FACILE FABRICATION OF THE VISIBLE-LIGHT DRIVEN NANOCOMPOSITES AS PHOTOCATALYSTS FOR THE DEGRADATION OF ORGANIC POLLUTANTS

Synopsis submitted to Madurai Kamaraj University for the award of the degree of

Doctor of Philosophy in Chemistry

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December-2018

SYNOPSIS

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Nanoscience and nanotechnology is an emerging technology and by the use of it may be able to create many new materials and devices with a vast range of applications in medicine, electronics, biomaterials, energy production etc [1]. Catalysts in nano level have potential photocatalytic application in environmental remediation due to their easy availability, nontoxic nature, inertness, biological and chemical stability [2-3]. Photocatalysis is the most attractive technique which opens a new route to solve the growing environmental pollutions and energy shortages by utilizing abundant sunlight to treat the serious problem of water pollution and solve the environmental problem [4].

One of the most pervasive problems which affect the people throughout the world is the contamination of water resources by various pollutants. There are different types of organic pollutants such as dyes, phenols, pesticides, herbicides and pharmaceutical ingredients are discharged into the environment from various industries. Most of them are highly toxic and carcinogenic in nature even at low concentrations and they can also easily accumulate into the food chain [5-6]. Problems with water are expected to grow worse in the coming decades, even in regions currently considered water-rich. A tremendous amount of research is needed to identify new methods of purifying water at lower cost and with less energy, while at the same time minimizing the use of chemicals and impact on the environment [7-8].

Today, semiconductors are usually selected as photocatalysts and Photocatalysis focuses mainly on the use of semiconductor metal oxides like TiO_2, ZnO, Fe_2O_3, CeO_2, SnO_2, etc [9-10]. The main advantages of using semiconductor metal oxides in photocatalysis are its high functionality, high photochemical stability, exhibiting tuneable properties which can be modified by size reduction, doping, using sensitizers and complete mineralization of organic pollutants.

To modify and further develop this technology, we can couple a narrow band-gap semiconductor with a wide band-gap semiconductor. This type of coupled semiconductors have great technological importance because of their promising arrangement of electronic structure, light absorption properties, and charge transport character [11-12]. This is one of the best environmentally benign technologies that offer great potential for complete elimination of toxic chemicals from the environment because of its high efficiency and broad applicability [13-14].

In this research work five different nanocomposites have been synthesized and their photocatalytic activity has been evaluated by the photodegradation of organic pollutants under visible light. The thesis consists of eight chapters.

CHAPTER-I

Introduction

A brief introduction about nanotechnology and nanomaterials, nanomaterial's types, its synthesis method and applications of nanotechnology, need for photocatalysts are described in **chapter 1.**

CHAPTER-II

Materials and methods

The general methods for the synthesis of nanomaterials, chemicals used, analytical techniques employed for characterization and photocatalytic activity are discussed in **chapter 2.**

CHAPTER-III

Facile synthesis of heterostructured p-$LaNiO_3$/n-TiO_2 as visible light active catalyst for photocalatytic degradation of 4-Chlorophenol

Chapter 3 expounds the synthesis of $LaNiO_3/TiO_2$ nanocomposite in different molar ratios by precipitation deposition method. The obtained nanocomposite's physicochemical properties were scrutinized by UV-Visible Diffuse Reflectance Spectroscopy (UV-Vis-DRS), Fourier Transform Infrared spectroscopy (FT-IR), Photoluminescence Spectroscopy (PL), X-Ray Diffraction (XRD), Energy Dispersive X-Ray Spectroscopy (EDX) and Field emission Scanning Electron Microscopy (SEM). Transmission Electron Microscopy (TEM) was employed to analyze the morphology of 7.5%$LaNiO_3$ /TiO_2. The photocatalytic efficiency and COD of the synthesized catalyst was examined by the degradation of 4-Chlorophenol (4-CP). The influence of various factors on the degradation of 4-Chlorophenol were investigated and in addition reusability and stability of the 7.5%$LaNiO_3/TiO_2$ catalyst was also investigated. UV-Vis DRS and PL are the evidences for extending light absorption in the visible region and improved photocatalytic activity of 7.5%$LaNiO_3/TiO_2$ is greater than 5.0% and 2.5% of nanocomposites. 7.5%$LaNiO_3/TiO_2$ nanocomposite shows the maximum degradation efficiency of 91% in 3-hours of simulated solar light irradiation with 78.21% COD removal. A possible photocatalytic mechanism has also been proposed and degradation follows pseudo-first order kinetics.

