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Ag_2MoO_4 nanoparticles encapsulated in g-C_3N_4 for sunlight photodegradation of pollutants

Ming Wu[a,1], Hongying Lv[b,1], Teng Wang[a], Zhimin Ao[a,*], Hongqi Sun[c], Chengyin Wang[b,*], Taicheng An[a], Shaobin Wang[d,*]

[a] Guangzhou Key Laboratory of Environmental Catalysis and Pollution Control, Institute of Environmental Health and Pollution Control, School of Environmental Science and Engineering, Guangdong University of Technology, Guangzhou 51006, China

[b] College of Chemistry and Chemical Engineering, Jiangsu Key Laboratory of Environmental Engineering and Monitoring, Yangzhou University, 180 Si-Wang Ting Road, Yangzhou, 225002, China

[c] School of Engineering, Edith Cowan University, Joondalup, WA 6027, Australia

[d] Department of Chemical Engineering, Curtin University, GPO Box U1987, Perth, WA 6845, Australia

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A B S T R A C T

Graphitic carbon nitride (g-C_3N_4), a promising metal-free photocatalyst, shows a high thermal stability, excellent chemical stability, and great optical absorption of solar light. However, a short life of activated electron-hole pairs limits g-C_3N_4 in practical applications. In this work, Ag_2MoO_4 nanoparticles encapsulated in g-C_3N_4 (Ag_2MoO_4/g-C_3N_4) was synthesized with a facile *in-situ* precipitation method. A variety of characterization techniques were applied for analyzing the compositions, morphologies and optical properties of Ag_2MoO_4/g-C_3N_4. The band structure of Ag_2MoO_4 produces a synergistic effect with g-C_3N_4, which can efficiently increase solar light absorption and reduce the recombination rate of the photo-induced electron-hole pairs. Therefore, this hybrid catalyst presents a much higher photocatalytic activity for the degradation of various organic pollutants (bisphenol A, acyclovir, and methyl orange) and strong stability under both artifical and real sunlight, which is promising for practical application.

1. Introduction

Since the 21st century, energy crisis and environmental pollution become more and more serious with the significant growth of population. Water pollution has attracted more attention as resources of drinking water are remarkably reducing. Organic wastes from industries and our daily living are toxic and harmful, which can contaminate water and eventually threaten human health [1]. Some of organic wastes like dyes [2], phenol [3], phenolic compounds [4,5], and pharmaceuticals etc. [6,7] cannot be directly bio-degraded [8,9]. Therefore, treatments of these organic wastes in water have been a hot research topic all over the world. Many methods have been explored, including photocatalysis [8–11], adsorption [12], electrochemical decomposition [13], microbial degradation [14], advanced oxidation [15] and others [16,17]. Photocatalysis is considered as a promising and environmentally friendly method for using clean solar energy and no emission of harmful substances (CO_2 and H_2O). Graphitic carbon nitride (g-C_3N_4) was discovered for water-splitting in 2009, which attracted great attention afterwards from all over the word [18–20]. Meanwhile, the excellent properties of g-C_3N_4, such as great thermal and chemical stability, good optical absorption for sunlight, make it one of the most popular photocatalysts in environmental and energy applications [21–23]. However, pristine g-C_3N_4 has not yet reached the requirements for practical applications due to the short time of the recombination of photogenerated electron-hole pairs [24,25].

Introduction of Ag or its compounds is considered as an effective strategy to enhance the photocatalytic activity of g-C_3N_4 by hindering the electron-hole recombination. For example, Ag [26–28], Ag_2O [29–32], Ag_2CO_3 [33], $Ag_2Mo_2O_7$ [34], Ag_3VO_4 [35], Ag_3PO_4 [36,37], Ag/$AgWO_3$ [38], and Ag/AgBr [39–43] have been attempted for enhancing photocatalytic activity of pristine g-C_3N_4. Another Ag-based compound, Ag_2MoO_4, was also investigated because of its excellent properties like great electrical conductivity, high antimicrobial activity, nontoxicity and great photocatalytic activity [44–48] for degradation of organic dyes. However, it can only be excited under ultraviolet light irradiation due to a wide bandgap of 3.05 eV [49–51]. Recently, Ag_2MoO_4/g-C_3N_4 was reported for degradation of a dye under visible light irradiation [52], but more research on its synthesis, catalytic

* Corresponding authors.
E-mail addresses: zhimin.ao@gdut.edu.cn (Z. Ao), wangcy@yzu.edu.cn (C. Wang), shaobin.wang@curtin.edu.au (S. Wang).
[1] These authors contributed equally to this work.

