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Photocatalysis and Its Application in Environmental and Energy Chemistry

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Abstract

Photocatalysis is a significant area of inorganic chemistry where light energy activates semiconductor materials to drive chemical reactions. These reactions are particularly important in environmental remediation and renewable energy production. Inorganic photocatalysts such as titanium dioxide, zinc oxide, and metal sulfides generate electron–hole pairs upon light absorption, which initiate oxidation and reduction processes. This mechanism enables degradation of pollutants, purification of water, and splitting of water into hydrogen and oxygen. The efficiency of photocatalysis depends on factors such as band gap, surface area, crystal structure, and defect density of the material. Understanding these relationships allows optimization of photocatalytic performance for practical applications. This article elaborates how photocatalysis contributes to environmental protection and sustainable energy solutions through inorganic material innovation.

Keywords:* *Photocatalysis and its application in environmental and energy chemistry

Introduction

Photocatalysis and its application in environmental and energy chemistry arise from the ability of certain inorganic semiconductors to absorb light and generate electron–hole pairs that participate in redox reactions (1). When photons with sufficient energy strike the surface of materials such as titanium dioxide or zinc oxide, electrons are excited to the conduction band, leaving holes in the valence band. These charge carriers migrate to the surface and interact with adsorbed species. The generated electrons reduce oxygen molecules while the holes oxidize water or organic pollutants, leading to degradation of harmful substances (2). This property makes photocatalysis highly effective for environmental cleanup, including removal of dyes, pesticides, and toxic chemicals from water sources. Photocatalysis also plays a crucial role in energy chemistry, particularly in water splitting for hydrogen production (3). The ability to convert solar energy into chemical energy offers a sustainable pathway for fuel generation. Structural characteristics such as band gap width, crystallinity, and defect sites influence the efficiency of light absorption and charge separation. Spectroscopic and structural analyses reveal how modifications such as doping and surface engineering enhance photocatalytic performance

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(4). These studies help correlate atomic structure with reactivity. Theoretical and experimental research together explain how electron–hole recombination can be minimized to improve efficiency (5). Thus, photocatalysis represents a strong connection between inorganic chemistry, environmental science, and renewable energy technology.

Conclusion

Photocatalysis provides a sustainable method for addressing environmental pollution and energy challenges using inorganic materials. By utilizing light energy to drive chemical reactions, photocatalysts reduce reliance on conventional energy sources and harsh chemical treatments. Their role in pollutant degradation and hydrogen production highlights their practical importance. Ongoing research into band gap engineering, surface modification, and nanostructuring continues to improve photocatalytic efficiency. As global interest in renewable energy and environmental protection grows, photocatalysis will remain a key focus area within inorganic chemistry. Its integration of material science and chemical reactivity demonstrates the power of inorganic compounds in solving real-world problems.

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