Dyes and Pigments 134 (2016) 487–497

Contents lists available at ScienceDirect

Dyes and Pigments

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

Sonocatalytic performance of ZnO/graphene/TiO_2 nanocomposite for degradation of dye pollutants (methylene blue, texbrite BAC-L, texbrite BBU-L and texbrite NFW-L) under ultrasonic irradiation

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ARTICLE INFO

Article history:
Received 29 February 2016
Received in revised form
19 July 2016
Accepted 3 August 2016
Available online 4 August 2016

Keywords:
ZnO/graphene/TiO_2
Sonocatalytic degradation
Dye pollutants
Catalyst

ABSTRACT

ZnO/graphene/TiO_2 (ZGT) was synthesized by a simple solvothermal method. The as-obtained samples were characterized by X-ray diffraction, transmission electron microscopy and energy dispersive X-ray spectroscopy. The band gap energy of the as-synthesized catalysts were performed by UV–vis diffuse reflectance spectroscopy. The sonocatalytic activities of catalysts were tested by the oxidation of methylene blue, texbrite BAC-L, texbrite BBU-L and texbrite NFW-L under ultrasonic irradiation, and compared with ZnO/graphene (ZG), graphene, ZnO and TiO_2, respectively. The results indicated ZGT displayed higher ultrasound activated sonocatalytic activity than other catalysts. The optimum conditions including irradiation time, pH, dye concentration, catalyst dosage and ultrasonic intensity were 120 min, 9, 20 mg/L, 1.00 g/L and 40%, respectively. The ZGT showed the higher enhanced sonocatalytic degradation of MB than other dyes. It is therefore evident that the ZGT can be applied as a highly effective sonocatalyst for dye pollutants. Moreover, a possible sonocatalytic degradation mechanism is discussed.

1. Introduction

Textile industry is one of the biggest environmental polluters, as they not only consume large amounts of water but also produce enormous volumes of wastewater from both dyeing and finishing processes [1]. Wastewater from the textile industry is intensely colored and contaminated with high concentrations of various dyestuff compounds such as suspended and dissolved salts, aromatic and halogenated compounds and many other refractory materials [2,3]. If treated unsuitably, it would pose serious threats to all aqua species because of the reduction of light penetration into the body of water, slower self-purification of streams and the hydrolysis of the various pollutants, which could lead to the production of a great number of toxic products [4]. Therefore, it is necessary to remove these dye contaminants from wastewater before it is discharged into the environment.

For the treatment of dye pollutants, several methods have been applied including membrane filtration [5], catalytic ozonation [6], heterogeneous Fenton's process [7], bioinformatics-aided microbial approach [8], osmosis process [9], nonionic microemulsion systems [10], coagulation process [11,12], combined process of coagulation/flocculation and nanofiltration [13], aerobic biotreatment [14], electrochemical treatment [15], adsorption [16–18], photocatalytic degradation [19–21] and sonocatalytic degradation [22–24]. However, in some of these, dye pollutants are only transferred from one phase to another leaving the problem essentially unsolved.

Recently, there have been new approaches for the treatment of dye pollutants, which effectively remove dyes and all of their derivatives from the water. For example, the application of sonochemical technique using ultrasound as an advanced oxidation process has received increasing research interest because this type of purification of dye wastewaters is highly efficient and can be easily operated [25–27]. During ultrasonic irradiation, ultrasound waves can induce rapid growth and cavitational collapse of the bubbles within the aqueous solution, which produces extremely high temperature (several thousand K) and pressure (some 10 MPa) in the bubble [28]. The generated temperatures near the bubbles are so high that the molecules of water (H_2O) are split forming reactive hydrogen atoms ($H^\cdot$) and hydroxyl radicals ($OH^\cdot$) with high oxidative activity, which can degrade various toxic dye targets in

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http://dx.doi.org/10.1016/j.dyepig.2016.08.006
0143-7208/