Photocatalytic properties of ZnO/CuO nanocomposite prepared in acidic media

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ABSTRACT

Coupling ZnO with CuO performs high photocatalytic efficiency due to its characteristic optical properties. In this work, the ZnO/CuO nanocomposite was synthesized with two different initial pH values in an acidic media through a simple one-step and cost-efficient chemical bath precipitation method. The photocatalytic activity of the as-prepared samples was studied employing 2 mg/L methylene blue (MB) under visible-light irradiation. Overall, the prepared sample at pH = 4.5 and pH = 1.5 demonstrated ~76% and ~66% photo-degradation efficiency of MB after 150 min, respectively.

INTRODUCTION

Owing to the growth of population and rising water pollutions, photocatalytic applications as a practical method for water treatment have attracted interest for the past decades as a sustainable technology. Coupling ZnO with a p-type semiconductor such as CuO (with a narrow band gap energy of 1.2-1.5 eV) has been reported to be efficient to avoid the mentioned drawbacks and enhancing the photocatalytic activity by prolonging the lifetime of the photo-generated charge carriers and lowering their recombination rate. Accordingly, ZnO/CuO nanocomposites can be obtained by diverse synthesis methods including chemical bath precipitation which is a facile, low-temperature method and has been widely used in the synthesis of nanostructures.

OBJECTIVES

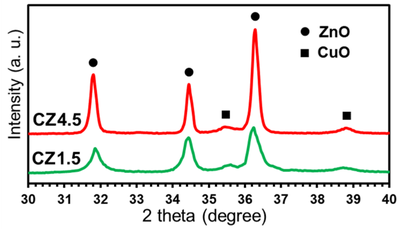
In this work, we prepared ZnO/CuO nanocomposite by a cost-efficient low-temperature CBD method using nitric acid, and the photocatalytic properties and characterization were investigated.

MATERIALS & METHODS

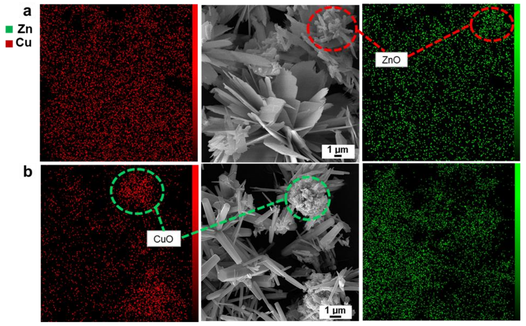
Zinc nitrate hexahydrate (ZNH), copper nitrate tetrahydrate, Hexamethylenetetramine (HMTA) as a pH buffer and nitric acid as a pH adjustment were used. The structural and morphological properties were analyzed using X-ray diffractometer (XRD) and field emission scanning electron microscopy (FESEM). The photoluminescence (PL) and the diffuse reflectance spectroscopy (DRS) spectra were measured to confirm the photoconductivity and investigate the absorption spectra of the samples. The photocatalytic activity of the samples was analyzed by using them in the degradation of 30 ml of MB solution under the irradiation of visible light.

RESULTS

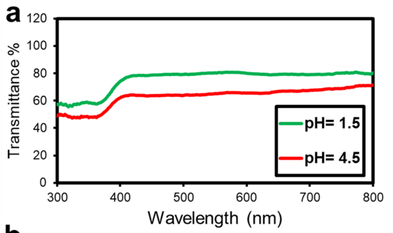
- The combination of excessive H+ ions with negatively charged OH- ions, restricts the formation rate of ZnO and CuO crystals in the CZ1.5 sample which results in decreasing the XRD peak intensities of wurtzite ZnO and monoclinic CuO in this sample.
- ZnO nanoparticle/CuO nanosheets and ZnO nanorods/CuO nanoflakes are formed according to the FESEM images. The shape-inducing effect of HMTA causes the different morphologies of ZnO/CuO nanocomposite through alteration of the synthesis pH value.
- According to the DRS analysis, the band gap energies of CZ1.5 and CZ4.5 samples were estimated at 3.08 and 2.9 eV, respectively. Accordingly, the morphological variation of the samples due to the change in pH value is the reason for the difference in band gap energies .
- The PL peak position of the CZ4.5 sample is lower than the CZ1.5 sample. The reduction of peak intensity represents diminution in the recombination rate of photogenerated electron-hole pairs, resulting in higher photocatalytic activity.
- Since the band gap energy of the CZ4.5 sample is narrower than that of the CZ1.5 sample, the CZ4.5 sample is more light-active than the CZ1.5 sample. Therefore, the CZ4.5 sample demonstrates higher photo-degradation efficiency of MB after 150 min.

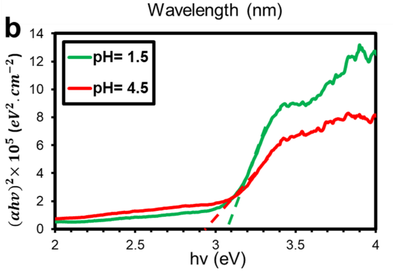


XRD patterns of the samples

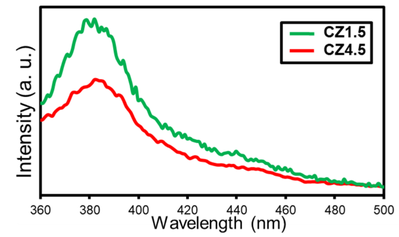


FESEM images of (a) CZ1.5 and (b) CZ4.5 and the corresponding Cu and Zn mapping images.





(a) DRS plot and (b) Tauc plots of the samples.



PL spectra of the as-prepared samples.

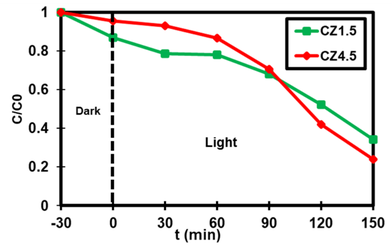


Photo-degradation rate of the samples.

CONCLUSIONS

The structural and morphological properties of the samples indicate the formation of ZnO/CuO nanocomposite in both samples. The DRS results show that the band gap energy of the CZ4.5 sample is smaller than the CZ1.5 sample. The reduction of electron-hole recombination rate in the CZ4.5 sample according to the PL spectra results in the enhancement of visible absorption. Thus, the CZ4.5 reveals higher degradation efficiency of MB under visible light.

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