Visible-Light-Active Nitrogen-Doped Titanium Dioxide: Preparation and Photocatalytic Application

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Heterogeneous photocatalysis has been an intensively investigated field of science for decades. The band gap of TiO_2 – the most commonly used semiconductor catalyst – is rather wide, therefore titanium dioxide can utilize only a small part of the sunlight's energy. However, there is an increasing demand for extending the sensitivity of this catalyst towards the visible-light region. A visible-light active photocatalyst can be more effective in energetical sense and as an indoor application also self-cleaning and antibacterial surfaces could be realized. Doping TiO_2 with different elements is a widespread technique to create defects in the crystal lattice, thus reducing the minimal energy needed to generate electron-hole pairs.

We synthesized nitrogen-doped TiO_2 by different methods. The physical properties and the photoactivity of the catalysts were studied in detail. In the photocatalytic experiments, coumarine was chosen as model compounds. The photoinduced processes were followed up by recording the absorption and emission spectra of the sample solutions.

The prepared N-TiO_2 – by hydrolysing titanium(IV) isopropoxide in a concentrated solution of NH_3 at low temperature – catalyst contained anatase phase, its specific surface area was around 50 m^2/g. According to SEM images, polydisperse size distribution is characteristic, the particles are of about 10-50 μm. The majority of the grains showed a hollow stucture, which was formed during the hydrolysis of the titanium precursor. The surface characteristics of the catalysts were investigated by inverse gas chromatography. The surface of TiO_2 samples has a Lewis base character, but there is a significant difference in the surface energy homogeneity of each sample.

The nitrogen-doped catalysts displayed a significant activity in the visible range: the initial production rate of 7-hydroxycoumarin was 10 times higher than the values measured for Degussa P25 TiO_2.

Silver nanoparticles were successfully deposited on the surface of N-TiO_2 via a photochemical method. Various concentrations of Ag (10^{-7} to 10^{-4} mol g^{-1}) were investigated in order to study the photoacatalytic efficiency under visible light. The concentration of Ag NPs indicated a critical role on the photoactivity and Ag/N-TiO_2 10^{-6} mol g^{-1} exhibited the highest photocatalytic performance in the coumarin solution. These photocatalysts have been successfully applied for degradation of various insecticides, fungicides and herbicides.

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