



ELSEVIER

Contents lists available at ScienceDirect

Materials Science in Semiconductor Processing

journal homepage: www.elsevier.com/locate/mssp

Facile sonochemical synthesis of BiOBr-graphene oxide nanocomposite with enhanced photocatalytic activity for the degradation of Direct green



Sandip P. Patil^a, Rahul P. Patil^b, Vilas K. Mahajan^b, G.H. Sonawane^{b,*}, V.S. Shrivastava^a, Shirish Sonawane^c

^a Nano-Chemistry Research Laboratory, G. T. Patil College, Nandurbar 425412, Maharashtra, India

^b Department of Chemistry, Kisan Arts, Commerce and Science College, Parola 425111, Maharashtra, India

^c Chemical Engineering Department, National Institute of Technology, Warangal 506004, Telangana, India

ARTICLE INFO

Article history:

Received 8 January 2016

Received in revised form

18 May 2016

Accepted 18 May 2016

Available online 2 June 2016

Keywords:

Sonochemical

BiOBr-graphene oxide

Direct green

Heterogeneous photocatalysis

Advanced oxidation process

ABSTRACT

The BiOBr-graphene oxide (BiOBr-GO) nanocomposite was successfully synthesized by sonochemical method. The as-synthesized nanocomposite was characterized by Scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS) and X-ray diffraction (XRD). The effect of incorporation of graphene-oxide with BiOBr on photocatalytic performance of BiOBr under exposure of UV-Visible light irradiation was systematically investigated. The percent removal of Direct green by BiOBr-GO at pH 7 was found to be 91.9% while by pure BiOBr it was 37%. This exhibits that BiOBr-GO shows enhanced adsorption and photocatalytic performance for removal of Direct green under UV-Visible light irradiation. Mechanism of Direct green degradation can be explained by AOP involving heterogeneous photocatalysis. The probable mechanism of photocatalytic degradation and mineralization of Direct green also explained by LC-MS analysis. The mineralization efficiency indicates the 91.7% TOC removal for the degradation of Direct green by BiOBr-GO.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Today dye pollution becomes major source of water pollution [1–4]. Various treatment methods including coagulation, membrane separation and adsorption process were employed for the treatment of dye wastewater. However these methods sometimes generate secondary pollutants [5]. Whereas biological treatment has limited application as some of the dyes are biologically stable. Advanced oxidation processes (AOPs) are good alternative for conventional treatment methods [6–9]. AOPs are considered to be efficient and clean technologies for the treatment of polluted water. AOPs are based on concept of production of highly reactive •OH radicals which can degrade various pollutants by yielding CO₂, H₂O and inorganic ions as final products. Complete mineralization of contaminants and their reaction intermediates by AOP does not generate secondary wastes, thus post treatment is not required [7]. AOPs involve cavitation process, Fenton reagent and photocatalytic oxidation [10,11]. Heterogeneous photocatalysis based on AOP have been widely investigated for wastewater

treatment applications.

In recent years, a great deal of interest has been devoted to semiconductor based heterogeneous photocatalysis. Number of study reports semiconductors viz., ZnO, TiO₂ as photocatalyst for the degradation of different pollutants. But these applications are limited as they are used only under ultraviolet (UV) irradiation [12,13]. For better utilization of visible light from solar light, it is necessary to develop visible light sensitive photocatalyst.

Recently bismuth oxyhalides, are reported to be one of the kind of efficient photocatalyst with adjustable light responsive property, sensitive to UV and visible light irradiation [14–16]. Shang et al. and Xiao et al. reported that, BiOX has layer structure characterized by [Bi₂O₂] slabs interleaved by double slabs of halogen atoms that efficiently induce the separation of photogenerated electron-hole pairs [14,15]. BiOBr with band gap 2.75 eV reported to be exhibit photocatalytic performance under visible light irradiation. However BiOBr has limited photocatalytic efficiency as it shows faster recombination of photogenerated electron-hole pairs. The photocatalytic efficiency of BiOBr can be improved by coupling and doping with carbonaceous materials and metals [17].

Recent studies shows that material researchers are greatly interested in graphene due to its remarkable and versatile properties with improved electrical, thermal and mechanical properties like

* Corresponding author.

E-mail address: drgunvantsonawane@gmail.com (G.H. Sonawane).

tunable band gap, high e^- mobility and larger surface area. Thus it is suitably used as photocatalyst. Graphene oxides (GO) containing highly reactive oxygen functional groups, thus used for chemical functionalization [18,19]. GO was doped with numerous nanoparticles like TiO_2 , ZnO , SnO_2 , Bi_2O_3 , BiOBr etc. to obtain composite material having good photocatalytic properties [20–22]. Several methods are reported for the synthesis of BiOBr -graphene oxide (BiOBr -GO) nanocomposite. Vadivel et al. reported synthesis of BiOBr -GO by ultrasonic dispersion of BiOBr into GO [17]. Zhang et al. reported in situ synthesis of BiOBr -GO by using KBr as a source of Br [23]. However, the preparation of the catalyst is time consuming process.

In the present study we report the facile sonochemical synthesis of BiOBr -GO nanocomposite by using Cetyl trimethyl ammonium bromide as a source of Br . The resulting nanocomposite was characterized by SEM, EDX and XRD. The photocatalytic performance of BiOBr -GO nanocomposite for the degradation of Direct green dye under different operating conditions under UV-Visible light irradiation was investigated. Meanwhile, the degradation intermediates were identified through LC-MS analysis and the degradation pathway was proposed.

