Nanocomposites and nanomaterials

Sol-gel synthesis, photo- and electrocatalytical properties of mesoporous TiO_2 modified with transition metal ions.

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Titanium dioxide is a promising material for application in environmental photocatalysis, for the generation of electricity in the solar and fuel cells, gas sensors, optical and protective coatings, electrochemical devices etc. Mesoporous nanosized titania films and powders modified with Co^{2+}, Ni^{2+}, Mn^{3+} and Cu^{2+} ions have been produced by templated sol-gel method and characterized by optical spectroscopy, XRD, and BET surface area measurements. After calcinations at 400°C, XRD patterns showed the anatase nanocrystalline phase formation (8–20 nm). The characteristic bands of Co^{2+} and Co^{3+} in octahedral and tetrahedral oxygen environment registered in diffusion reflectance spectra indicated the formation of Co_3O_4 spinel phase; crystallization of M/TiO_2 powders after heat treatment at 650°C led to an appearance of absorption bands belonging to Ni^{2+} or Mn^{3+} ions in an octahedral and Cu^{2+} in tetrahedral environment.

Band gap energy and the position of flat band potentials were estimated by photoelectrochemical measurements. Photocatalytic activity of metal-doped TiO_2 powders and films coated on titanium electrodes were tested in the processes of dichromate ion reduction, drinking water denitrification and electrocatalytic reduction of dissolved oxygen.

Energy level diagrams of synthesized films were design using the direct electrochemical measurements that allowed predicting high activity of the semiconductors in the electro- and photocatalytic processes. The increase of efficiency of electrocatalytic oxygen reduction due to the incorporation of small amounts of transient metal ions (up to 1%) was observed. The raise of metal ion content led to the lowering of the electrocatalytic activity. The optimal content of cobalt (1-5%), nickel and copper (5%), manganese (1%) ions in TiO_2 is shown to provide the maximum efficiency of dichromate ion reduction. The incorporation of cobalt, nickel, copper and manganese ions in TiO_2 led to the enhancement of the photocatalytic water denitrification process with formation of dinitrogen.