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Iron oxide nanocatalyst with titanium and silver nanoparticles: Synthesis, characterization and photocatalytic activity on the degradation of Rhodamine B dye

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Nowadays, there is a growing concern about the environmental impacts of colored wastewater. Thus, the present work aims the synthesis, characterization and determination of photocatalytic activity of iron oxide (Fe_2O_3) nanocatalyst, evaluating the effect of hybridization with titanium ($\text{TiNPs-Fe}_2\text{O}_3$) and silver ($\text{AgNPs-Fe}_2\text{O}_3$) nanoparticles, on the degradation of Rhodamine B dye (RhB). Nanocatalysts were characterized by XRD, SEM, TEM, FTIR, N₂ porosimetry (BET/BJH method), zeta potential and DR5. Photocatalytic tests were performed in a slurry reactor, with the nanocatalyst in suspension, using RhB as a target molecule, under ultraviolet (UV) and visible radiation. Therefore, the photocatalytic activity of the nanocatalysts (non-doped and hybridized) was evaluated in these ideal conditions, where the $\text{AgNPs-Fe}_2\text{O}_3$ sample showed the best photocatalytic activity with a degradation of 94.1% ($k = 0.0222 \text{ min}^{-1}$, under UV) and 58.36% ($k = 0.007 \text{ min}^{-1}$, under visible), while under the same conditions, the $\text{TiO}_2\text{-P25}$ commercial catalyst showed a degradation of 61.5% ($k = 0.0078 \text{ min}^{-1}$) and 44.5% ($k = 0.0044 \text{ min}^{-1}$), respectively. According with the ideal conditions determined, reusability of the $\text{AgNPs-Fe}_2\text{O}_3$ nanocatalyst was measured, showing a short reduction (about 8%) of its photocatalytic activity after 5 cycles. Thus, the Fe_2O_3 nanocatalyst can be considered a promising catalyst in the heterogeneous photocatalysis for application in the degradation of organic dyes in aqueous solution.

Dyes are substances with high application potential in the most diverse areas, mainly to color the final products of textile, precious stones, leather, paper, plastics and food. For example, it is estimated that there are more than 100,000 synthetic dyes, with an annual production of more than 700,000 tons worldwide, generating a significant amount of wastewater¹. In addition, these colored waters are characterized by complex aromatic compounds, making their biodegradation difficult, becoming an environmental liability. Thus, advanced processes are needed to promote their correct treatment in order to meet environmental norms and legislation².

In this context, the Advanced Oxidative Processes (AOPs), highlighting the heterogeneous photocatalysis, becomes an attractive alternative, since they are technologies with potential to oxidize a great variety of complex organic compounds³, using a highly oxidant and less selective species (the hydroxyl radical, $^{\bullet}\text{OH}$), capable of mineralize many organic compounds⁴. Thus, the heterogeneous photocatalysis involves the photoactivation of a semiconductor (catalyst), under visible or ultraviolet radiation, with energy equal to or greater than band gap energy⁵, promoting oxy-reduction reactions on the catalytic surface and thus the degradation of organic pollutants.

Among the most used catalysts are titanium dioxide (TiO_2), cadmium sulfide (CdS), zinc oxide (ZnO), zinc sulphide (ZnS), tungsten trioxide (WO_3), tin dioxide (SnO_2) and iron oxide III (Fe_2O_3)⁶. However, these catalysts

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**Harekrushna Sahoo, Jitendra Kumar
Sahoo**



