Synthesis and Characterization of Pure and Metal Oxide Nanocomposite and their Photocatalytic Study for Methylene Blue Dye Solution

V.R. Huse[a], S.P. Kamble[b], D.H. Bobade[b]
[a]Department of Physics, MGSM's, Arts, Science and Commerce College, Chopda, Dist. Jalgaon, India.
[b]Department of Physics, C.T. Bora College, Shirur Dist. Pune, India
*Corresponding author: spkamble008@gmail.com

ABSTRACT

The samples of pure and metal oxide nanocomposites (NiO, ZnO and NiO:ZnO) were synthesised by co-precipitation method. The X-ray diffraction, scanning electron microscopy and UV-Visible (UV-vis) spectroscopy have been used for the characterization of synthesized materials. The lattice parameter, volume cell, atomic packing factor, grain size, have been calculated by using XRD data. SEM study shows that the prepared material of NiO is in spherical shape while the ZnO is hexagonal nanorod and nanotubes. The photocatalytic activities of NiO, ZnO and NiO:ZnO nanocomposites for methelyne blue solution shows that the NiO:ZnO nanocomposites degrades the methylene blue solution faster than the pure NiO and ZnO samples.

Key Words—Co-preciptation method; UV- Visible spectroscopy; photocatalytic activity.

INTRODUCTION

Synthesis of mono dispersed nanoparticles is of significant importance in potential applications. In recent years, nickel oxide (NiO) nanoparticles have attracted extensive interests due to its novel optical, electrical, magnetic, thermal and mechanical properties. NiO is regarded as a p–type semiconductor for oxides of the 3d transition metals which show very low mobility of current carriers. Although, the fundamental transport properties of NiO such as the electrical conductivity, Hall effect and Seebeck effect have been intensively studied. It shows an antiferromagnetic behavior and received great deal due to their potential for exhibiting magnetization reversal by quantum tunnelling. The large surface area to volume ratio of antiferromagnetic nanoparticle makes it reasonable to correlate their magnetic behavior with surface effects. For instance, it has been demonstrated that NiO nanoparticles exhibits weak ferromagnetism and/or superparamagnetic nature that increases with decreasing particle size.

ZnO is one of the versatile and technologically important semiconducting materials which have a direct wide band gap (3.37 eV). It has attracted considerable attention due to its optical, electrical, and photocatalytic properties. It crystallizes in a wurtzite structure and exhibits n-type conductivity. ZnO is one of the semiconductors having good chemical and thermal stability. Because of its typical properties such as resistivity controlover the range 10-3 to 105Ω cm, transparency in the visible range, high electrochemical stability, direct band gap, absence of toxicity and abundance in nature. Nanostructures ZnO have many potential application in photocatalysis [1-2], solar cell [3-4], gas sensors [5-6], fuel cells [7], photovoltaics [8], antibacterial action[9] and so on. Various methods have been reported for the synthesis of undoped and doped ZnO nanopaticles with different morphology, different size and various shapes, bipyramidal, ellipsoidal, prismatic, nanorod and nanowire [10]. With the transparency,

stability and bio-friendly features itwould be one of the most important metal oxides in future research and applications. ZnO exhibits various morphologies by varying its preparative parameters. The one dimensional (1D) nanostructures of ZnO, including nanowires, nanorod, nanodisc, nanobelts and nanotubes have been attracting vast interest in the field of nanotechnology. The novel functions of these ZnO nanostructures arrays have been revealed successfully in the nanolasings, piezoelectric nano generators, nano resonators, photonic crystals, photodetectors, optical modulator waveguides, light-emitting diodes, field emitters, gas sensors, solar cells, and so on.

However, it still remains a big challenge to develop simple and reliable synthetic methods for the preparation of ZnO nanorods, which strongly affect the properties of nanostructured materials.

Experimental Details

Synthesis of NiO nanoparticles

The sample of NiO nanoparticles was prepared by simple co-precipitation method. Nickel nitrate ($NiNO_3 \cdot 9H_2O$), sodium hydroxide (NaOH) and distilled water was used. The 1M $NiNO_3 \cdot 9H_2O$ was dissolved in 100 ml distilled water in a beaker (say beaker A) and 1M NaOH was dissolved in 100 ml distilled water in a beaker (say beaker B). Both the beakers A & B were stirrered for 2 hours at room temperature. The solution of beaker A then dropwise added in beaker B and stirrer it for 3 hours at room temperature. A green coloured precipitate was formed. After stirring, the precipitate was aged for 20 hours at room temperature. The precipitate then filtered and washed several time with distilled water. The product then dried at 120°C for 2 hrs in an oven. Dried powder of SnS was ground for 10 minutes and then calcined at 400°C in furnace for 6 hours.

