HCTL Open International Journal of Technology Innovations and Research (IJTIR)
http://ijtir.hctl.org
Volume 16, July 2015
e-ISSN: 2321-1814, ISBN (Print): 978-1-943730-43-8

Synthesis and Study of Magnesium Oxide and Cadmium Doped Magnesium Oxide Nanoparticles

Prateek Kumar Gour[1], Sanchita Dass Roy[2]

gourprateek0000@gmail.com

Abstract

Magnesium Oxide play a very important role in any areas of chemistry, physics and material science like other metal oxide, MgO have good reactivity. They have a vast number of structural geometries with an electronics structure that can show metallic, semiconductor and insulator character. It exhibits a rock salt structure. Nanoscale MgO & Cd-MgO powders are generated by quick precipitation technique. Magnesium Nitrate, Cadmium nitrate, Sodium hydroxide and Sodium hydrogen carbonates were used as precursors and PVP as caping agent. The both nanostructure characterized by UV-visible spectroscopy by using tauc plot method. We estimated that the effect of doping on MgO nanoparticles. This indicates that a blue shift in the band gap for both the pure and doped MgO. The doped MgO gives wide band gap as compare to pure MgO. Conductivity also measure of both materials. The MgO nanoparticles are more conductive as compare to Cd-MgO nanoparticles.

Keywords

MgO (Magnesium oxide) & Cd-MgO, Polyvinyl pyrrolidone (PVP)

Introduction

Nanotechnology is the future industrial revolution and it will be a most growing field at present in the world. Nanomaterials are very useful because of its nano size. During the last few years, synthesis of metal oxide nanomaterials has attracted the researchers due to its potential application. The MgO nanoparticles used in many application like catalyst, refractory materials, paints, superconductor product & so on. Magnesium Oxide and Cd-MgO nanoparticles are synthesized by various techniques like sol-gel method, spray pyrolysis by several researchers. Now the present work were prepared the MgO & Cd-MgO nanoparticles by quick precipitation method and to characterize both nanoparticles by UV-spectroscopy techniques. MgO and Cd-MgO nanoparticles has prepared by different other methods but these conventional methods are usually produce large particles & irregular size with low specific surface area. MgO is a versatile metal oxide having many application in different fields like catalyst, medicine, refractory material, heating apparatus, infrared optics, electrochemical sensors, antimicrobial material, in coating and many other application. We obtained band gap of the nanostructure MgO & CdMgO by using tauc plot method.

[1,2]Department of Nanotechnology, Medicaps Institute of Science and Technology, Indore, MP, India.

A tauc plot is used to determine the optical gap or Tauc gap, in semiconductors. The Tauc gap is often used to characterize practical optical properties of amorphous materials.

A Tauc plot is a convenient way of displaying the optical absorption spectrum of a material, pioneered by Jan Tauc who proved that momentum is not conserved even in a direct optical transition. Typically, a Tauc plot shows the quantity hv (the energy of the light) and the quantity $(\alpha hv)^{1/r}$ on the ordinate, where α is the absorption coefficient of the material. The value of the exponent r denotes the nature of the transition.

- r = 1/2 for direct allowed transitions
- r = 3/2 for direct forbidden transitions.
- r = 2 for indirect allowed transitions
- r = 3 for indirect forbidden transitions

The conductivity of these nanoparticles are also measure by using conductivity meter. Conductivity of a solution is a measure of its ability to conduct electricity. The SI unit of conductivity is Siemens per meter (S/m).

Methods and Materials

The starting materials used in quick precipitation technique were Magnesium Nitrate ($Mg(NO_3)_2$), Cadmium Nitrate ($Cd(NO_3)_2$), Sodium hydrogen Carbonate ($NaHCO_3$), Sodium hydroxide (NaOH) and polyvinyl pyrolidone (PVP). In this work MgO & Cd-MgO nanoparticles were prepared using quick precipitation method. For Cd-MgO cadmium nitrate was added and other materials are same as MgO process.

Experimental Procedure

In this process 1M solution of $MgNO_3$ was prepared by dissolving $MgNO_3$ in distilled water. Similarly $NaHCO_3$ & NaOH solution was prepared by dissolving suitable quantity in distilled water & also PVP solution was prepared by using distilled water.