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Advanced Nanocatalysts for Biodiesel Production Bhaskar Singh, Ramesh Oraon, 2022-09-22 *Advanced Nanocatalysts for Biodiesel Production* is a comprehensive and advanced book on practical and theoretical concepts of nanocatalysts dealing with future processing techniques towards environmental sustainability. The book critically discusses on latest emerging advanced nanocatalysts for biodiesel production aimed at reducing complexities and cost in the quest to meet future energy demands. Efforts have been made at clarifying the scope and limitations of biodiesel production in large scale commercialization. The book discusses the size dependent catalytic properties of nanomaterials and their working mechanisms in biodiesel production. Life cycle assessment of optimized viable feedstock from domestic as well as industrial waste is also addressed to improve the efficiency of biodiesel production. The book will be a valuable reference source for researchers and industrial professionals focusing on elementary depth analysis of nanocatalyst multifunctional technological applications in seeking key ideas for mimicking biodiesel production towards ecology and the economy. **Key Features** Provides a comprehensive environmental assessment of advanced nanocatalysts for biodiesel production to meet the world's energy demands. Discusses the green platform based nanocatalysts like metal oxides sulphides 2D layered material synthesis and their relevance for biodiesel production. Presents a pathway for cheaper cleaner and more environmentally friendly processing techniques for biodiesel production. **Functionalized Magnetic Nanomaterials** Shikha Gulati, 2025-10-08 This contributed volume provides a comprehensive exploration of functionalized magnetic nanomaterials (FMNs) detailing their historical development, fundamental properties and synthesis techniques. It focuses on surface functionalization strategies, characterization methods and the various industrial applications of FMNs in fields like catalysis, environmental remediation and renewable energy. The chapters cover the mechanisms behind FMNs effectiveness in catalysis and pollution control as well as their roles in advanced material design and chemical sensing. Finally, the book discusses the challenges of scaling up production for industrial use and highlights future trends and innovations in this rapidly evolving field. It is a valuable resource for graduates, researchers and professionals working in the areas of materials science, nanotechnology, chemistry and environmental science. *Nanotechnology* Martín F. Desimone, Rajshree B. Jotania, Ramdas B. Khomane, Ratiram G. Chaudhary, 2025-06-30 *Nanotechnology* has the potential to revolutionize the way we address environmental challenges. From water purification, renewable energy and pollution remediation, nanomaterials offer new and innovative solutions to some of the most pressing problems facing our planet. This book discusses the latest advances in nanotechnology and its potential applications for environmental protection and sustainability. The book covers a wide range of topics from the fundamental principles of nanotechnology to specific case studies of nanomaterials being used to solve real world environmental problems. This book is intended for researchers, students, professionals and policymakers. **Synthetic Applications** Rajender S. Varma, Bubun Banerjee, 2022-05-09 Magnetic nanocatalysts are becoming an important tool for greener catalytic processes in

chemical transformations in view of the ease of their removal from a reaction medium This book explores assorted magnetic nanocatalysts their deployment in synthesis chemical transformation and their recovery and reuse Various thematic topics embodied include magnetic nanocatalysts for S S bond formation N heterocycle formation C heteroatom bond formation silica supported catalysts multicomponent reactions including their recyclability another available volume emphasizes the utility of magnetic nanocatalysts in industrial appliances

Biogenic Wastes-Enabled Nanomaterial Synthesis

Abhishek Kumar Bhardwaj, Arun Lal Srivastav, Swapnil Rai, 2024-06-08 This book encompasses the knowledge about diverse types of advanced functional nanomaterial development using biogenic materials and associated applications along with various types of waste materials Biomass generated from different industries has been long identified as major organic waste and it is a one of the major sources of contamination in the environment This book will provide the global scenarios of low cost biogenic materials and their suitability pretreatment and the ways to synthesize different kinds of nanomaterials NMs including carbonaceous organic inorganic and polymeric methods The quantitative and qualitative characterization and applications of NMs will also be discussed in this book along with scientific and technical knowledge to manage suitable waste materials for NMs synthesis Significant gaps and similarities between chemical synthesis and green synthesis along with their mechanism will be covered in detail as a point of comparison The book will also contain the information on the need of policies required for waste management and option for their utilization along with the sources of their generation The book also contains latest broad aspects of both practical and theoretical fabrication of metal NPs using biogenic waste materials An emphasis has been made on the recent research related to advance NPs and their application This book will be useful for undergraduate students teachers engineers and researchers especially those working in areas of environmental science material science physical science biotechnology biochemistry and microbiology

Nanocatalysts in Biofuel Process Optimization

Mohammad Rehan, Abdul-Sattar Nizami, Meisam Tabatabaei, Konstantinos Moustakas, Asim Laeeq Khan, Mohammad Zain Khan, 2021-11-26

Application of Nanotechnology for Resource Recovery from Wastewater

Jitendra Kumar Pandey, Syed Mohammad Tauseef, Suvendu Manna, Ravi Kumar Patel, Vishal Kumar Singh, Ankit Dasgotra, 2024-02-06 Most of the time industrial wastes contain recoverable resources that would be useful in other applications For example greywater have enough nutrient to support the growth of microalgal biomass that are useful for biofuel production Similarly solid waste generated in metal extraction industries often contain high concentration of other metals that could be extracted using various processes This book presents a critical overview on the current nanotechnologies that are being utilized for extraction of valuable resources from various industrial and domestic wastes This book presents research reviews and case studies on the extraction of metal organic compounds energy and nutrients from waste through nanotechnological interventions

