Enhanced photocatalytic performance under visible light irradiation due to controlled morphology evolution of ZnO nanostructure

S. Harish[1]*, J. Archana[1] M. Navaneethan[1], S. Ponnusamy[2], C. Muthamizhchelvan[2], Y. Hayakawa[1,]
[1] Research Institute of Electronics, Shizuoka University, 3-5-1 Johoku, Naka-ku, Hamamatsu, Shizuoka 432-8011, Japan
[2] Centre for Nanoscience and Nanotechnology, Department of Physics, SRM University, Kattankulathur, Chennai 603203, Tamil Nadu, India
E-mail – aravindharri@gmail.com

1. Introduction

Photocatalysis has received considerable attention during the past decades owing to its potential application in solar energy conversion and environmental purification. ZnO is considered to be one of the most promising semiconductor materials, and has been extensively investigated for the photocatalytic degradation of organic compounds [1]. Furthermore, ZnO has attracted considerable attention owing to its nontoxicity, wide ultraviolet (UV) light absorption, and low cost. Additionally, ZnO absorbs over a large fraction of the solar spectrum [2]. In this work, we report the synthesis of ZnO with well-defined morphologies, such as nanoparticles and nanoflakes, by controlling the concentration of ethylenediamine employed as a passivating agent. The photocatalytic activity of the prepared ZnO samples was assessed by measuring the degradation rate of methylene blue in aqueous solution under visible light irradiation. Methylene blue is a heterocyclic aromatic chemical compound used as an organic dye.

2. Experimental method

In a typical synthesis, 2.195 g $Zn(CH_3COO)_2{\cdot}2H_2O$ (0.2 mol) was dissolved in 50 mL deionized water and allowed to stir for complete dissolution of the compound. Then, NaOH (0.2 mol/L) was added dropwise to the above solution until the solution pH reached 12 for 10 h. The obtained white precipitation was separated by centrifugation, washed with deionized water and ethanol for several times, and dried at 80 °C for 1 h. The resulting sample was termed as EZ0. For the synthesis of EDA-passivated nanostructures, EDA at varying amounts of 0.4, 0.6, 0.8, and 1 mL was added to $Zn(CH_3COO)_2{\cdot}2H_2O$ solution, and the remaining procedure was followed as described above. The samples were termed as EZ0.4, EZ0.6, EZ0.8, and EZ1, respectively.

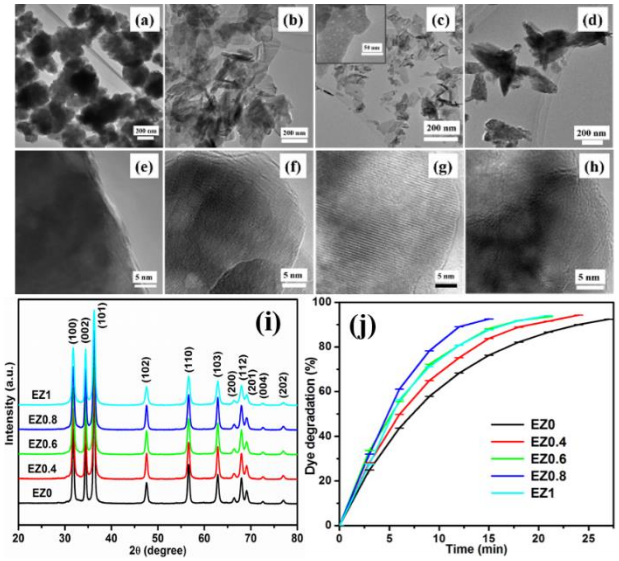

Figure 1 (a - h) TEM and HRTEM, (i) X-ray diffraction and (j) dye degradation plot of pure and EDA passivated ZnO.

3. Results and discussion

The TEM and HRTEM images of EZ0, presented in Fig. 1a and e, revealed the presence of agglomerated nanoparticles with particle sizes of ~200–300 nm. Furthermore, HRTEM analysis of a ZnO nanoparticle revealed that the nanoparticles were crystalline. The addition of EDA at varying concentrations considerably influenced the morphological size. However, the diameter of the nanoflakes of EZ0.8 was smaller (50–70 nm) and the length varied from 200 to 500 nm (Fig. 1c). The obtained morphological results clearly demonstrate that EDA plays an important role on the formation of ZnO nanostructures. Figure 1(i) shows the XRD patterns. The synthesized samples exhibited similar diffraction peaks with no change in relative intensity of the peaks. All the diffraction peaks were indexed to the hexagonal phase of ZnO (JCPDS Card No. 80-0075). The morphology- and size-dependent photocatalytic degradation of MB was studied under visible light irradiation. Maximum degradation efficiency was observed for ZnO nanoflakes; the MB-related absorbance peak completely disappeared after 15 min of irradiation as shown in Fig. 1(j).

[Reference]

[1] N.C.S. Selvam, J.J. Vijaya, L.J. Kennedy, ,Ind. Chem. Res. 51, 16333-16345, (2012).
[2] M. Faisal, S. Bahadar, M.M. Rahman, A. Jamal, M.M. Abdullah, Appl. Surf. Sci. 258, 7515–7522, (2012)