2. Materials and methods

2.1. Chemicals and materials

All the chemicals used in the present study are of A.R. grade. Graphite powder, Bismuth nitrate and Cetyl trimethyl ammonium bromide (CTAB) were procured from S.D. Fine Chemicals, India and used without further purification.

2.2. Preparation of Direct green solution

Direct green is direct dye with molecular weight 767.7 g mol^{-1} (M.F. $\text{C}_{34}\text{H}_{23}\text{N}_7\text{O}_8\text{S}_2\text{Na}_2$). Stock solution (500 mg L^{-1}) of Direct green was prepared in distilled water. The experimental solutions of desired concentrations are prepared by diluting stock solution with distilled water.

2.3. Sonochemical synthesis of BiOBr -GO nanocomposite

GO was prepared ultrasonically from graphite powder by modified Hummer's method [24]. In the synthesis of BiOBr -GO, $0.1 \text{ mmol Bi}(\text{NO}_3)_3 \cdot 5\text{H}_2\text{O}$ was dissolved in 20 mL nitric acid (1.5 M) to avoid hydrolyzation of Bi^{3+} ions. The nitric acid can prevent formation of the precipitate of BiONO_3 . Then 2 wt\% of GO was added into $\text{Bi}(\text{NO}_3)_3$ solution. The resulting solution was sonicated for 30 min to produce uniform suspension. Sonication was performed with ultrasonic probe sonicator operating at 20 KHz , 150 W (Dakshin Ultrasound, Mumbai, India) which was equipped with a titanium probe (10 mm of diameter). The CTAB solution was obtained by adding 0.2 mmol CTAB into 90 mL distilled water. The CTAB solution then slowly added into above dispersion with continuous stirring. The resulting suspension was heated to 90°C for 60 min with continuous stirring. The resulting precipitate obtained by centrifugation, was washed with absolute alcohol and deionised water and finally dried at 80°C to obtain BiOBr -GO nanocomposite.

2.4. Characterization of nanocomposite

The SEM images were taken using the Hitachi S-4800 (Japan) FESEM. The EDS analysis was performed by using Bruker X Flash 5030. The XRD pattern of the samples were measured on a Bruker D 8 Advance X-ray diffractometer (Germany) using

monochromatized $\text{Cu K}\alpha$ ($\lambda=0.15418 \text{ nm}$) radiation under 40 kV and 40 mA and scanning over the range of $10^\circ \leq 2\theta \leq 80^\circ$.

2.5. Adsorption experiment

To study the adsorption of Direct green on BiOBr -GO nanocomposite, the Direct green dye solution is magnetically stirred with BiOBr -GO nanocomposite in dark for 60 min to ensure adsorption-desorption equilibrium between the Direct green and BiOBr -GO nanocomposite. Then changes in concentration of Direct green are determined by UV-vis double beam spectrophotometer (Systronics, India model- 2203) at $\lambda_{\text{max}}=627 \text{ nm}$. The amount of Direct green adsorbed on BiOBr -GO nanocomposite is calculated by Eq. (1).

$$q_t = \frac{(C_o - C_t)V}{W} \quad (1)$$

where q_t (mg g^{-1}) is the adsorption capacity at time t ; C_o (mg L^{-1}) is the initial Direct green concentration and C_t (mg L^{-1}) is the Direct green concentration at time t ; V (L) is the initial volume of dye solution and W (g) is the amount of nanocomposite.

2.6. Photocatalytic experiment

Photocatalytic degradation of Direct green by BiOBr -GO nanocomposite was carried out in a photocatalytic reactor under UV-Visible light irradiation with the help of a 500 W halogen lamp. Cooling water jacket is used to maintain temperature inside the reactor. Different nanocomposite doses are added to the 50 mL dye solution having concentration $25\text{--}100 \text{ mgL}^{-1}$ and then placed in a photocatalytic reactor. At regular intervals, 3 mL sample was withdrawn and after centrifugation, changes in the dye concentration were determined by UV-visible double beam spectrophotometer. The percentage removal of Direct green was calculated by Eq. (2).

$$\text{Percentage removal} = \left(\frac{C_o - C_t}{C_o} \right) 100 \quad (2)$$

3. Results and discussion

3.1. SEM and EDX analysis

The SEM image of BiOBr -GO is shown in Fig. 1(a). The SEM image of BiOBr -GO shows flower like morphology with crystal structure having irregular size and shape. Furthermore, SEM of BiOBr -GO shows well distribution of aggregated, wavy GO sheets in the BiOBr matrix. This could enhance photocatalytic activity of BiOBr by smoothening electron transfer. Fig. 1(b) shows that BiOBr -GO contains C K(51.22%), O K(35.45%), Bi K(10.72%) and Br K (2.61%). Presence of Bi and Br peaks in the EDX spectra proves existence of BiOBr in the BiOBr -GO nanocomposite.

3.2. XRD analysis

The crystal phase and structural information of BiOBr -GO composite material was evaluated by using XRD study. The XRD pattern of BiOBr -GO is shown in Fig. 2. The diffraction pattern of BiOBr -GO shows major peaks at 2θ of 10.8° , 21.3° , 24.4° , 31.3° , 38.7° , 45.4° , 52.6° , 56.5° , 66.8° and 75.9° , corresponds to (0 0 1), (0 0 2), (1 0 1), (1 0 2), (1 1 2), (0 0 4), (2 1 1), (2 1 2), (2 2 0), and (3 1 0) planes respectively. These peaks show resemblance with reported results [17]. The intense and sharp peaks reflect the crystalline nature of BiOBr -GO nanocomposite.

Download English Version:

<https://daneshyari.com/en/article/728909>

Download Persian Version:

<https://daneshyari.com/article/728909>

[Daneshyari.com](https://daneshyari.com)