Photocatalytic Reaction Engineering

Hugo de Lasa
Benito Serrano
Miguel Salaices

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About the Authors

Hugo de Lasa is a Professor at the Faculty of Engineering of the University of Western Ontario in Canada. He is the Director of the Chemical Reactor Engineering Centre (CREC), the author of many peer reviewed publications, several books, and patents, and co-founding editor of the International Journal of Chemical Reactor Engineering. As a teacher, Dr. de Lasa has been actively involved in the training of numerous graduate students. His activities have contributed to furthering the understanding of the science and the technology of chemical reactors. Dr. de Lasa is the recipient of several awards and distinctions which include the Research Excellence Award from the University of Western Ontario (1998), the Fellowship of the Chemical Institute of Canada (2000), the Medal of Research and Development from the Professional Engineers of Ontario (2000), the Award in Industrial Practice (2001) and the R.S. Jane Lecture Award (2004) both from the Canadian Society for Chemical Engineering.

Benito Serrano-Rosales is a Professor at the Department of Chemical Engineering, of the Universidad Autónoma de Zacatecas in Mexico. Dr. Serrano is a tenured member of the Mexican Sistema Nacional de Investigadores (S.N.I.) holding a significant record of referred publications and conference proceedings. His research focuses on environmental remediation, with emphasis on water decontamination using photocatalysis. Dr.Serrano is actively involved in university research and in the supervision of graduate students. He is a member of the AMIDIQ (Academia Mexicana de Investigación y Docencia en Ingeniería Química) and has collaborated in this capacity in the organization of several Mexican and international conferences. Dr. Serrano has established valuable working relationships with several universities in Canada, USA, Mexico and Latin America.

Miguel Salaices-Arredondo is a PhD graduate from the University of Western Ontario in Canada. Since 1990, Dr. Salaices has worked as a research engineer in the Nuclear Energy Department of the Instituto de Investigaciones Eléctricas in Mexico. His research interests include the development of reactors for water treatment with a focus on the optimization and the modeling of radiation distribution in photocatalyst suspended media. Dr. Salaices is also involved in the development of computational systems for the

improvement of reactor safety in nuclear power plants. He has contributed to a considerable number of refereed papers, technical reports, design specifications, and refereed proceedings. Dr. Salaices is a member of the Mexican Nuclear Society and a tenured member of the Mexican Sistema Nacional de Investigadores (S.N.I.).

Preface

The pursuit of knowledge and discovery ebbs and flows. Peaks of innovation and discovery are often followed by periods of calm that invite reflection and reassessment, which in turn motivate renewed efforts towards further advancement. It is our view that the study of photocatalytic reaction engineering is in a phase of reassessment. The very principles of reaction engineering are under review at this time when environmental pressures and social concerns are changing the way we perceive and use technology. The application of photocatalytic reaction technology holds great promise in these changing times.

It is our aspiration to offer with this book a coherent and comprehensive treatment of the subject with thoroughly integrated contributions of the three co-authors.

Chapter I examines the basic principles involved in modeling photocatalytic reaction rates. Clarification in this area is needed as it is often lacking and is required for proceeding with the design, the simulation and the scale-up of the photocatalytic reactor units. Once these concepts are established, Chapter II describes various novel photocatalytic reactors designed by research groups around the world including the Photo-CREC reactors, developed in the context of the authors' research activities at the Chemical Reactor Engineering Centre (CREC), the University of Western Ontario in London, Canada and at the Universidad Autónoma de Zacatecas, Mexico. This chapter provides insight on the opportunities to extend the application of this technology through innovation in chemical reactor engineering.

Chapter III addresses the need of reviewing various types of photocatalysts, power sources and auxiliary equipment available for photocatalytic studies. Description of these matters is of essential importance for establishing radiation source power spectra, their lifetime and their power decay, for describing the available tools for macroscopic radiation balances and for effective kinetic and reaction rate modeling.

Chapter IV elucidates the methodology to develop a macroscopic radiation balance. This methodology allows the effective assessment of absorbed irradiation and irradiation transmission involving apparent extinction coefficients. The focus is put on demonstrating the applicability of these relatively simple functions to make the prediction of photon transfer and photon absorption a tractable mathematical problem. Thus, this chapter provides valuable tools from the perspective of the photocatalytic reactor designer.

Chapter V addresses the important task of accounting for the complex network of photochemical reactions, establishing viable kinetic modeling. This modeling is essentially based on a series-parallel model of the photocatalytic reaction network.

Examples are given to demonstrate the extent of applicability of this approach to the photoconversion of phenol.

Furthermore, the extensive applicability of photocatalysis has essentially become a problem of energy efficiency. As a result, the quantification of these energy efficiency factors is a major issue. Thus, Chapter VI considers these factors from two perspectives: quantum efficiencies and Photochemical Thermodynamic Efficiency Factor (PTEF), the latter being a new efficiency factor introduced by the authors.

Chapter VII addresses the need to account for both physical and chemical phenomena, reaction and adsorption. In fact, consideration of these combined phenomena is, in the view of the authors, essential to provide effective kinetic and rate modeling for the photo conversion of organic and inorganic pollutants. Cases with several organic species are presented including methylene blue, phenol, chloro-phenol, di-chloro-phenol, catechol, and pyrogallol.

Air decontamination is another potential innovative application of photocatalysis. Chapter VIII focuses on air decontamination using Photo-CREC reactors. Several examples are provided by examining the photoconversion of acetone, iso-propanol, and acetaldehyde. Special attention is paid to the quantum efficiencies for air decontamination, exceeding 100% in many cases, which demonstrates the distinctive chain mechanism character of the photoconversion of organic pollutants in air.

Finally, Chapter IX, discusses recent research on the concurrent oxidation-reduction of organic and inorganic compounds and on the inactivation of model microorganisms. These two applications of photocatalysis have the potential of significantly improving the prospects for this novel technology.

In summary, our book contains an up-to-date discussion of photocatalytic reaction engineering and the application of these principles. Altogether it is an invitation to reflect on the possibilities of photocatalysis as a new and unique technique with great potential for air and water treatment. We offer our book as a contribution to the development of reaction engineering in photocatalysis as well as to the extensive potential for application of this technology.

We would like to express our appreciation to the University of Western Ontario, Canada, the Universidad Autónoma de Zacatecas, México and the Instituto de Investigaciones Eléctricas, México for their onthusiastic support of this project.

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Hugo de Lasa
University of Western Ontario, Canada
Benito Serrano
Universidad Autónoma de Zacatecas, México
Miguel Salaices
Instituto de Investigaciones Eléctricas, México

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