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Visible-light photosensitization of ZnO by Bi_2MoO_6 and AgBr: Role of tandem n-n heterojunctions in efficient charge transfer and photocatalytic performances

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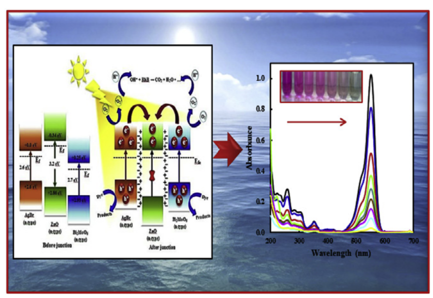
HIGHLIGHTS

- $ZnO/Bi_2MoO_6/AgBr$ nanocomposites as efficient photocatalysts are reported.
- The $ZnO/Bi_2MoO_6/AgBr$ (20%) nanocomposite exhibited the highest activity.
- Activity was 76.4-folds greater than ZnO in RhB degradation under visible light.
- The enhanced activity was attributed to tandem n-n heterojunctions.

GRAPHICAL ABSTRACT



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ABSTRACT

Efficient visible-light active $ZnO/Bi_2MoO_6/AgBr$ nanocomposites were fabricated using ultrasonic-assisted method. Crystallinity, structural, morphological, optical, and textural features of the photocatalysts were investigated by XRD, SEM, TEM, EDX, FT-IR, UV–Vis DRS, PL, and BET techniques. Photocatalytic performance of the ZnO sample was remarkably increased by combining with Bi_2MoO_6 and AgBr, due to formation of tandem n-n heterojunctions. The as-prepared $ZnO/Bi_2MoO_6/AgBr$ nanocomposites exhibited excellent photocatalytic activity and stability under visible light in comparison with the ZnO, ZnO/Bi_2MoO_6, and ZnO/AgBr samples. About ~97% of RhB was removed in 70 min by the optimized $ZnO/Bi_2MoO_6/AgBr$ (20%) nanocomposite, which is 76.4, 4.75, and 17.3 times as fast as the ZnO, ZnO/Bi_2MoO_6 (20%) and ZnO/AgBr (20%) photocatalysts, respectively. It was confirmed that due to improved utilization of visible light, considerable separation of the charge carriers, and enlarged surface area, the $ZnO/Bi_2MoO_6/AgBr$ (20%) nanocomposite exhibited greatly improved photocatalytic activity in degradations of various dye contaminants under visible-light illumination. In addition, plausible photocatalytic degradation mechanism for the highly enhanced performances were also proposed.

1. Introduction

Rapid industrialization and population growth have demanded production of different chemicals. Pouring of these synthetic compounds to the environment has promptly increased water pollution [1]. On the other hand, sources of drinking water is considerably limited in many countries. In these regards, water and wastewater treatment have become one of the most critical issues for the human being. In comparison with the usual treatment

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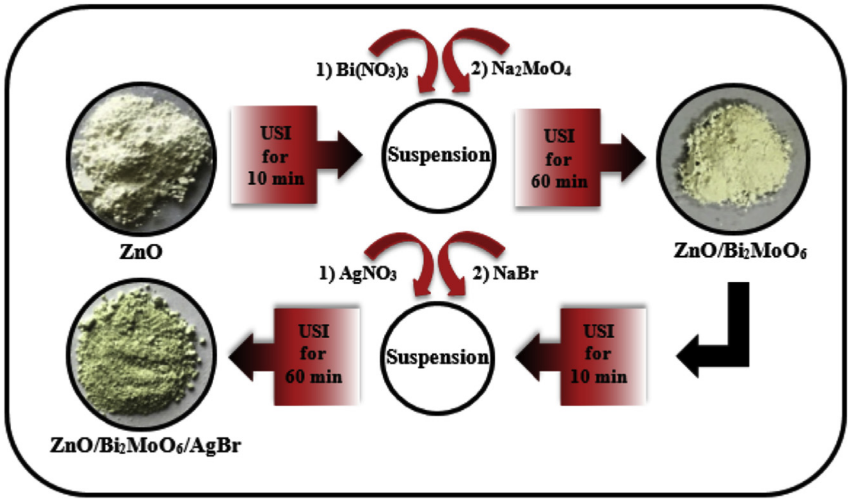

