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Synthesis and characterization of MnTe nanoparticles and its photocatalytic activity

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MnTe nanoparticles have been synthesized by hydrothermal method. The materials were characterized by X-ray diffraction, Diffuse reflectance UV-Vis spectroscopy and FTIR analysis. The prepared MnTe nanoparticles were evaluated for the dye degradation of methylene blue by visible light photocatalyst.

Keywords: MnTe, methylene blue, photocatalytic activity.

Introduction

In recent days the transition-metal telluride semiconductors have provoked wide attention due to their excellent optoelectronic and thermodynamic properties, and exhibit potential applications in photovoltaic devices, solar cells, photodetectors, biosensors, thermoelectric materials, photovoltaic cells and optical filters[1]. Among the transition-metal tellurides, manganese telluride (MnTe) is one of the p-type semiconductors and has a narrow optical direct band gap of 1.26 eV and indirect band gap of 0.8 eV respectively[2]. These compounds have many favorable properties such as direct band gap, high absorption coefficient and good transparency in the visible region. The photocatalytic degradation of organic dyes by using metal telluride semiconductors[3,4] has attracted considerable attention because of its high effectiveness in complete oxidation of harmful organic dyes using visible light irradiation. Methylene blue (MB) is used for dying purpose which caused severe health effect such as vomiting, diarrhea etc. Here, the MnTe nanoparticles are readily available to accept photogenerated electrons from excited semiconductor which facilitates dioxygen reduction and thereby it showed an enhanced visible-light photocatalytic activity for the decomposition of reactive dye methylene blue.

Experimental

Manganese telluride was synthesized by hydrothermal method in which sodium tellurite (Na_2TeO_3, 0.005 mol) and 0.005 mol of manganese nitrate was added to 30 ml double distilled water separately and both solutions are dissolved under constant stirring for 30 min under room temperature[5]. Then 20 ml of hydrazine hydrate was added slowly under constant stirring for 30 min. The mixture was then transferred to a Teflon-lined autoclave with a capacity of 100 ml, maintained at 140°C for 8 h. The obtained black product of metal telluride was washed with water, ethanol for several times by using centrifugation. Finally the product was allowed to dry at room temperature and further in vacuum oven at 60°C for 24 h.

Results and discussion

The crystalline phase of MnTe nanoparticle was displayed in Fig. 1. The 2θ values are observed at 27.8°, 36.3°, 42.9° and 47.2° corresponds to hexagonal phase and it is well matched to the JCPDS card (No. 65-6261). Thus the XRD pattern clearly gives the evidences for the formation of the

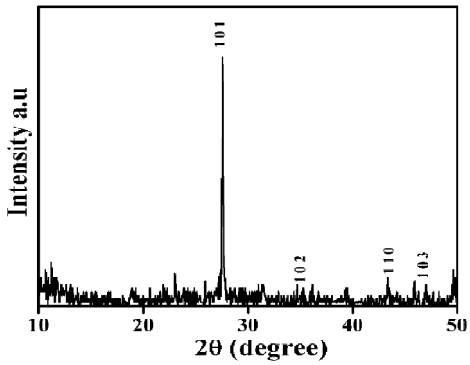

Fig. 1. XRD pattern of MnTe.

MnTe nanoparticle. Further no other secondary phase is occurred in the XRD pattern.

Fig. 2. exhibits the FTIR spectrum of the prepared MnTe. The absorption band appears at 420 cm^{-1} corresponds to the M-O vibrations. The appearance of band at 671 cm^{-1} is attributed to the Mn-Te bond. The peak at 1419 cm^{-1} corresponds to N-H bending vibrations and the corresponding stretching vibration of N-H appeared at 3418 cm^{-1}.

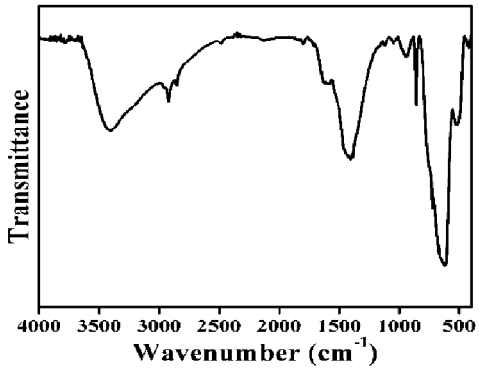

Fig. 2. FTIR spectrum of MnTe.

