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

Thesis by

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In Partial Fulfillment of the Requirements

for the Degree of

Doctor of Philosophy

California Institute of Technology

Pasadena, California

2010

(Defended October 13, 2009)

ACKNOWLEDGEMENTS

Over the last six years of my graduate school time at Caltech, I have learned great things not only about science and academics, but also about the life, the truth, and the faith. It was a quite tough lesson especially in the beginning, but I have to say I have truly enjoyed every moment of learning and I am so grateful to have these kinds of experience in my life. I believe this is possible only because of all the people supporting me in many ways and I would like to acknowledge them.

First of all, I would like to thank my advisor, Prof. Michael Hoffmann, for all the support and guide throughout the years. He gave me many opportunities, which are very important to build up my academic career, and he was always supportive whenever I proposed new research topics or brought some problems of ongoing study or even personal matter. I also thank to the committee members, Prof. Paul Wennberg, Prof. Harry Gray in Chemistry, and Prof. Mark Davis in Chemical Engineering. As the option representative, Prof. Paul Wennberg was always ready to help and cheer me when I went through a hard time in the beginning as the international graduate student. Prof. Harry Gray and Prof. Mark Davis gave me helpful comments for future research. I also thank Prof. Nathan Lewis in Chemistry, who served as a committee chair of my Ph.D. candidacy exam, for his great advice in the middle of graduate research.

Also, I want to thank all my collaborators. Dr. Suyong Ryu and Dr. Bill Balcerski help me when I started my first research works in the lab. and Prof. Hyunwoong Park helps me to figure out a new research topic when he was a postdoc in Hoffman group. Prof. Luciana Silva who was a visiting professor from Brazil showed me her passion for science and soccer when we worked together and also sent me a greeting postcard and

photo-book of her hometown, Salvador, when she went back. Prof. Wonyong Choi and Prof. Kwhang-ho Choo gave me helpful comments not only for my research, but also for my future academic career during their sabbatical staying at Caltech. I would like to thank Dr. A. J. Colussi for his insightful comments during every group meeting and Dr. Nathan Dalleska for his great technical support. I also worked with several visiting students and surf students like Sheng Hong Soong and Ning Du. They helped some experiments, and at the same time, gave me a great opportunity to help and teach them as a mentor.

I would like to thank all the former and current members of Hoffmann group for the helps. We had many group meetings, lab cleaning/organization (which is the most difficult job!), and fun group activities together; Dr. Christopher Boxe, Dr. Marcelo Guzman, and Dr. Chad Vercitis welcomed me when I joined Hoffmann group and showed good examples in academic after graduation. Jie Cheng was the one of the longest friend in the lab. and Dr. Shinichi Enami was always a supportive friend. Tammy Campbell and Rifka Kameel were the best officemates and I am so grateful that I could have never-ending girls-only chatting time in the office. Dr. Rich Wildman was a super-nice friend and my savior in the first year. Dr. Megan Ferguson and Dr. Kate Campbell were great woman colleagues when I worked in Prof. Janet Hering group. I also thank all the department/Keck lab. crew, Fran Matzen, Cecilia Gamboa, Linda Scott, Dian Buchness, and Mike Vondrus for their support and kindness.

I want to thank all my friends that I met during my graduate school life for their help and encouragement. Especially, I thank Dong-whan Kim and Jung-sook Kim GSN for their spiritual advice. Through their passion and dedication, I could learn and practice

what the faith is and how I should live my life as Jesus' disciple and as a lifetime Soonjang, which means a true spiritual leader serving others with love.

Finally, I want to give all my thanks to my family. My husband, Wonhee is my biggest supporter, greatest friend, and closest spiritual partner in all ways. I truly believe Wonhee is a man who God sent to me to express His love and show His will in my life. I also thank my beloved parents, sister Jihye and brother Jiwon. With their consistent love, support, and prayers in tears, I could be able to go through all the hardships. My parents-in-law always supported and cheered me so that I could focus on my study.

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., Ni(0)/NiO/ $KNbO_3$/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 TiO_2 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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