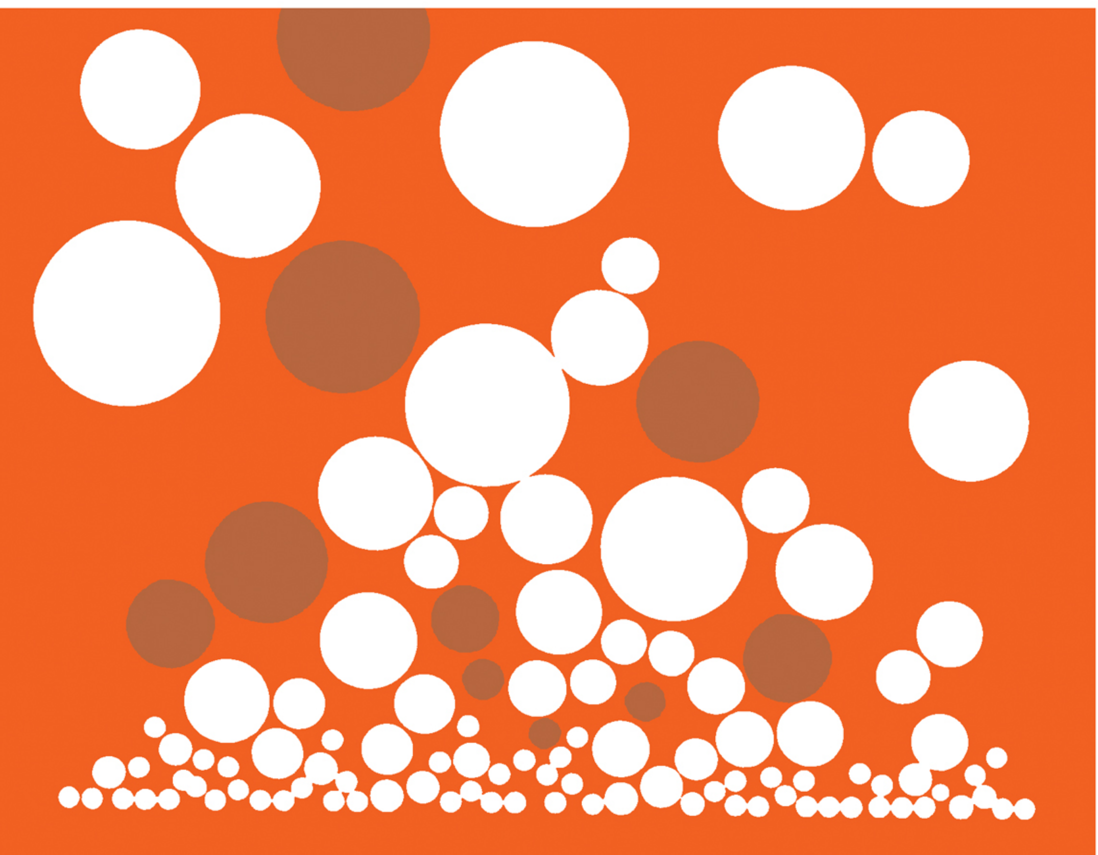
adsorptive bubble separation techniques

EDITED BY **ROBERT LEMLICH**



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Edited by **Robert Lemlich**
Department of Chemical
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Preface

This is the first comprehensive book to cover the various adsorptive bubble separation techniques. It is a contributed volume, with various authors for its twenty chapters.

The editor is responsible for defining the scope of the work, and in general for selecting the topic for each chapter. The authors of the chapters were also selected by the editor and invited to write on the basis of their specialized knowledge in their respective areas. However, each author was given wide latitude to treat his material as he saw fit. The overall result is a highly authoritative compilation which, it is hoped, will prove to be both informative and readable.

Chapter 1 introduces the various adsorptive bubble separation techniques. Chapter 2 deals with certain pertinent properties of foam which are common to many of them. Then, Chapters 3 through 8 individually discuss several of these techniques; namely, foam fractionation, ion flotation, precipitate flotation, mineral flotation, bubble fractionation, and solvent sublation. The remaining chapters, 9 through 20, summarize the results of numerous separations, as well as the results of additional investigations into the mechanisms of the various techniques. As a special feature of interest, the final six chapters (arranged in alphabetical order by country) comprise a summary of work, dealing principally with the separation of surfactants and metallic ions, at several places around the world.

The editor expresses his thanks to the contributors and to the staff of Academic Press for making this volume possible.

ROBERT LEMLICH

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V. V. Pushkarev

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CHAPTER 1 INTRODUCTION

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I. OVERVIEW

All techniques or methods of separation, whether physical or chemical, are based on differences in properties. For example, among the more familiar techniques, distillation is based on differences in volatility, and liquid extraction is based on differences in solubility.

The *adsorptive bubble separation* techniques are among the less familiar methods. This generic name was first proposed by Lemlich (1966), with *adsubble* techniques as the convenient contraction. The full generic name has since been accepted by common consent (Karger *et al.*, 1967).

The adsubble techniques are based on differences in surface activity. Material, which may be molecular, colloidal, or macroparticulate in size, is selectively adsorbed or attached at the surfaces of bubbles rising through the liquid, and is thereby concentrated or separated. A substance which is not surface active itself can often be made effectively surface active through union with or adherence to a surface active *collector*. The substance so removed is termed the *colligend* (Sebba, 1962).

Adsubble processes can be found in nature: in sea foam and bubbling marshes. Among human endeavors, the earliest occurrence is probably among the culinary arts in such phenomena as the slightly bubble-aided floating of some constituents in certain boiling soups and other preparations. Another early example is in the pouring of beer. Certain components of the beer can concentrate in the foam to a sufficient degree to alter the flavor (Nissen and Estes, 1940).

In 1878 Gibbs derived the celebrated adsorption equation that bears his name (Gibbs, republished 1928). About the turn of the century, attempts were