



## Editorial

# Heterogeneous Photocatalysis

Mario J. Muñoz-Batista <sup>1,\*</sup> and Rafael Luque <sup>2,3</sup>

<sup>1</sup> Department of Chemical Engineering, Faculty of Sciences, University of Granada, Avda. Fuentenueva, s/n, 18071 Granada, Spain

<sup>2</sup> Departamento de Química Orgánica, Universidad de Córdoba, Edificio Marie-Curie (C-3), Ctra Nnal IV-A, Km 396, E14014 Córdoba, Spain

<sup>3</sup> Peoples Friendship University of Russia (RUDN University), 6 Miklukho-Maklaya str, 117198 Moscow, Russia

\* Correspondence: mariomunoz@ugr.es

Heterogeneous photocatalysis is a subtype of catalysis that refers to chemical processes catalysed by a semiconductor solid under proper illumination conditions. As is well-described in related literature and schematically represented in Figure 1, the light-excited photocatalysts generate holes and electrons. The electrons and holes at the surface may initiate a reductive and an oxidative reaction pathway, respectively, which allow for the utilization of this scheme for a wide range of applications, from the selective organic synthesis of high-value products [1,2], production of energy toward CO<sub>2</sub> reduction [3], water splitting and alcohol reforming reactions [4,5] to the degradation of undesired chemicals or pollutants and pathogens [5,6]. In addition, advantageously, the photocatalytic processes can be carried out in both gas and liquid media and using mild operating conditions [6–9]. TiO<sub>2</sub>- and TiO<sub>2</sub>-based materials are the most widely used photocatalysts. Such materials, in addition to ZnO-based and more recently g-C<sub>3</sub>N<sub>4</sub>-based materials (among many other semiconductors), have shown outstanding results in many photocatalytic applications [5]. Figure 1 also describes some of the open research lines in the photocatalysis field.

Besides the aforementioned photocatalytic materials and application fields, there are many research groups working on the design of more efficient photoreactor setups. The optimization of operating conditions and scaling-up schemes, as well as the modeling of light-matter interaction, are some of the topics with a high research activity [8,10,11]. Such tasks must be based on an in-depth understanding of the photocatalytic phenomena. As is well-described by Fernández-García et al. [12], advanced spectroscopic studies must consider the analysis of the solid catalysts (i.e., the light-matter interaction), which is particularly important for those spectroscopies rendering the information of the bulk. Finally, we would also like to highlight the advantages of using the quantum efficiency parameter to describe the efficiency of the photocatalytic process. According to IUPAC recommendations, the quantum efficiency calculation requires the determination of the ratio between the number of molecules reacting (reaction rate) and the number of photons interacting with the solid (photon rate). The last parameter typically involves, in the first place, the measurement and modeling of the light source emission properties and, subsequently, the light absorption capability of the photocatalysts [13,14].

The Special Issue aims to further contribute to the momentum of research and development in photocatalysis by featuring some original research papers as well as one review paper.

As described in a fine review contribution included in this collection, the development of sustainable yet efficient technologies to store solar light into high-energy molecules, such as hydrocarbons and hydrogen, is a pivotal challenge in 21st century society. The photoreforming of biomass-derived substrates, as well as CO<sub>2</sub> photoreduction, have been extensively studied and well-reviewed by Signoretti et al. The contribution presents a complete analysis, from understanding chemical bases to the process development of these technologies, focusing on both materials and process (operating conditions and reactor setups alternatives) [15].



