Chapter 6
Modified TiO2 Nanomaterials as Photocatalysts for Environmental Applications

Dessy Ariyanti
https://orcid.org/0000-0003-3490-5492
Universitas Diponegoro, Indonesia

Aprilina Purbasari
Universitas Diponegoro, Indonesia

Dina Lesdantina
Universitas Diponegoro, Indonesia

Filicia Wicaksana
University of Auckland, New Zealand

Wei Gao
University of Auckland, New Zealand

ABSTRACT

Since the water splitting breakthrough using semiconductor reported in 1972, titanium dioxide (TiO2) has been extensively investigated as a promising material used in broad range of research areas. TiO2 is a transition metal oxide semiconductor with three distinct polymorph crystalline structures. With that alone TiO2 established remarkable performance as photocatalyst for organic photodegradation in the irradiation of UV. However, improvement on the light absorption properties that support the excellent photocatalytic activity still needs to be pursued for wider environmental application. In this book chapter, the limitations of TiO2 as photocatalyst were discussed especially in the industrial wastewater treatment application. The strategies in overcoming the limitation by TiO2 morphology and surface modification were also presented. The modified TiO2 nanomaterials proves to have excellent photocatalytic activity in dyes (Rhodamine B, Methyl Orange and Methylene Blue) as representative of organic pollutant degradation and Cu (II) reduction as representative of inorganic pollutant.

DOI: 10.4018/978-1-6684-5629-3.ch006

INTRODUCTION

Water pollution is one of the dangerous problems threatening the world's environmental system. Climate change, population growth, fast economic development, and change in consumption patterns are the main cause of water scarcity. Meanwhile, enormous human activities lead to contamination concerns with detrimental effects on human health and ecosystems. Major sources of water pollution are human settlement and industrial and agricultural activities. Globally, over 80% of wastewater is discharged without prior treatment. It consists of sewage that is discharged directly into water bodies and an estimated 300-400 MT of polluted waste dumped by industries every year (World Water Assessment Programme (United Nations et al., 2021).

The release of untreated wastewater remains a common practice, especially in developing countries, due to a lack of infrastructure, technical and institutional capacity, and financing (World Water Assessment Programme (United Nations) et al., 2021). Developing countries, home of most large-scale agriculture products harvested and giant industries such as textile and other products release polluted water consisting of fertilizers and pesticides, organic waste, heavy metals, pathogens, and other emerging pollutants. Polluted water increases the environmental threats leading to eutrophication and water scarcity with potentially serious threats to human health (Unesco et al., 2020).

Wastewater consists of various colloidal particulates, pathogenic microorganisms, and organic and inorganic pollutants. Organic pollutants include dyes, colourants, pesticides, fertilizers, hydrocarbons, phenols, plasticizers, biphenyls, detergents, oils, greases, pharmaceuticals, proteins, and polysaccharides. Wastewater with a large number of organic pollutants (suspended solids) can reduce the light available to photosynthetic organisms and organic oxidation in the water (Rashed, 2013). Meanwhile, inorganic pollutants come in the form of chemical pollution, including heavy metals (Cu, Cr, Pb, Ni, etc.) (Liang et al., 2021). The removal of organic pollutants become an important task in the water treatment industry as they associate with the formation of disinfection by-products (DBPs). For instance, trihalomethanes (THMs) and halo acetic acids (HAAs) can be formed when certain organic species react with chlorine or chloramine which is a threat to public health. The discharge of untreated effluent in water bodies not only leads to eutrophication and human health risks but also contributes significantly to Green House Gas (GHG) emissions in the form of nitrous oxide and methane. In addition, the presence of heavy metals and other inorganic compounds with a concentration above the minimum level could have detrimental effects on human health and ecosystems as it is poisonous, non-degradable and, easily accumulates (Tomczyk et al., 2020; B. Yu et al., 2000). Therefore, the development of wastewater treatment technology that is technically

Related Content