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Enhanced photocatalytic degradation of methylene blue using Fe_2O_3/graphene/CuO nanocomposites under visible light

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ABSTRACT

A visible light-responsive photocatalyst of Fe_2O_3/graphene/CuO (FGC) nanocomposite was successfully synthesized via a simple solvothermal method. The characteristics of the as-prepared graphene/mixed metal oxides were examined by XRD, SEM, EDS, TEM, and HR-TEM, and its magnetic property was evaluated by VSM. The analysis clearly revealed that the FGC hybrid catalyst, having a bandgap of 1.82 eV, has the ability to absorb visible light as observed from the UV–vis diffuse reflectance spectrum. The photocatalytic performance of FGC, subjected to visible light, in degrading methylene blue was evaluated. Its photocatalytic degradation property was found to be higher in the presence of visible light as compared to the other catalysts. In addition, the postulated mechanism of the photocatalytic property of this graphene/mixed metal oxides hybrid composite has been discussed. The present work demonstrates that this graphene/metal oxide hybrid nanocomposite can also be applied as a highly potent photocatalyst degrader for other dye pollutants.

1. Introduction

At present, organic dyes are one of the biggest environmental polluters since they cause severe pollution even at low concentrations which not only affects the transparency of the water but also creates aesthetic problems [1,2]. Hence, effective treatment of these textile effluents before their discharge into the environment is mandatory. Till date, several techniques, such as adsorption [3,4], membrane [5], photocatalysis [6], and many others [7–15] have been developed for the removal of organic dyes from textile effluents. Among these, the photocatalysis technique has emerged as a promising process for degrading dyes from wastewater as it can not only decolorize the wastewater but also achieve complete degradation of the dyes in it [16].

Among the various heterogeneous photocatalysts, copper oxide (CuO) has been widely used because of its photoconductive as well as photochemical properties that have various advantages. For example, it has a narrow bandgap (1.2 eV) and its electrical resistance and bulk density are quite low [17]. Its surface area and porosity are high and it can also exhibit strong absorption in the visible region when exposed to solar radiation [18]. However, one of the drawbacks of CuO is its poor photocatalytic activity for dye pollutant degradation. This is because the energy levels in the conduction band are more positive than the hydrogen reduction potential and this leads to fast recombination of the photo-generated charge carriers [19,20]. Another drawback of using CuO in wastewater treatment is the difficulty in its separation from the wastewater. Traditional separation techniques such as filtration, centrifuge and coagulation are generally used for catalyst removal. However, these techniques not only lead to serious losses of the catalyst but also lead to high energy consumption [21]. Therefore, techniques have been developed in order to overcome the disadvantages of CuO and improve the separation and lifetime of the photo-generated charge carriers. Heterojunction catalysts have attracted significant attention due to their unique properties in the photocatalysis process. Constructing a heterojunction of a catalyst is a common and effective way of promoting charge separation as well as prolonging the lifetime of the charge carrier [22].

Recently, various magnetic nanoparticles such as $CoFe_2O_4$/BiOI [23], Ag/$Bi_2Fe_4O_9$ [24], Fe_3O_4/ZnO [25] and many others [26–29] have been incorporated into the photocatalytically active materials, not only to allow catalyst separation by using an external magnet and

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