SYNTHESIS OF TiO₂-CdS PHOTOCATALYST & STUDYING ITS PHOTOCATALYTIC ROLE FOR: (i) CARBAMAZEPINE DEGRADATION & (ii) WATER SPLITTING, UNDER SOLAR & UV RADIATION

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Motivation & Relevance to Research

The existing technologies that are employed on wastewater treatment plants are found to be insufficient as far as the treatment of a rapidly growing number of contaminants such as pharmaceuticals, dyes, and several other industrial chemicals are concerned. In particular, the carbamazepine (CBZ), one of the common antidepressants that is only 52% metabolized by human body, showed insignificant degradation on UV treatment. However, preliminary results in our lab have shown effective degradation under UV activated TiO₂ photocatalyst. In project, we synthesized the novel CdS-TiO₂ photocatalyst that is believed to be capable of utilizing a broader visible range of solar light by the process called Inter-particle charge transfer (IPCT) to drive the more efficient redox reaction that produces advanced oxidative degradation of carbamazepine. In addition, a renewable & inexpensive method of H₂ production by photocatalytic splitting of water by this photocatalyst will also be studied. The trade off between these two functions of this visible-active photocatalyst will be optimized.

Project Objectives

To develop a general technique to synthesize TiO₂-CdS photocatalyst for:

1. Carbamazepine degradation
   - Testing degradation rates under various experimental conditions
   - Proposing a general reaction mechanism and global reaction kinetics
   - Evaluation of overall efficiency of this photocatalyst for this purpose

2. Hydrogen production by photocatalytic water splitting
   - Testing H₂ production rates under various experimental conditions
   - Proposing a general reaction mechanism and global reaction kinetics
   - Evaluation of overall efficiency of this photocatalyst for this purpose

3. Developing an optimized operating conditions for its dual function

Methods & Methodology

Sol-Gel synthesis of TiO₂ nanoparticles using titanium isopropoxide precursor

1. Sol formation by hydrolysis of the precursor:
   - Dissolve titanium isopropoxide (precursor) in alcohol (e.g. ethanol)
   - Mix the solution in water followed by vigorous stirring that causes hydrolysis of the precursor forming titanium hydroxide (sol form)
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2. Gel formation by condensation of the Sol:
   - Condensation of titanium hydroxide (sol) forms the TiO₂ (gel)
   - Water condensation
   - Alcohol condensation

3. Aging of the Gel:
   - Over the time, polycondensation occurs that increases the 3-D gel network

4. Drying & Calcination:
   - Gel is subjected to drying at ambient condition for a long time or calcined

5. Recovery of the synthesized TiO₂-CdS photocatalyst from the mixture

Analysis

Using the UV/Visible Spectrophotometer, absorbance by the sample is measured, and by applying the Beer-Lambert’s equation, the concentration of the sample is determined:

\[ A = \epsilon I \Rightarrow \epsilon = \frac{A}{I} \]

Results & Future Work

- TiO₂-CdS composite photocatalyst was successfully synthesized in the laboratory for performing the experiments
- Characterization of this photocatalyst will be done: (i) particle size using Dynamic Light Scattering (DLS) and (ii) XRD for elemental analysis
- Suspension based photocatalytic degradation studies of carbamazepine will be performed in UV and Visible lights using photocatalytic reactor present in Dr. Arce’s lab (PH 353)
- The progress of the reaction will be analyzed using Spectrophotometer (Dr. Sanders’ lab, Prescott 401)
- Coating-based continuous process for CBZ degradation will be performed in lab scale and the results will be upscaled and eventually implemented in practice
- Photocatalytic water splitting for H₂ generation using Platinum doped TiO₂-Cds will be studied.

References


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