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Hydrothermal preparation of P25–graphene composite with enhanced adsorption and photocatalytic degradation of dyes

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HIGHLIGHTS

- P25–graphene composite with different graphene content was prepared.
- As graphene content increasing, the absorption intensity of visible light and the specific surface area was increased.
- P25–graphene composite has better adsorption capacity and photocatalytic degradation efficiency for dyes removal.

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ABSTRACT

Graphene, a 2-D carbon material, has unique electrical properties and high specific surface area. In recent years, carbon materials were impregnated into TiO_2 photocatalysts and become a research focus since the pure TiO_2 has limited adsorption and photocatalytic ability. In this study, P25–graphene (GN) nanocomposite photocatalyst was prepared by hydrothermal methods. The reduction of graphene oxide and loading of TiO_2 (Degussa P25) on GN were completed at the hydrothermal process. By controlling the amount of P25 and the concentration of graphene oxide dispersions, P25–graphene composite with different graphene content was prepared. The nanocomposites were characterized using TEM, XRD, N_2 adsorption/desorption analyzer, UV–vis DRS and TGA. As graphene content increasing, the absorption intensity of visible light and the specific surface area was increased. The results showed that P25–graphene composite has better adsorption capacity and photocatalytic degradation efficiency for MB (methylene blue) and RBk5 (reactive black 5) dyes removal. For 10 mg L^{-1} MB, the adsorption removal efficiency can reach above 90% with P25–10% GN dosage of 0.4 g L^{-1}. The saturated adsorption capacity of MB is 50 mg g^{-1} under the same condition. For 10 mg L^{-1} RBk5, the degradation removal efficiency can reach more than 90% with 365 nm UV light irradiation.

1. Introduction

Dyes are widely used in textile, cosmetics and other industries. Effluents from these industries have high content of organic pollutants, salts, chemical oxygen demand (COD), suspended solids (SSs) and fluctuating pH [1]. The dye wastewater has such complex composition, making the conventional biological treatment method restricted [2]. Since the 1980s, the TiO_2 has been playing an important role in environmental pollution control because of its high efficiency at room temperature, low cost [3] and non-toxicity. However, with a band gap of 3.2 eV, pure TiO_2 is only able to absorb and use the ultraviolet light (UV light, only 3–5% of the solar energy) [4] and recombination of photogenerated electron–hole pairs [5] is also a problem. The previous study showed that TiO_2 combined with carbon or silica materials such as activated carbon [6], carbon nanotubes [7], fullerenes [8], tetramethyl orthosilicate [9], tetraethyl orthosilicate [10] can reduce the photo-generated electron–hole recombination rate and improve the photocatalytic properties of TiO_2. Geim's research team found graphene and attracted widespread concern in 2004 [11]. Graphene, a two-dimensional carbon material, is characterized by excellent electrical properties (mobility of charge carriers 200,000 $cm^2\,V^{-1}\,s^{-1}$ at room temperature) [12], thermal properties (thermal conductivity

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