CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

William Porayouw

Project Number

S0619

Project Title

Constructing Earth-Abundant Core Shell Plasmonic Photocatalysts for Hydrogen Production via Water Splitting

Abstract

Objectives

Currently, new alternatives for current greenhouse gases are of great interest, and hydrogen is a major player in the race for a new main source of fuel. Hydrogen can be produced through a photocatalytic water splitting process, and although titanium dioxide (TiO2) is a well known photocatalyst, factors such as its high recombination rate and an absence of a visible light absorption peak hinders its performance. By constructing transition metal-metal oxide core shell nanostructures (CSNs) that introduce copper (Cu) as a co-catalyst core, these issues with the semiconductor material can be addressed.

Methods

To create efficient photocatalysts for hydrogen production, synthesis methods for earth abundant core shell Cu@TiO2 nanostructures were designed. In order to construct these CSNs, a Cu core was synthesized through a modified sol-gel method with Hexamethylenediamine (HDA) as a capping agent and glucose (C6H12O6) as a reducing agent, and size and morphology was controlled to create uniform nanostructures. Then, titanium isopropoxide (TIP) was hydrolyzed into TiO2 with a diethanolamine (DEA) base catalyst, and coated on the Cu core with the assistance of HDA as a surfactant.

Results

The CSNs were characterized through TEM and SEM imaging, UV-vis spectroscopy, and a photocatalytic test based on light irradiation. After 5 hours in a photocatalytic chamber, it was found that industrial grade TiO2 produced the least amount of hydrogen, while prepared hollow TiO2 produced twice as much as the industrial type, and Cu@TiO2 produced the greatest amount of hydrogen, about 100 times as much as industrial TiO2.

Conclusions

Cu successfully accelerated the semiconductor-light reactions by expanding the absorption spectra of TiO2 and optimizing its plasmonic resonance property, lowering the band gap, and reducing recombination. In addition, Cu, is a cost-effective and earth-abundant potential co-catalyst, which makes the metal convenient for large scale manufacturing. Therefore, the Cu@TiO2 CSNs proved to be efficient photocatalysts that should be further explored.

Summary Statement

I constructed novel core shell nanostructures that utilized titania as a semiconductor shell and copper as a plasmonic core in order to optimize photocatalytic efficiency.

Help Received

This project was completed at the Yin Lab at the University of California, Riverside. Thank you to Dr. Yadong Yin and graduate student Yubo Tan, who offered mentorship and guidance throughout the duration of this project.