Faculty of Education
Chemistry Department

Production of Renewable Energy and Industrial Wastewater Treatment Using Different Titanium Dioxide Nanocomposites

Thesis Submitted

By

Saad Mahmoud Abdel Aziz Asal

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Approval Sheet

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ABSTRACT

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Pure and x mol% Ln^{3+} modified TiO_2 nanomaterials (Ln^{3+} = Eu^{3+} or Sm^{3+} ions, x = 0, 0.007, 0.020, 0.050, 0.070 mol%) synthesized by a sol–gel at pH = 2. Structure and surface properties of the photocatalysts were characterized by XRD, UV-vis/DR, FT-IR, XPS and N_2 adsorption–desorption at 77 K measurements. The prepared lanthanide doped TiO_2 nanomaterials have anatase phase and exhibit Ti–O–Ln bond. The absorption spectra of the prepared samples reflect the increasing photoresponse of doped samples to visible light over pure TiO_2 and commercially available P25. Surface area is remarkably increased due to lanthanide ion-doping. XPS analysis confirms the presence of Eu^{3+} and Sm^{3+} ions in the doped samples (Eu^{3+}/TiO_2 and Sm^{3+}/TiO_2) in addition to the Ti^{4+} and O. The prepared pure and Ln^{3+} modified TiO_2 nanomaterials, as well as, commercially available P25 were applied for photocatalytic generation photobiogas/hydrogen from acetic acid under N_2 atmosphere. The main gaseous products of CH_3COOH decomposition using these nanomaterials were CH_4 and CO_2. Trace amounts of C_2H_6 and H_2 were also detected in the reaction mixture. Moreover, it was observed that the quantities of all identified gases increased with elongation of irradiation time. The most active photocatalysts towards CH_4 and H_2 generation were Ln^{3+}/TiO_2 containing 0.050 and 0.02 mol. % of Sm and Eu, respectively. In addition, these nanomaterials were also applied for photocatalytic degradation of textile dyes from water under atmospheric condition. Remazol red RB 132 (RR) and brilliant blue (BB) were selected as examples of textile dyes which already used for dying in many factors. The results show that the Ln doping brought about remarkable improvement in the adsorption efficiency and photocatalytic activity over pure TiO_2. The optimal UV light reactivity of the photocatalysts for dyes decolorization was achieved for 0.02 and 0.05 mol% of Eu^{3+} and Sm^{3+} ions, respectively. The results revealed that the Ln^{3+} modification can improve the effectiveness of the photocatalysts compared to pure and commercially available TiO_2 provided that a proper amount of modifying ions is used. Other important parameters which influenced the effectiveness of photobiogas/hydrogen generation and textile wastewater purification in case of Ln^{3+} modified samples were high surface area and low crystallite size of anatase. Furthermore, the presence of lanthanide oxide on the surface of TiO_2 creates a charge imbalance. Therefore, the hydroxide ions would be adsorbed on the surface as we can see from XPS measurements. The hydroxide ions act as hole traps that inhibit electron/ hole pairs recombination as well.

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