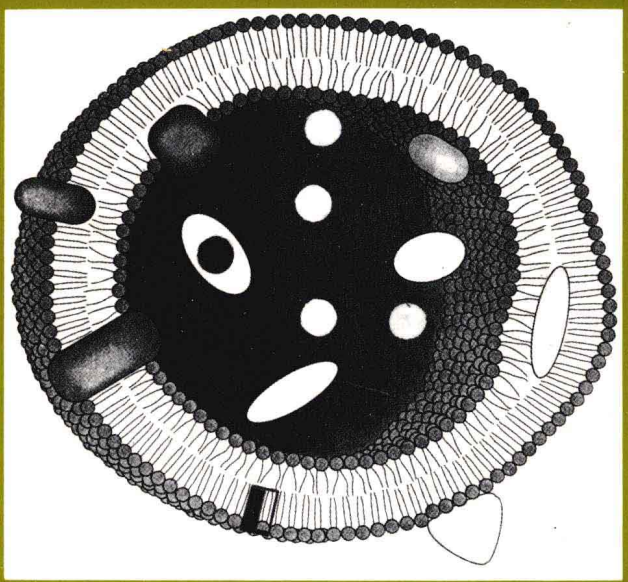
surfactant science series

volume 62

VESICLES



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VESICLES

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Marcel Dekker, Inc. New York • Basel • Hong Kong

Library of Congress Cataloging-in-Publication Data

Vesicles / edited by Morton Rosoff.
p. cm. — (Surfactant science series; v. 62)
Includes index.
ISBN 0-8247-9603-9 (hardcover: alk. paper)
1. Liposomes. 2. Surface chemistry. I. Rosoff, Morton. II. Series
RS201.L55V47 1996
574.87'4—dc20 96-15201
CIP

Marcel Dekker, Inc.
270 Madison Avenue, New York, New York 10016

Current printing (last digit):

10 9 8 7 6 5 4 3 2 1

PRINTED IN THE UNITED STATES OF AMERICA

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Preface

The Pythagorean view of the formation of the universe from the commingling of the elements—earth, air, fire, and water—notably omits oil. Oil and water are the Yin and Yang—in molecular terms, the spatial separation of dichotomous groups or segments, hydrophilic and oleophilic—underlying the formation of multitudes of organized assemblies or microphases.

Monolayers, multilayers, micelles, microemulsions, bilayers, and vesicles are an important set of interrelated states of matter. In particular, two-dimensional closed membranes or liposomes, consisting of a bilayer(s) of phospholipid molecules surrounding an aqueous core(s), form a reservoir for encapsulation and a diffusion barrier. Vesicles exhibit many basic and applied phenomena, serve as a model for the fundamental unit of biological structure—the cell membrane—and are uniquely suited to bridge the biological and materials sciences. From an academic viewpoint, they are represented at the growing tips of such active topics as self-assembly, self-organization, and complexity.

Reviews can serve a variety of functions, not the least of which is providing literature references sufficient to outline the development of a subject as well as its most recent results. For newcomers who need to learn more about a field, reviews fulfill a high form of education not available in formal courses. For the experienced researcher there is the stimulation of critical surveys and fresh ideas. Finally, for the authors, expository writing about a research area is a genuine form of scientific activity (recall that Mendeleev discovered the periodic table while planning an elementary chemistry textbook).

With the widening applications of vesicles and investigations to characterize the systems themselves, a multiauthored comprehensive review would be encyclopedic. Rather, this volume presents selected topics as signposts indicating the

scope and direction of vesicle research. According to the "80/20" rule of the Pareto principle, named after the nineteenth-century Italian economist Vilfredo Pareto, 80% of the value of a group of items is generally concentrated in only 20% of the items. Hence, the average reader will probably be interested in only 20% of the topics. Nevertheless, it is hoped that a synthesis of ideas drawn from different (but related) subjects will create new and fruitful general conceptions. Often overlooked is the serendipitous breakthrough of a given idea when transplanted to another context. Undoubtedly, scattered among the diverse chapters lie solutions in search of problems.

The book is divided into four sections covering some main topics in vesicle research: physical and surface chemistry; methods; drug delivery; and diverse applications.

I thank the contributors for making this book possible and hope that it will be opened with expectation and closed with profit.

Morton Rosoff

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Contents

I
Physical and Surface Chemistry

The papers in this section represent some of the research being devoted to basic vesicular properties.

Studies of lipid monolayers considered as half a vesicle bilayer provide insight into the structure and dynamics of vesicles unobtainable through other techniques. By reducing the dimensionality of the system, monolayer studies allow for simplification of complex thermodynamics. The first chapter deals with the relationship between lipid bilayers in the form of vesicles and monolayers at the air-water interface.

In Chapter 2, a wide survey of liposomal topics is presented ranging from the use of molecular acoustics for studying the mechanical properties of liposomes and protein-lipid interactions to vesicle fusion, photochemistry, and energy transfer.

The next paper, Chapter 3, describes the correlation between the phase behavior of vesicles and microemulsions. The importance of the HLB of the surfactant for the formation of reverse vesicles is discussed and the methods for preparing reverse vesicles by dispersion or spontaneous transition are described.

Chapter 4 reviews the phenomenon of phase separation in bilayers. The formation of lipid and protein domains and its consequences, particularly for biology, are examined from the viewpoints of thermodynamics and kinetics.

Interaction of surfactants or amphiphiles with vesicles is important for the solubilization of bilayer membranes as well as their preparation. Additionally, surfactant vesicle interaction serves as a model for the stability of vesicles in the presence of foreign molecules. These matters and the effect of surfactants in the sublytic concentration range are taken up in Chapter 5.

The next contribution, Chapter 6, treats the statistical mechanics of membrane conformational fluctuations. Both fluid and polymerized vesicles are discussed. Shape instabilities may play a role in biological processes such as endocytosis and cell recognition.

1

The Relationship and Interactions Between Lipid Bilayers Vesicles and Lipid Monolayers at the Air/Water Interface

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I. INTRODUCTION

There are several reasons for inquiring into the relationship between lipid bilayers in the form of vesicles and monolayers at macroscopic interfaces, particularly at the air/water interface.* Historically, the most important and perhaps still foremost reason is that monolayers at the air/water interface allow measurements of interaction of membrane-active molecules with an array of lipids that approximates a bilayer membrane in ways that are either not possible or are very difficult with the bilayer itself. The most common such measurement is penetration by the foreign molecule of the monolayer, the extent of which is easily monitored either as an increase in surface pressure of the monolayer at constant area or an increase in area of the monolayer at constant surface pressure. These measurements can be used to

*Although a bilayer is obviously composed of two monolayers, the latter term, unless specified otherwise, implies a monolayer of lipid at the air/water interface.