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# Nanocomposites for Visible Light-induced Photocatalysis

Springer

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# Preface

The frequent release of hazardous and toxic chemicals into water bodies as well as repeated anthropogenic and industrial activities is of great alarm because these pollutants contaminate rivers, lakes, and underground aquifers. The traces of contaminants ranging from dyes, pharmaceutical drugs, hormones, and sunscreen to pesticides are being spreading in different types of water bodies. Furthermore, most of these contaminants are recalcitrant compounds and cannot be decomposed by the conventional wastewater treatment methods. Therefore, many treated effluents that are considered "safe" for disposal still contain toxic and hazardous pollutants. Generally, these compounds are untraceable when ingested or absorbed by living organisms and are subsequently accumulated, causing adverse health effects. Thus, considerable efforts have been put for the development of suitable, safe, clean, and environment-friendly purification process that can decompose and degrade the recalcitrant organic contaminants from wastewater to reduce negative effect on plants and animals.

Advanced oxidation processes (AOPs) have been considered as an alternate method for the degradation, detoxification, and removal of several toxic organic pollutants in wastewater. The principle of AOPs is to produce superoxide and hydroxyl radicals in water, which are very powerful oxidants capable of oxidizing wide range of organic pollutants without selectivity. Among these AOPs, heterogeneous photocatalysis in the presence of semiconductor or semiconductor-based nanomaterials has shown efficiency in degrading a wide range of indistinct refractory organics into readily biodegradable compounds and eventually mineralizing them to innocuous carbon dioxide and water. Heterogeneous photocatalysis has been actively investigated as a promising self-cleaning, deodorization system, as well as antibacterial agents, and their applications in photocatalytic process are desirable for the purification of water through removing various types of pollutants and bacteria. However, the key part of the heterogeneous photocatalysis is the semiconductor material used as a catalyst. A photocatalyst is defined as a substance that is able to make chemical transformations of the contaminants repeatedly coming to its contact into greener products in the presence of light while regenerating its chemical composition after each cycle of such interactions. The physicochemical properties of the material are crucial for high conversion efficiency stability in the electrolyte which are usually established as per, e.g., composition, size, shape, and morphology. This book comprises following 11 chapters that deal with several types of photocatalyst materials, and their role in several chemical photocatalytic transformation and mechanism:

Chapter 1, "Introduction of Nanomaterials for Photocatalysis", deals with the present research scenario of visible light-induced photocatalysis and its importance. In particular, why nanocomposites are needed to be developed for the visible light-induced photocatalysis and their prime roles in enhancing the performance. In addition, how and where such photocatalysts would find practical and industrial applications is briefly mentioned in this chapter.

Chapter 2, "Basic Principles, Mechanism, and Challenges of Photocatalysis", provides the basic principles and mechanisms that has already been known and developed. It also discusses the role of nanotechnology in the photocatalysis, especially the visible light-induced photocatalysis and present challenges in photocatalysis research.

Chapter 3, "Nanocomposites and Its Importance in Photocatalysis", focuses on the importance of different types of nanocomposites for visible light-induced photocatalysis for possible applications. Nanocomposites include inorganic/organic, inorganic/polymer, and mixed oxides, and photocatalytic performance of those with their merits and demerits.

In Chap. 4, the role of metal nanoparticles and its surface plasmon activity on nanocomposites for visible light-induced catalysis is outlined. The fabrication of different types of nanocomposites involving different metal nanoparticles which are responsible for the enhanced visible light-induced catalysis is thoroughly discussed along with mechanism.

Chapter 5 deals with mixed metal-oxides nanocomposites for visible light-induced photocatalysis. The strategies used for the synthesis of mixed metal oxide nanocomposites and their performance for visible light-induced photocatalysis are delineated in this chapter.

In Chap. 6, synthesis and photocatalytic application of various nanoporous nanocomposite materials are included.

Chapter 7 deals with various polymeric nanocomposites for visible light-induced photocatalysis covering their synthesis and characterizations. Polymer-based nanocomposites include artificial and natural polymer nanocomposites.

In Chap. 8, role of several carbon-based nanocomposites including metal–graphene and metal–CNT nanocomposites in visible light-induced photocatalysis is discussed.

Chapter 9, "g-$C_3N_4$/Carboneous Polymer-Based Nanocomposites Towards Visible Light-induced Photocatalysis", deals with the nanocomposites of g-$C_3N_4$ with carbonaceous $\pi$-conjugated/polymeric materials for visible light-induced photocatalysis such as NO removal, $CO_2$ reduction and oxygen reduction reactions, water splitting to liberate $H_2$ fuel, and degradation of pollutants.

Chapter 10, “Titanium-Based Ternary Mixed Metal Oxide Nanocomposites for Visible Light-induced Photocatalysis”, focuses on the mixed metal oxide nanocomposites for visible light-induced photocatalysis.

Chapter 11 discusses novel applications and future perspectives of nanocomposites. It will also include self-cleaning of glasses (window panes) using photoactive materials, novel paints, tiles, etc.

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