

DEVELOPMENT OF VISIBLE-LIGHT-ACTIVE
PHOTOCATALYST FOR HYDROGEN PRODUCTION AND
ENVIRONMENTAL APPLICATION

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ABSTRACT

Semiconductor photocatalysis has been intensively studied in recent decades for a wide variety of application such as hydrogen production from water splitting and water and air treatment. The majority of photocatalysts are, however, wide band-gap semiconductors which are active only under UV irradiation. In order to effectively utilize visible solar radiation, this thesis investigates various types of visible-light active photocatalysts including metal ion-doped TiO_2 , nanocomposites of potassium niobate (KNbO_3) and CdS with Ni co-catalyst, and a mixed-phase CdS matrix interlinked with elemental Pt deposits.

Thirteen different metal ion-doped TiO_2 nanoparticles are synthesized. I compare the effects of individual dopants on the resulting physicochemical properties and corresponding photocatalytic activities with respect to the catalysis of several reactions under visible-light irradiation. I found several metal ion-doped TiO_2 nanoparticles such as Pt, Cr, and V had visible-light photocatalytic activities and the presence of rutile phase in these metal ion-doped TiO_2 may affect their photoreactivities. In addition, visible-light photocatalytic activities of TiO_2 are enhanced by co-doping with two metal ions.

Hybrid nanocomposite photocatalysts based on CdS nanoparticles (e.g., $\text{Ni}(0)/\text{NiO}/\text{KNbO}_3/\text{CdS}$, Zeolite/CdS, and nanocomposites of Q-sized cubic phase CdS and bulk-phase hexagonal CdS interlinked with elemental Pt deposits) are also studied. Different types of CdS nanocomposite photocatalysts are synthesized, optimized, and characterized using various analytical techniques. It is shown that these nanocomposites can enhance inherent photocatalytic activity of bulk-phase CdS for hydrogen production via effective

charge separation of photogenerated electrons and holes in CdS under visible-light irradiation.

Additionally, a sub-pilot size hybrid electrochemical system with Bi-doped TiO₂ anodes and SS cathodes for the degradation of organic pollutants and simultaneous hydrogen production has been developed to make the electrochemical system more economically viable. This system degrades a variety of organic pollutants and real wastewater with simultaneous production of hydrogen at the current efficiencies of 50~70%. Furthermore, it is demonstrated that this electrochemical system can be driven by a photovoltaic (PV) cell.

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