



Review

# Recent Developments in ZnS-Based Nanostructures Photocatalysts for Wastewater Treatment

Luminita Isac <sup>1,2,\*</sup> and Alexandra Enesca <sup>1</sup>

<sup>1</sup> Product Design, Mechatronics, and Environmental Department, Transilvania University of Braşov, 500036 Braşov, Romania

<sup>2</sup> Renewable Energy Systems and Recycling Research Center, Transilvania University of Braşov, 500036 Braşov, Romania

\* Correspondence: isac.luminita@uniibv.ro

**Abstract:** The continuous growth of the world population has led to the constant increase of environmental pollution, with serious consequences for human health. Toxic, non-biodegradable, and recalcitrant organic pollutants (e.g., dyes, pharmaceuticals, pesticides) are discharged into water resources from various industries, such as textiles, leather, pharmaceuticals, plastics, etc. Consequently, the treatment of industrial wastewater, via a sustainable technology, represents a great challenge for worldwide research. Photocatalytic technology, an innovative technique based on advanced oxidation process (AOP), is considered a green technology with promising prospects in the remediation of global environmental issues. In photocatalysis, a very important role is attributed to the photocatalyst, usually a semiconductor material with high solar light absorption capacity and conductivity for photogenerated-charge carriers. Zinc sulfide (ZnS), as n-type semiconductor with different morphologies and band gap energies ( $E_g = 3.2\text{--}3.71\text{ eV}$ ), is recognized as a promising photocatalyst for the removal of organic pollutants from wastewater, especially under UV light irradiation. This review deals with the recent developments (the last five years) in ZnS nanostructures (0D, 1D, 3D) and ZnS-based heterojunctions (n-n, n-p, Z-scheme) used as photocatalysts for organic pollutants' degradation under simulated (UV, Vis) and sunlight irradiation in wastewater treatment. The effects of different synthesis parameters (precursors' type and concentration, capping agents' dosages, reaction time and temperature, metal doping, ZnS concentration in heterostructures, etc.) and properties (particle size, morphology, band gap energy, and surface properties) on the photocatalytic performance of ZnS-based photocatalysts for various organic pollutants' degradation are extensively discussed.

**Keywords:** ZnS nanostructures; heterojunctions; photocatalysis; organic pollutants; wastewater treatment



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## 1. Introduction

Wastewater loaded with toxic, non-biodegradable organic pollutants represents a real problem, both for aquatic environments and for human life and development. Industrial wastewater originates mainly from the textile industry, but also from the plastics, paper, food, and cosmetic industries, due to the large amount of water used in the various technological stages, especially during the dyeing process [1]. It has been estimated that the wastewater from textile production contributes approximately 20% of the total industrial polluted water [2].

The presence of a very small concentration of organic dyes in water (less than 1 ppm for some dyes) may have serious consequences for the environment, but more for the population health, such as skin and eyes irritations, respiratory and gastric tracts affections, quadriplegia, tachycardia, tissue necrosis, and cancer [3–4].

The dyes most used industrially are azo dyes (usually with an aromatic structure) which, under natural conditions, require a long time to degrade due to their high photosta-

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## **Table of Contents Recent Research Developments In Nanostructures Vol 11999**

1. Understanding the eBook Recent Research Developments In Nanostructures Vol 11999
  - The Rise of Digital Reading Recent Research Developments In Nanostructures Vol 11999
  - Advantages of eBooks Over Traditional Books
2. Identifying Recent Research Developments In Nanostructures Vol 11999
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Recent Research Developments In Nanostructures Vol 11999
  - User-Friendly Interface
4. Exploring eBook Recommendations from Recent Research Developments In Nanostructures Vol 11999

- Personalized Recommendations
- Recent Research Developments In Nanostructures Vol 11999 User Reviews and Ratings
- Recent Research Developments In Nanostructures Vol 11999 and Bestseller Lists
- 5. Accessing Recent Research Developments In Nanostructures Vol 11999 Free and Paid eBooks
  - Recent Research Developments In Nanostructures Vol 11999 Public Domain eBooks
  - Recent Research Developments In Nanostructures Vol 11999 eBook Subscription Services
  - Recent Research Developments In Nanostructures Vol 11999 Budget-Friendly Options
- 6. Navigating Recent Research Developments In Nanostructures Vol 11999 eBook Formats
  - ePub, PDF, MOBI, and More
  - Recent Research Developments In Nanostructures Vol 11999 Compatibility with Devices
  - Recent Research Developments In Nanostructures Vol 11999 Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Recent Research Developments In Nanostructures Vol 11999
  - Highlighting and Note-Taking Recent Research Developments In Nanostructures Vol 11999
  - Interactive Elements Recent Research Developments In Nanostructures Vol 11999
- 8. Staying Engaged with Recent Research Developments In Nanostructures Vol 11999
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Recent Research Developments In Nanostructures Vol 11999
- 9. Balancing eBooks and Physical Books Recent Research Developments In Nanostructures Vol 11999
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Recent Research Developments In Nanostructures Vol 11999
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Recent Research Developments In Nanostructures Vol 11999
  - Setting Reading Goals Recent Research Developments In Nanostructures Vol 11999
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Recent Research Developments In Nanostructures Vol 11999

- Fact-Checking eBook Content of Recent Research Developments In Nanostructures Vol 11999
- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
- 14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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