Study the Synthesis of CuO/ZnO nanocomposite by Mortar and Pestle and its Characterization

[1]G. G. Patil, [2]Sayyad S. B.
[1]Assistant professor, [2] Assistant professor and Head
[1]Dept. of Electronic Science K.T.H.M. College Nashik (M.S.) India
[2] Department of Physics, Milliya Arts, Science & Management Science College, Beed, (M.S.), India

Abstract: Metal Oxide nanocomposite reveals various applications in the fields of Solar cells, medical, biological, sensors and optical. In this work we formed p-CuO/n-ZnO nanocomposite with simple Mortar and Pestle at room temperature.CuO acts like p- type semiconductor and ZnO acts like n-type semiconductor. These two materials taken in 1:1, 1:2 and 2:1weight ratio and mixed together to form the composite of CuO/ZnO. This composite material is grinded in Mortar and Pestle for five hours continuously. The obtained CuO/ZnO nanocomposite material is then characterized by XRD and FTIR. The XRD result showed the crystalline nature of the CuO/ZnO composite material. The formation of CuO/ZnO nanocomposite is confirmed using XRD.

Keywords: CuO/ZnO, nanocomposite,Mortar and Pestle, XRD, FTIR

Introduction

Nanocomposite:

The field of nanocomposite materials has had the attention, imagination, and close scrutiny of scientists and engineers in recent years. This scrutiny results from the simple premise that using building blocks with dimensions in the nanosize range makes it possible to design and create new materials with unprecedented flexibility and improvements in their physical properties. This ability to tailor composites by using nanosize building blocks of heterogeneous chemical species has been demonstrated in several interdisciplinary fields. The most convincing examples of such designs are naturally occurring structures such as bone, which is hierarchical nanocomposite, built from ceramic tablets and organic binders. Because the constituents of a nanocomposite have different structures and compositions and hence properties, they serve various functions. Thus, the materials built from them can be multifunctional. Taking some clues from nature and based on the demands that emerging technologies put on building new materials that can satisfy several functions at the same time for many applications, scientists have been devising synthetic strategies for producing nanocomposites. These strategies have clear advantages over those used to produce homogeneous large-grained materials. Behind the push for nanocomposites is the fact that they offer useful new properties compared to conventional materials. The concept of enhancing properties and improving characteristics of materials through the creation of multiple-phase nanocomposites is not recent. Nanoscience and nanotechnology primarily deal with the synthesis, characterization, exploration, and exploitation of nanostructured materials. These materials are characterized by at least one dimension in the nanometer (1nm to100nm) range. The physical and chemical properties of nanomaterial can differ significantly from those of the atomic-molecular or the bulk materials of the same composition. The unique feature of the structural characteristics, energetics, response, dynamics, and chemistry of nanostructures constitutes the basis of nanoscience. Proper control of the properties and response of nanostructures results in new devices and technologies.Nano sized particles of less than 100 nm in diameter having increasing attention for the wide range of new applications in various fields of industry. Such particles have different properties than bulk materials. [1]

1. Synthesis of nanoparticles

There are a large number of techniques available to synthesize different types of nanomaterials in the form of colloids, clusters, powders, tubes, rods, wires, thin films etc. Some of the already existing conventional techniques to synthesize different types of materials are optimized to get novel nanomaterials and some new techniques are developed.

Mechanical Methods:

The synthesis of nanomaterial by physical method. It includes mechanical milling method. It is one of the simplest ways of making nanoparticles of some metals and alloys in the form of powder. There are various types of grinding mills such as planetary, vibratory, rod, tumbler etc. In this work we have used simple Mortar and pestle method..In this method of nanoparticle synthesis, three different weight ratios of CuO/ZnO are used. They are 1:1, 1:2 and 2:1.ZnO (Zinc oxide) is a wide band gap n-type semiconductor material with 3.3 eV energy gap and high excitation binding energy of 60 meV, due to this reason the different morphologies of the material was possible like nano rings, nano tubes, nano rods, nano sheets and nano wires [**2-4**]. CuO (Copper oxide) is an inorganic p-type semiconductor material having 1.85 eV direct band gap [**5**]. The combination of ZnO/CuO semiconductor nano materials forms p-n heterojunction means that, electron donor-acceptor pairs observed in between n-type metal oxide and p-type metal oxide [**6**]. It can be used in various applications because of the improvement in the field emission within the devices and simultaneously increase the charge carrier separation [**7-9**]. This present work, deals with the CuO/ZuO metal oxide nanocomposite junction synthesis, characterization. The novelty of this study is to form the CuO/ZnO nanocomposite junction with very simple method using Mortar and Pestle. The CuO/ZnO powder is taken weight percentages 1;1, 1:2 and 2:1 and mixed to form the composite material. Each sample is taken in properly cleaned mortar and Pestle and mechanically milled continuously for 5 clock hours at room temperature.The obtained CO/ZuO nanocomposite materials were characterized by X-ray diffractometer and Fourier Transform Infrared Spectroscopy.

