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ChE book reviews

TRANSPORT PHENOMENA IN LIQUID EXTRACTION

By G. S. Laddha and T. E. Degaleesan
McGraw-Hill, 1978, 485 pages

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From the title, one might expect this book to be confined to the study of theoretical and experimental developments in the field of transport phenomena. While this is the authors' main emphasis, they also give an overview of other important facets of the practice of liquid extraction. The general orientation is very similar to the well known book by Treybal (1963)*, and it seems appropriate to use Treybal's work as a frame of reference for this review.

Laddha and Degaleesan begin with a brief discussion of common industrial applications of liquid extraction, followed by chapters devoted to the fundamentals: phase-equilibrium thermodynamics, theories of diffusion and interphase mass transport, and calculational methods for stagewise extraction and countercurrent differential extraction. The material follows a logical sequence, and practicing engineers will be comfortable with the format, which emphasizes conventional graphical methods, overall NTU's and HTU's, etc. Treybal, however, covers much of the same material in more depth. Also, Laddha and Degaleesan fail to cite the more recent theories for the prediction of liquid-liquid equilibria, and they do not discuss the use of modern calculational methods for extractor design and simulation. There is an incorrect statement, repeated in several places, that the distribution coefficient is given by *slope* of the distribution curve, which is not true in general.

The next two chapters deal with the behavior of single drops and multiple interacting drops dispersed in a continuous phase, with an emphasis on the fluid dynamics and mass transfer characteristics of such systems. There is also a qualitative discussion of the important Marangoni effects. The material is presented in a unified form, whereas in Treybal it is much more scattered.

The next major section of the book begins with a description of the different types of extraction devices used in practice and gives a brief summary of the factors that might influence the selection of a device for a specific application. Following this, six common types of contactors: spray, packed, perforated-plate, rotary-agitated, and pulse-agitated columns, and mixer-setter extractors, are treated in individual chapters. Each chapter contains performance correlations and design criteria that can be used for the given contactor. These chapters comprise about one half of the book, and are perhaps its best feature.

The final chapter reviews the special problems that arise when extraction is accompanied by

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**Liquid Extraction*, by R. E. Treybal, McGraw-Hill, 1963.

CHEMICAL PROCESS SYNTHESIS

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composition of the total flowsheet generation problem leads to the identification of many of the synthesis subproblems mentioned before such as heat integration, separations sequencing, etc. in which much progress has been made. The decomposition principle might also be applied recursively to the solution of each of these subproblems. A special case arises if the decomposition is done in such a manner that at least one of the resulting subproblems is recognized immediately as solvable by some available technology. If this process is repeatedly and successfully applied until no unsolved subproblem remains, the result is equivalent to the systematic specification of a finite sequence of technologies which together form a feasible design for the original processing problem.

The heat integration synthesis problem described previously is amenable to such a decomposition strategy. At each stage, a stream to be heated and another to be cooled (either two process streams or a process stream and a utility) for which required tasks remain are selected and, if thermodynamic or other constraints are met, simultaneously solved with immediately recognizable technology (an exchanger, furnace, etc.). Should this heat exchange match fail to perform the required task completely for a process stream (reach the desired final temperature or phase state), the remaining task, or 'residual', is simply included among the other as yet unsolved process heat transfer tasks for consideration in successive stages. With appropriate available utilities, this systematic generation scheme will produce a feasible design in a finite number of steps. Different designs result from alternative streams or possible portions of streams selected for each match and from how strictly the various task specifications and other constraints are met. The number of such designs for heat integration among M streams is on the order of $((M/2)!)^2$.

Specification of separation sequences for multicomponent mixtures is another synthesis subproblem for which systematic generation approaches have been proposed. The problem arises in reactor feed preparation, product purification, by-product recovery, waste treatment and other situations where the tasks of increasing concentration or component isolation are specified. In a simplified form, a mixture is to be separated into each of its components using a sequence of technologies which sharply split a single multicomponent feed stream into two outlet streams, one containing some subset of the feed components and the other containing the remaining components. Differences in various physical properties of the components such as volatility or solubility are exploited by various technologies to effect the desired separations. If S different separation technologies are available (such as simple, azeotropic and extractive distillation, extraction, fractional crystallization, etc.), the number of different design sequences for the complete separation of an N-component mixture is on the order of $S^{N-1}(2N-2)!/(N!(N-1)!)$. □

*EDITOR'S NOTE*s *The concluding section of Dr. Siirola's lecture will be published in the next issue of* CEE *(Summer, 1982).*

REVIEW: TRANSPORT PHENOMENA

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chemical reaction. This subject is only given a very brief treatment by Treybal. The theoretical discussion in the present work draws heavily from results obtained in studies of chemical absorption. Although there are a few data for liquid-liquid systems, there should be more. The presentation generally falls short of the state-of-the-art in this area.

Topics covered by Treybal but not discussed in the present work include calculational methods for multicomponent extraction, methods for laboratory and small-scale extractions, economics of extraction processes, and the competing factors involved in the selection of a solvent. In general, Treybal's book has the same theoretical basis, but a more practical, process-oriented flavor than the present work.

The subject material is probably too specialized for the book to find much use in the undergraduate chemical engineering curriculum. It seems better suited as a reference for students and industrial practitioners with a special interest in liquid extraction. It would have been more valuable in this regard had the authors included more references to the recent literature. Only 2% are from the period 1971-1978, with the most recent of these being from 1974.

A final minor criticism: the printing quality in the review copy was noticeably inferior to that found in most technical books printed in the U.S. The type was uneven and generally too light, and pages were often slanted from the verticle. □