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Editorial

Nanocomposites for Photocatalysis

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1. Introduction

Dr. Oomman K. Varghese and I were honored to accept the kind invitation from Assistant Editor Andy Yang to act as Guest Editors. We aimed to bring together authors who could contribute high-level papers and reviews and we believe that we succeeded in this task. This is particularly due to the wonderful cooperation of Andy Yang and her competent team. Moreover, we owe particular thanks to all the authors who contributed their excellent papers to this Special Issue. This collection comprises 13 articles, covering key aspects of the topic of Nanocomposites for Photocatalysis, together with a variety of innovative approaches.

2. Sn(IV)porphyrin-Anchored TiO_2 Nanoparticles via Axial-Ligand Coordination for Enhancement of Visible-Light-Activated Photocatalytic Degradation

A visible-light-active photocatalyst, known as SnP/AA@TiO_2, was developed via leveraging the coordination chemistry between a hydroxo-ligand in a specific tin complex, denoted as SnP, and adipic acid (AA) attached to the surface of TiO_2 nanoparticles. This synthesis led to a strong bond between the SnP complex and the TiO_2 nanoparticles, which was confirmed through various analytical techniques [1].

SnP/AA@TiO_2 demonstrated a remarkable improvement in photocatalytic activity when exposed to visible light, particularly for the degradation of Rhodamine B dye (RhB) in aqueous solutions. Under visible-light irradiation, the catalyst achieved a high RhB degradation efficiency of 95% within just 80 min, with a constant rate of 0.0366 min^{-1} [1].

What sets SnP/AA@TiO_2 apart from other photocatalysts, such as TiO_2 and SnP@TiO_2, is its superior performance in terms of degradation efficiency, lower catalyst usage, and increased reusability. This suggests that SnP-anchored photocatalysts is a more efficient choice for photocatalytic applications, particularly in the context of wastewater treatment and environmental remediation [2].

3. Designing Highly Active S-g-C_3N_4/Te@NiS Ternary Nanocomposites for Antimicrobial Performance, Degradation of Organic Pollutants, and Their Kinetic Study

This research focused on the synthesis of pure nickel sulfide (NiS) nanoparticles, Te-doped NiS nanoparticles (Te@NiS), and nanocomposites combining sulfur-doped g-C_3N_4 (S-g-C_3N_4) and Te@NiS through a hydrothermal process. Several analytical techniques, including XRD, FTIR spectroscopy, SEM-EDX imaging, and Tauc plots for band gap determination, were employed to confirm that material synthesis had occurred [3].

This study successfully synthesized Te-doped NiS nanoparticles and sulfur-doped g-C_3N_4/Te@NiS nanocomposites. These materials exhibited promising properties for photocatalytic applications, particularly in the degradation of organic dyes, and demonstrated potential benefits in antifungal and antibacterial applications, rendering them valuable for various environmental and healthcare-related uses [4].

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4. Photocatalytic Reduction of Cr(VI) to Cr(III) and Photocatalytic Degradation of Methylene Blue and Antifungal Activity of Ag/TiO_2 Composites Synthesized via the Template-Induced Route

This study focuses on the development of silver and titanium dioxide (Ag/TiO_2) composite photocatalysts for water treatment, a critical area of environmental protection. The composites were effectively synthesized using a template-induced method and underwent thorough characterization using XRD, FTIR spectroscopy, SEM, and EDX, confirming their composition and structural properties. The SEM analysis revealed that the particle size and shape of the composites could be controlled via adjusting the reactant concentrations and calcination temperatures, while the XRD patterns indicated the presence of anatase crystalline phases [5].

In addition to water treatment, the study evaluated the antifungal properties of these composites against two fungi, *S. macrospora* and *S. maydis*. The 0.01 Ag/TiO_2 nanocomposites exhibited the highest antifungal activity, with inhibition zones measuring 38.4 mm and 34.3 mm for *S. macrospora* and *S. maydis*, respectively [5].

Overall, the findings indicate that the synthesized Ag/TiO_2 composites are effective in both photocatalytic and antifungal applications, showing their potential for multifaceted environmental and health-related uses [6].

5. Synthesis of $Zn_3V_2O_8$/rGO Nanocomposite for Photocatalytic Hydrogen Production

In this study, a composite material consisting of zinc vanadate and reduced graphene oxide ($Zn_3V_2O_8$/rGO) was successfully synthesized using a simple method. Various advanced characterization techniques, including powder X-ray analysis, scanning electron microscopy, energy-dispersive X-ray spectroscopy, and UV–visible spectroscopy, were employed to confirm the formation of the $Zn_3V_2O_8$/rGO composite [7].

The primary application explored for this composite material was as a photocatalyst for hydrogen generation through a photocatalytic process. Impressively, the $Zn_3V_2O_8$/rGO photocatalyst exhibited a substantial hydrogen generation rate of 104.6 $\mu molg^{-1}$. Furthermore, it demonstrated an excellent cyclic stability, indicating that it could be reused effectively as a photocatalyst [7,8].

