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According to the literature data, the double pyramid structured TiO_2 photocatalysts with exposed (001) facets exhibit higher photocatalytic activity due to better separation of charge carriers. In addition, doping and surface modification of TiO_2 with noble metals allows to expand the semiconductor's application capabilities by the utilization of solar radiation (due to the existence of localized surface plasmon resonance).

The aim of the research was to obtain decahedral TiO_2 modified with mono- and bimetallic nanoparticles (Ag, Au, Pt, Pd, Rh, Ru, Ag/Pt, Ag/Au, Au/Pd, Au/Pt) and better understanding degradation pathway of isotopically labeled (1-^{13}C) phenol under UV-Vis irradiation. The effect of (i) method used to obtain nanoparticles deposited on the surface of semiconductor (radiolysis and photodeposition method), (ii) type, composition and size of the deposited nanoparticles, and (iii) type and amount of metals (mono- and bimetallic nanoparticles) on the photoactivity under UV-Vis and Vis irradiation was investigated. Phase and chemical composition analysis as well as identification of ^{13}C-labeled phenol degradation intermediates was performed for selected photocatalysts. It has been shown that the photocatalytic degradation efficiency of TiO_2 nanosheets modified with monometallic nanoparticles depended on the amount, size and type of noble NPs deposited on semiconductor surface. Furthermore, it has been demonstrated that the method used to deposit noble metal had influence on the photocatalytic activity of decahedral TiO_2 particles modified with bimetallic nanoparticles. The highest phenol degradation rate (0.52 $\mu mol \cdot dm^3 \cdot min^{-1}$) under the visible light irradiation was observed for sample obtained by simultaneous photodeposition of Au/Pt metal ions on the semiconductor surface. It has been shown that phenol degradation proceeded mainly by hydroxyl radicals attack. Based on the research of identification of the phenol degradation products in the presence of noble metal nanoparticles modified photocatalyst, it was concluded that the degradation pathway of hydroquinone or benzoquinone can be carried out by several pathways. In the case of Rh-TiO_2 series of photocatalysts, it has been shown that doping of TiO_2 with rhodium leading to an increase in photocatalytic activity in phenol degradation process under both, UV-Vis and Vis irradiation. The highest photocatalytic activity was observed in the case of decahedral TiO_2 doped with 0.2 wt. % of rhodium. Based on the XPS analysis, it was concluded that rhodium was present in the form of Rh^{3+} ions, which may be responsible for enhanced photoactivity. During phenol oxidation, the main identified intermediates of phenol degradation were hydroquinone, catechol, maleic acid, fumaric acid and malonic acid.