# Synthesis and Characterization of Zinc Oxide (ZnO) and Magnesium doped Zinc Oxide (Mg-ZnO) Nanoparticles by Chemical precipitation method

Rini Singh, A A Koser
*Department of Nanotechnology, Medi-Caps Institue of Science and Technology, Indore*

***Abstract – Zinc oxide(ZnO) is one of the most widely used inorganic material since it has a wide bandgap of 3.37 eV and high mechanical and thermal stability. It belongs to II-VI semiconductor group. Doping with selective elements offers an effective method to enhance and control the electrical and optical properties of ZnO nanostructures, which is crucial for its practical applications. Mg-doped ZnO have significant interests owing to their unique optical, piezoelectrical and electrical properties. In this paper, we have reported the Synthesis of ZnO and Mg-doped ZnO nanoparticles using thioglycerol as a capping agent by using chemical precipitation method. The characterization of ZnO nanoparticles and Mg doped ZnO nanoparticles using UV spectrophotometer revealed a significant change in property due to doping and we observed the shift in the wavelength, this patent the change in the bandgap as well. The particle size was calculated using effective mass approximation method which comes out to be 3.77 nm for ZnO nanoparticles and 4.48 nm for Mg doped ZnO nanoparticles.***

***Keywords: ZnO; Mg doped ZnO; Precipitation; Bandgap; UV spectrophotometer.***

## I. INTRODUCTION

There are various nanomaterials which are synthesized and are being used in various applications such as Titanium dioxide ,silicon carbide, zinc oxide etc. Among these Zinc oxide is most widely used material, ZnO is an non-living compound also known as zincite and occurs hardly ever in nature, generally in a crystalline form. It usually appear as a fair crystalline powder, which is nearly insoluble in water. Most of ZnO which is used commercially is produced synthetically. ZnO is actually a wideband gap(3.37 eV) semiconductor of the II-VI semiconductor group and it has a large excite on binding energy of 60 meV.. The doping of the semiconductor is n-type which is due to oxygen vacancies. Zinc oxide (ZnO) has a stable wurtzite structure.

This has several favorable properties like high electron mobility, good transparency, wide band gap for semi-conductivity, high room-temperature luminescence, etc. These properties are used in applications for electrodes in liquid crystal displays [1]. It is used in transparent electronics, ultraviolet (UV) light emitters, piezoelectric devices and chemical sensors. Zinc oxide particles have been found to have superior UV blocking properties compared to its mass substitute. This is one of the reasons why it is frequently used in the preparation of sunscreen lotions, and is entirely photostable. The different fabrication methods, such as vapor-phase transport [2-4], pulsed laser deposition(PLD) [5], chemical vapor deposition(CVD) [6,7] and electrochemical deposition [8], have been widely used to prepare ZnO nanostructures. In most of these methods, various capping agents are used to prevent the growth of particles with time. Doping with selective elements offers an effective method to enhance and control the structural, electrical and optical properties of nanoparticles which is crucial for its practical applications. By doping the ZnO with other elements various changes occurs in its particle size, band gap etc.

ZnO doped with elements such as Al, Mn, Cd, Ni etc has been studied.[9,10].By doping with a wider band gap material[11],the band gap of the ZnO particle can be tuned for manufacturing light-emitting devices operating in a wider wavelength region. The doping of ZnO with a metal(Al,Cu etc) can change its properties. A suitable method for prepairing doped ZnO with less working cost, less synthesis time, fine size range and better properties is a challenge for us. In this paper, we have reported the Synthesis of ZnO and Mg-doped ZnO nanoparticles using thioglycerol as a capping agent by using chemical precipitation method and the characterization of the prepaired nanoparticles is done by using UV spectrophotometer.

