Synthesis and Characterization of Pure Zinc Oxide Nanoparticles by Precipitation Method

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ABSTRACT
We synthesized zinc oxide nanoparticles by precipitation method using zinc sulfate and sodium hydroxide as raw materials. The synthesized zinc oxide nanoparticles were characterized by X-Ray Diffraction (XRD) and UV spectroscopy to obtain crystal morphology and its optical properties. By XRD analysis, we obtained pure structure of zinc oxide nanoparticles and average size was found to be 27.65 nm. We obtained pure wurtzite hexagonal structure of zinc oxide nanoparticles by XRD having lattice parameters a=b=3.2490 and c=5.2070. UV absorption studies were carried out to obtain the optical properties of synthesized particles. The maximum absorbance was observed at 330 nm.

Keywords: ZnO, chemical synthesis, XRD, UV spectroscopy.

I. INTRODUCTION
Zinc oxide is multifunctional material which has unique chemical and physical properties. Because of its unique properties many researchers works on it. It is n-type semiconductor material which has many applications in various fields. It is used as transparent conductive layer in organic solar cells [1], used as a catalyst for water treatment, in cosmetics and medicated creams [2] and in food packaging etc. Zinc oxide is key element for many industrial processes like paints, ceramics, rubber, soap, textiles, and floor coverings. Zinc oxide is wide band gap material which is widely used in polymer solar cells as thin layer coating. The wide band gap of zinc oxide allows devices to operate at higher temperatures. The semiconducting property of zinc oxide is recently a high researched field for its application in photo electronic devices. There are various methods for the formation of zinc oxide nanoparticles like chemical co-precipitation [3-6], sol-gel method [7], hydrothermal method [8], chemical vapor deposition [9] and electrochemical method [10]. We use the chemical co-precipitation method because this method is cheap, easy and does not require any special equipment. The absorbance effect plays an important role in measuring the band gap of synthesized material. This property is useful for making its use in solar cell technology.

II. EXPERIMENTAL DETAILS
Materials used:
Zinc sulfate hepta hydrate (98% pure) and sodium hydroxide (97% pure) were used in experiment without any further purification. All chemicals used were Rankem laboratory reagent grade and obtained from NFCL Limited, New Delhi. Distilled water is used for preparation of solution.

Synthesis procedure:
We have synthesized zinc oxide nanoparticles by simple co-precipitation method. We used zinc sulfate hepta hydrated and sodium hydroxide as starting materials. Aqueous solution is prepared by dissolving 4gms of zinc sulfate in 100ml distilled water. This was stirred under electromagnetic agitation for 10 min so that zinc sulfate can be dissolved properly. The prepared aqueous solution of sodium hydroxide is added drop by drop into zinc sulfate solution for 30 min by touching the walls of container. The ratio of aqueous solutions of zinc sulfate and sodium hydroxide was maintained as 1:2. After the complete addition of sodium hydroxide into zinc sulfate solution, the reaction is allowed to proceed for 4 hours under electromagnetic agitation. The solution is vigorously stirred for 1 hour. A milky white precipitate will obtain which is allowed to settle for 24 hours. The precipitate obtained was washed with distilled water many times and filtered using filter paper. The filtered precipitate is dried in a muffle furnace for 2 hours at 130°C. The obtained
dried powder was grind to fine powder by using agitate mortar. The powder was then calcined at 300°C.

III. RESULTS AND DISCUSSION

XRD Analysis:
XRD is a technique that is used for determination of crystallographic structure of solid materials. We characterized the zinc oxide sample by X-Ray Diffraction technique to obtain crystal morphology and average particle size using Scherer’s formula. The X-Ray Diffraction patterns for powder sample were recorded by using Bruker D8 Advance diffractometer with Ni filtered Cu Kα radiation. The patterns were recorded over a 2θ range of 10-80°. The average particle size by using Debye Scherer’s formula found to be 27.65 nm. The XRD peaks of zinc oxide sample calcined at 300°C is shown in Fig.3. These patterns are showing hexagonal crystal system with wurtzite structure which have lattice constants a= b= 3.2490 and c= 5.2070 respectively.

![Fig.1 Setup used for electromagnetic agitation.](image1)

![Fig.2 Synthesized powder before grinding.](image2)

![Fig.3 XRD patterns of Zinc Oxide nanoparticles](image3)
UV Spectroscopy analysis:
To determine the optical properties of synthesized zinc oxide nanoparticles UV spectroscopy is used. The absorbance plays an important role in preparation of thin films for the application in solar cells. For determination of UV absorbance methanol was used as reference solvent. Solution of zinc oxide in methanol is prepared. Absorbance is checked for wavelength range of 220-900 nm. The UV spectrum of zinc oxide sample is shown in fig 4. For the prepared solution, highest absorbance was observed at 330 nm which shows that particles formed are showing blue shift in wavelength. The absorbance was determined using Shimadzu UV 3600 UV-Vis Spectrometer.

![UV spectrum of synthesized Zinc oxide nanoparticles](image.png)

IV. CONCLUSION
We synthesized zinc oxide nanoparticles by simple precipitation method using zinc sulfate and sodium hydroxide in distilled water. XRD study gives pure hexagonal wurtzite structure of ZnO with size of 27.65 nm. This method gives less agglomeration between particles because of the absence of chlorine ions in it. Because of the less agglomeration and pure structure, the dispersion was found to be good in methanol solvent. UV study gives maximum peak of synthesized nanoparticles at 330 nm which shows a blue shift in wavelength.

REFERENCES