To prepare the precursor for MgO, $MgNO_3$ & PVP solution was taken in a 250ml beaker and kept above in the magnetic stirrer & allowed to stir for 10-15 minutes at room temperature at 350-400 RPM. Then 50ml of 1M solution of $NaHCO_3$ was slowly added to it using funnel drop by drop under constant stirring condition. The 50ml of 1M NaOH was slowly added into the above resulting solution under stirring. In this whole process was carried out under constant stirring condition (1300 RPM). After addition of surfactant & precipitation agent the constituent mixture was allowed to stir for 3 hrs without altering any parameters.

After completion of the whole reaction process very finely powdered white precipitate MgO was settled at the bottom of the beaker. Then the fine powder was separated carefully from filter paper. The whole precipitation was washed thoroughly with the help of doubly distilled water to make precipitate free from tracer of foreign element. The resulting substrate ($Mg(OH)_2$ precursor) was kept in air oven for proper drying for 1 hour at 80°C for complete drying. Then the MgO nanoparticles was obtained via controlled calcination process using muffle furnance for 3 hrs at 350°C.

Similarly follow the same procedure for Cd-MgO but only Cadmiun nitrate (10% of $MgNO_3$) was added in $MgNO_3$ solution.

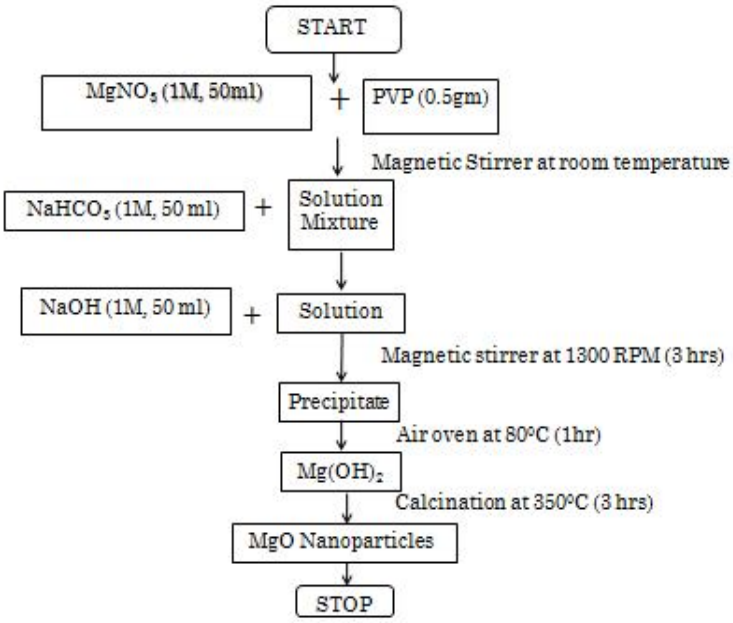
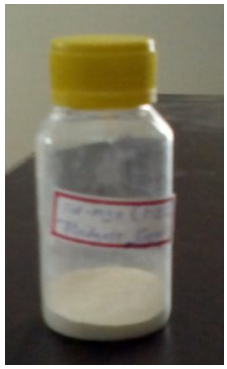


Figure: Synthesis of MgO Nanaprticles

MgO nanoparticles



Cd-MgO Nanoparticles

Characterization

MgO and Cd-MgO nanoparticles were characterized by UV-Spectroscopy.

UV-Spectroscopy

UV-Spectroscopy gives the information about the band gap of nanoparticles. By using UV we can draw the tauc plot & study the band gap of the particles.

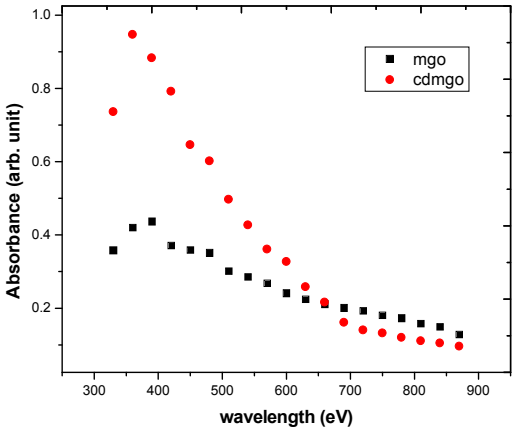


Figure: UV graph for MgO & CdMgO

By using UV-graph we can't estimated the band gap directly because of its certain limitation it doesn't give the particular peak for these range of UV-Spectrophotometer.