The study suggests that the improved photocatalytic performance of the $Zn_3V_2O_8$/rGO composite may be attributed to synergistic interactions between its components. Importantly, this composite is considered environmentally friendly and cost-effective, so it is a promising candidate for various photocatalytic applications, particularly in the context of hydrogen production for clean energy purposes [9].

6. Deep Eutectic Solvent-Mediated Synthesis of $Ni_3V_2O_8$/N-Doped RGO for Visible-Light-Driven H_2 Evolution and Simultaneous Degradation of Dyes

This study addresses the pressing challenges in the energy and environmental sectors, specifically focusing on photochemical hydrogen evolution and the degradation of synthetic dyes in water. The researchers employed a deep eutectic solvent to synthesize a novel material, the $Ni_3V_2O_8$/N-doped reduced graphene oxide hybrid (NiV/NR), abbreviated to NRGO. The synthesized NiV/NR hybrid, along with NRGO and pristine NiV, underwent extensive characterization using techniques such as XRD, SEM, TEM, UV-DRS, XPS, and various photo-electrochemical methods [10].

The research also focused on the photocatalytic degradation of anionic (methyl orange—MO) and cationic (crystal violet—CV) dyes. Under visible-light irradiation, the NiV/NR hybrid demonstrated a high efficiency, degrading 94.6% of MO and 96.7% of CV. Positive results were achieved for the simultaneous degradation of dyes and total organic carbon (TOC) removal [11].

This paper introduces a novel NiV/NR hybrid material synthesized using a deep eutectic solvent and demonstrates its remarkable efficiency in hydrogen generation and dye degradation. The material's stability, reusability, and potential for various applications position it as a valuable asset in addressing energy and environmental concerns [12].

7. Excellent Adsorption of Dyes via $MgTiO_3$@g-C_3N_4 Nanohybrid: Construction, Description, and Adsorption Mechanism

This report explores the removal of the hazardous Rhodamine B dye (RhB) from aqueous solutions using $MgTiO_3$@g-C_3N_4 nanohybrids synthesized via an ultrasonic method in an alcoholic solvent. Various analytical techniques, including HRTEM, EDX, XRD, BET, and FTIR, were employed to characterize the $MgTiO_3$@g-C_3N_4 nanohybrids [13].

The research presents $MgTiO_3$@g-C_3N_4 nanohybrids as effective and reusable materials for the removal of Rhodamine B dye from aqueous solutions. The study provides valuable insights into the adsorption process, including the optimal conditions, isotherm modeling, and kinetic behavior, thus contributing to our understanding of the mechanism behind the removal process [14].

8. Co, Cu, Fe, and Ni Deposited over TiO_2 and Their Photocatalytic Activity in the Degradation of 2,4-Dichlorophenol and 2,4-Dichlorophenoxyacetic Acid

This study investigates the photocatalytic properties of pure TiO_2 nanoparticles synthesized via the sol–gel method and subsequently modified with 5% by weight of Co, Cu, Fe, and Ni ions through the deposition–precipitation method. The nanomaterials underwent thorough characterization using various techniques, including SEM, TEM, UV–Vis DRS, X-ray diffraction (XRD), nitrogen physisorption, and X-ray photoelectron spectroscopy (XPS) [15].

The study explored the modification of TiO_2 nanoparticles with various metal ions and characterized their physical and chemical properties. Photocatalytic evaluation demonstrated that the Ni/TiO_2 nanomaterial was the most effective in degrading 2,4-D and 2,4-DCP, showing it to be a promising candidate for photocatalytic applications in water treatment and environmental remediation [16].

9. Photocatalytic Evaluation of TiO_x Films Produced via Cathodic Arc-PVD with Silver Addition via UVC Photo-Reduction Method

In this study, titanium (Ti) was used as a commercial cathode material, and a cathodic arc physical vapor deposition (arc-PVD) process was employed to deposit TiOx coatings on Raschig rings. The coatings were created using varying ratios of argon (Ar) and oxygen (O_2): 440/60, 400/100, and 300/100 [17].

This research involved the deposition of TiOx coatings using arc-PVD, subsequent oxidation to form TiO_2, and the addition of Ag to enhance photocatalytic properties. The study explores the coatings' effectiveness in degrading organic dyes and removing fecal coliforms from different water matrices and highlights their potential applications in environmental and water treatment contexts [18].

10. Synergistic Correlation in the Colloidal Properties of TiO_2 Nanoparticles and Its Impact on the Photocatalytic Activity

This study explores the relationship between the photodegradation rate of methylene blue (MB) and the effective surface charge of titania nanoparticles (TiO_2 NPs) in an aqueous solution. The key findings and observations include the following.

Colloidal dispersions of TiO_2 NPs, ranging in size from 4 to 10 nm, were prepared for heterogenous photocatalysis experiments. Acidic TiO_2 dispersions with a pH range from 3.6 to 4.0, characterized by a positive zeta potential and a smaller hydrodynamic diameter, exhibited a higher colloidal stability. The TiO_2 NPs with optimal dispersion properties demonstrated pseudo-first-order kinetics for the degradation of MB. The highest rate constant observed was 5×10^{-2} min^{-1}, leading to a 98% MB conversion within 75 min under UV light. This enhanced rate was attributed to a synergistic effect between the surface area, charge, and optimal hydrodynamic diameter of the TiO_2 NPs [19].

