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Nanophotocatalysis and Environmental Applications

Detoxification and Disinfection

Springer

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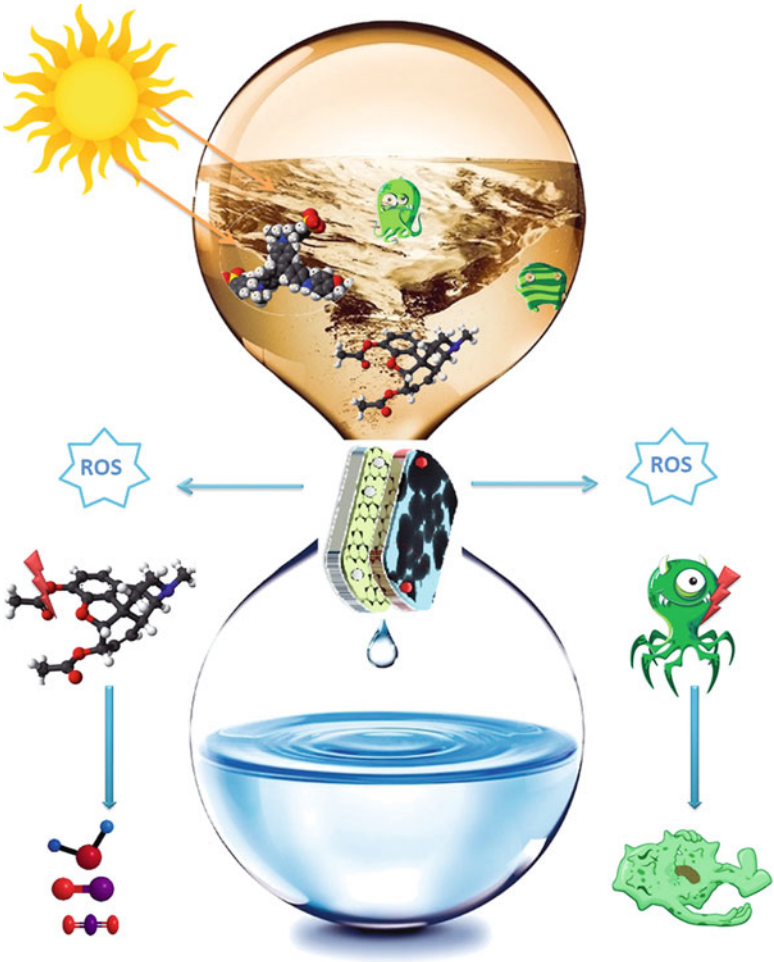
Preface



Photocatalytic water detoxification and disinfection

In the recent decades, the world has encountered severe environmental challenges in terms of water pollution, climate change, and increasing infectious diseases. The irregular speed and quantum at which anthropogenic activities are growing have ended up in the wasting of resources, exposure to toxins, and pollution rise all over the world. These ubiquitous problems throughout the globe have been worsened in the developing part of the world due to the industrial revolution and poor monitoring and control of anthropogenic activities.

The discharge of wastewater is increasing into water bodies and on land, and varieties of new emerging nonregulated pollutants are entering into the water bodies. The severe shortage of potable water requires more focus on recycling, remediation, and reuse. Conventional pollutant treatment and disinfection methods have their own disadvantages with efficiency and cost issues. The most dignified solutions for various environmental issues are resource management and cost-effective technologies for pollution mitigation and disinfection. Among various cost-effective and viable technologies used for mitigating environmental detoxification, advanced oxidation process-based photocatalysis is the most pioneer one. Principally, it is indeed a "green" technology thriving on light especially on naturally and abundantly available solar energy and oxygen from air under ambient conditions.

The phenomena that came into the news with "Honda-Fujishima" effect proved to be one of most effective techniques to degrade persistent and emerging contaminants from aqueous medium utilizing light. After the secondary treatment of polluted water, photocatalysis is trusted for the next stage as it claims to mineralize the complex organic pollutants into water and carbon dioxide using hydroxyl and superoxide radicals. The scientific community, as well as the industrial players, has then utilized this to the maximum with continuous innovations in the designing of photocatalytic materials, pilot-scale experiments, and practical treatment of water using natural solar light.

However, various new sources of production, disposals from medicine and plastics industry, agriculture, and household conveniences have led to huge widespread toxic pollutants. It has been an issue of concern for the general public as well as scientists and governments. On a broader line, these are classified as pharmaceuticals, personal care products, and endocrine disruptors. These have challenged the existing "star" photocatalytic materials and methodologies. New and highly advanced photocatalysts and improvement in existing photocatalytic technologies are thus required. Therefore, continuous research is going on various solar-active materials with multipronged capabilities.

