12

SEMICONDUCTOR NANOMATERIALS FOR ORGANIC DYE DEGRADATION AND HYDROGEN PRODUCTION VIA PHOTOCATALYSIS

Leticia M. Torres-Martínez, Isaías Juárez-Ramírez, and Mayra Z. Figueroa-Torres

Departamento de Ecomateriales y Energía, Facultad de Ingeniería Civil-Universidad Autónoma de Nuevo León, Avenida Universidad y Avenida Fidel Velázquez S/N, Ciudad Universitaria, San Nicolás de los Garza, ~~Mexico~~

UNCORRECTED PROOFS

12.1 INTRODUCTION

The combination of nanotechnology and photocatalysis for clean environment and for providing a renewable energy source has been one of the most important research subjects in recent years. In particular, photocatalytic processes using semiconductor materials in nanoparticle size have been demonstrated to be effective technologies for organic compound degradation and hydrogen production from water splitting. The interest is because in these photocatalytic processes, solar energy can be used as a primary energy source to activate the semiconductor material used as catalyst. It is well known that the photocatalytic process is carried out through the activation of a semiconductor material with ultraviolet (UV) or visible light irradiation [1, 2].

The photocatalytic process involves the generation of electron–hole pairs in the valence and conduction bands of the semiconductor. However, the recombination reaction of electrons and holes commonly tends to occur quickly, diminishing the semiconductor activity [3–9]. Therefore, an electron acceptor added to the reaction mixture is adequate. Hence, it is necessary to carry out modifications of electronic structure, crystal structure, or physicochemical properties in order to enhance the activity of semiconductor materials [10, 11]. In recent years, several chemical methods such as hydrothermal, ~~solution combustion~~, sol–gel, and coprecipitation have been employed to synthesize new and better semiconductor materials with strict control of composition, homogeneity, size and particle shape, as well as use low temperature for their synthesis.

Particularly, during the past decade, several semiconductor nanomaterials with specific structural, physicochemical, and electronic characteristics have been designed and prepared in our laboratory for use as active materials in photoinduced processes. These catalysts could present better photocatalytic performance than TiO_2, due to the different methods of preparation like sol–gel, hydrothermal, colloidal, coprecipitation, and mechanical milling. Additionally, the presence of metal transition cations as dopant agents modifies the band gap value in order to activate the catalysts under UV and visible light irradiation. Therefore, in this chapter several ceramic semiconductor nanomaterials corresponding to the following binary and ternary oxides families are presented: (i) perovskite-type structure, for example, $NaTaO_3$, La:$NaTaO_3$, and Sm:$NaTaO_3$; (ii) pyrochlore-type structure, for example, Sm_2MTaO_7 (M = Fe, In, Ga) and Bi_2MTaO_7 (M = Fe, In, Ga); (iii) rectangular tunnel–type structure, for example, $Na_2Ti_6O_{13}$; and (iv) SiC–TiO_2 compounds. These materials have been tested as catalysts for the photodegradation of methylene blue, rhodamine B, and indigo carmine under UV or visible light source, as well as a catalyst for hydrogen production from water splitting under UV light [12–23]. The main research activities of our group focus on both the performance–structure aspects and the effects of the synthesis route.

Nanomaterials for Environmental Protection, First Edition. Edited by Boris I. Kharisov, Oxana V. Kharissova, and H. V. Rasika Dias.
© 2014 John Wiley & Sons, Inc. Published 2014 by John Wiley & Sons, Inc.