Progress in Materials Science 92 (2018) 33–63

Contents lists available at ScienceDirect

Progress in Materials Science

journal homepage: www.elsevier.com/locate/pmatsci

Nitrogen-doped simple and complex oxides for photocatalysis: A review

Wei Wang [a], Moses O. Tadé [a], Zongping Shao [a,b,*]

[a] *Department of Chemical Engineering, Curtin University, Perth, WA 6845, Australia*
[b] *Jiangsu National Synergetic Innovation Center for Advanced Material, State Key Laboratory of Materials-Oriented Chemical Engineering, Nanjing Tech University, Nanjing 210009, China*

ARTICLE INFO

Article history:
Received 28 April 2016
Accepted 13 September 2017
Available online 15 September 2017

Keywords:
Photocatalysis
Nitrogen-doped oxides
TiO_2
Perovskite
Solar energy

ABSTRACT

Semiconductor-based photocatalysis plays a vital role in counteracting worldwide environmental pollution and energy shortage. How to design a visible-light-active photocatalyst is critical for efficient solar energy utilization. Many oxides including TiO_2 are only photoactive in ultraviolet light and doping is an important strategy to extend the photoactive zone. Anion doping is superior to cation doping, which generates more harmful electron-hole recombination centers. Nitrogen doping is more effective than carbon/sulfur doping to achieve high visible-light response. Since 2001, nitrogen-doped TiO_2 photocatalysts have attracted increasing attention due to their strong oxidizing power and considerable visible light response. Considering the fixed atomic environment in simple oxides, complex oxides are more attractive as photocatalysts because of their more flexible physical and chemical properties. To date, no review focuses on the designation strategies for nitrogen-doped simple/complex oxides with high visible-light photoactivity. In this review, the recent progress involving nitrogen-doped simple/complex oxides for photocatalysis is comprehensively summarized. Emphasis is placed on the factors that determine photocatalytic activity and related strategies for the design of active nitrogen-doped oxides. The future challenges are also discussed. This review aims to provide a summary of recent progress in nitrogen-doped oxides for photocatalysis and some useful guidelines for the future development.

© 2017 Elsevier Ltd. All rights reserved.

Contents

* Corresponding author at: Department of Chemical Engineering, Curtin University, Perth, WA 6845, Australia.
E-mail address: zongping.shao@curtin.edu.au (Z. Shao).

https://doi.org/10.1016/j.pmatsci.2017.09.002
0079-6425/© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

Our modern society is built strongly on fossil fuels, which, however, are limited resources and non-renewable in nature. In addition, the burning of fossil fuels produces huge amounts of greenhouse gases and environmental pollutants. Therefore, clean and renewable energy alternatives are highly desirable for the sustainable development of our society. Among the various kinds of renewable energies, solar energy calls for urgent attention because of its cleanness and huge abundance. Approximately 3,850,000 exajoules (EJ) of solar power irradiate the earth each year [1]. It is also interesting that the total amount of energy accumulated in all fossil resources equals the solar energy received by the earth over only 7 days, and 1 h of solar power irradiation is the equivalent to more than the world's energy consumption for an entire year [2]. Clean water shortage has become another serious obstacle towards a sustainable future. Only 3% of the earth's water is fresh water, and two-thirds of that amount is stored in frozen glaciers or otherwise unavailable for our use. The clean water shortage has recently become more serious due to increasing overpopulation and the serious water pollution due to human activities. Currently, approximately 1.1 billion people worldwide lack access to fresh water, and 2.7 billion people have scarce water for at least one month of the year, based on the results of the World Wide Fund (WWF) organization [3]. Wastewater purification may be an important way to solve or at least mediate the clean water shortage problem.

In the past, worldwide efforts have been undertaken to use sunlight for energy production, environmental protection and water purification, in which photocatalysis plays a crucial role. Hydrogen is believed to be an ideal energy material whose combustion releases only clean water, and the combination of hydrogen and fuel cells may provide an alternative energy system for the future, while photocatalytic water splitting is one of the most important methods of hydrogen production, which allows the utilization of the huge resources of solar energy as energy source and widely available water as a hydrogen storage material. On the other hand, photocatalytic wastewater purification allows the use of solar energy for the direct degradation of organics to harmless substances in water. For both reactions, efficient photocatalysts are required. Therefore, tremendous efforts have been conducted in the development of efficient photocatalysts for the water splitting reaction and/or the degradation of organic substances [4–14].

The prerequisite of an efficient photocatalyst for hydrogen production from water splitting is that the redox potential for the evolution of hydrogen and oxygen from water and for the formation of active species such as hydroxyl radicals ($OH^{\cdot}$), hydrogen peroxide (H_2O_2) and superoxide ($O_2^{\cdot-}$) should lie within the band gap (BG) of a semiconductor photocatalyst [15]. The basic principle for the photocatalytic degradation of organic compounds is similar to the photocatalytic water

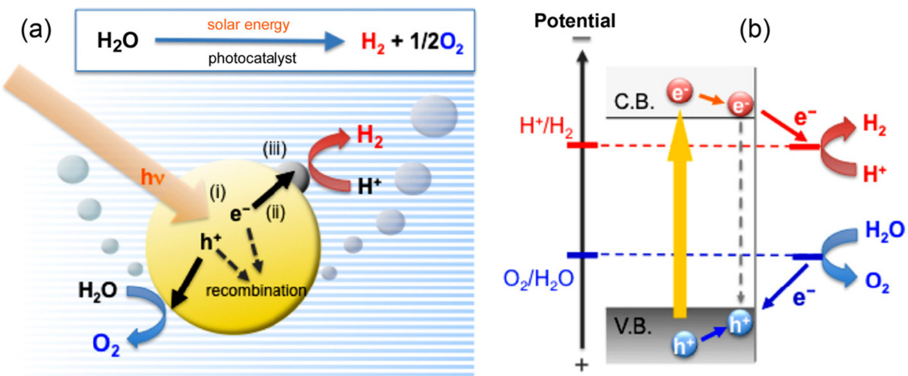

Fig. 1. Schematic illustration of water splitting over semiconductor photocatalyst [19].

Download English Version:

https://daneshyari.com/en/article/5464284

Download Persian Version:

https://daneshyari.com/article/5464284

Daneshyari.com