## II. MATERIALS AND METHODS

Zinc acetate, Zinc sulphate, Potassium hydroxide, NaOH, DMSO, Magnesium sulphate, Methanol, Ethanol, is used in performing the experiments. Thioglycerol is used as a capping agent in the preparation of ZnO and MgZnO nanoparticles. Distilled water is used throughout the experiment for the preparation of solutions. The Chemical

Precipitation method is used for the preparation of ZnO and Mg-doped ZnO nanoparticle. Chemical precipitation is a formation of a separable solid substance from a solution, either by converting the substance into an insoluble form or by changing the composition of the solvent to diminish the solubility of the substance in it.

## III. SYNTHESIS OF ZNO NANOPARTICLES:

The chemical precipitation method was performed in our laboratory for the synthesis of ZnO and Mg doped ZnO nanoparticles. For the preparation of ZnO nanoparticle 0.2M(0.8gm) of Zinc acetate is mixed in 100 ml of distilled water.20 ml of DMSO solution is mixed in zinc acetate solution.Constant stirring of the solution is done on the magnetic stirrer at 560 rpm for 30 minutes.1.2M of KoH is mixed in 100 ml distilled water in other beaker and 10 ml of ethanol is mixed in KoH solution. This KoH solution is added dropwise into the zinc acetate solution kept on the magnetic stirrer.The solution is stirred for 5 min. Add 0.3ml of thioglycerol into the solution. Constant stirring is done for 1 hour till the solution turns milky. Thus the prepared solution is then washed 3 times with methanol.

## IV. SYNTHESIS OF MG-ZNO NANOPARTICLES

For the preparation of Mg doped ZnO nanoparticles,0.2M of NaOH is mixed in 100 ml of distilled water,0.1M of Zinc sulphate is mixed in 100 ml of distilled water and 0.01M of Magnesium sulphate is mixed in 100 ml of distilled water.Like this three different solutions are made in different beakers.Now, a single mixture of zinc sulphate and magnesium sulphate is made in a beaker and kept on magnetic stirrer on 560 rpm.NaOH solution is added dropwise into the mixture of solutions under constant stirring.Add 0.3ml of Thioglycerol into the solution and keep the solution at room temperature for 3 hours under constant stirring.The prepared solution is centrifuged for 40 minutes at 2000 rpm.The centrifuged Mg-ZnO was then washed with ethanol several times using filter paper.

## V. CHARACTERIZATION

There are different characterization techniques used to study the various properties of nanoparticles such as Scanning electron microscopy(SEM),X-ray spectroscopy, We have used **UV-Vis spectrophotometer** to study the band gap of ZnO and Mg-doped ZnO nanoparticles. We had taken UV of the ZnO and Mg-ZnO nanoparticles.

The samples of ZnO and Mg-Zno are diluted with distilled water and mixed properly. The sample is then filled in a cuvette and distilled water is filled in the other cuvette. After calibration, we had taken UV of the ZnO and Mg-ZnO nanoparticles.

The variation in the wavelength and absorbance is observed for both the ZnO and Mg doped ZnO nanoparticles samples.

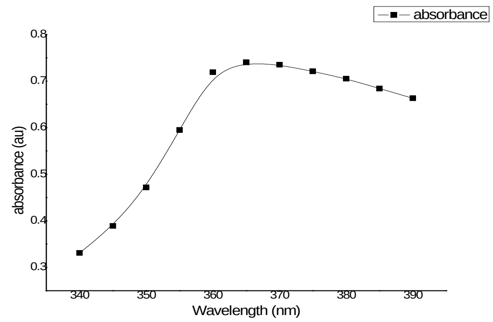



Fig:5.1 UV Graph between Absorbance and Wavelength for ZnO nanoparticles.