2. Experimental

Materials: The ZnO and CuO analytical grade material purchased from Modern Science industries nashik and used without further purification.

Selection of material:

Zinc oxide

Zinc Oxide is an inorganic compound with the formula ZnO. It is white coloured powder insoluble in water. It acts like n type of semiconductor.

Copper oxide

Copper oxide nanoparticles appear as a brownish-black powder. They can be reduced to metallic copper when exposed to hydrogen or carbon monoxide under high temperature. It behaves like p type semiconductor.

Table 1: Physical and chemical properties of Copper oxide and zinc oxide

Parameter	**ZnO**	**CuO**
Molecular formula	ZnO	CuO
Molar mass	81.408 g/mol	79.55 g/mol
Odour	Odourless	Odourless
Appearance	White	Black
Density	5.606 g/cm^3	6.31 g/cm^3
Melting point	1975°C	1201°C
Oiling point	2360°C	2000°C
Solubility on water	0.16 mg/100 mL (30 °C)	Insoluble
Band gap energy	3.3eV	1.85eV

2.1 Synthesis of CuO/ZuO Nanocomposite junction

CuO (Copper oxide) is an inorganic p-type semiconductor material having 1.85eV direct band gap. ZnO (Zinc oxide) is a wide band gap n-type semiconductor material with 3.3 eV energy gap and high excitation binding energy. These two materials taken are analytical grade and used without further purification.Preparation of composite of ZnO/CuO has been done by mixing the powder of CuO and ZnO in the weight ratio of 1:1, 1:2 and 2;1. The each sample of CuO/ZnO nanocomposite junction is prepared separately. Each of the CuO/Zno sample is mechanically milled for 5 clock hour continuously at room temperature and the samples of CuO/ZnO nanocomposite junctions in the weight ratio1:1, 1:2 and 2:1 aresynthesized.

2.2 Characterizations

The synthesized CuO/ZnO nanocomposite junctions of weight ratios 1:1, 1:2 and 1:3 were characterized by techniques like X-Ray Diffraction and Fourier Transform Spectroscopy. The crystallinity and phase identification of sample of CuO/ZnO nanocomposite junction was investigated in the scanning range of the scanning range of 5- 80˚θ with the measurement temperature 25˚C, operating at 40 kV and 40 mA. The phase was identified using the standard JCPDS data files. The band gap energy of the samples were found using FTIR

