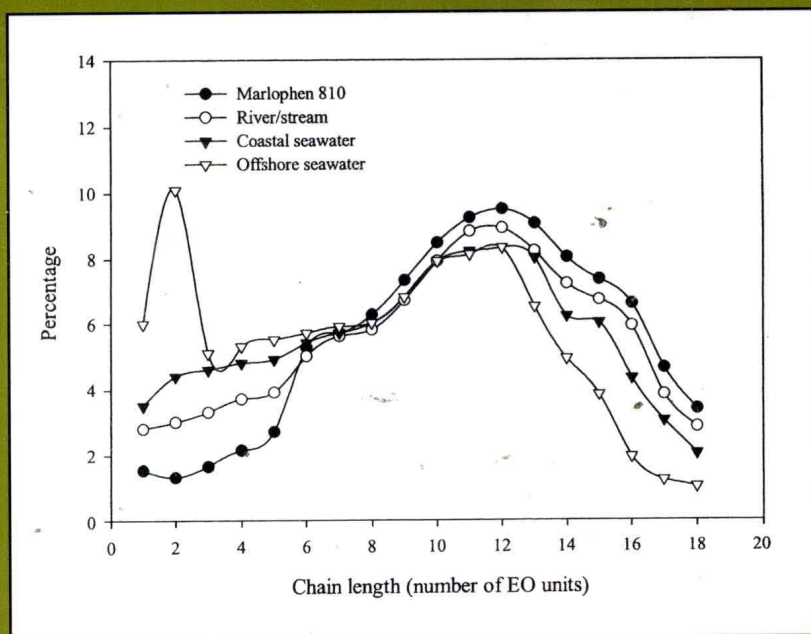


surfactant science series

volume **121**

# HANDBOOK of DETERGENTS

## Part B: Environmental Impact



edited by

Uri Zoller

# **HANDBOOK of DETERGENTS**

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*Haifa University–Oranim  
Kiryat Tivon, Israel*

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*Cover figure:* Typical (compared with a reference commercial product) homologous distribution profile of APEOs (% of total concentration) in surface water.

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# Handbook Introduction

The battle cry for sustainable development is persistent in all circles, gaining acceptance, worldwide, as the guiding rationale for activities or processes in the science–technology–environment–economy–society interfaces targeting improvement and growth. Such activities are expected to result in higher standards of living, leading eventually to a better quality of life for our increasingly technology-dependent modern society. Models of sustainable development and exemplary systems of sustainable management are continually being developed and/or adapted and creatively applied, taking into consideration human needs versus wants on the one hand, and long-versus short-term benefits and tradeoffs on the other.

“Detergents” constitute a classic case study within this context: this is a multi-dimensional systemic enterprise, operating within complex sociopolitical/technoeconomical realities, locally and globally, reflecting in its development and contemporary “state-of-affairs” the changing dynamic equilibria and interrelationships between demands/needs, cost/benefits, gains/tradeoffs, and social preferences. Interestingly, it is not surprising, despite the overall maturity of the consumer market, that detergents continue to advance more rapidly than population growth.

The soap and detergent industry has seen great change in recent years, responding to the shifts in consumer preferences, environmental pressures, the availability and cost of raw materials and energy, demographic and social trends, and the overall economic and political situation worldwide. Currently, detergent product design is examined against the unifying focus of delivering to the consumer performance and value, given the constraints of the economy, technological advancements, and environmental imperatives. The annual 2–3% growth of the detergent industry and a higher growth in personal care products reflect impressive developments in formulation and application. The detergent industry is thus expected to continue steady growth in the near future.

For the detergent industry, the last decade of the twentieth century has been one of transformation, evolution, and even some surprises (e.g., the increase of heavy-duty liquid detergents at the expense of powder detergent products). On both the supplier and consumer market sides (both remain intensely competitive), the detergent industry has undergone dramatic changes, with players expanding their offerings, restructuring

divisions, or abandoning the markets altogether. This has resulted in the consolidation of the market, especially in the last several years, and this trend appears to be gaining momentum. The key concepts have been and still are innovation, consumer preferences, needs, multipurpose products, cost/benefit, efficiency, emerging markets, partnership-cooperation-collaboration-merging (locally, regionally, and globally), and technological advancements. Although substantial gains and meaningful rapid changes with respect to the preceding concepts have been experienced by the surfactants/detergents markets, the same cannot be said for detergent/surfactant technology itself. The \$9-billion-plus detergent ingredients market has many entrenched workhorse products. This may suggest that the supply of “solutions” to most cleaning “problems” confronted by consumers in view of the increasing global demand for a full range of synergistic, multifunctional detergent formulations having high performance and relatively low cost, and the need for compliance with environmentally oriented (green) regulation, may be based on modifications of existing technologies. What does all this mean for the future of the detergent enterprise? How will advances in research and development affect future development in detergent production, formulation, applications, marketing, consumption, and relevant human behavior as well as short- and long-term impacts on the quality of life and the environment? Since new findings and emerging technologies are generating new issues and questions, not everything that can be done should be done; that is, there should be more response to real *needs* rather than *wants*.

