; Edited by Boris Y. Zaslavsky, Marcel Dekker, Inc.; New York, 1994; xiii + 696 pp. $ 195.00. ISBN 0 8247 9461 3.

In a word, this book is exhaustive. The author uses data from his laboratory and that of others to thoroughly treat the topics of water structure, phase separation, and several bioanalytical applications of aqueous two-phase systems. Little is devoted to the use of aqueous two-phase systems as a biomolecule separation tool at the preparative or industrial levels; other references cover this well [1–3]. The price of the book, which merits due consideration, appears to reflect the focused coverage of aqueous two-phase partitioning.

The first third of the book begins with a discussion of the structural dynamics of liquid water. More than thirty pages of theoretical and experimental evidence presented in the first chapter are basically summarized with the following statement: 'Essentially all the experimental information reported in the enormous literature on the subject implies that the presence of an additive in water alters the solvent properties of the aqueous medium in the solution relatively to those in pure water'. The second chapter considers how aqueous solutions of macromolecules can be treated as two-phase systems. Water being a highly ordered solvent has its structure easily perturbed by this class of solute. Therefore, the chemistry of non-ideal solutions of polymer solutes is described in terms of 'vicinal water', those aqueous solvent molecules found near interfaces, and 'bulk water', the remaining water molecules with significantly different physical properties. Chapter 3 suggests a mechanism for phase separation in aqueous solutions of polymers where the peculiar solvent properties of water play an important part in achieving the critical point of aqueous two-phase systems. It is proposed that discontinuities in the structure of water formed around dissimilar polymers generate turbidity that is followed by phase separation.

Chapters 4 and 5 comprise the second part of the book. Data are presented suggesting that solvent characteristics are germane to partitioning in aqueous two-phase systems. The physical properties of both phases differ in several respects. These differences are smaller than those found in organic-water two-phase systems, but large enough to present solute molecules with two significantly different environments. Therefore, it is proposed that the asymmetric partitioning of solutes in aqueous two-phase systems is the result of differences between the interactions of the solute and solvent in each phase, and, if present, interactions between the solute and the phase-forming polymers.

The final part of the book consists of four tightly coupled chapters describing the attributes of aqueous two-phase partitioning that make it a unique bioanalytical tool. Although it is stated that aqueous two-phase systems have thus far been used 'solely as a separation method on the laboratory and industrial scales', analytical applications of the technique exist in the literature. For example, the measurement of protein interactions has been quantified with aqueous two-phase partitioning [4,5]. The author also suggests other bioanalytical applications that exploit the advantages of aqueous two-phase partitioning. These include quantifying biomolecule hydrophobicity and the relative measurement of biomolecule identity and purity. One of the most exciting applications presented in this section is the study of the organization of biological systems; an example being the intricate environment of cellular cytoplasm. Whether the concentrated solution of ions, metabolites, macromolecules, and organelles that comprise the cytoplasm induces phase separation in living cells is still being debated [6]. Nevertheless, aqueous two-phase systems better approximate the significant fraction of intracellular chemistry occurring at macromolecular interfaces than do models based on the chemistry of dilute and nearly ideal solutions.

In this largely analytical treatise, technical aspects play a major role. Of the abundant illustrations and figures, several of those reprinted from previous work would have benefited from an update. For example, the reprinted hand-drawn two-dimensional schematic illustration of the structure of liquid water (Fig. 1.1) is informative, but a three-dimensional stereogram of the same structure, which could be generated with modern graphics software, would have made an even greater impact. Notwithstanding, the compendium of 163 phase diagrams forms an impressive section of the book and is the largest collection of these data since the publication of Albertsson's book on the subject [1]. Many of the phase diagrams come from the author's laboratory. Each diagram is complemented with essential data including the properties of each phase-forming component, a numerical tabulation of phase compositions, and a parameter called the tie-line slope or STL. The STL is used both as a check on the reliability of a phase diagram and as a physical characteristic of a two-phase system that is affected by polymer molecular weight, salt concentration, and temperature.

The editorial aspects of the book detract somewhat from its technical strengths. I found the repetition of a section heading and half a paragraph on two separate pages quite confusing (pgs. 49–50). Furthermore, sentences similar to the following are dispersed throughout the text (pg. 65): 'It follows from the essentially all the aforementioned experimental data that the aqueous solution of a polymer additive may be viewed as a particular solvent of the aqueous nature.' One also finds a reference to an obscure chemist named 'Van der Walls' (pg. 294).

Although the modern application of aqueous two-phase partitioning of biomolecules is nearly four decades old, the author considers it to still be in its infancy (pg. 497). A lack of understanding of the fundamental principles underlying the partitioning process is the most likely reason that the technique is not yet considered to be a 'mature' biomolecule separation tool; it remains highly empirical. Dissecting the mechanisms of the partitioning process appears to be as daunting a task as predicting protein secondary structure from amino acid sequence data. The author enthusiastically justifies the research effort that will be required to further develop the technique as both an industrial-scale biomolecule separation process and a laboratory-scale bioanalytical tool. When viewed from this perspective, the book offers an unusual foray into the promising realm of aqueous two-phase partitioning.

References

[1] Albertsson, P.A. (1986) Partition of cell particles and macromolecules, Wiley, New York.
[2] Walter, H., Brooks, D.E. and Fisher, D., Eds. (1985) Partitioning in aqueous two-phase systems. Theory, methods, uses, and applications to biotechnology, Academic Press, San Diego.
[3] Walter, H., Johansson, G. and Brooks, D.E. (1991) Analyt. Biochem. 197, 1–18.
[4] Westrin, H. and Backman, L. (1983) Eur. J. Biochem. 136, 407–411.
[5] Berglund, A., Backman, L. and Shanbhag, V.P. (1984) FEBS Lett. 172, 109–113.
[6] Walter, H. and Brooks, D.E. (1995) FEBS Lett. 361, 135–139.

Kenneth A. Giuliano

Information about books for review in FEBS Letters should be sent to: Professor J.E. Celis, Department of Medical Biochemistry. Ole Worms Allé, Building 170, University Park, Aarhus University, DK-8000 Aarhus, Denmark.

SSDI 0014-5793(95)00485-8