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Hydrogen photoproduction under visible irradiation of Au–TiO_2/activated carbon

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ABSTRACT

The photoproduction of hydrogen has been performed under visible light irradiation of Au–TiO_2/activated carbon (AC) materials prepared by different activation methods. Results were compared against those obtained under ultraviolet irradiation. Characterization of TiO_2, AC and Au–TiO_2/AC was performed by adsorption–desorption N_2 isotherms, surface pH (pH_{PZC}), infrared spectroscopy (FTIR), X-ray diffraction (XRD), X-ray photoelectronic spectroscopy (XPS), diffuse reflectance UV–vis spectroscopy (DR/UV–vis), and transmission electron microscopy (TEM). The present results showed that functional groups on the carbon surface are responsible to enhance 2.6 times the photocatalytic activity of Au nanoparticles deposited on TiO_2. Characterization suggests that carboxylate anions detected on surface of some AC interact with metallic center at TiO_2 and this surface interaction would be responsible of the enhancement in the photoactivity.

1. Introduction

TiO_2 is the best photocatalyst for treatment of waste waters; however, most of commercial TiO_2 have two important operational limitations such as low surface area and its photoactivity is limited to UV irradiation. Several studies have been performed to solve the first limitation employing co-supports [1,2]. Particularly, activated carbons (AC) have shown to increase remarkably TiO_2 photoactivity for photodegradation of pollutants in waste waters and poisonous chemicals [3–14]. This cooperative effect has been attributed not only to the high surface area of AC but also to the low-strength of adsorption that permits the diffusion of pollutants from support to active phase [2,3]. Concerning to the second limitation, the influence of carbon deposits or carbon-doped titania has been studied and different points of view have been proposed [9–11]. Most of works suggest that enhanced photocatalytic activity on TiO_2/AC catalysts is not due to a change in band energy of semiconductor but to a remarkable influence of the functional surface groups of AC on TiO_2 optoelectronic properties, primarily by the interaction between some of these groups, mainly carboxyl anions or cyclic ethers with Ti atoms as proposed some authors and us [7–9,12–17].

Another way to solve the second limitation of TiO_2 corresponds to the deposition of noble metal nanoparticle exhibiting surface plasmon band as gold supported on TiO_2 because the possibility of gold photosensitization of titania by electron injection into the conduction band [18]. An important application of Au–TiO_2 photocatalysts concerns to hydrogen photoproduction [19]. This process is clearly influenced by parameters such as Au loading, particle size, surface area, and others which play important roles on the photocatalytic activity of TiO_2 [18]. The main objective of the present work is to study the photoproduction of H_2 under ultraviolet and visible irradiation of Au–TiO_2 supported on AC prepared by different activation methods in order to verify the influence of functionalization of AC upon the Au–TiO_2 photoactivity. The combination of Au nanoparticles deposited on TiO_2 and simultaneously supported on AC for the photoproduction of hydrogen is firstly reported in the present manuscript.

2. Experimental

2.1. AC synthesis

AC powders were prepared from sawdust of *Tabebuia pentaphyla* wood by changing experimental conditions and the activation temperature in order to introduce different physicochemical properties [20], mainly, texture and in the nature and density of the functional groups on carbon surface. Physical activation by gasification under CO_2 flow at 800 °C and pyrolysis under N_2 flow at 1000 °C by 1 h where firstly performed [13]. These AC were denoted AC_{CO_2} and

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