

Photocatalytic Reaction Engineering

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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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