Iron Oxide Nanoparticles for Biomedical Applications

Sophie Laurent, Morteza Mahmoudi, 2017-10-20 Iron Oxide Nanoparticles for Biomedical Applications Synthesis Functionalization and Application begins with several

chapters covering the synthesis stabilization physico chemical characterization and functionalization of iron oxide nanoparticles The second part of the book outlines the various biomedical imaging applications that currently take advantage of the magnetic properties of iron oxide nanoparticles Brief attention is given to potential iron oxide based therapies while the final chapter covers nanocytotoxicity which is a key concern wherever exposure to nanomaterials might occur This comprehensive book is an essential reference for all those academics and professionals who require thorough knowledge of recent and future developments in the role of iron oxide nanoparticles in biomedicine Unlocks the potential of iron oxide nanoparticles to transform diagnostic imaging techniques Contains full coverage of new developments and recent research making this essential reading for researchers and engineers alike Explains the synthesis processing and characterization of iron oxide nanoparticles with a view to their use in biomedicine

Synthesis and Characterization of High Quality Iron Oxide Nanoparticles of Controlled Size, Shape and Magnetic Properties Pablo Guardia Girós, Universitat de Barcelona. Departament de Física Fonamental, 2009

Characterization of Iron Oxide Thin Films as a Support for Catalytically Active Nanoparticles, 2013

Iron Oxide Nanoparticle Surface Modification Richard Hoff, 2019 Multifunctional nanomaterials can be engineered to aid in the diagnosis of diseases enable efficient drug delivery monitor treatment progress over time and evaluate treatment outcomes This strategy known as theranostics focuses on the combination of diagnostic and therapeutic techniques to provide new clinically safe and efficient personalized treatments The evaluation of different nanomaterials properties and their customization for specific medical applications has therefore been a significant area of interest within the scientific community Iron oxide nanoparticles specifically those based on iron II III oxide magnetite Fe_3O_4 have been prominently investigated for biomedical theranostic applications due to their documented superparamagnetism high biocompatibility and other unique physicochemical properties The aim of this thesis is to establish a viable set of methods for preparing magnetite iron oxide nanoparticles through hydrothermal synthesis and modifying their surfaces with organic functional groups in order to both modulate surface chemistry and facilitate the attachment of molecules such as peptides via covalent bond formations Modifying their surfaces with biomolecules such as peptides can further increase their uptake into cells which is a necessary step in the mechanisms of their desired biomedical applications The methods of nanoparticle synthesis surface functionalization and characterization involving electron microscopy e g SEM TEM zeta potential measurements size analysis i e DLS and FT IR spectroscopy will be presented

Convergent Nanotechnologies Stanislav Kolisnychenko, 2015-02-10 Special topic volume with invited peer reviewed papers only

Iron Oxide Nanoparticles and Their Applications Patricia Villegas, 2021 Iron oxide nanoparticles demonstrate a number of unique properties including superparamagnetism biocompatibility and non toxicity which make them an ideal candidate for a variety of applications as described in this book Chapter One deals with the recent advances in various synthetic procedures of iron oxide based nanocomposites their characterization methods and their potential applications in energy storage devices supercapacitors

fuel cells and more Chapter Two summarizes current applications of immobilized enzymes based on iron oxide magnetic nanoparticles and discusses future growth prospects Chapter Three reviews the properties and applications of enzymatic sensors in exploiting tyrosinase glucose oxidase and other enzymes for sensing a broad range of biomedical species Chapter Four discusses magnetic magnetite and maghemite iron oxide nanoparticles from a variety of perspectives Chapter Five describes how nano iron oxides could be used to remove pollutants from the environment Chapter Six provides a comprehensive review of the catalytic applications of iron oxide nanoparticles in organic synthesis high temperature reactions gas phase processes wastewater treatment and supercritical upgradation of heavy petroleum oils Chapter Seven details the photocatalytic degradation of a class of toxic aromatic pollutants namely phenols and substituted phenols using different types of photocatalysts in the nano size range for effective removal these compounds from water bodies Lastly Chapter Eight elucidates various magnetic nanomaterials based adsorbents used in adsorption techniques for wastewater treatment