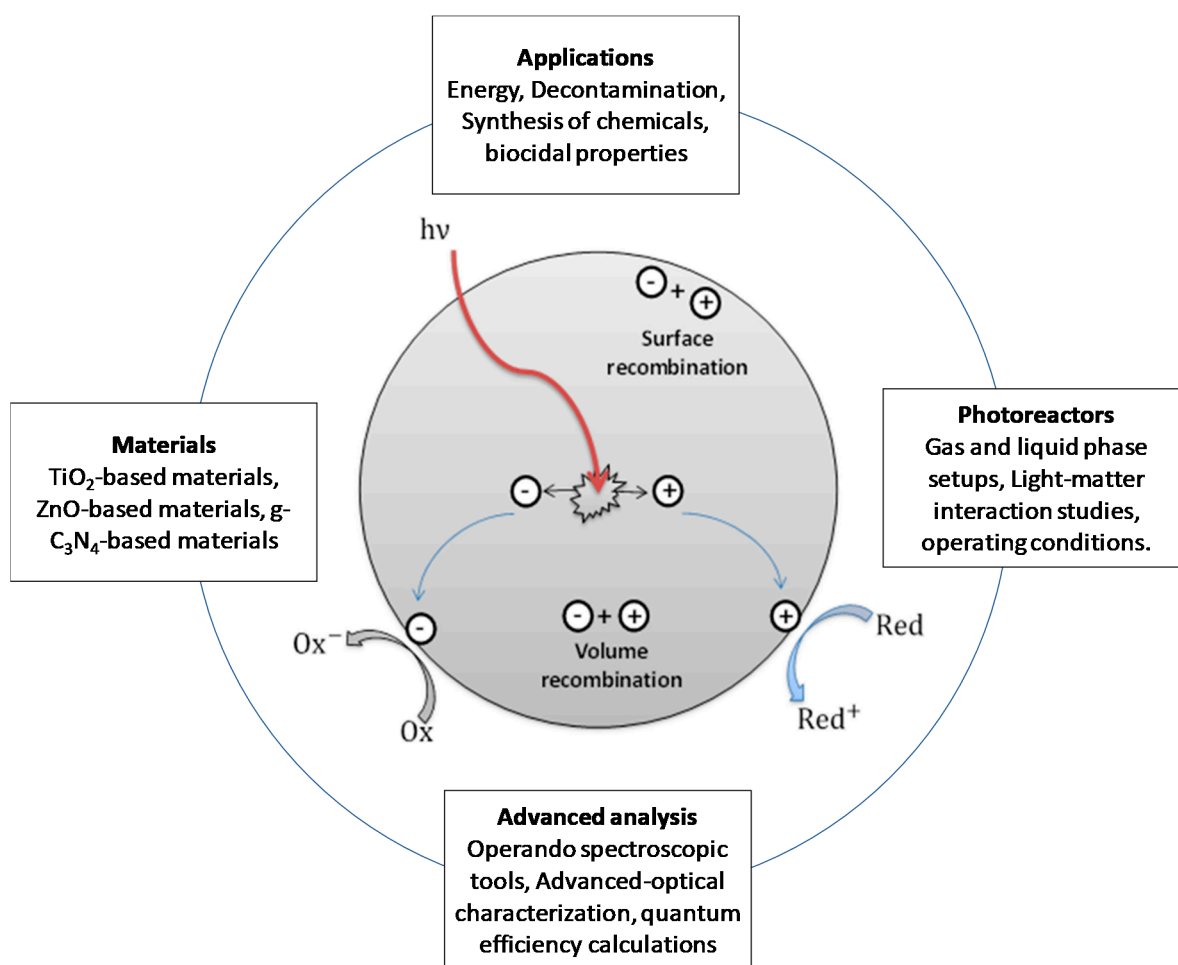
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**Figure 1.** Schematic representation of the photo-activation and primary reaction steps of a semiconductor and the main open research lines in the photocatalysis field.

The antimicrobial and photocatalytic properties of the Ag<sub>2</sub>O/TiO<sub>2</sub> heterojunction are reported by Janczarek and Kowalska et al., showing that Ag<sub>2</sub>O/TiO<sub>2</sub> photocatalysts exhibited high antimicrobial activities. Although antibacterial activity was mainly associated with Ag<sub>2</sub>O presence, a clear synergistic effect was found under irradiation conditions, which was explained by considering the electrostatic attraction between the negative surface of microorganisms and the positively charged Ag<sub>2</sub>O under illumination conditions of the Ag<sub>2</sub>O/TiO<sub>2</sub> structure [16].

The photodegradation of stearic acid using copper oxide heterojunction thin films prepared by magnetron sputtering is presented by José Montero and Lars Österlund. Variations of the oxygen partial pressure resulted in an oxide composition ranging between Cu, Cu-Cu<sub>2</sub>O, Cu<sub>2</sub>O-CuO<sub>1-x</sub> and CuO with remarkable photocatalytic results. The authors remarked that heterojunction films were more difficult to fabricate, which was explained in terms of a thermodynamic driving force to form single-phase oxide. The well-structured control that can be obtained using magnetron sputtering will be fully exploited in the coming years while considering a definitive dependence of the superficial structure in the photocatalytic process [17].

Montmorillonite-TiO<sub>2</sub> nanocomposites using during the photodegradation of 1,2,4-trichlorobenzene are also presented. Both ultrasonic and stirring methods were used to synthesize the samples, while a complete characterization approach provided relevant results about the chemical, morphological and structural properties of the catalysts as well as the photo handling charges and mechanism pathway [18].

The photo-Fenton reaction has been described by many authors as one of the most promising ways to remove highly hazardous organic species. In this special issue, natural Tunisian materials containing very important amounts of iron were reported as catalysts for an effective degradation of 4-Chlorophenol via the photo-Fenton process in a contribution by Bel Hadjltaief, Elena Gálvez et al. The Negligible metal leaching and catalyst re-utilization results without any loss of activity confirmed a remarkable catalytic stability of natural catalysts, opening a new window in the materials field for this application [19].

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