PREFACE

In recent years, the international community has been increasingly concerned about the stresses imposed on the natural environment by many chemical and energy-generating processes. As a result, the world is witnessing an accelerated development and implementation of new green technologies. These green technologies are called to provide ecologically responsible solutions for the much needed supply of drinking water, clean air, and various forms of energy.

Photocatalysis holds great promise for delivering these ground-breaking technologies. Photocatalysis is a truly environmentally friendly process where irradiation, either near UV or solar light, promotes photoexcitation of semiconductor solid surfaces. As a result, mobile electrons and positive surface charges are generated. These excited sites and electrons accelerate oxidation and reduction reactions, which are essential steps for pollutant degradation and other photoinduced chemical transformations such as water splitting.

Photocatalysis and its related technological issues have been strongly influenced by recent publications. The present Volume 36-*Photocatalytic Technologies* of the Elsevier's *Advances in Chemical Engineering Series* aims at offering a comprehensive overview of the state-of-the-art photocatalytic technology. In order to accomplish this, several prominent researchers were invited to contribute a chapter for the Volume 36.

Chapter 1 examines the phenomenological principles involved in the modeling of photocatalytic reactions including the photo-adsorption of chemical species. This chapter proposes a method to quantify photo-adsorbed species onto irradiated TiO_2. The technique is applied to the oxidation of phenol and benzyl alcohol.

Chapter 2 considers the removal of inorganic water contaminants using photocatalysis. Metal cations react via one-electron steps first leading to unstable chemical intermediates, and later to stable species. Three possible mechanisms are identified: (a) direct reduction via photo-generated conduction band electrons, (b) indirect reduction by intermediates generated from electron donors, and (c) oxidative removal by electron holes or hydroxyl radicals. The provided examples show the significance of these mechanisms for the removal of water contaminants such as chromium, mercury, lead, uranium, and arsenic.

Chapter 3 addresses the photocatalytic mineralization of organic species in water and its enhancement by using ferric ions. This methodology uses Photo-CREC reactors with Fe-promoted TiO_2. It is shown that 5 ppm of Fe in water provides an optimum iron concentration able to maximize the rates of

oxidation and mineralization for both phenol and its aromatic intermediates. This chapter also describes a parallel–series kinetic reaction network. This reaction network and the derived kinetic parameters are most suitable for describing the improved phenol photocatalytic oxidation with ferric ions.

Chapter 4 reports research progress on hydrogen production via water splitting using photocatalysis. It is stated that while water splitting with UV light shows good prospects, water splitting under visible light requires a significant efficiency improvement provided by an enhanced utilization of irradiated photons per molecule of hydrogen produced. In order to accomplish this, new nanomaterials manufactured under close control of crystallinity, electronic structure, and morphology are proposed.

Chapter 5 addresses the scaling-up in photocatalytic reactors with catalyst irradiation being identified as a most important engineering design parameter. It is stated that the photocatalytic reactor design involves a skilful combination of a highly and uniformly irradiated photocatalyst, and an intensive mixing of the TiO_2 suspension. In order to attain these design objectives, several reactor designs are reviewed such as a multiple tube reactor, a tube light reactor, a rotating tube reactor, and a Taylor vortex reactor.

Chapter 6 describes solar-powered photocatalytic reactors for the conversion of organic water pollutants. Nonconcentrating reactors are identified as some of the most energetically efficient units. It is reported that the absorption of radiation is a critical parameter in the efficiency reactor evaluation. The radiative transfer equation (RTE) solution under the simplified conditions given by the P1 approximation is proposed for these assessments.

Chapter 7 reports a scaling-up procedure for photocatalytic reactors. The described methodology uses a model which involves absorption of radiation and photocatalyst reflection coefficients. The needed kinetics is obtained in a small flat plate unit and extrapolated to a larger reactor made of three concentric photocatalyst-coated cylindrical tubes. This procedure is applied to the photocatalytic conversion of perchloroethylene in air and to the degradation of formic acid and 4-chlorophenol in water.

Chapter 8 addresses the treatment of contaminated air streams using photocatalysis. Special attention is given to the distinction between reaction kinetics and mass transport processes. The reviewed studies show the evolution from the early days of TiO_2 photocatalysis, where the aim was to understand the basic process parameters, to today's development of phenomenological models assisting in the scaling-up of units.

In summary, the present issue of *Advances in Chemical Engineering* Volume 36 offers an up-to-date overview and discussion of principles and applications of photo catalytic reaction engineering. Altogether, Volume 36 is an invitation to reflect on the possibilities of photocatalysis as a promising technology for green reaction engineering.

Hugo I. de Lasa and Benito Serrano Rosales,
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