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# Synthesis And Characterization of ZnO Hexagon

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## ABSTRACT

***A simple low temperature co-precipitation method, which was based on the reactions of zinc nitrate and hexamethylenetetramine (HMT) in aqueous medium at 375 K for 24 h, was proposed for the synthesis of hexagonal ZnO nanoparticles. The ratio of zinc nitrate and HMT was 1:1 M. Structural, morphological, and optical characterization of the as-synthesized nanoparticles was done through X-ray diffraction, field-emission scanning electron microscopy, photoluminescence spectroscopy, and ultraviolet-visible spectroscopy. The novelties of present work was we achieved first time hexagonal structure of ZnO at nanolevel at relatively low temperature (375 K) than reported in the literature and semiconducting band gap for hexagonal ZnO nanoparticles. This research articles, provides an efficient method for synthesis of hexagonal structure of ZnO at nanolevels. Ultra-violet spectra indicated that the as-synthesised hexagonal ZnO has a direct band gap of about 2.78 eV.***

***Keyword: -*** *Band gap; Hexagonal ZnO; Co-precipitation Method ;Nano -particles.*

## 1. INTRODUCTION

Due to their outstanding optical, electrical and thermal properties properties, synthesis and investigation of semiconducting materials in different fields of science such as physics, chemistry, material science and nanotechnology has been increased. Among the various semiconductor nanomaterials, zinc oxides (ZnO) as a large-band-gap semiconductor [1]. It is one of the 'toughest' materials in the II-VI group of periodic table. ZnO synthesizes by various methods with variety of nanostructure morphologies [2]. ZnO has established to possess various kinds of morphologies from nano to micro-crystals [3]. The crystalline morphology, orientation and surface architecture of nanostructures controlled during the preparation processes is useful in diverse applications [4]. The ZnO is semiconductor with a wide energy band gap in the near-UV region (3.4 eV) and have wide range of applications with superior electron mobility, high exciton binding energy and light emitting diodes. It also presents excellent thermal stability, high transparency, pyroelectric and piezoelectric properties, and gas sensing applications [5, 6]. Because of the wide bandgap (~3.37 eV), ZnO nanostructures are ideal UV sensitive semiconductors for optoelectronic applications. ZnO nanoparticles function as UV absorbing and charge carrier generating materials [7]. However, because ZnO has an order of magnitude higher electron mobility as compared to $TiO_2$, there is still rich scope and opportunity to improve the efficiency of ZnO-based photovoltaic applications. Kathalingam *et. al.* [8] reported shape dependent electrical property of ZnO nanorodes synthesized by aqueous solution method. Space-charge-limited current conduction and photo response were study under room-ambient condition and different illumination for ZnO nanorods. In present work, a relatively simple, efficient and low temperature method has been developed to synthesis hexagonal ZnO nanoparticles. The novelties of present work are we achieved first time hexagonal structure of ZnO at nanolevel at relatively low temperature (375 K) than reported in the literature and semiconducting band gap for hexagonal ZnO nanoparticles.

## 2.EXPERIMENTAL

All the reagents were of analytical grade and they were used without further purification. ZnO nanoparticles were prepared via co-precipitation method using zinc nitrate ($Zn(NO_3)_2 \cdot 6H_2O$) and hexamethylenetetramine ($C_6H_{12}N_4$). In the typical procedure, a stock solution of 1M solution of $C_6H_{12}N_4$ was prepared by dissolving suitable quantity in distilled water. Similarly 1M $Zn(NO_3)_2 \cdot 6H_2O$ solution was prepared by dissolving in distilled water. 1 M solution of HMT was added dropwise in, the solution stirred vigorously under 0 °C for 1 h, then centrifuged for 20 min. ZnO gels were achieved by this way. After this procedure, prepared solution was washing several times with doubled distilled water and filtrate with cellulose nitrate filter papers. The final product was dry at room temperature for

overnight and then heating at 375° C for 24 hours. The prepared sample was characterized by X-ray diffraction spectroscopy, Field effect-scanning electron microscopy (FE-SEM), photoluminescence (PL) and ultraviolet-Visible (UV-Vis) spectroscopy.

**3.RESULT AND DISCUSSIONS**

Fig.1. shows XRD spectrum for hexagonal ZnO nanoparticles synthesizes by co-precipitation method. The prepared nanoparticles were characterized by an X-ray diffraction pattern was acquired from Rigaku miniflex-II diffractometer with CuKα radiation in the range 10°-70°. The reflections at 2θ of 32.07, 35.08, 36.57, 47.98, 57.15, 63.14, and 68.37 are attributed to hexagonal wurtzite of ZnO (JCPDS Card Zincite, ZnO, 01-074-9941). The absence of other impurity peaks clearly points that prepared sample was highly pure.