X-ray Diffraction Analysis

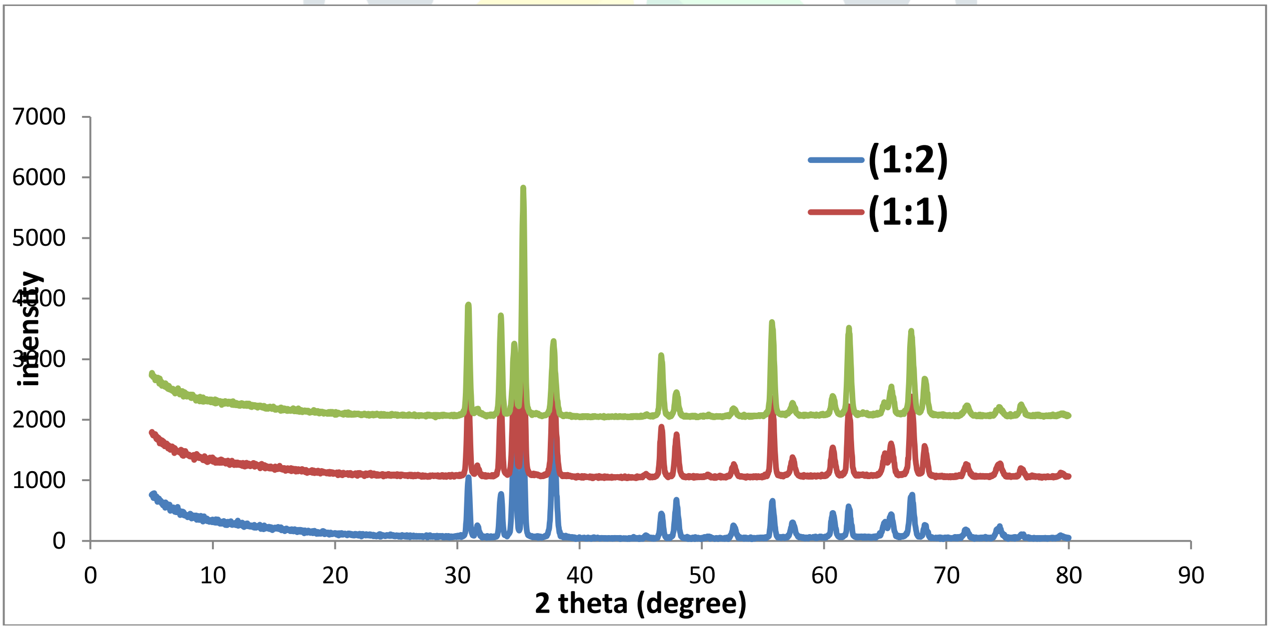

Fig.1 XRD of CuO/ZnO nanocomposte in the weight ratio of 1;1, 1:2 and 2;1.

Figure1 shows the XRD pattern of CuO/ZnO nanocompsite in the weight ratio of 1:1, 1:2 and 2:1 synthesized by Mortar and Pestle at room temperature. The 2Ɵ angle used between 5 to 80^0.

Table2. XRD analysis of CuO/ZnO nanocomposite

Nanocomposite CuO/ZnO	FWHM	% crystalinity	% amorphous	Crystal size A^0	Crystal size In nm
1:1	2.214	88.3	11.7	41.8	4.18
1:2	5 to 80	88.7	11.3	38.1	3.81
2:1	5 to 80	88.3	11.7	367.4	36.74

From the table1 of XRD analysisCuO/ZnO nanocomposite material, it is observed that in 1:1 weight ratio CuO/ZnO nanocompiste, the crystallinity is 88.3% shows that it is crystalline and the crystal size is 4.18nm. In 1:2 weight ratio of nanocomposite, crystal size is 3.81nm while crystallinity is 88.7%. In 2:1 weight ratio of CuO/ZnO nanocomposite the crystallinity is 88.3% while the crystal size is 36.74nm.
The average crystallite was measured by Debye-Scherrer's equation:

$D = K.\, \lambda / \beta cos\theta$

where-Debye-Scherrer's constant (0.9), λ- wavelength of the radiation (for CuKα1=0.154 nm), β-full width half maximum of the particular peak, θ- Bragg's angle

The crystal size is found to be same as that given in table 1. The XRD pattern matched with the JCPDS cards 36-1451 and 89-5899 for ZnO (hexagonal) and CuO (monoclinic) respectively.

3.2 FTIR analysis:

FTIR analysis used to find band gap energy of nanomaterial. The band gap energy is the difference between the top of the valence band to the bottom of the conduction band. In order for an electron to jump from a valence band to a conduction band, it requires a specific amount of energy for the transition. The band gap energy of the insulators is>4eV. The measurement of band gap energy is important in nanomaterial.FTIR spectrophotometer was also used to analyze the functional group of CuO-ZnO nanocomposite. The wavelength of 4000-400 cm-1was used for the analysis of functional group of the samples.

