Anna Krukowska

Doctoral Dissertation

Influence of physicochemical properties on the photocatalytic activity of modified potassium tantalum

Abstract

The main scientific aim of PhD thesis was to explain the influence of physicochemical properties on the photocatalytic activity of modified potassium tantalum under Vis/ UV-Vis light irradiation in environmental protection and energy production processes. The use of photocatalytic semiconductors has been considered as effective, ecological and economical methods to remove pollutants from water, wastewater and air as well as to produce energy from renewable sources.

The doctoral dissertation consists of three publications, which are preceded by a theoretical introduction and a substantive discussion of the research. Introduction contains information on the mechanism of photocatalysis, semiconductor potassium tantalum and the possibility of its modification. Mono-/bimetallic nanoparticles (Au, Ag, Pt, Pd, Rh, Ru or Au/Pt, Ag/Pd, Rh/Ru) decorated surface and/or rare earth ions (Y, Yb, Ho, Pr, Er) doped lattice of perovskite type ($KTaO_3$)/ pyrochlore type ($K_2Ta_2O_6$) photocatalysts were prepared. The physicochemical properties of the modified potassium tantalum (e.g. absorbance, photoluminescence and magnetic properties, morphology, crystalline structure and surface elemental composition) were investigated. The photocatalytic activity and stability of modified potassium tantalum under Vis/ UV-Vis light irradiation were examined in degradation reaction of model contamination (phenol in the water phase and toluene in the gas phase) as well as in H_2 generation (water photodecomposition with addition organic compound). Models of crystal structures of potassium tantalum (perovskite and pyrochlore) and physicochemical processes (doping of semiconductor and adsorption of O_2 and H_2O molecules) were designed. Mechanisms of excitation of modified potassium tantalum depending on the conditions of the photocatalytic reaction have also been proposed. Structure modification and surface modification of potassium tantalate affect on its physicochemical properties and thus influence on increase in photocatalytic activity.

Keywords: heterogeneous photocatalysis; potassium tantalate; perovskite $KTaO_3$/ pyrochlore $K_2Ta_2O_6$; rare earth ion doping; noble metal photodeposition; Vis/ UV-Vis photocatalytic activity; pollutant degradation; H_2 generation.