PR190001

Development of Hybrid Nanostructures for Photocatalysis and Water Splitting

Associated Centre in A-DIRAC: Centre for Advanced Materials

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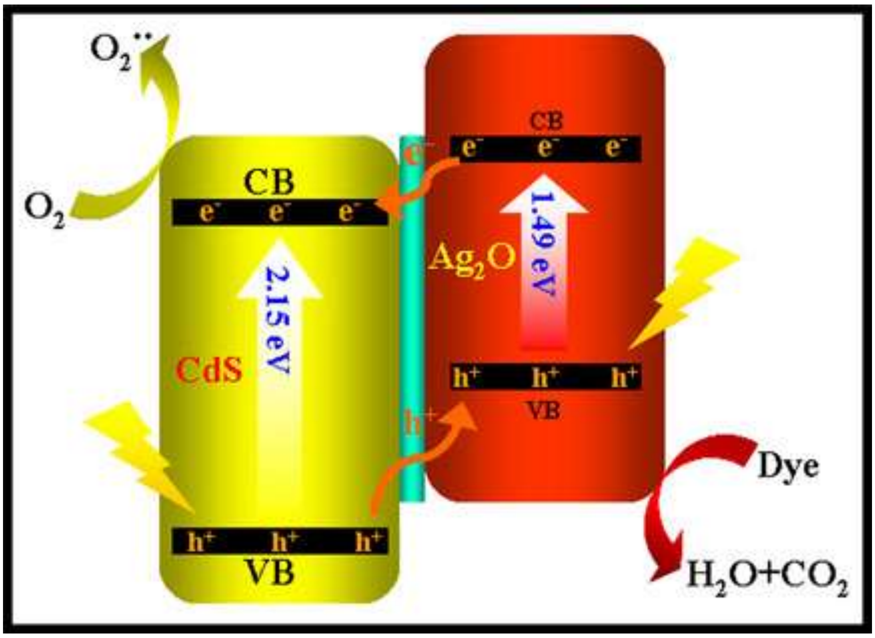
Project Description and its implementation

Aim of the project:

The main aim of the project is to address challenges in the treatment of polluted water, focusing on dye degradation in wastewater from the textile industry using the mechanism of visible light photocatalysis.



Schematic Representation of Photocatalysis mechanism

Introduction:

Global warming is a main concern at present which can turn life on earth hostile for the future generations. The need to save the planet has to be addressed with top priority through the development of sustainable, renewable, green and clean solutions. . Water pollution has been a problem for decades, not only for human beings but also for other living beings and vegetation as well, from the time industrialization expanded. Water resources are massively polluted by toxic discharge from these industries and has been reason for several chronic diseases in living beings.. In addition to the fatal diseases that it causes in living beings, the intake of these toxic pollutants through water lead extinction of aquatic life, which in turn affect the natural ecological cycle. The printing and dyeing materials with complex organic composition form the principal industrial wastewater contaminant which resist to degrade even after decades or even centuries. Hence a robust solution for effective water treatment to advance towards a sustainable future is the need of the hour. At this juncture, photocatalysis comes into picture with its strong ability for dye and organic pollutant degradation where the complex organic pollutants can be broken down into simple inorganic substances like carbon dioxide and water that are free from the residues of secondary pollutants. With the advantage of visible light illumination from freely, naturally and endlessly available sunlight, photocatalytic oxidation is more effective than its conventional counterparts of adsorption, absorption, coagulation, flocculation, precipitation, ultrafiltration, air striping, reverse osmosis, membrane technologies or ozonation which focuses on transforming organic compounds from one phase to another

Formation of Nanocomposites

Present investigation reports the synthesis of stable as well as visible-light active CdS/Ag_2O nanocomposite photocatalysts in three varied ratios to be engaged in degradation of methylene blue (MB) dye. As-synthesized photocatalysts have been characterized with the aid of diverse characterization techniques such as X-ray diffraction (XRD), FT-Raman, Fourier transform infrared spectroscopy (FT-IR), X-ray photoelectron spectroscopy (XPS), UV-visible and Photoluminescence (PL) spectroscopy, and transmission electron microscopy (TEM). XRD pattern clearly depicts the presence of hexagonal CdS phase and cubic Ag_2O phase. Results show a remarkable enhancement of photocatalytic activity for MB degradation especially for CdS/Ag_2O nanocomposite with maximum efficiency up to 88.8%. Moreover, the effective bandgap of CdS/Ag_2O (1: 2) nanocomposite has been significantly reduced to 1.71 eV from pure CdS (2.15 eV). It can be derived that CdS/Ag_2O photocatalysis may be envisaged for treatment of diluted waste water containing organic pollutants. We also report the realization of high-quality crystalline CdS/Mn_3O_4 nanocomposite by simple cost-effective chemical method in air.. We have performed theoretical calculations and experimental analysis in order to understand the synthesized nanocomposites. X–ray diffraction results showed that the CdS/Mn_3O_4 nanocomposites were cubic and orthorhombic mixed structure which is in well agreement with the theoretical studies. Field emission scanning electron microscopy images of CdS/Mn_3O_4 confirmed the formation of well distributed nanocomposites. The outcomes of DFT calculations provide results for the bandgap calculation of pure CdS, Mn_3O_4 and the CdS/Mn_3O_4 nanocomposites. Photoluminescence studies with interesting visible light absorption demonstrated the great potentiality of the as-synthesized nanocomposites towards photocatalytic applications that could be a detailed research scope for our future studies.

Photocatalysis

The synthesized nanocomposites exhibited strong visible light absorption and emission in the red region with high enhancement. The observed low PL intensity for CM nanocomposites indicates its potential candidacy in having good photocatalytic activity. The applications of photocatalytic activity includes removal of environmental pollutants, dye degradation, antibiotic reduction and water splitting hydrogen technology. The photocatalytic materials have a tendency for direct energy transfer from light interaction to highly reactive chemical species. Currently, nanostructured heterojunction photocatalysts are becoming more promising than the individual components because it creates synergic effects giving rise to high photocatalytic activity. The main advantage of the heterostructure is that it prevents the faster electron–hole recombination reaction and hence sufficient time for electron /or hole to reach the surface of the photocatalyst. Therefore, the rate of redox reaction increases via electron–hole enrichment.

Research Collaborator:

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List of publications and Outcome:

Sophia, P. Joice, D. Balaji, T. James Caleb Peters, D. Sathish Chander, S. Vishwath Rishaban, P. Vijaya Shanthi, K. R. Nagavenkatesh, and M. Rajesh Kumar. "Solar Induced Photocatalytic Degradation of Methylene Blue by CdS/Ag_2O Nanocomposites." ChemistrySelect 5, 14 (2020) 4125-4135. https://doi.org/10.1002/slct.202000475

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