Another issue of environmental concern is increasing toward biohazards such as bacteria, virus, and other microorganisms in drinking water resources. This has increased the risk of deadly diseases in humans and aquatic species. Conventional disinfection methods are failed as many of these microbes developed resistance to ultraviolet, chlorination, and antibiotics too. Semiconductor-based photocatalysis is proved to be beneficial for water disinfection, i.e., inactivation and photo-killing of microbes *via* generation of reactive oxygen species. Hence, photocatalysis has been used for environmental detoxification and disinfection which includes organic pollutants, heavy metal, inorganic contaminants removal, and microbial killing.

Shifting from single photocatalysts to heterojunctions, nanocomposites, molecularly imprinted catalysts, sensitized nanomaterials, photocatalytic membranes, and heterostructures has led to better results and higher efficiencies.

Nanophotocatalysis and Environmental Applications: Detoxification and Disinfection focuses on existing and novel applications of photocatalysts in environmental detoxification as well as disinfection. Photodegradation of organic and inorganic pollutants including dyes, drugs, pesticides, hormones, heavy metals, antibiotics, microbes, bacteria, fungi, and carcinogens is discussed on various novel photocatalysts such as biomass- and phosphor-based photocatalysts, nanocarbon- and polymer-supported nanostructures, ferrite nanoparticles, magnetic materials, etc. Based on thematic topics, the book edition contains the following 10 chapters:

Chapter 1 intends to explore an overview of the mechanisms and promising research activities on photocatalytic nanoparticle-assisted heavy metal detoxification.

Chapter 2 discusses the effect of parameters and pathways (transformation products) of solar photocatalysis of antibiotic groups usually found in aquatic systems such as macrolides, sulfones, lincosamides, and quinolone.

Chapter 3 addresses the advancements to overcome the drawbacks of pure semiconductor oxide by the incorporation of biomass-derived carbonaceous materials for the fabrication photocatalysts used to remove organic pollutants from water. This chapter also highlights the types, properties, and conversion of biomass into biochar, activated carbon, or any other carbonaceous materials. The preparation of biomass-based support and the mechanisms of biomass-derived photocatalysis are discussed in detail.

Chapter 4 aims to highlight recent advancements in the application of Bi-photocatalysts and its heterostructures used in environmental protection. The review explores photocatalytic degradation of antibiotics, nonsteroidal anti-inflammatory drugs, beta-blockers, anticonvulsant, hormones, resorcinol, bisphenol A, and derivatives available in aqueous systems. The applications of Bi-based photocatalysts for treating NOx, water splitting, and CO_2 reduction to CO and CH_4 are discussed.

Chapter 5 describes solutions for enhancing the photon distribution inside the photoreactors using inorganic and organic light-emitting particles (phosphors)) coupled with photocatalysts. This chapter also underlines the difference between inorganic particles having down-conversion, up-conversion, and long afterglow luminescence properties. Additionally, the use of up-conversion organic phosphors is proposed. Finally, some examples concerning the use of semiconductors coupled with different photoluminescent materials in the removal of pollutants from water and wastewater are discussed.

Chapter 6 explores the applications of TiO_2 nanostructures (0D to 3D) functionalized with various polymeric and nanocarbon hybrid photocatalytic materials for photodegradation of chemical pollutants. Various chemical synthesis methods, surface modification with various polymers and nanostructured carbons, composition, morphological structures, growth mechanism, physicochemical properties, electronic and optical characteristics, and photocatalytic mechanism of

various heterostructured TiO_2-based photocatalysts are discussed in details. The future challenges in the fields of photocatalytic environmental remediation and hydrogen generation are also mentioned.

Chapter 7 gives a brief introduction of nanomaterials including their classification, shape and structure, type of nanomaterials, and applications in degradation of recalcitrant organic contaminants. The process intensification using sono-hybrid advanced oxidation processes of sono-photocatalysis and heterogeneous Fenton-like reaction for wastewater treatment is discussed.

Chapter 8 explores a brief review of various magnetic-based photocatalytic nanomaterials used for photocatalytic disinfection and degradation processes. The factors influencing the catalytic performance along with the disinfection mechanisms are also discussed.

Chapter 9 presents a review of the literature on the various types of photocatalytic materials, their mechanism of action for photocatalytic water disinfection, and photocatalysts with microbial activity.

Chapter 10 discusses the importance of photocatalysts and their medicinal application in the daily life of human beings. The properties of photocatalysts in relation to the nanoscale are discussed. The medicinal applications of photocatalysts such as antifungal, antimicrobial, anti-cancerogenic are also discussed in detail.

This book is the consequence of the commendable cooperation of authors from various interdisciplinary fields of science. It thoroughly examines the most generous, start to finish, and forefront research and reviews. We are thankful to all the contributing authors and their coauthors for their regarded commitment. We may moreover need to thank all copyright holders, authors, and other individuals who agreed to use their figures, tables, and schemes. Yet every effort has been made to secure the copyright approvals from the individual proprietors to consolidate reference to the imitated materials, we should need to offer our sincere proclamations of disappointment to any copyright holder if unintentionally their benefit is being infringed.

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