Scheme 1. The preparation procedure of the ZnO/Bi_2MoO_6/AgBr nanocomposites.

strategies, heterogeneous photocatalytic processes have displayed attractive features of environmentally friendly, low price, unselectively destroying of pollutants, and ambient working parameters [2,3]. Hence, more attentions have been paid for application of these processes to address environmental concerns [4–8]. In spite of many appealing properties, widespread applications of ZnO in these processes are considerably impeded due to rapid recombination of photoinduced e^-/h^+ pairs, resulting in limited activity. Additionally, due to wide band gap of ZnO, it does not have ability to utilize visible-light fraction of the solar energy [9,10]. Hence, different strategies have been exploited to suppress recombination of the photoinduced charge carriers and extend its optical response to visible region. In recent years, it was found that coupling of narrow-band gap semiconductors is an effective modification pathway [11–21]. Although many attempts have been paid to fabricate different ZnO-based visible-light-driven (VLD) photocatalysts, it is strongly necessary to explore more efficient photocatalysts.

Among bismuth-based photocatalysts, Bi_2MoO_6 is n-type narrow band gap semiconductor (Eg = ~2.7 eV) [22]. Recently, many VLD photocatalysts have been introduced using Bi_2MoO_6, owing to its attractive physicochemical properties including high thermal stability and appropriate band gap [22–24]. On the other hand, AgBr is n-type semiconductor with a narrow band gap of 2.6 eV.

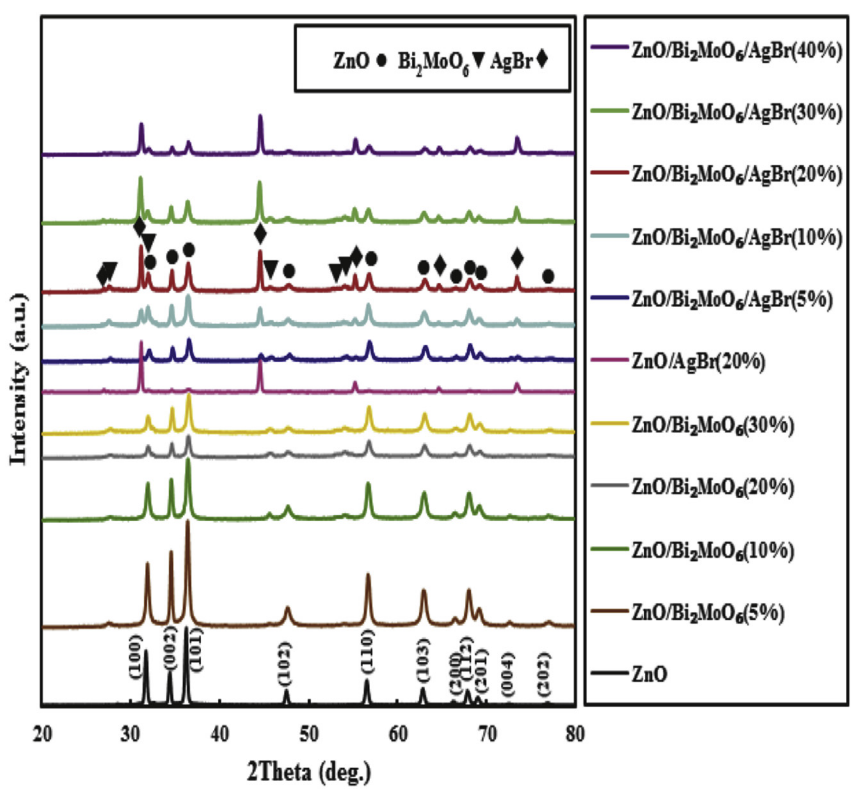

Fig. 1. XRD patterns for the ZnO, ZnO/AgBr (20%), ZnO/Bi_2MoO_6 and ZnO/Bi_2MoO_6/AgBr nanocomposites.