Are all the questions discussed above reflected in the available professional literature for those who are directly involved or interested engineers, scientists, technicians, developers, producers, formulators, managers, marketing people, regulators, and policy makers? After a thorough examination of the literature in this and/or related areas, I came to the conclusion that a comprehensive series was needed that focuses on the practical aspects of the topic and provides the detergent industry perspective to all those involved and interested. The *Handbook of Detergents* is an up-to-date compilation of works written by experts each of whom is heavily engaged in his or her area of expertise, emphasizing the practical and guided by a common systemic approach.

The aim of this six-volume handbook (Properties, Environmental Impact, Analysis, Formulation, Applications, and Production) is to reflect the above and to provide readers who are interested in any aspect of detergents a state-of-the-art comprehensive treatise, written by expert practitioners (mainly from industry) in the field. Thus, various aspects involved—raw materials, production, economics, properties, formulations, analysis and test methods, applications, marketing, environmental considerations, and related research problems—are dealt with, emphasizing the practical in a shift from the traditional or mostly theoretical focus of most of the related literature currently available.

The philosophy and rationale of the Handbook of Detergents series are reflected in its title, its plan, and the order of volumes and flow of the chapters (within each volume). The various chapters are not intended to be and should not necessarily be considered mutually exclusive or conclusive. Some overlapping facilitates the presentation of the same issue or topic from different perspectives, emphasizing different points of view, thus enriching and complementing various perspectives and value judgments.

There are many whose help, capability, and dedication made this project possible. The volume editors, contributors, and reviewers are in the front line in this respect. Many others deserve special thanks, including Mr. Russell Dekker and Mr. Joseph Stubenrauch, of Marcel Dekker, Inc., as well as my colleagues and friends in (or associated with) the detergent industry, whose dedication and involvement facilitated this work. My hope is that the final result will complement the tremendous effort invested by all those who contributed; you the reader, will be the ultimate judge.

*Uri Zoller*  
*Editor-in-Chief*

# Preface

Regardless of the state-of-the-art and affairs in the detergent industry worldwide, with respect to scientific, technological, economic, safety, and regulatory aspects of detergent production, formulation, application, and consequently consumption, their environmental impact constitutes and will continue to be an issue of major concern. This is particularly so given the operating global free-market economy, which is supposed to, and is expected to, ensure sustainable development. Avoidance of detrimental environmental impact primarily requires *prevention* rather than *correction*, which in turn should dictate what the detergent industry should do and what needs to be accomplished in the future to ensure environmentally-oriented sustainable development, given contemporary shifts in consumer preferences, the availability and cost of raw materials and energy, demographic and social trends, and the overall economical/political situation worldwide.

This second volume (Part B) of the six-volume series *Handbook of Detergents* deals with the potential environmental impact of detergents—surfactants, builders, and sequestering/chelating agents—as well as other components of detergent formulations as a result of their production, formulation, usage/consumption, and ultimate disposal into the various compartments of the environment, particularly the aquatic compartment. Since commercial detergent formulations comprise many homologs, oligomers/polymers, and isomers, their identification, quantification, distribution, and persistence as well as specific and/or synergistic environmental impact (toxicity, estrogenicity, health risk, exotoxicity, and other factors) should be assessed, to be used as the solid and reliable scientific basis for action.

This volume is a comprehensive treatise on the multidimensional issues involved, and represents an international industry–academia collaborative effort of over 50 experts and authorities worldwide.



Part I, “The Multidimensionality of Detergent-Related Environmental Impact and Its Assessment” contains:

- A historical review of detergents and the environment
- A critical review and discussion of the distribution rate, effects, biodegradation, toxicology, and ecotoxicology of surfactants and other components of detergent formulations
- Risk assessment, life-cycle assessment, biodegradability, toxicity, and structure–activity relationships of detergent components and their evaluation
- An examination of the environmental impact of detergent packaging
- Environmental safety legislation on detergents

The topics addressed in Part II, “Environmental Behavior, Effects, and Impact of Detergent Components,” include:

- The fate, effects, safety, survival, distribution, biodegradability, biodegradation, ecology, and toxicology of anionic, cationic, and nonionic surfactants
- Environmental impact and ramifications of inorganic detergent builders, chelating agents, bleaching activators, perborates, and other components of detergent formulations
- Toxicology and ecotoxicology of minor components in personal care detergent formulations
- Biodegradation of surfactants in sewage treatment plants and in the natural environment
- Science versus politics in the environment-related regulatory process

All the above are accompanied and supported by extensive research-based data, occasionally accompanied by a specific “representative” case study, the derived conclusions of which are transferable.

This resource contains more than 2300 cited works and is aimed to serve as a practical reference for environmental, surfactant, chemical/biochemical, toxicological/ecotoxicological scientists and engineers, regulators, and policy makers associated with the detergent industry. I thank all the contributors who made the realization of this volume possible.

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