By using UV-Vis Diffuse reflectance spectroscopy the optical properties of prepared sample were obtained. Fig. 3 exemplifies the UV-Vis spectrum of MnTe and inset figure shows the band gap plot of $(\alpha h\upsilon)^2$ vs $h\upsilon$. The calculated band gap value for MnTe is 2.7 eV[6].

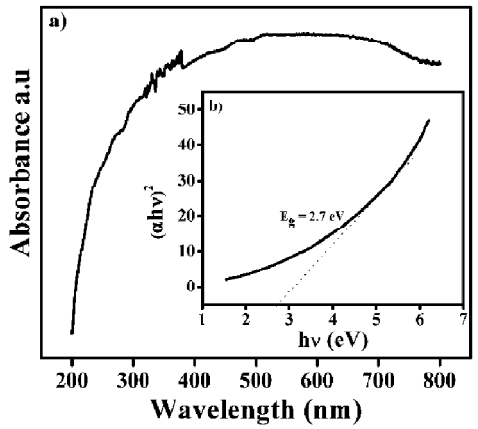

Fig. 3. (a) DRS-UV-Vis spectrum of MnTe and inset figure and (b) plot of $(\alpha h\upsilon)^2$ vs $h\upsilon$.

Photocatalytic activity:

The prepared material was irradiated under visible light for the degradation of methylene blue and evaluated for its photocatalytic activity. The photo chamber was designed with a 500 W xenon lamp. 100 ml of reaction mixture containing 0.001 *M* of methylene blue and 0.02 g of MnTe was taken for the photocatalytic degradation of methylene blue and the solution was irradiated under visible light for 2 h. At regular time intervals the concentration of the solution was taken out from reaction mixture[7,8].

By using UV-Vis spectroscopy the analysis of photocatalytic degradation was examined which was shown in Fig. 4(a). The plot of dye degradation percentage vs time (min) shown in Fig. 4(b). While increasing the time it was observed that the intensity of the methylene blue peak get decreased,

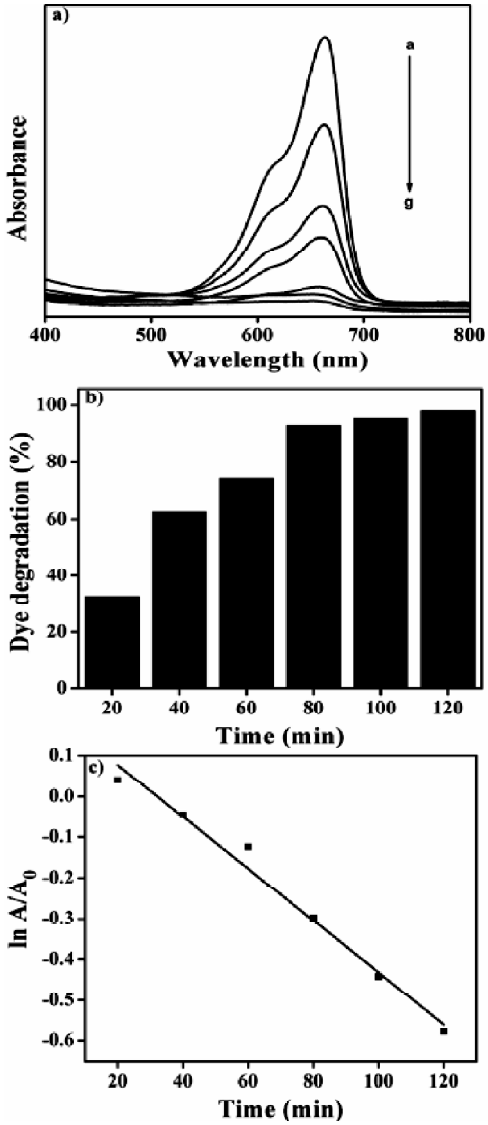

Fig. 4. (a) UV-Vis absorption spectrum of MB (a to g) (0 min to 120 min), (b) plot of dye degradation vs time (min) and (c) plot of ln A/A_0 vs time (min).

meantime the 74.2% of methylene blue degraded in 60 min and at 120 min 98.15% was degraded under visible light degradation[9]. The rate constant was obtained by calculating the slope of plot between (ln A/A_0) vs irradiation time and the value of k for MnTe is found to be 6.36×10^{-3} min^{-1}.

Conclusion

The MnTe nanoparticles was synthesized by hydrothermal method. The formation of MnTe was confirmed by XRD analysis. The estimation of band gap value for MnTe was found to be 2.7 eV. The photocatalytic degradation of methylene blue by using MnTe nanoparticles under visible light was estimated. From the above results it can be concluded that MnTe material exhibits good photocatalytic activity towards MB degradation.

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