

Chapter 1

Plastic Degradation by Photocatalysis: Basic Concepts and General Mechanisms

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Owing to their several desirable properties, plastics have brought a lot of convenience to us and have become an integral part of our lives. However, being non-biodegradable, the disposal and treatment of waste plastic remain a ubiquitous issue. Conventional treatment strategies may not be able to satisfactorily break the C-C, C-O or C-H bonds inherently present in their structures. Photocatalysis presents one of the promising routes for addressing the growing need of plastic waste treatment/disposal. This approach employs semiconductor materials as photocatalysts. When exposed to light of appropriate wavelength, these photocatalysts generate electron-hole pairs that initiate redox reactions, forming highly reactive oxygen species (ROS) such as hydroxyl radicals. These ROS can effectively break down polymer chains in plastics through a series of oxidative reactions, ultimately leading to polymer fragmentation or even complete mineralization to CO₂ and water. This chapter discusses the basic principles of photocatalysis, the photocatalytic method and the general mechanism involved in the degradation of plastics.

Introduction

Plastics are used extensively because they provide several advantages that have made them an essential component of modern life. But the production, usage, and disposal of plastics in a linear consumption paradigm presents serious problems for sustainability and the environment. The concept of circular economy promotes a more sustainable method of producing, using, and disposing plastics, and offers a framework to solve these issues (1). Through extensive reuse, repair, remanufacturing, and recycling, the circular economy paradigm seeks to maximize the value derived from materials and products in an effort to divorce economic growth from resource consumption (2). This closed-loop strategy is especially relevant for tackling the world's plastic waste problem, as only 17% of the roughly 300 million tons of plastics generated each year are recycled successfully (3, 4). Landfilling and incineration, the conventional linear processes, are not sustainable and result in resource depletion, greenhouse gas emissions, and degradation of the environment.