Enhanced photocatalytic performance of Cu-modified TiO_2: the effect of titania matrix

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Titanium(IV) oxide (titania, TiO_2) is a semiconductor with a great potential to apply as a photocatalyst. TiO_2 is low-cost and non-toxic material with high activity and good stability in photocatalytic reactions. However, titania has some limitations such as poor overlapping of the solar spectrum. Fast recombination between charge carriers: electrons and holes is also detrimental for the efficiency of photocatalytic reaction. These limitation can be solved by modification of titania with metals.

A large number of studies on photocatalysis have been conducted using copper to modify TiO_2. The presence of copper species can enhance the photocatalytic degradation due to electron trapping by the copper ions leading to the prevention of electron–hole recombination. The majority of papers about Cu–TiO_2 concerns this topic.[1-3] It has also been found out that copper may extend the light absorption of titania to the visible light region (also as plasmonic photocatalyst) and incorporate photocatalytic properties into this material in this wavelength range. In both cases the role of copper species with multivalent states in the photocatalytic reaction still remains unclear. Copper is also interesting metal due to its antibacterial properties. The discussion about the type of copper species responsible for visible light photocatalytic activity has been proceeded. Other important research topic is the study of the influence of titania matrix on photocatalytic activity of Cu-modified titania. Moreover the role of oxygen vacancies in TiO_2 matrix is also considered in the discussion.

Different types of titania were selected to serve as a matrix for copper modifier. Two self-prepared anatase titania with different morphology: octahedral anatase particles (OAPs) with eight exposed thermodynamically stable {101} and decahedral anatase particles (DAPs) with two types of crystal facets {101} and {001}, were selected to the study. Comercially available mixture of anatase and rutile: Evonik P25 and fine anatase nanoparticles: Ishihara ST-01 were also chosen as a titania matrix. Selected types of TiO_2 were modified with copper by photodeposition or impregnation method with copper salt. Photocatalytic activity was tested in the following reaction systems: UV/vis induced decomposition of acetic acid, dehydrogenation of methanol under UV/vis irradiation (Fig. 1) and oxidation of 2-propanol under vis irradiation.

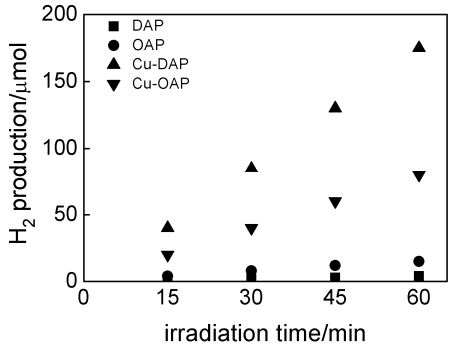

Fig.1 Photocatalytic activity for methanol dehydrogentation on bare and Cu-modified DAPs and OAPs.

Modification of selected TiO_2 by copper improved their photocatalytic properties. The direction of improvement is connected with the type of titania matrix (effect of TiO_2 morphology, phase content) and selected modification method what influences existed form of copper determining the mechanism of the enhancement of photocatalytic activity.

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