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Review Article

Nanostructured semiconductor photocatalysts: Physics and their applications towards sustainable society

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Abstract

The development of human societies, the excessive use of fossil fuels, and the expansion of industrial activities have significantly led to severe environmental issues, including water, air, and soil pollution. Therefore, in order to address these challenges, the application of clean and sustainable technologies has received considerable attention in recent years. In this context, the use of nanostructured semiconductor photocatalysts with suitable valence and conduction band energy levels, along with sufficient incident light intensity and proper wavelength for their activation, has emerged as a promising and effective approach to achieve sustainable development. Semiconductor photocatalysts, owing to their unique physical properties such as tunable bandgap and high specific surface area, as well as efficient charge carrier separation and transport, are capable of driving chemical reactions under appropriate illumination with high conversion efficiency. Moreover, due to their significant potential in protecting water resources and ecosystems, nanostructured photocatalysts have gained considerable attention in industrial wastewater treatment. Their primary application has been extensively reported particularly in the degradation of persistent and toxic pollutants such as pharmaceutical residues and synthetic dyes, especially in textile industries. This study provides the fundamental physics and underlying mechanisms of the photocatalytic degradation reactions of pharmaceutical and dye pollutants from industrial wastewater on the surface of suitable semiconductor photocatalysts, with an emphasis on their role in promoting sustainable community development. Furthermore, various types of semiconductor materials used as photocatalysts are introduced. The report then investigates several factors that affect their performance, including environmental reaction conditions, pollutant type (pharmaceutical or dye), design of photocatalyst crystal structure, and construction of heterojunction between two semiconductors. Finally, the current challenges in scaling up photocatalytic technology for industrial applications under real solar light are discussed.

Keywords: Semiconductor photocatalyst, Sustainable Development, Industrial wastewater treatment, Dye and drug degradation

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