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Photocatalytic performance of acid exfoliated graphitic carbon nitride ($g-C_3N_4$) for the degradation of dye under direct sunlight

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A B S T R A C T

Graphitic carbon nitride ($g-C_3N_4$) is one of the most promising semiconductor materials applied in photocatalytic applications. However, the photocatalytic performance of bulk $g-C_3N_4$ was not satisfactory due to poor visible-light absorption, quick recombination, and low amount of active interfacial reaction sites. In this study, we have modified the bulk $g-C_3N_4$ by acid (nitric, hydrochloric and sulphuric) exfoliation to enhance the photocatalytic degradation of methylene blue (MB) and methyl orange (MO) dye. Sulfuric acid-treated $g-C_3N_4$ photocatalyst (CN-S) presented significant photocatalytic degradation toward both MO and MB compared to the pristine $g-C_3N_4$. The photocatalytic degradation performance for CN-S is found to be ~ 96.89 % for MO and ~ 93.12 % for MB under 150 min under direct sunlight irradiation. Free radical scavenging tests showed the superoxide radicals ($\bullet O_2^-$) were mostly responsible to the photodegradation of dyes while comparing to hydroxyl radicals (•OH) and photo-induced holes (h^+). Which is attributed by Photoluminescence (PL) and time resolved PL emission spectra indicated a low electron-hole pair's (e^-/h^+) recombination and longer charge-carrier lifetime. Moreover, the CN-S showed excellent recyclability for up to 5 runs with a slight reduction of degradation performance from 96.89 to 90.55 % for MO and 93.12 % to 88.84 % for MB dye, respectively. Ultimately, the results demonstrated that CN-S was a superb photocatalyst for the elimination and deterioration of MB and MO dyes from wastewater.

1. Introduction

Industrial development is one of the key factors causing water pollution. An estimated 200,000 tons of textile dyes are produced annually worldwide, with the majority of these dye wastewaters coming from the paper, printing, paper, food processing and tannery industries [1–3]. Dye-containing wastewater is full of hazardous, non-biodegradable, toxic, and carcinogenic chemicals that widely affects human health and environment [4]. The consumption, ingestion, and inhalation of dye-treated wastewater are responsible for potential human health risks, including chronic diseases, respiratory infections, eye and skin irritations [5–7]. Similarly, there are potential barriers for the growth of aquatic organisms that interrupt ecological steadiness [5,8], over significantly reduces the absorbed or reflected sunlight [9–11]. Therefore, treating contaminated water before releasing into the environment is essential for human and environment as well as ensure sustainable water management. Although we human beings are responsible for generating wastewater for our daily needs, that's why we have to solve the issues to launch a better and sound world tomorrow. To date, adsorption [12], coagulation-flocculation [13], membrane filtration [14], electrochemical [15], photo-Fenton [16], photocatalysis [17], biological [18,19], and hybrid methods [20] are the most commonly used approaches for eliminating the curse of dye wastewater [21,22]. Among them, pollutants have been reduced through the widespread application of advanced oxidation processes (AOP) based photocatalytic treatment approach [23].

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