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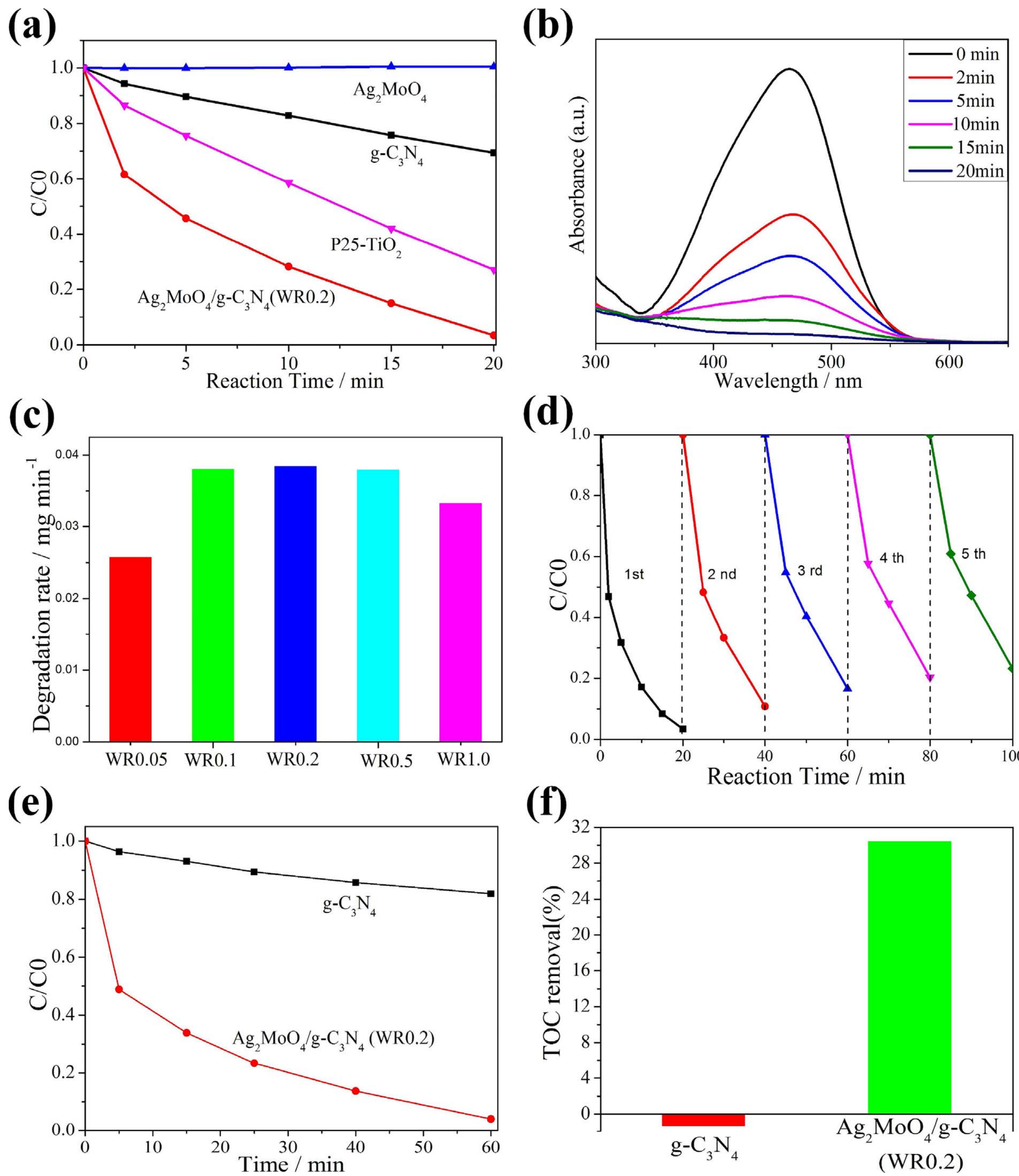

Fig. 1. (a) Photodegradation of MO with Ag_2MoO_4, g-C_3N_4, Ag_2MoO_4/g-C_3N_4(WR0.2) and P25-TiO_2. (b) The given time UV/Vis spectrum of MO degradation solution by Ag_2MoO_4/g-C_3N_4(WR0.2). (c) Photodegradation rate of MO with different Ag_2MoO_4/g-C_3N_4 samples under 20 min reaction. (d) Recycle tests of Ag_2MoO_4/g-C_3N_4(WR0.2) for photodegradation of MO. The photocatalytic reactions of (a-d) were conducted with simulated sunlight (Xe-light). (e) Photodegradation of MO with g-C_3N_4 and Ag_2MoO_4/g-C_3N_4(WR0.2) under natural sunlight irradiation. (f) TOC removal of MO degraded by g-C_3N_4 and $AgMoO_4$/g-C_3N_4 (WR0.2) after photocatalytic reaction under natural sunlight irradiation.

mechanism and wide application for different organic pollutants is still required.

In this paper, we report a simple synthesis of Ag_2MoO_4/g-C_3N_4 hybrids using a facile *in-situ* precipitation method. The Ag_2MoO_4/g-C_3N_4 samples showed much higher photocatalytic activity than pristine g-C_3N_4 in degradation of organic pollutants including bisphenol A, acyclovir, and methyl orange (MO) under sunlight irradiation. The photocatalytic reaction mechanism and enhancement mechanism of this hybrid catalyst under sunlight were also investigated.

2. Experiments

2.1. Chemicals

Urea ($CO(NH_2)_2$, Aladdin Chemistry Reagent Co., Ltd, ≥99.5%), sodium molybdate ($Na_2MoO_4{\cdot}2H_2O$, Tianjin Chemical Reagent Co., Ltd, ≥99.0%), silver nitrate ($AgNO_3$, Guangzhou Jinhua Chemical Reagent Co., Ltd, ≥99.8%) were used with no further purification. Ultrapure water with a resistance of 18.2 MΩ·cm was obtained from an instrument Unique-R20.