Formation of Black Titania by Ammonolysis for Photocatalytic Hydrogen Production

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White titanium dioxide (W-TiO_2) has been considered a great semiconductor photocatalyst for various photocatalytic applications due to its abundability and favourable properties such as low cost, low toxicity, good photocatalytic activity and chemical stability. However, optical absorption is confined to the ultraviolet region (UV) owing to its broad bandgap (3.0 eV for rutile and 3.2 eV for the anatase phase) thus rendering it active for only 5% of solar radiation [1]. By using different gas treatment methods, oxygen vacancies and other surface modifications can occur, leading to an effective alteration of the optoelectronic and catalytic properties [2] and the subsequent formation of black coloured titanium dioxide (B-TiO_2). As a result, black titania possesses narrower band gap or mid-gap states compared to white TiO_2 which enhances its visible light absorption. Additionally, the highly defective structure can suppress electron-hole recombination and facilitate charge transfer processes [1].

In this work, black titania was formed by thermally treating white titanium dioxide powders under ammonia (NH_3) atmosphere at different temperature protocols. The effect of annealing protocol on the formation and characteristics of black titania was studied after treatment at 450°C, 500°C, 550°C, 600°C, and 650°C. The samples have been characterized using techniques such as X-Ray diffraction, SEM/EDS analysis and XPS measurements before and after treatment. Finally, the powders were evaluated as catalysts for water splitting and hydrogen gas (H_2) production under solar light radiation. The photocatalytic experiments were carried out using a Shimadzu gas chromatographer (GC) equipped with a thermal conductivity detector (TCD) to determine the best photocatalyst powders.

Figure 1: (a) White and (b) Black titania formed by ammonolysis

References

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