Core-shell $ZnFe_2O_4$/ZnS composite synthesized by Hydrothermal method

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1. Introduction

$ZnFe_2O_4$ have several advantages with their high electromagnetic performance, excellent chemical stability, low coercivity and photoluminescence nature with a great potential in many applications including photocatalyst, magnetic data storage, drug delivery, white light emitting diodes, soft magnets and low-loss materials at high frequencies, etc[1]. ZnS is a wide band-gap semiconductor showing good emission in the blue and UV region, and ZnS nanostructures have found many applications for phosphors, solar cells, and IR window. We report here the preparation and characterization of core-shell $ZnFe_2O_4$/ZnS nanocomposites, aiming to use the advantages of both $ZnFe_2O_4$ and ZnS to realize a potential magnetically recyclable photocatalyst.

2. Expertimental

The core-shell $ZnFe_2O_4$/ZnS composite was first synthesized by a hydrothermal method. The morphology and the average particle size were investigated using a scanning electron microscopy (SEM) and transmission electron microscope (TEM). The phase determination of the as prepared powders was performed using an X-Ray diffractometer (XRD). Diffuse reflectance measurements (DRS) on dry powders were performed. Photoluminescence (PL) measurement was performed at room temperature. The magnetic properties were studied with vibrational sample magnetometer (VSM) by the applied magnetic field up to 1 T.

3. Results and Conclusion

The XRD of ZnFe2O4/ZnS composites clearly revealed the diffraction peaks from spinel $ZnFe_2O_4$ and cubic ZnS. The average nanocrystallite size (D) of $ZnFe_2O_4$ was around 29.72 nm by using the Debye – Scherrer formula $D=0.89\lambda/\beta\cos\Theta$. In addition to core, XRD result showed ZnS shell was 4nm thick. This result also agreed well with the SEM observation of morphology [Fig. 1]. The TEM images of $ZnFe_2O_4$/ZnS composite exhibit that ZnS was grown at the surface of $ZnFe_2O_4$ nanoplates of 40-80 nm in diameter and ~10 nm in thickness.

The comparison between the UV – Vis DRS spectra of the $ZnFe_2O_4$/ZnS composites and bare $ZnFe_2O_4$ nanoparticles showed that the optical absorption maximum increase remarkably after the deposition of ZnS on the surface of $ZnFe_2O_4$. The shift of the absorption probably originated from the hybridization and strong electronic coupling between $ZnFe_2O_4$ and ZnS nanoparticles. The band gap energy of $ZnFe_2O_4$/ZnS was calculated by plotting a graph between the square of the Kubelka – Munk function $F(R)^2$ and energy in electron volts. From the Kubelka – Munk plots the optical band gap of $ZnFe_2O_4$ and $ZnFe_2O_4$/ZnS are 2.0 and 2.2eV, respectively. Compared to the bare the band gap was increased for the composite material mainly due to the much larger band gap energy of ZnS (3.7 eV). Much enhanced photoluminescence was observed in the ZnFe2O4/ZnS composites

due to the good optical property of ZnS [Fig. 2]. The ZnFe2O4/ZnS composites showed lower saturation magnetization as compared to the bare $ZnFe_2O_4$ nanoparticles, presumably attributed to the coating of ZnS nanoparticles.

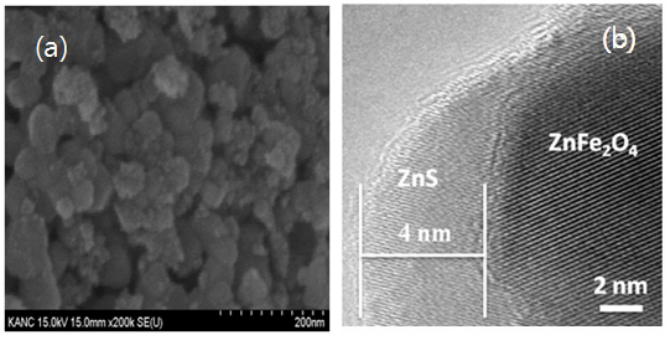

Fig. 1 (a) SEM image, and (b) high resolution TEM image of $ZnFe_2O_4$/ZnS composites.

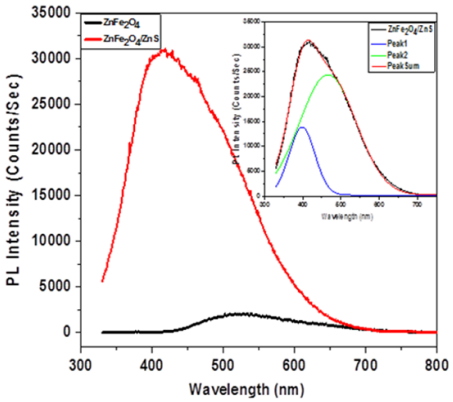

Fig. 2 The optical properties of $ZnFe_2O_4$/ZnS composites and bare $ZnFe_2O_4$ nanoparticles.

4. Reference

[1] N. Ponpandian et al. J. Appl. Phys. 92. 2770. (2002)

[2] Yuanyuan Sun et al. Mater. Lett. 98. 124–127 (2013)