Structural Design, Characterization, and Property Investigation of Iron Oxide Song Li, 2009 Global environmental pollution and energy issue are considered as two greatest challenges that human society is facing now Semiconductor photocatalysis is expected as a highly promising strategy for both harvesting solar energy and decomposing unwanted organics in water and air by solar light irradiation The main problem of TiO₂ the most widely studied photocatalyst material by now is that its band gap is as wide as 3.1 eV making it absorb only the UV part of the incident solar irradiation Iron oxide has a proper band gap of about 2.1 eV which lies in the visible region of solar spectrum and allows utilization of 45% of the solar radiation Together with the environmental compatibility and low cost iron oxide is considered as a good candidate for visible light photocatalyst For the purpose of exploiting iron oxide as effective photocatalyst we have prepared iron oxide nanoparticles of various shapes and investigated their photocatalytic activities The objective of the present dissertation is to develop and characterize iron oxide photocatalyst which is highly responsive to visible light Nanostructured iron oxide and oxyhydroxide nanoparticles with various morphologies were designed and synthesized via hydrothermal route Stabilizer molecules with different capping groups were applied in the reaction system to control the morphology of the final products The effects attributed to the interaction between capping groups of stabilizer molecules and iron oxide surfaces To elucidate the growth mechanism of iron oxide particles a TEM based trace method was proposed to characterize the crystalline planes and directions of a faceted nanoparticle and therefore its shape The Miller indices of surface planes can be determined through coordinate transformation after the determination of the edge vectors in the TEM screen coordinate system Methyl orange a representative azo dye pollutant in textile industry was chosen as the model contaminant molecule to evaluate the photocatalytic performance of the obtained powders A systematic study including the influence of the reaction conditions the kinetics and the route of the oxidation of the methyl orange molecules was carried out to explore the mechanism of photocatalytic degradation of organic molecules over iron oxide under visible light irradiation It was found that

the photodegradation of methyl orange over iron oxide was more like a semiconductor photocatalysis process rather than a surface reaction process of ligands to metal charge transfer. Moreover, the visible light photocatalytic activities of iron oxide can be tuned by controlling the morphologies, especially the crystallographic facet of the iron oxide nanoparticles. Post-treatment techniques were adopted to enhance the ability of iron oxide photocatalyst to decompose organic pollutant molecules. The iron oxide nanopowders were modified by loading noble metals such as Ag and Au nanoparticles. Photocatalytic experimental results showed that the abilities of loaded metal particles to inhibit the electron-hole pair recombination depend on the relative positions between their work functions and conductive band position of the iron oxide. To overcome the problem caused by the short free distance of charge carriers inside iron oxide nanorod arrays of iron oxide, were prepared. The results show that the photocatalytic activity of iron oxides can be improved by microstructure optimization and surface modification.

Advanced Materials Engineering and Technology II Mohd Mustafa Al Bakri Abdullah, Liyana Jamaludin, Alida Abdullah, Rafiza Abd Razak, Kamarudin Hussin, 2013-12-05. Selected peer-reviewed papers from the 2013 International Conference on Advanced Materials Engineering and Technology ICAMET 2013 November 28-29 2013 Bandung Indonesia.

Preparation and Characterization of Iron Oxide and Hydroxide Based Nanomaterials Guillermo Carbajal-Franco, 2011.

Iron Oxide Nanoparticles for Biomedical Applications Sophie Laurent, 2017. 11.3.1 Characteristics of Iron Oxide Nanoparticle Based Contrast Agents for Cancer Imaging and Therapy. 11.3.1.1 Size. 11.3.1.2 Shape. 11.3.1.3 Composition. 11.4 Conclusion. References. Index.

Synthesis, Characterisation and Applications of Iron Oxide Nanoparticles German Salazar-Alvarez, Tekniska högskolan i Stockholm. Institutionen för materialvetenskap, 2004.

Chemical Engineering Progress, 2007.

Iron Oxide-Based Nanocomposites and Nanoenzymes Harekrushna Sahoo, Jitendra Kumar Sahoo, 2024-01-01. This contributed volume provides a comprehensive understanding of synthetic protocols, characterization techniques, and current applications of iron oxide based nanocomposite and nanoenzyme materials. It covers basic concepts and recent advancements in iron oxide based nanocomposites and nanoenzymes, focusing on their synthesis, characterization, and functionalization for specific research applications. The different chapters in the book highlight key characterization techniques including Fourier Transform Infrared Spectroscopy, X-ray diffraction, Scanning Electron Microscopy, and Transmission Electron Microscopy, among others, while it also explores various applications of these materials, such as adsorption of heavy metals and dyes, gas sensors, biomedical applications, photocatalysis, and photovoltaic sensors. This book serves as a valuable resource for researchers and graduate students working in the fields of materials science, chemistry, physics, and biotechnology.

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Characterization Of Iron Oxide Nanocatalyst In Introduction

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