Preparation and Investigation of Sulfur and Nitrogen Co-Doped TiO_2

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Titanium dioxide is a semiconductor widely used as a photocatalyst in heterogeneous photocatalysis due to some factors such as its good optical activity, low cost, high chemical stability, and non-toxicity. However, its large band-gap energy considerably limits its application; only UV light can be employed for the excitation in the systems based on titanium dioxide catalysts. Hence, to broaden the possibilities of their utilization in indoor ambients, a significant decrease of the band-gap energy is indispensable, i.e. an extension of the photoactivity into the visible-light range. As a consequence of this demand, several techniques have been intensively investigated to narrow this band-gap energy and shift light the absorption of TiO_2 towards the longer-wavelengths. One effective solution is the doping of titanium dioxide with different elements (i.e., C, S, N, and F) to create defects and introduce new energy states in its crystal lattice.

In this work, we have synthesized a sulfur and nitrogen co-doped TiO_2 (S,N-TiO_2) by a low-temperature solvothermal method and also by low-temperature solvothermal method combined with calcination under both argon and air atmospheres. In our study, titanium(IV) butoxide was used as precursor of titanium dioxide and thiourea as a source of sulfur and nitrogen. Coumarin was selected as an organic model compound for the photocatalytic experiments and its degradation was monitored by spectrophotometry, while the produced 7-hydroxycoumarin was measured by spectrofluorometry. Preliminary tests demonstrated that under visible-light illumination the non-calcined catalyst was inactive, whereas after its calcination a low amount of 7-hydroxycoumarin was produced, indicating a rather low photoactivity that under these circumstances. Moreover, all catalysts were active upon UV-light irradiation, however, the coumarin degradation rates were different for each catalyst investigated, and remarkably distinct characteristics in the emission intensity (formation and degradation rate) of 7-hydroxycoumarin were observed. This phenomenon suggested that deviating reaction mechanisms occurred in this system, depending on the catalyst used.

Furthermore, the diverse behavior observed can originate from various features of the catalysts such morphologies, crystallographic phases, chemical elements content, thermal stability, and specific surface area. Therefore, these properties were also investigated.

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