CHAPTER-IV

Exceptional UV-Visible light-driven Photocatalytic activity over BiOI/CeO_2 Nanocomposite

Chapter 4 annotates the fabrication of BiOI-CeO_2 nanocomposites in three different molar ratios 1%, 3% and 5% of BiOI-CeO_2 and their photocatalytic activity towards Ciprofloxacin Hydrochloride (CFH). The structure and morphological characteristics of the fabricated BiOI-CeO_2 composites were confirmed by UV-Vis-DRS, FTIR, Photoluminescence Spectroscopy (PL), X-ray diffraction, SEM with EDAX techniques. The photocatalytic activity of 1%, 3% and 5% BiOI-CeO_2 catalyst was compared and 3% BiOI-CeO_2 ratio was found to show superior activity than 1% and 5% BiOI -CeO_2 molar ratio and t components BiOI, CeO_2. The band edges of materials have been theoretically calculated on the basis of Mulliken electronegativity of atoms. The effect of operational parameter such as pollutants concentration, pH, dosage and OH radical trapping, COD has been investigated in details. The kinetics of the photo degradation reaction correlated with the pseudo-first-order model. The stability of the 3% BiOI-CeO_2 nanocomposite was examined by recycling the experiments.

CHAPTER-V

Fabrication of mesoporous $CuBi_2O_4$/CuS nanocomposite and study of its photocatalytic activity

Chapter 5 describes the synthesis of Novel $CuBi_2O_4$/CuS nanocomposite with different mass ratios 1%, 5%, 10% of $CuBi_2O_4$ by the solid–phase and precipitation-deposition method. The physical and photophysical properties of the photocatalyst have been characterized by UV-visible diffuse reflection spectra, FT-IR spectroscopy, photoluminescence spectra (PL) X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray spectrometry (EDX), transmission electron microscopy

(TEM) and BET- surface area respectively. The prepared photocatalytic material of 10% $CuBi_2O_4$/CuS nanocomposite exhibited higher photocatalytic performance as well as excellent degradation of para-Amino Phenol (p-AP) than that of 5% $CuBi_2O_4$/CuS, 1% $CuBi_2O_4$/CuS, $CuBi_2O_4$, and CuS, respectively. The results of PL indicated that $CuBi_2O_4$ and CuS could combine well to form a composites structure which facilitated electron-hole separation, and led to the increasing photocatalytic activity. The mechanism of enhanced photocatalytic activity was proposed on the basis of the experimental results and estimated energy band positions. It also observed that $CuBi_2O_4$/CuS composites showed better antibacterial activity against staphylococcus and bacillus.

CHAPTER-VI

Fabrication of an eco-friendly, stable Chitosan capped Fe_2O_3-CeO_2 Nanocomposite and its photocatalytic activity under visible-light

Chapter 6 explains the synthetic route of Chitosan capped Fe_2O_3-CeO_2 nanocomposite by two-step process. The microstructure, purity, morphology, and spectroscopic properties of the resultant samples have been characterized using XRD, EDX, SEM, TEM, FT-IR and UV-Vis DRS techniques. Photocatalytic activity of the prepared samples was investigated by the photodegradation of pollutants (Rhodamine B and 4-Chloro Phenol) under visible-light irradiation. The photocatalytic experiments exposed that the ternary Chit-Fe_2O_3-CeO_2 nanocomposite has an enhanced activity than the binary and pure photocatalysts, which was attributed to the synergistic effect between metal oxides and the support of the biopolymer. The kinetics of the photodegradation, possible mechanism, COD and hydroxyl radical trapping experiments were also examined. The reuse and stability analysis validated the stability of the ternary photocatalyst.

CHAPTER-VII

Facile Synthesis of curcumin stabilized heterogeneous NiO/CdO nanocomposite photocatalyst under visible-light irradiation

Chapter 7 explores the fabrication of a ternary Curcumin stabilized NiO/CdO nanocomposite using precipitation deposition method. Optical properties, Chemical composition, phase purity, crystal size, surface area and the microstructure of the obtained photocatalyst were investigated by UV–Vis diffuse reflection spectroscopy, FT-IR spectroscopy, X-ray diffraction, energy dispersive X-ray analysis, Brunauer-Emmett-Teller surface analysis, Scanning Electron Microscopy (SEM) and High Resonance Transmission Electron Microscopy (HR-TEM). The ternary nanocomposite shows an enhanced photocatalytic activity with maximum degradation efficiency under visible light irradiation for the photodecolourisation of crystal violet compared with binary NiO/ CdO nanocomposite, pure NiO and CdO. The stability of the photocatalyst and the influence of various operational parameters such as pH, catalyst dosage and initial dye concentration on the photo degradation were investigated in detail. Langmuir -Hinshelwood model was used to elucidate the kinetics of the photodegradation of crystal violet. The enhancement in photocatalytic activity demonstrates the synergistic effect and efficient charge separation among NiO, CdO and Curcumin.

CHAPTER-VIII

Chapter 8 consists of the summary and conclusion of this work. In this research work, the successful synthesis and characterization of different metal oxide nanocomposites and their photocatalytic activity under visible light irradiation for the degradation of organic pollutants were studied. It is expected that the metal oxide nanocomposites with high photocatalytic activity will greatly contribute a new imminent to eliminate the organic pollutants from industrial wastewater.

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