In summary, the study demonstrates that the photodegradation of methylene blue is influenced by the effective surface charge and colloidal stability of TiO_2 nanoparticles in aqueous solutions. Acidic dispersions with a positive zeta potential and a smaller particle size exhibit an enhanced photocatalytic activity. This finding emphasizes the importance of surface properties in heterogeneous photocatalysis [20].

11. TiO_2-La_2O_3 as Photocatalyst in the Degradation of Naproxen

This study addresses the environmental issue of naproxen pollution in sewage effluents, which is primarily caused by its widespread use as an anti-inflammatory drug. To combat this problem, the researchers investigated the use of titanium dioxide (TiO_2) as a promising photocatalyst for degrading naproxen (NPX) [21].

The researchers synthesized Ti-La mixed oxides with varying lanthanum (La) contents (0, 1, 3, 5, and 10 wt.%) via the sol–gel method. These mixed oxides were tested as photocatalysts for the degradation of naproxen [21].

The photocatalytic activity of these materials was assessed, and they exhibited a high efficiency in degrading naproxen, with degradation rates ranging from 93.6 to 99.8 wt.% after 4 h under UV irradiation [21].

This research highlights the use of Ti-La mixed oxides, primarily composed of titanium dioxide, as effective photocatalysts for the degradation of naproxen in water. These materials showed promising photocatalytic activity, demonstrating potential in addressing the environmental challenges associated with the widespread use of naproxen as an anti-inflammatory drug [22].

12. Effect of Temperature on the Adhesion and Bactericidal Activities of Ag^+-Doped $BiVO_4$ Ceramic Tiles

This research focused on investigating the impact of temperature on both the adhesion and disinfection properties of a coating made from Ag^+-doped $BiVO_4$ ($Ag^+/BiVO_4$).

Disinfection experiments were conducted to evaluate the antimicrobial properties of the samples. It was found that the silver-modified samples exhibited effective disinfection activity within the annealing temperature range of 450–650 °C [23].

Among the samples, that which was annealed at 650 °C demonstrated the highest coating adhesion. Furthermore, it effectively eliminated *Escherichia coli*, *Staphylococcus aureus*, *Shigella*, and *Salmonella bacteria* after just 2 h of visible-light irradiation [23,24].

In summary, this study investigated the effects of the annealing temperature on $Ag^+/BiVO_4$ coatings. The authors observed that higher temperatures led to improved adhesion and enhanced disinfection activities, meaning that the coating proved especially effective against various pathogenic bacteria when annealed at 650 °C. This research demonstrates the potential of $Ag^+/BiVO_4$ coatings for application in disinfection and antimicrobial surface treatments [25].

13. Bio-Inspired Synthesis of Carbon-Based Nanomaterials and Their Potential Environmental Applications: A State-of-the-Art Review

This article addresses the growing challenges of providing safe drinking water and clean water worldwide. To address these issues, there is a growing emphasis on implementing environmentally sustainable nanomaterials (NMs) with unique properties, such as high efficiency, selectivity, earth abundance, renewability, low manufacturing costs, and stability [26].

The article reviews the progress made in the past ten years in manufacturing novel carbon-based NMs using waste materials and natural sources as precursors. It discusses how these materials can be applied to water treatment and purification [27].

Carbon-based NMs are explored in terms of their potential in treating industrial and pharmaceutical wastewater, as well as addressing groundwater and drinking water purification challenges. The focus is on enhancing these materials, developing innovative nano-sorbents, and removing ionic metals from aqueous environments [28].

The article discusses both the latest developments and the challenges associated with environmentally friendly carbon and graphene quantum dot NMs. It highlights the ongoing research efforts in this area and the potential of these NMs to play a crucial role in addressing global water quality issues [26,29].

The article highlights the significance of sustainable nanomaterials, particularly carbon-based NMs, in addressing water-related challenges. It emphasizes the use of eco-friendly synthesis techniques and explores their applications in water treatment and purification, offering hope for more sustainable and efficient water management practices in the future [26,30].

14. Preparation and Real-World Applications of Titania Composite Materials for Photocatalytic Surface, Air, and Water Purification: the State of the Art

This article discusses potential applications of the semiconducting transition metal oxide titanium dioxide (TiO_2), which is a cost-effective and non-toxic material known for its excellent photocatalytic properties. TiO_2 has shown promise in various fields due to its antibacterial, antiviral, antifungal, antialgal, and air-cleaning capabilities under UV or sunlight exposure [31].

In summary, this paper highlights the remarkable potential of TiO_2 in various real-world applications but also acknowledges the challenges that remain, especially regarding the need to maintain consistent photocatalytic activity in practical settings. The review provides insights into common preparation methods and offers suggestions for overcoming hurdles in order to facilitate the broader adoption of TiO_2 as a photocatalyst [31,32].

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