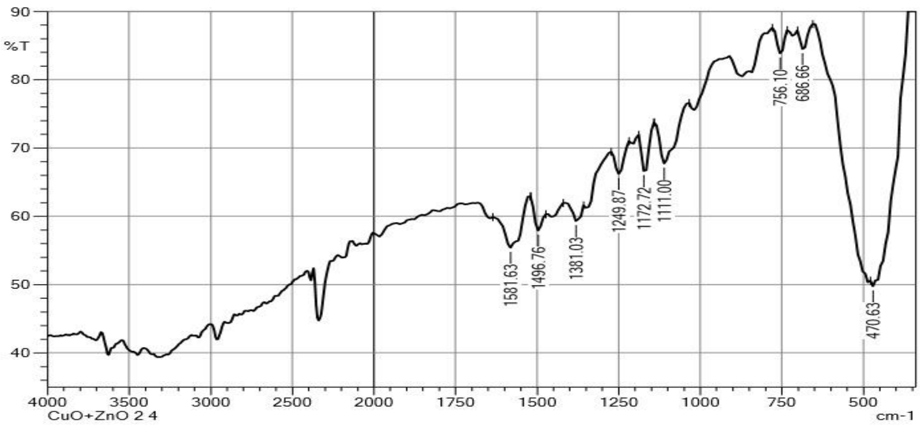

Fig.2: FTIR of CuO/ZnO nanocomposite in 1:2 weight ratio

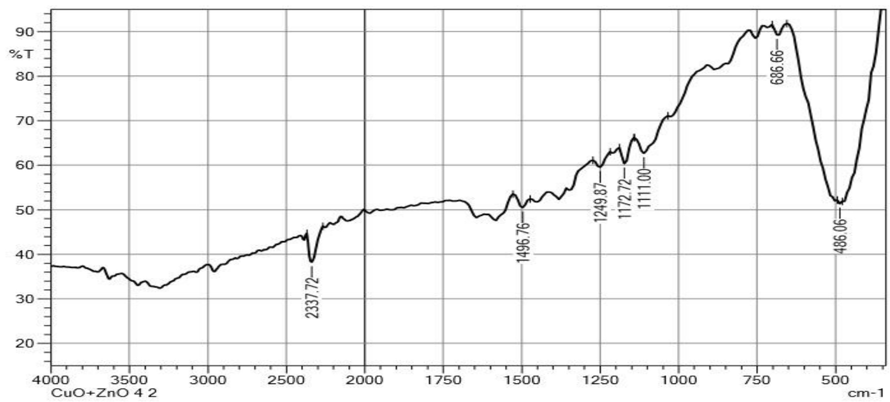

Fig. 3: FTIR of CuO/ZnO nanocomposite in 2:1 weight ratio

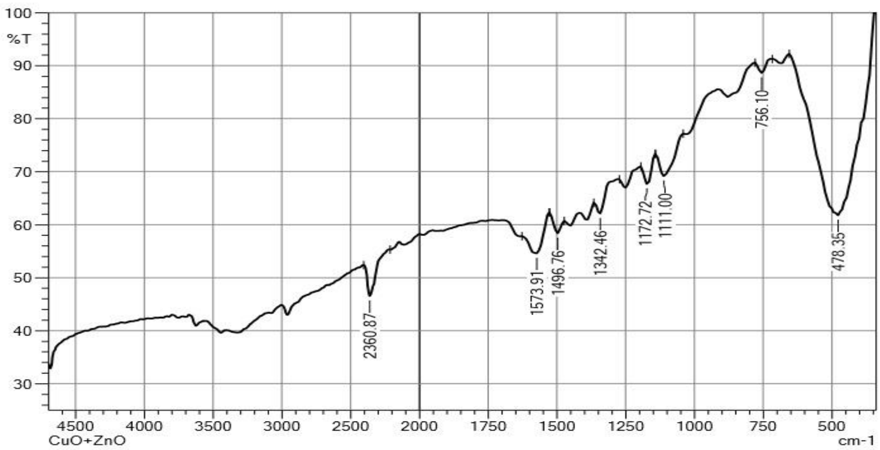

Fig. 4: FTIR of CuO/ZnO nanocomposite in 1:1 weight ratio

Table2.The FTIR results

Sr. No.	Nanocomposite material	Peak wavelength cm^{-1}	Intensity
1	CuO/ZnO 1:1	478.35	61.75
2		756.10	88.65
3		1111.00	69.14
4		1175.72	67.68
5		1342.46	62.09
6	CuO/ZnO 1:2	470.63	49.73
7		686.66	84.49
8		786.10	83.86
9		1111.10	67.73
10		1172.72	66.63
11	CuO/ZnO 2:1	486.06	51.38
12		686.66	89.25
13		1111.00	62.68
14		1172.72	60.35
15		1249.87	59.56