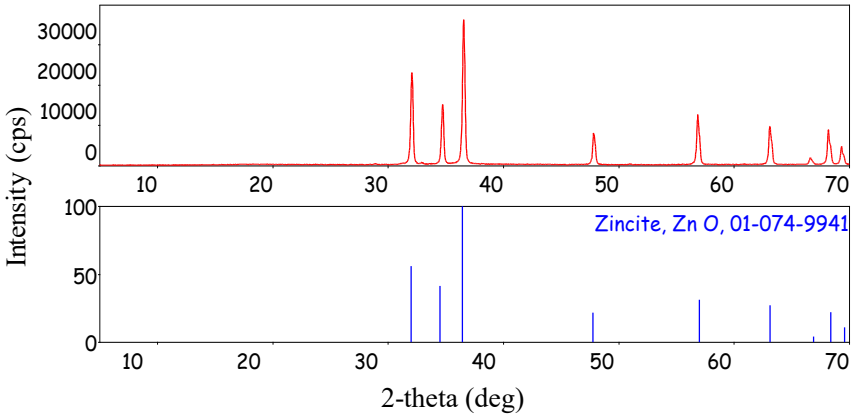


**Fig. 1. XRD pattern of the synthesized hexagonal ZnO nanoparticles with JCPDS card.**

Sample was further investigated with FE-SEM analysis. It can be observed from Fig. 2 that the length and diameter of hexagonal ZnO nanoparticles are 150-250 nm and 70-100 nm respectively. Fig. 2 presents hexagons of dissimilar size and shapes; these hexagons display an unruffled surface with a perfect hexagonal shape of various length and diameters, and most of the rods are connected. The FE-SEM image at low magnification (figure 2(a)) indicates that ZnO has a dense and compact morphology. From the image at higher magnification (figure 2(b)), it is observed that each individual hexagon has a pure hexagon-like structure with an average diameter of 100 nm. A careful examination reveals that the thickness of the nanorode is around 155 nm. Furthermore, each hexagon has almost the different thickness.

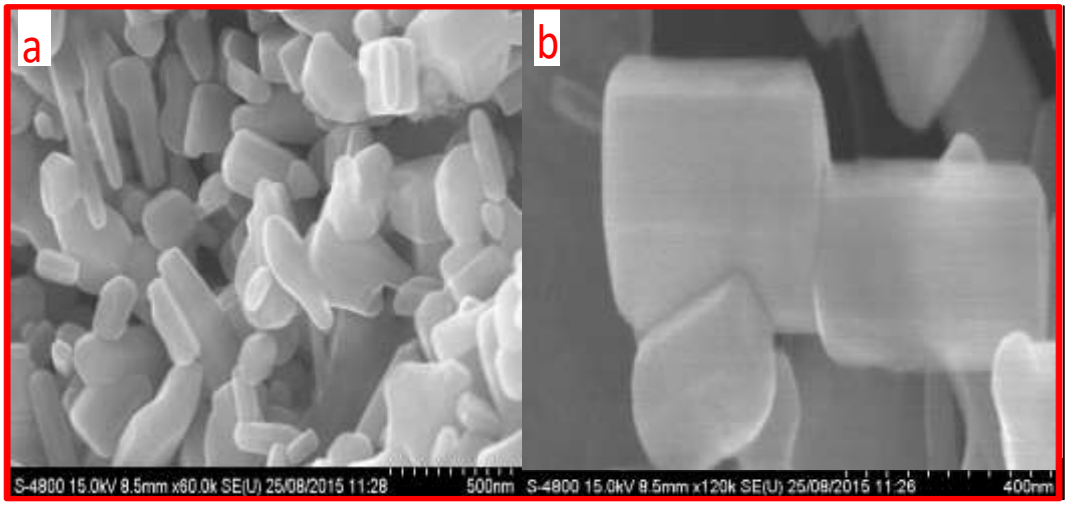


**Fig. 2.** (a) FESEM image showing nanorods of various size, (b) FESEM image of 3 hexagonal ZnO nanoparticles indicating a nearly parallel arrangement

Further confirmation of synthesized of hexagonal ZnO nanoparticles was made by UV-Vis spectroscopy by taking spectra of synthesized ZnO nanoparticles. Fig. 3 shows the optical absorption spectra of the hexagonal ZnO samples range between 200-800 nm. The absorption spectra show linear absorption toward the longer wavelength side. The hexagonal ZnO prepared by co-precipitation shows stronger absorption. The curves indicate weak absorption spectra

in the wavelength ranges from visible light to near infrared and strong absorption at the wavelength less than 350 nm. Higher absorption of hexagonal ZnO nanoparticles suggests that the sample has prominent internal surface area. Therefore, the present approach can be considered a suitable methodology for obtaining hexagonal nanoparticles with absorption in UV-Vis range for different applications.

