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„Struktury półprzewodnikowe na bazie ditlenku tytanu oraz metali ziem rzadkich do zastosowań fotokatalitycznych”

Abstract

Heterogeneous photocatalysis is a promising method for the pollution degradation or removal from the gas and aqueous phases (water, wastewater, and air treatment technologies) as well as for hydrogen production.

The doctoral dissertation consists of four publications, which are preceded by an introduction discussing the motivations and outline of the thesis, and a substantive discussion of the research. The introduction includes information on the main principles of heterogeneous photocatalysis and limitations in the application of rare earth ions modified titanium dioxide. The available literature lacks information concerning the excitation mechanism of the RE^{3+}-TiO_2 photocatalytic system and novel ways to overcome the up-conversion limitations.

The aim of this work was to obtain new semiconductor structures based on broadband titanium dioxide with rare earth ions or with metal-organic frameworks containing rare earth metals with specific physicochemical and/or luminescent properties. The introduction of the proposed modifications to TiO_2 aims to obtain a stable material with enhanced absorption in the visible range.

In this study, four series of photocatalytic systems were prepared: **(i)** TiO_2 nanotubes modified with rare earth metals (RE^{3+} = Ho, Er, Nd, Y, Ce, Tm), **(ii)** TiO_2 nanoparticles modified with holmium and carbon, **(iii)** hybrids based on TiO_2 spheres and metal-organic frameworks containing rare earth metals in their structure (RE^{3+} = Nd, Er, Ho, Tm), and **(iv)** hybrids based on TiO_2 nanoflowers and titanium-substituted cerium-organic frameworks with terephthalate linkers modified by various groups (-Br, -NH_2, -NO_2) or their derivatives (N-heterocyclic or biphenyl groups). The photocatalytic activity under UV-Vis and Vis light irradiation was examined in the degradation reaction of model contamination – phenol in the water phase and toluene in the gas phase, and hydrogen production. The elucidate a possible mechanism, photoluminescence properties, identification of generated reactive species, and the quantum efficiency as a function of the excitation wavelength (action spectra) was investigated.