The result of FTIR spectra of CuO/ZnO nanocomposite synthesized by Mortar and Pestle method with the weight ratio 1:2, 2:1 and 1:1are given in figure1, figure2 and figure 3 respectively. The result summary of FTIR spectra is given in table2. The result shows that in 1:1 weight ratio of CuO/ZnO nanocomposite the sharp peak is obtained at wavelength 478.35cm. When the weight ratio of CuO/ZnO nanocomposite is 1:2, the sharp peak obtained at 470.63cm. When the weight ratio of CuO/ZnO nanocomposite is 2:1, the sharp peak obtained at 486.06cm.

3. Result and discussion

The obtained CuO/ZnO nanocomposites by motar and pestle method in weight ratio 1:1, 1:2 and 2:1 is characterized by XRD.in order to identify its crytallinity and type of crystal. Then the CuO/ZnO nanocomposite is characterized by Fourier Transform Infrared Spectroscopy FTIR. It gives the bonding between the atoms and the band gap energy of nanocomposite [10-15].

Conclusion

The Cu-ZnO nanocomposite was successfully synthesized using simple mortar and pestle method at room temperature without using post annealing treatment. The crystallinity of the CuO/ZnO nanocomposite with weight ratio 1:1 is found to be 88.3% and crystal size is 4.18nm. The crystallinity of the CuO/ZnO nanocomposite with weight ratio 1:1 is found to be 88.7% and crystal size is 3.81nm. The crystallinity of the CuO/ZnO nanocomposite with weight ratio 2:1 is found to be 88.3% and crystal size is 36.74nm. Confirmation of sample structural, elemental composition, and optical properties were investigated using XRD, and FT-IR. The mechanical milling with mortar and pestle technique was found to be ancost effective and simplest method for the preparation of CuO/ZnO nanocompositeusing analytical grade powder form material.

References

[1] Sulabha K. Kulkarni, (2015)
[2] S.K. Chakaravarti and J. Vetter, Radiat. Measure. 29: 149–159 (1998).
[3] E. Peled, V. Livshits, and T. Duvdevani, J. Power Sources 106: 245–248 (2002).
[4] Y. Liu, J.Y. Lee, E.T. Kang, P. Wang, and K.L. Tan, React. Funct. Polym. 47: 201–213 (2001).
[5] T.D. Li, L.M. Gan, C.H. Chew, W.K. Teo, and L.H. Gan, Langmuir 12: 5863–5868 (1996).
[6] Qi, Q.; Zhang, T.; Yu, Q.; Wang, R.; Zeng, Y.; Liu, L.; Yang, H; Sensors and Actuators, B, 2008, 133, 638.
[7] Srivastava, R.; Yadav, B. C.; Adv. Mat. Lett., 2012, 3, 197.
[8] Kumar, H.; Rani, R; Int. Lett. Chem. Phys. and Astronomy, 2013, 14, 26.
[9] Simon, Q.; Barreca, D.; Gasparotto, A.; Maccato, C.; Tondello, E.; Sada, C.;
[10] Comini, E.; Sberveglieri, G.; Banerjee, M.; Xu, K.; Devi, A.; Fischer, R. A; Chem. Phys. Chem., 2012, 13, 2342
[11] Al-Dmour, H.; Taylor, D. M; Appl. Phys. Lett., 2009, 94, 223309.
[12] Chang, T.; Li, Z.; Yun, G.; Jia, Y.; Yang, H; Nano-Micro Lett., 2013,5, 163.
[13] Soejima, T.; Takada, K.; Ito, S; Appl. Sur. Sci., 2013, 277, 192.
[14] Sheini, F. J.; Singh, J.; Srivasatva, O. N.; Joag, D. S.; More, M. A; Appl. Sur. Sci., 2010, 256, 2110.
[15] CH. Ashok, K. Venkateswara Rao*, CH. Shilpa Chakra Journal of Advanced Chemical Sciences 2(x) (2016) xx–xx