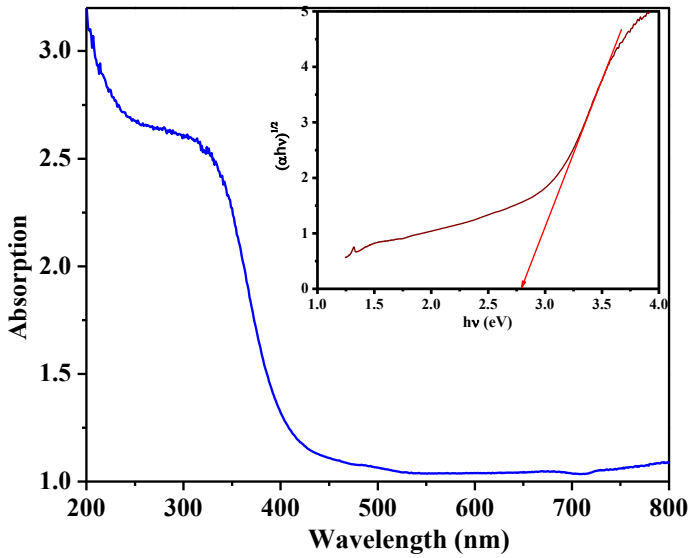


Fig.3. UV-Vis spectrum of the as-synthesized hexagonal ZnO nanoparticles.

Fig.4. shows the room temperature photoluminescence spectrum of hexagonal ZnO synthesized using co-precipitation method. Strong emission peak centred at 395 nm was observed in ZnO. The ZnO sample exhibits not UV bandgap luminescence but also oxygen defects luminescence was observed. The photoluminescence spectra shows the two prominent peaks at 395 is because of Zn while small peak observed around 466 nm is due to presence of oxygen. Peaks appear due to transition of exciton state in ZnO indicating that hexagonal ZnO nanoparticles have high crystalline phase and good optical properties. The observed PL spectra, due to recombination of photo generated holes with singly ionized charge state of specific defect. Furthermore, absence of the green yellow emission in our samples indicates the potential of our synthesis method to produce a low concentration of oxygen defects and high optical quality of hexagonal ZnO.

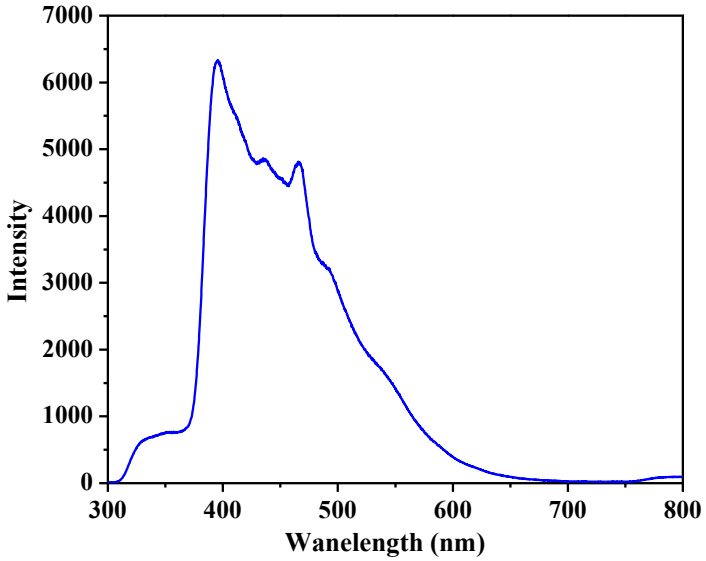


**Fig. 4.** Room temperature PL spectrum of the as-synthesized hexagonal ZnO nanoparticles.

## 4. CONCLUSIONS

Texture characterization was performed using XRD and FE-SEM was clearly suggested the formation of hexagonal ZnO nanoparticles via co-precipitation method low temperature than the established methods. Similarly, an optical characteristic of nanoparticles that is the absorption was confirmed by UV-Vis spectroscopy. The as-synthesized nanoparticles had a direct band gap of about 2.78 eV, and exhibited a defect-induced strong emission at 395 nm. Pl spectrum was reported both UV bandgap luminescence and oxygen defects luminescence.

## 5. ACKNOWLEDGEMENT

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