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Efficiency Factors in Photocatalytic Reactors: Quantum Yield and Photochemical Thermodynamic Efficiency Factor

Photocatalytic efficiency is evaluated using quantum yields (QYs) and the photochemical thermodynamic efficiency factor (PTEF). The PTEF allows establishing reactor efficiency as the ratio of utilized enthalpy for the formation of consumed OH• free radicals over the absorbed photon energy. A key consideration for the evaluation of efficiency factors is the establishment of macroscopic energy balances together with an accurate assessment of evolved and absorbed photons. Of considerable help are the experimental devices developed at the Chemical Reactor Engineering Centre (CREC)/University of Western Ontario (UWO) laboratories. Photoconversion kinetics is required for calculation of the OH• consumption rates and establishment of the related kinetic parameters. PTEFs and QYs have been applied by CREC-UWO researchers for efficiency calculations in photocatalytic reactors for the decontamination of air, water, and hydrogen production.

Keywords: Energy efficiency factors, Photocatalysis, Photocatalytic reactors, Photochemical thermodynamic efficiency factor

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1 Introduction

Heterogeneous photocatalysis is a very active field of research for water and air decontamination, hydrogen production, and other areas. It can be used in conjunction with solar light for both air and water treatment [1–5]. Thus, photocatalysis opens a great opportunity to new technologies for water and air remediation, as well as for the manufacturing of environmentally friendly fuels such as is the case of hydrogen.

In order to achieve further progress, it is important to use and define fundamentally based efficiency parameters. This allows the comparison of experimental results and reactors, obtained at different laboratories under diverse experimental conditions. The basic principle in photocatalysis is illustrated in Fig. 1.

A semiconductor material, such as TiO_2, can be irradiated with photons, having an energy content that exceeds the band gap energy. As a result, an electron is promoted from the valence band to the conduction band, with a pair of charges being generated as: (a) a negative delocalized electron, which may reduce oxygen, cations, and other species and (b) a positive hole, which may contribute to the oxidation of hydrocarbons, and anion species. As a result, photocatalysis provides a valuable approach to carry out chemical reactions for the removal of organic and inorganic species from water and air. In addition, this principle can also be applied for water splitting with hydrogen production.

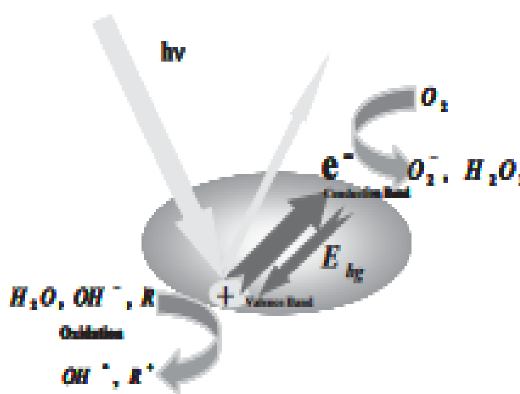

Figure 1. Excitation of the semiconductor and depiction of the reactions carried out by the generated electrical charges. Adapted from de Lasa et al. [6].