DETERGENCY

THEORY AND TEST METHODS

(in two parts)

PART I

edited by W. G. CUTLER and R. C. DAVIS

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PREFACE

The detergent process is very widely used today. Despite its acceptance and wide usage, it is a process not completely defined and understood. There is no general agreement as to test methods for measuring the effectiveness of the detergent process. The present book is intended to provide both industrial and academic research workers with a compilation of test methods in use today and background information as to the theoretical basis of these tests. Perhaps such a volume will stimulate new interest in further investigation in the field of detergency.

The timing of this book is considered appropriate when viewed in the light of changes in detergent formulations that appear inevitable at this point in time. The entire concept of detergency and the relation of detergents to our environment are being scrutinized in many laboratories now.

The author list has been chosen to provide representatives from detergent producers, those specialized in applications of detergents, and universities. There has been no attempt to conform to a group presentation or render a group opinion. Each author has been left free, within the constraint of a general outline, to present and interpret data from his viewpoint and experience.

For the convenience of the reader and to expedite publication schedules, this volume of the Surfactant Science Series is being presented in two parts. Part I treats the fundamentals of the soil removal process and methods for its evaluation. Part II consists of topics related to a more complete understanding of the detergency process, particularly treating several topics of current interest. The indexes to the entire volume appear at the end of Part II. These indexes permit the reader to examine contributions to the theory of detergency in the scientific literature and serve to identify those researchers who have made contributions to this theory.

A number of people have contributed to this book. The editors wish to thank the contributing authors and their Companies. The support of the Whirlpool Corporation in permitting the editors to undertake the task of compiling this volume is also acknowledged. Special thanks are also due to Dr. Martin Schick for his many suggestions and for critical review of the book outline; to Richard Matthias, Whirlpool's electron microscopist,

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Chapter 1

INTRODUCTION

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I. DETERGENT PROCESS: DEFINITION AND SCOPE

A simple definition of the detergent process—or detergency—is: the removal of soil (matter out of place) from a substrate immersed in some medium, generally through the application of a mechanical force, in the presence of a chemical substance which may lower the adhesion of the soil to the substrate. The process is completed when the soil is maintained in suspension so it can be rinsed away.

The detergent process has been known in some form or other since ancient times (1). It might be assumed, therefore, that it has been studied well and is completely understood and defined. Such, however, is not the case. When it is considered that the medium in which cleaning can take place may be aqueous, nonaqueous, or mixed; that many types of forces can be applied; and that the surfaces and soils involved are very numerous, then the real complexity of the detergent process is apparent, and it is perhaps not so surprising that there is much knowledge which is fundamental to an understanding of the detergent process that still needs to be gathered.

Although the process of detergency may not be thoroughly and completely understood, it is a process that is very widely used today. If we consider only the domestic cleaning of wearing apparel, this application alone serves to indicate the magnitude of the use of the detergency process. It is

estimated (2) that in the United States today some 50-52 million clothes washers are in use in homes; and that about 90% of American homemakers own washing machines. Daily, these machines apply the detergency process to millions of pounds of soiled clothing. When we also consider the commercial laundry, the dry cleaner, domestic and commercial cleaning of dishes, hard surface cleaning, the cleaning of metals, etc., then we realize that the detergency process is a very important process in our daily lives.

II. TEST METHODS

Test methods to determine the effectiveness of detergents have long been sought. Considering the complexity of the detergency process, it is not unusual that there is a lack of general accord on recognized testing methods. Many investigators have decided that the only acceptable test is a practical one conducted under the conditions encountered in actual end-use application. There are, however, controlled laboratory tests that have value if only for purposes of screening samples for later practical tests. Harris (3) has collected and published both kinds of tests.

A number of organizations have attempted to standardize the test methods used in evaluating the detergency process. These organizations include the American Society for Testing and Materials (4, 5), the American Association of Textile Chemists and Colorists (6), the American Home Laundry Manufacturers Association (7) (now a part of the Association of Home Appliance Manufacturers), the Association of Home Appliance Manufacturers (8) and many others. They have not met with complete success, but they have stimulated further research into the detergency process.

III. BRIEF DESCRIPTION OF THIS WORK

The original intent of this book was to provide an updated version of the Harris (3) volume. However, it is the opinion of the editors that another compilation of test methods without an examination of the theory on which they are based is relatively meaningless. Therefore, it has been our intent in compiling this work to provide general background information about detergents and soils and a considerable discussion of the current status of knowledge of the detergency (soil removal) process.

When one begins an attempt to describe the detergency process it is difficult to limit the subject matter brought into the description. This difficulty has been encountered in compiling this book. It is the feeling of the editors that an understanding of detergency necessitates examining such topics as fluorescent whitening, bleaching, stain removal, action of enzymes, fabric abrasion, and others. The toxicological and dermatological effects of detergents are also important. The importance of the above topics has broadened the scope of this book.

It is the intent of the editors to provide in this book, then, a compilation of frequently used tests related to detergency and a state-of-the-art report on the theory of detergency. It is the editors' hope that such a volume will inspire additional research efforts toward a complete understanding of the detergency process and the generation of a series of definitive tests for evaluation of the effectiveness of this process.

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Chapter 2

DEFINITION OF TERMS

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I. INTRODUCTION

Although this book is primarily concerned with the test methods for surfactants and detergents, and although the various test methods are discussed in detail by the authors of the following chapters, an introduction to the subject of surfactants and detergents may be helpful to some readers. The purpose of this chapter is to provide, in brief form, a definition of some of the principal terms for surfactant studies, detergency studies, and test methods and to provide typical detergent formulations and discuss the purpose of their components.

II. DEFINITION OF TERMS FOR SURFACTANT STUDIES

A. Wetting, Wetting Agents, Rewetting

The ease with which a surface can be wetted by water or by other liquids is an important property from many considerations, including detergency, waterproofing, oilproofing, dyeing, dispersion of pigments, and water adsorption. Wetting agents are classified practically according to their ability and speed in displacing air from solid surfaces. A requirement of a wetting agent is evidently to reduce both the surface tension of the liquid and its interfacial tension against the solid.

B. Surface Tension

Surface tension is the work required to extend a surface by unit area. It is the consequence of the unsymmetrical force field acting on molecules in the surface which results in a net inward attraction on them perpendicular to the surface. Surface tension, a free energy, is expressed in ergs per square centimeter or in the mathematically equivalent unit of dynes per centimeter.

C. Interfacial Tension

Interfacial tension is the equivalent of surface tension at the boundary between two phases. It is the work required to extend the interface by unit area and has the same units as surface tension.

D. Contact Angle

Contact angle in a solid-liquid-gas system is the angle between the liquid-gas surface and the liquid-solid interface at the point where the three phases come together. It is a measure of the degree to which a solid body is wetted by a liquid.