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,,Nowe materiały na bazie bizmutu do zastosowań fotokatalitycznych''

Heterogeneous photocatalysis is a promising method used for the degradation of environmental pollutants in water and air as well as for the production of hydrogen as a "clean source of energy." Among the photocatalysts used in photocatalytic processes, those containing bismuth atoms in their structure deserve special attention. Semiconductors containing this atom typically have a narrow band gap, which allows them to be excited by visible light. Additionally, these materials have a semi–metallic character that can be used as a cocatalyst in photocatalytic reactions. Furthermore, bismuth-based semiconductors are highly susceptible to surface and structural modifications. In the case of halide perovskites, the presence of bismuth in their structure increases their resistance to oxidation under natural conditions.

The aim of this doctoral dissertation was to develop a method for synthesizing new bismuth materials with photocatalytic properties. This work consists of two main parts. The first part is a theoretical introduction that includes information about the basis of heterogeneous photocatalysis, limitations in the use of wide-bandgap semiconductors, methods for their modification, and the motivation for creating bismuth-based photocatalytic systems. The second part presents three scientific articles, preceded by an introduction to the methods of preparing photocatalysts and techniques used to evaluate their physicochemical properties, a description of the methodology of the photocatalytic experiments conducted, and a brief discussion of the research contained in each article. As part of the research, three series of photocatalytic systems were obtained: (i) semiconductor composites consisting of a TiO_2 matrix with a highly developed surface modified with Bi_2S_3 quantum dots, including Bi_2S_3 quantum dots doped with erbium or ytterbium ions, (ii) $Cs_3Bi_2X_9$ metal halide perovskites (where X = Cl, Br, I, Cl/Br, Cl/I, or Br/I) and composites consisting of a g–C_3N_4 matrix and $Cs_3Bi_2(Cl/Br)_9$ nanoparticles deposited on its surface, (iii) halide perovskites of the $A_3Bi_2I_9$ type (where A denotes methylammonium (MA), formamidinium (FA), cesium (Cs), or rubidium (Rb)) and $Cs_2B'BiI_6$ (where B' = Cu, Ag, Au, or In). The photocatalytic activity of the obtained materials was tested in the UV–Vis and Vis ranges in the process of phenol degradation in the aqueous phase for the second series of photocatalysts (ii), and in the reaction aimed at generating hydrogen for the first and third series of photocatalysts (i, iii). The photocatalytic experiments carried out and the comprehensive characterization of the properties of the new photocatalytic systems allowed for a precise explanation of the mechanisms underlying the processes and an assessment of the stability of the photoactive materials.