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Degradation of Organic Pollutants by ZnO Decorated Fe_3O_4/rGO Nanocomposite

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Extended Abstract

Recalcitrant organic compounds that are often toxic and non-biodegradable present in the waste water have led to serious environmental pollution. Remediation of such chemicals by the photo-Fenton process is one of the well-recognized advanced oxidation process (AOP) [1]. Herein, we report a magnetically separable tertiary composite, zinc oxide-decorated Fe_3O_4/rGO, as a heterogeneous catalyst for photo-Fenton degradation of organic pollutants in aqueous media under ambient conditions [2].

In this study, zinc oxide nanoparticles were hydrothermally deposited on the surface of Fe_3O_4/GO composite that was synthesised by a Solvothermal process [3]. The physicochemical properties of the as–synthesised composite were explored using scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and photoluminescence (PL) studies. The as-prepared catalyst showed superior stability and, due to the presence of the magnetic Fe_3O_4 nanospheres, could be conveniently separated from the reaction system with an external magnet for reuse. The photo-Fenton activity of the as-prepared catalysts was evaluated by analysing the photodegradation of MB in an aqueous solution under visible irradiation. For the degradation of MB, 20 mg of the as-prepared catalyst was used into a 100 mL reactor containing 50 mL of an aqueous solution of 10 mg/L MB and 30 μM H_2O_2. The pH of the reaction mixture was maintained at 7. The photocatalytic activities of the as-prepared composites were evaluated by monitoring the discoloration of methylene blue (MB) under visible light irradiation ($\lambda \geq 420$ nm). The concentration of the MB solution was analysed by measuring the absorbance peak at characteristic 664nm wavelength using a UV–vis spectrophotometer.

The as-synthesized, ZnO-decorated Fe_3O_4/rGO composite exhibited superior catalytic activity for the degradation of azo dye compared to pristine ZnO, ZnO/Fe_3O_4, Fe_3O_4, and Fe_3O_4/GO. The higher efficiency of the as-synthesized nanocomposite is attributed to the synergetic effect of hydroxyl radicals generated via photoreduction of the ferric ions to the ferrous ions due to photo-Fenton process and photoexcitation of ZnO nanoparticles after irradiation of light. In ZnO-decorated Fe_3O_4/rGO nanocomposite, the electrons in the valance band of ZnO can be excited to conduction band under the irradiation of visible light. These electrons are quickly transported to the graphene interlayer thereby prolonging the lifetime of photogenerated charged electron-hole pair [4]. The interlayer of graphene not only reduces the recombination of photoelectron but also can strengthen the combination between ZnO and Fe_3O_4. Thus, the whole process includes the photo-Fenton process due to the rapid redox reaction between Fe^{2+} and Fe^{3+} the photocatalytic activity of ZnO [5]. Overall, with visible irradiation, the electron transfer between the ferric ions and the ferrous ions are accelerated by rGO and ZnO, thereby promoting the continuous generation of •OH radicals. These resulting •OH radicals are responsible for the degradation of MB. It was also observed that the catalytic reduction efficiency of the as-synthesized composite was almost the same after four successive reactions without a considerable decrease in efficiency. Thus as-synthesized composite displayed excellent stability and recycling performance which was attributed to the magnetic property of Fe_3O_4. The presented photo-Fenton reagent synthesis protocol is efficient, less toxic, and low-cost to produce a unique nanocomposite.

All of these merits indicate that the composite catalyst is a promising candidate for the degradation of organic compounds under visible light in environmental remediation applications.

Keywords: Photo-Fenton, Methylene blue (MB), Photodegradation, Fe_3O_4 nanospheres, Reduced Graphene oxide (rGO)

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