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Synthesis and enhanced visible-light photocatalytic activity of wollastonite/g-C_3N_4 composite

Guangyuan Yao, Zhiming Sun*, Shuilin Zheng

School of Chemical and Environmental Engineering, China University of Mining and Technology (Beijing), Beijing 100083, PR China

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ABSTRACT

The novel wollastonite/g-C_3N_4composites were synthesized via a simple calcination and acid leaching process. The as-prepared photocatalysts were characterized by XRD, HRSEM, PL, UV–vis DRS, ESR and BET. The phtotocatalytic performance of the as-synthesizedcomposites was evaluated by the photo-degradation of Rhodamine B under visible light irradiation. The visible-light photocatalytic activity of the as-prepared samples is much higher than that of pure g-C_3N_4. The Di/Wo(H^+)-4:3 sample displays the optimal photocatalytic performance towards RhB under visible light and its reaction rate constant is 6.5 times that of pure g-C_3N_4. Meanwhile, the Di/Wo(H^+)-4:3 presents a good durability and reusability. The improved photoactivity of the Di/Wo(H^+) composite could be attributed not only to its high surface area and porosity but also to the synergistic effect of the g-C_3N_4 and wollastonite, which can effectively promote the separation of photogenerated electron-hole pairs and consequently enhanced its photoactivity.

1. Introduction

Recently, more and more attention has been focused on the environmental pollution problems and energy shortage. A large number of photocatalysts including TiO_2 [1], ZnO [2], BiOX(X = Cl, Br, I) [3–5], CdS [6] and graphitic carbon nitride(g-C_3N_4) [7] have been explored and applied to the degradation of various contaminants. Among various photocatalysts, graphitic carbon nitride (g-C_3N_4) can be one of the most promising candidates for its good practical application performance under visible light irradiation due to its suitable band gap (2.7 eV), high thermal and chemical stability, environmental friendliness and low cost [8]. Nevertheless, the photocatalytic activity of g-C_3N_4 is greatly restrained by its low surface area and high recombination rate of the photo-generated electron-hole pairs [9,10]. Hence, in order to improve its photocatalytic performance, numerous methods have been proposed, including doping with heteroatoms (C, S, B and P) [11–15], coupling with semiconductor [16–18], copolymerizing with organic molecules [19,20], designing appropriate pore structure [9,21,22], controlling morphology [23–25]. Although the photocatalytic performance of g-C_3N_4 can be improved by the above methods, the g-C_3N_4 based photocatalysis requires further enhancement due to its easy agglomeration, difficult separation and low adsorption ability.

To solve these practical disadvantages, the g-C_3N_4 has been proposed to be loaded on natural minerals, such as montmorillonites [26], kaolinite [27] and diatomite [28], which can not only effectively reduce the production cost, but also greatly improve its photoactivity. Among these carriers, fibrous or layered minerals seem to be the most promising candidates as layered g-C_3N_4 carriers due to the form of the tighterinterface. Wollastoniteis a kind of chain silicates, which has been extensively used in the ceramic and cement industries [29]. Moreover, it has received considerable attention due to its good bioactivity and biocompatibility in recent years. The structure of wollastonite consists of infinite chains composed of a pair of corner-sharing tetrahedral alternating with a single tetrahedron with one edge parallel to the chain direction, and layers of Ca atoms in octahedral coordination alternate with layers of Si atoms. Due to its abundance, thermal resistance, chemical and mechanical stability, low cost, good biocompatibility, as well as its fibrous nature which makes it easier to combine with two dimensional (2D) layered materials and forms 2D/2D structure, wollastonite can be a promising substrate for immobilization of a variety of photocatalysts. And under highly

* Corresponding author.
E-mail addresses: zhimingsun@cumtb.edu.cn, szmcumtb@hotmail.com (Z. Sun).

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acidic conditions, the element Ca can be extracted from the crystal lattice while maintaining the original fibrous framework and greatly increasing its surface area [30]. To the best of our knowledge, the photoactivity of wollastonite combining with g-C_3N_4 has not been reported before.

In the present study, we synthesize a novel kind of wollastonite/g-C_3N_4 composite via a simple calcination and acid leaching process. Through the calcination and acid leaching process, the surface area of the composites could be increased, and more adsorption and photocatalytic reaction sites would be generated, which then could promote the photoactivity. The synthesis, characterization and photoactivity of the wollastonite/g-C_3N_4composites were investigated. The structure, morphology and physicochemical properties of the as-prepared hybrids were characterized byXRD, HRSEM, PL, UV–vis DRS, ESR and BET, respectively. The photocatalytic performance was evaluated by the degradation of Rhodamine B in aqueous solution under visible light. The influence of the mass rates of dicyandiamide and wollastoniteon the visible-light driven photocatalytic efficiency was also investigated. In addition, the enhanced photocatalytic performance and the enhancement mechanism were also systematically studied based on the experimental results.

