Chapter 3
Emerging Sustainable Materials to Improve Green Energy:
Environmental Applications and Future Scope

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ABSTRACT

The need for affordable, effective, and sustainable energy production is growing globally. Functional material applications are growing in significance due to recent advancements and discoveries in materials science and technology. An indispensable manual for creating and using these materials in producing sustainable energy is provided by functional materials for sustainable energy applications. The first section examines functional materials for solar energy, such as thermophotovoltaic device modeling, photoelectrochemical cells, and silicon-based, thin-film, and dye-sensitized photovoltaic solar cells. Functional materials for the synthesis and storage of hydrogen are the subject of part two. In part three, functional materials for fuel cells are further examined. Part two discusses functional materials for hydrogen synthesis and storage.

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1. INTRODUCTION

In order to effectively tackle the issues posed by the growing worldwide energy requirements of a growing populace, as well as the corresponding environmental fallout from a society still mostly dependent on fossil fuels, highly inventive, efficient, and progressively sustainable solutions must be discovered (Lesar et al., 2012). In this sense, there are a number of ways to produce and store renewable energy from biomass, geothermal, wind, water, or the sun; nevertheless, the successful application of these methods depends largely on materials technologies. Consequently, it is crucial to produce sustainable materials.

This is no easy task, as these new materials must, in addition to being low cost, scalable, industrially and economically attractive, and based on highly abundant and renewable resources, also achieve application performances in environmental or renewable energy conversion that surpass those of current technologies (Chen et al., 2013). Thus, it is the responsibility of materials scientists to create innovative, high-performing, and sustainable materials to address the problem of supplying renewable energy to everyone while minimizing environmental effects.

Carbon is the most prevalent element in the biosphere, behind oxygen, in the context of developing sustainable materials. These elements, when combined with hydrogen, are used by nature to generate the building blocks for sustainable energy storage, such as carbohydrates. Similar to this, carbon-based systems—such as electrodes in energy storage devices, electrocatalysis, photocatalysis, heterogeneous catalysis, biofuels, etc.—are progressively playing a significant part in developing sustainable energy conversion technologies (Diallo, Fromer, & Jhon, 2014; Fleischer & Grunwald, 2008).

These materials are extremely beneficial to renewable energy technologies, as they power components found in fuel cells, solar panels, wind turbines, energy storage, and ultimately increase efficiency and promote cleaner energy sources. By using lightweight materials, electronic parts, and alternative fuels, sustainable materials are also revolutionizing transportation and drastically lowering the industry's environmental effect. Tailored sustainable materials in water treatment also tackle the problems of pollution and water scarcity, greatly improving the environmental performance of essential water management systems (Assey & Malasi, 2021). The effective use of these sustainable materials into engineering projects demonstrates their potential and offers insightful information about their advantages, difficulties, and practical uses. As sustainability becomes more and more important to industries, it is imperative that these materials are continuously explored and integrated in order to shape an environmentally conscious future (Messerli, Murniningtyas, Eloundou-Enyegue, Foli, Furman, Glassman, & van Ypersele, 2019).