Tauc Plot

Step to convert UV data into tauc plot:

1. Obtain absorption cofficient from absorbance data

$$\alpha = A/L$$

where L = cuvette length

2. Convert wavelength into energy

$$E = hc/\lambda$$

3. Plot a graph between E & $(\alpha E)^2$ and intercept on X axis gives bandgap.

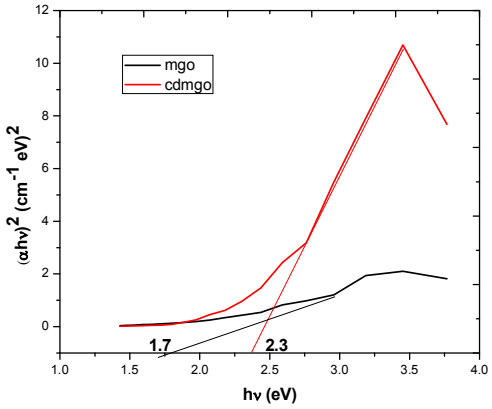


Figure: Tauc plot for MgO & CdMgO

Conductivity Measurement

Conductivity measurement is done by using conductivity meter which gives the digital output of the sample. Conductivity is basically used for measure the concentration of dissolved solids which have been ionized ina polar solution such as a water. The meter which is used to measure the electrical conductivity is called conductivity meter. The laboratory conductivity meter employs a two electrodes method. The electrodes are cylindrical & arranged concentrically. The electrodes are usually made of platinum metal.

Figure: Conductivity meter

Results

There is clearly a variation in the curves due to doping of cadmium in the MgO nanoparticles.

Band gap of nano structure are less than bulk bandgap. We found that Band gap for MgO is less than the CdMgO. The straight line gives the value of the energy band gap in tauc plot. The band gap for Mgo and CdMgO nanoparticles were found to be 1.7 and 2.3 eV.

The conductivity meter gives the digital output of both nanoparticles. Conductivity of MgO found to be 2.26 mS/m & Cd-MgO gives 1.34 mS/m. Hence MgO nanoparticles are more conductive a compare to Cd-MgO nanoparticles.

Conclusion

Conductivity of the material depend upon the no of free carrier & surface area of material. Defects plays an important role in the nanostructure oxygen vacancies at the grain defects & Mg vacancies at the grain boundaries cause no of free carrier & only responsible for small ferromagnetism. High surface area to volume ratio due to the formation of the nanoparticles. Due to the above reason the bandgap of the nanoparticles is less than the bulk. Hence MgO & CdMgO nanoparticles can show semiconductor behaviour in constrast to the insulating behaviour of the bulk. From the result we conclude that the shift in the band gap of nanoaprticle is due to the quantum confinement. The band gap of MgO is less than the Cd-MgO nanoparticles which is also confirm by using conductivity measurement which shows that MgO is more conductive as compare to Cd-MgO nanoparticles.

References

1. A versatile route to synthesize MgO nanocrystals by combustion technique, Kaviyarasu, K.Devarajan, P.A. (2011) Der pharma chemica 3(5),pp. 248-254

2. K. Kaviyarasu and Prem Anand Devarjan, Synthesis and characterization studies of cadmium doped MgO nanocrystal for optoelectronics application. Advance in Applied Science Research , vol 2(6), 2011,pp. 131-138

3. S. Devi Meenakshi et al., Elixir Nanotechnology, Vol. 50, 2012, pp. 10618-10620

4. K Kaviyarasu et al. “Synthesis and characterization studies of cadmium doped MgO nanocrystals for optoelectronics application” Pelagia research library, advances in applied science research, vol 2, pp. 131-138, 2011.

5. Hakimeh MIRZAEI et al. “microwave assisted sol-gel synthesis of MgO nanoparticles and their catalytic activity in the synthesis of Hantzch 1,4-dihydropyridines”, Chinese journal of catalysis, vol 33, pp. 1502-1507, 2012.

6. S.Devi Meenakshi et al. “ Synthesis and characterization of magnesium oxide nanoparticles”, Elixir Nanotechnology, vol 50, pp. 10618-10620,2012.