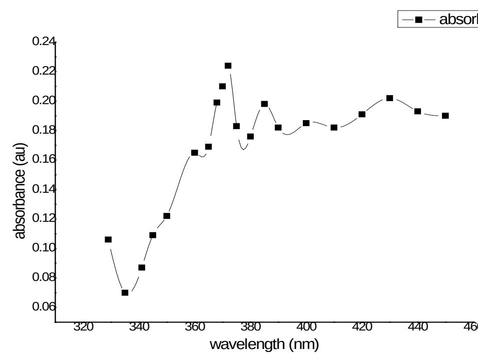



Fig:5.2 UV Graph between Absorbance and Wavelength for Mg doped ZnO nanoparticles.

## VI. RESULTS AND DISCUSSION

ZnO and Mg-ZnO nanoparticles have been synthesized using simple precipitation method by using thioglycerol as a capping agent. The UV characterization of ZnO and Mg doped ZnO nanoparticles is done by us with the help of UV spectrophotometer.

- UV-Vis spectroscopy of ZnO and Mg-ZnO is performed and the absorptions peaks are obtained at 365nm and 367 nm.

- The bandgap ($E_g$) of ZnO and Mg-ZnO is calculated by using the formula:

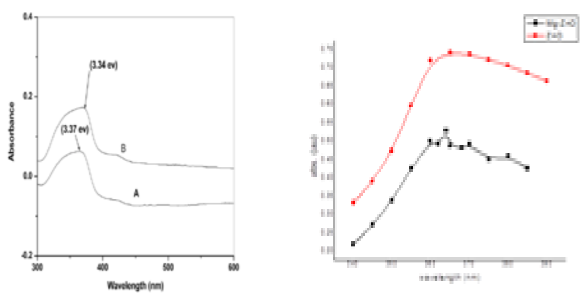
$$E_g = \frac{hc}{\lambda}$$

Where h is the plank's constant c is the velocity of light and $\lambda$ is the wavelength. The band gap of ZnO is found to be 3.40 eV and band gap of Mg-ZnO is found to be 3.38 eV.

Thus, UV spectroscopy revealed that the ZnO and Mg-ZnO has turned into nanoparticle with band gap of 3.40 eV and 3.38 eV which is higher than the corresponding bulk ZnO i.e 3.3 eV .

The band gap of ZnO is 3.40 eV and band gap of Mg-ZnO is 3.38 eV. The band gap of ZnO is decreased on doping with Mg. The optical band gap of doped and undoped ZnO nanoparticles is been studied. we observe that the band gap of doped ZnO is shifted slightly towards longer wavelength region.

The comparison of referred graph is done with the obtained experimental graph of UV which shows the variation between wavelength and absorbance for both ZnO nanoparticles and Mg-ZnO nanoparticles.




Reffered Graph Experimental Graph

Fig 6.1 : Comparison of Referred and Experimental graph of ZnO and Mg-ZnO UV graph between wavelength and absorbance for ZnO and Mg-ZnO nanoparticles.

The particle size was calculated by using effective mass approximation method which comes out to be 3.77 nm for ZnO nanoparticles and 4.48 nm for Mg doped ZnO nanoparticles.This shows that the particles obtained on synthesis are nanoparticles.The results are matching with the work done by Saber Faramji Shayesteh [12].The bandgap of the doped ZnO is decreased which is in resemblence with the results of the work done by Saber Faramji Shayesteh .

There are some differences in our experimental and reffered work:

- In our experiment we have used thioglycerol as a capping agent instead of CTAB(Cetyl trimethylammoniuim bromide) which is used in the work done by Saber Faramji Shayesteh.
- The absorbance of ZnO is more than in Mg-ZnO whereas its opposite in other case. It is due to the change in capping agent and the variation in the amount of distilled water which is used to dilute the sample for UV spectroscopy.

## VII. CONCLUSION

ZnO and Mg doped ZnO nanoparticles were synthesized using the chemical precipitation method in our laboratory by using thioglycerol as a capping agent.The particle size of ZnO and MgZnO was found to be 3.77 nm and 4.48 nm.The optical bandgap of doped and undoped nanoparticles was studied and it is found that the bandgap of doped ZnO was shifted slightly towards longer wavelength region..

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