2. Experimental

2.1. Materials

Wollastonite (Wo) is obtained from Jiangsu Province, China. Dicyandiamide ($C_2H_4N_4$), rhodamine B ($C_{28}H_{31}ClN_2O_3$, RhB), edetate disodium (EDTA-2Na), benzoquinone (BQ), *tert*-butanol (TBA) and the other chemicals used in the experiments were purchased from Beijing Reagent Co. (Beijing, China). All chemicals

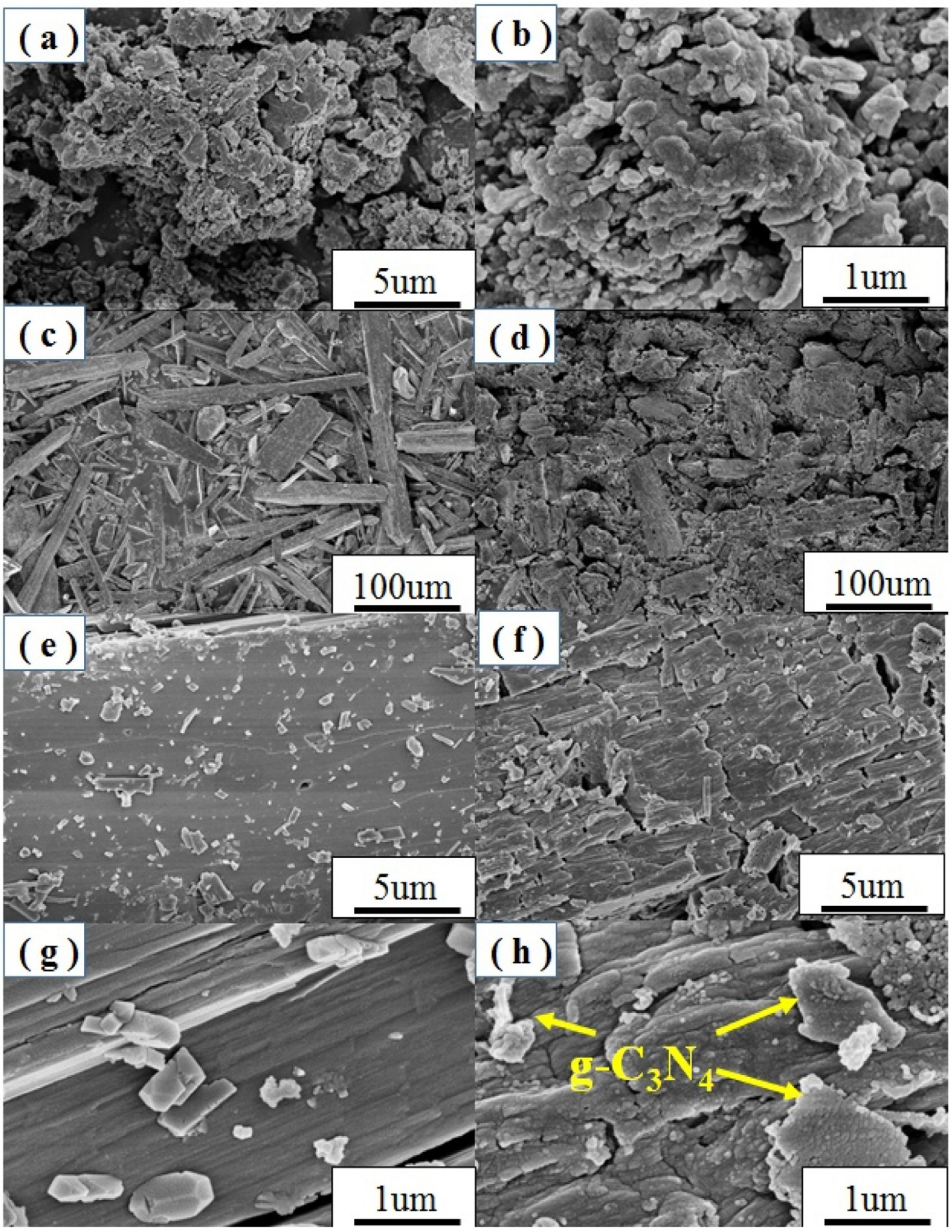

Fig. 1. SEM images of g-C_3N_4 (a and b), wollastonite (c, e and g) and Di/Wo(H^+)-4:3 composites (d, f and h).