Synthesis of ZnO nanorods

The sample of ZnO nanorod was prepared by co-precipitation method. Zinc acetate [$Zn(COOH)_2 \cdot 2H_2O$], sodium hydroxide (NaOH) and distilled water was used. The 1M $Zn(COOH)_2 \cdot 2H_2O$ was dissolved in 100 ml distilled water in a beaker (say beaker A) and 2M NaOH was dissolved in 100 ml distilled water in a beaker (say beaker B). Both the beakers A & B were stirrered for 2 hours at 50°C. The solution of beaker A then dropwise added in beaker B and stirrer it for 20 hours at room temperature. A white coloured precipitate was formed. The precipitate then filtered and washed several time with distilled water. The product then dried at 120°C for 2 hrs in an oven. Dried powder of ZnO was ground for 10 minutes and then calcined at 400°C in furnace for 6 hours.

Synthesis of NiO:ZnO nanocomposites

The sample of NiO/ZnO nanocomposite was prepared by simple chemical method. The 1M of prepared SnS nanoparticles and 1M of prepared ZnO nanorods was dissolved in 15 ml distilled water in separate beakers and then stirrered it for 30 minutes at room temperature. After 30 minutes, solution of NiOnanopowder was mixed in solution of ZnOnanorods and then stirrerd it again for 30 minutes. The final homogeneous solution of NiO and ZnO was heated on oven at 120°C for 4 hrs. The final product of NiO:ZnO nanocomposite was ground for 10 minutes.

Results and discussions

Figure 1(a, b, c) show the X-ray diffraction (XRD) patterns of NiO, ZnO and NiO/ZnO nanocomposites respectively. The observed diffraction pattern of NiO sample reveals the hexagonal wurtzite structure and matches with the standard JCPDS card no 89-1397. The X–ray powder diffraction patterns of the calcined sample shown in figure 1a shows only peaks due to NiO sample can be clearly indexed to a hexagonal structure, without any observable peaks of impurity phases. The XRD pattern of ZnO shown in figure 1(b) is similar to that of pure NiO. The spectrum shows well defined diffraction peaks with good crystallinity. The XRD pattern of NiO/ZnO nanocomposite shown in figure 1(c) shows the peaks of NiO and ZnO.

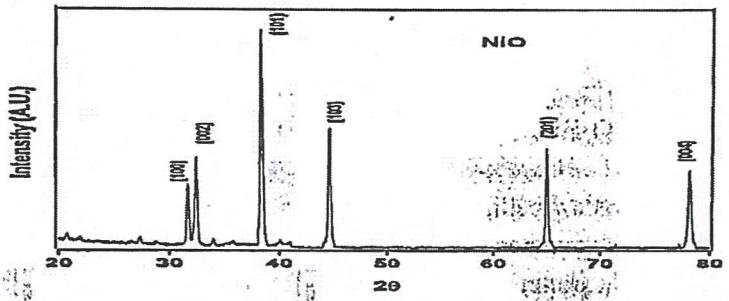

Fig. 1a. XRD pattern of NiO sample.

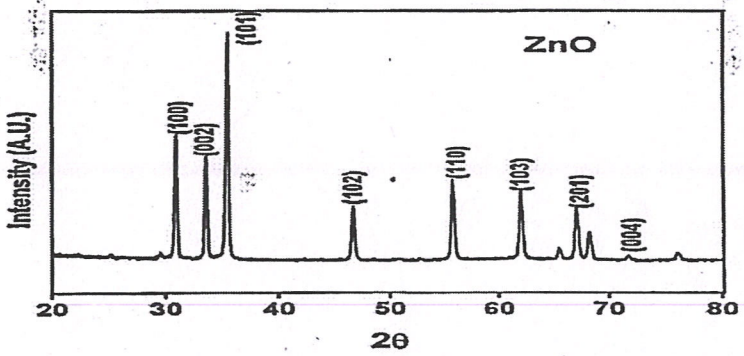

Fig. 1b. XRD pattern of ZnO sample.