Nanocomposites and nanomaterials

Synthesis of nonporous nitrogen doped iron/titania thin films and their optical, structure and photocatalytic activity in redox photoreactions

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Chemical stability, non toxicity and high photocatalytic activity of titania are the key properties in its application for environmental photocatalysis. However, only a small fraction (3-5%) of the solar energy (<390 nm) can be absorbed TiO_2. The modification of TiO_2 by non-metals and metal ions leads to increase sensitivity to visible light and change the optical, structural and photocatalytic properties of semiconductor. Nitrogen incorporation in TiO_2 matrix leads to the decrease of its band gap energy as a result of the oxygen atom substitution by nitrogen. In addition to, introduction d-block metals can cause to decrease the recombination rate for the photoinduced charge carriers enhancing the activity of the semiconductors.

The non-porous titania films modified with Fe^{3+} and nitrogen ions were synthesized by sol-gel. Thermal treatment of the films with the ratio of components Ti:Fe =1:1 was performed at 450, 500 and 600 °C. The analysis of the optical spectra showed that the absorption edge of N/Fe/TiO_2 films was shifted to the long-wavelength region comparing with undoped TiO_2. The calculations of band-gap values of the films point that the introduction of iron ions and nitrogen in the structure of TiO_2 influences on their values.

As shown by XRD results, no anatase phase is formed in structure of the films, while two phases, as namely pseudobrookite (Fe_2TiO_5) and landauite ($Fe_2Ti_2O_7$) are registered, where the predominant phase is pseudobrookite. The formation of two phases is also confirmed by two band gap energy values calculated from the optical spectra. The presence of nitrogen ions into the structure leads to crystallization retention and the formation of smaller particles.

Photocatalytic activity was studied in the processes of toxic dichromate ions reduction and tetracycline hydrochloride (TC) degradation. The highest photoresponse in the reduction process was observed for the film calcined at 450 °C under both UV and vis irradiation. The photocatalytic efficiency of N/Fe/TiO_2 films with thermal treatment at 450 °C in the oxidation process was enhanced under UV light. It must be noted that the activity of the film calcined at 450 °C is increased in 2 times in comparison with the nitrogen doped TiO_2 under visible light. Thus, the modification of titania by iron and nitrogen ions is advantageous for the photocatalytic activity.