CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

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Project Number

38809

Project Title

TiO2 Hollow Shell around Gold Nanoparticles: A More Efficient Photocatalyst

Abstract

Objectives/Goals

Synthesize gold nanoparticles surrounded by a TiO2 hollow shell to serve as a more efficient photocatalyst.

Methods/Materials

First, the gold nanoparticles were prepared by mixing the prepared gold precursor with trisodium citrate. Then, polyvinylpyrrolidone (PVP) was coated on the gold nanoparticles to prevent them from aggregating. The nanoparticles were then coated with a layer of silica. The titania was coated over the silica, and the silica was then etched, which created a hollow space around the gold nanoparticles. Hydrochloric acid (HCl) was added so that the TiO2 surrounding shell would remain intact under high temperature conditions during calcination. Titania hollow shells without a gold core were synthesized as a control. The TiO2 and the gold-nanoparticles with TiO2 were then compared to see which of the two would be a more efficient photocatalyst in the degradation of the organic dye Rhodamine B (RhB). The 3 samples analyzed were: RhB blank sample, RhB with only TiO2 hollow shell, and RhB with Au@TiO2 catalyst. 1 mL of each sample was taken every 10 minutes for one hour. The UV-visible absorption spectrophotometer was used to compare breakdown rates of the RhB in each of the 3 samples.

Results

The RhB decomposed the slowest with no catalyst. When the TiO2 shell was sonicated in the sample, the RhB degraded at a much faster rate. The reaction worked the best with the Au@ TiO2 photocatalyst, especially with the samples taken from thirty minutes to sixty minutes. At ten minutes, the TiO2 had a slightly more efficient breakdown, but the gold and titania quickly surpassed the rate of the reaction using only titania.

Conclusions/Discussion

Using gold nanoparticles in a TiO2 shell is a more efficient photocatalyst. This is due to the surface plasmon resonance property of gold nanoparticles which causes them to absorb and scatter light. This in turn optimizes the excitation of electrons in the titania hollow shell, leading to the formation of more electron hole pairs. Formation of electron hole pairs serves as the basis for the photocatalytic activity of titania. This can be used in many reactions such as decomposition of organic dyes and redox reactions including the splitting of water to produce hydrogen gas. It is a possible solution for a cleaner source of hydrogen gas.

Summary Statement

Optimal photocatalytic activity was achieved by combining a gold nanoparticle inside a titania hollow shell.

Help Received

This project was completed at Dr. Yadong Yin's lab in the Department of Chemistry at the University of California Riverside. Graduate student Rashed Aleisa mentored me in this project.