Investigation of Metal Oxide Nanoparticles Using *Punica granatum* Seed Extract

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ABSTRACT

Zinc oxide has significant importance as it has various applications in many industries due to its versatile properties which can be enhanced by production at the Nanoscale. Major applications of ZnO in material science are due to its greater refractive index value, considerable thermal conductivity, binding, biocompatibility, and anti-bacterial characteristics. Many physical and chemical Synthesis techniques are adopted but along with synthesis, these methods carry impurities that lead to a reduction of yield of pure Nanoparticles. Adoption of a sustainable route i.e. Green route for the synthesis of Nanoparticles considerably enhances the properties and effectiveness of NP's, as it is a less hazardous method than other chemical and physical methods. Zinc oxide NPs have been successfully prepared by sustainable extraction (green synthesis) using biological substrate (Fresh Punica granatum seed). Characterization techniques i.e. XRD, DRS, FTIR, UV reveals crystalline structure, Band Gap, Transmission, and absorption spectra of the sample. Miller indices values from the XRD plot are (100) (002) (101). The average grain size obtained from XRD analysis is 17nm and crystal geometry is hexagonal. Grain size ranges from 15nm to 40nm can have the best effect for antibacterial and antifungal applications. Bandgap energy shows the semiconductor range of ZnO Nanoparticles.

Keywords: Nanoparticles, Green Route, Characterization, Semiconductor, Antibacterial.

Article History
Received: 29 May 2021
Accepted: 30 September 2021
Published: 30 October 2021

INTRODUCTION

A new class of material that has captivating properties and incredible scientific potential is that nanomaterials. Nanomaterials are categories as metals, ceramics, polymers, and composites (Azam et al., 2012). However, these materials are not distinguished by their chemistry, but rather by size. This ability provides prospects to progress in mechanical, electrical, magnetic, and other properties that don't appear to be otherwise possible (Tran et al., 2009). Numerous physical and chemical characteristics revealed by matter may experience affected changes as particle size

approaches atomic magnitudes J. Yao et al., 2014. Such as, within the macroscopic domain materials that are opaque, on the nanoscale may become transparent; some solids converted into liquids, chemically stable materials converted into combustible, and insulators become conductors (Gao et al., 2017). Moreover, during this nanoscale domain, properties may depend upon the size. In origin a number of these effects are quantum mechanical, some are associated with surface phenomena (Kelsall et al., 2005). As the size decreases, the quantity of atoms located on the surface sites of a particle increases intensely. Due to these exceptional and weird properties, nanomaterials are finding positions in, biomedical, sporting, electronic, energy production, and other commercial applications (Barth et al., 2010; Callister et al., 2020; Buzea et al., 2007; Wang, 2018).

Zinc oxide is a white powder that's insoluble in water, inorganic in nature with the chemical formula ZnO (Murty et al., 2013). ZnO is widely used as a chemical in numerous ingredients and goods including, batteries, plastics, ceramics, ferrites, cement, lubricants, paints, adhesives, sealants, pigments, foods, rubbers, glass, fire retardants, and first-aid tapes (Chaudhuri et al., 2017). Although naturally, it occurs in mineral zincite, utmost zinc oxide is produced synthetically (Moezzi et al., 2012). Because of oxygen vacancies or zinc interstitials, the natural doping of the semiconductor is n-type. Good transparency, high electron mobility, wide bandgap, and powerful luminescence at room temperature, are several fortunate properties of semiconductors (Kim et al., 2017). Hexagonal wurtzite and cubic zinc blende are two main crystalline forms of Zinc oxide. At ambient conditions, the wurtzite structure is most stable and thus in common (McGlynn et al., 2010). This present research approach to eco-friendly approach for sustainable synthesis of ZnO Nanoparticles using Punica Granatum seed for bio-reduction of ZnO Nanoparticles. Synthesized ZnO NPs are characterized by XRD, DRS, FTIR, and UV. The aimed research is an approach for the application of ZnO in antibacterial and antifungal activities (H. Von Wenckstern et al., 2009).

MATERIALS AND METHODS

Fresh Punica Granatum from domestic farmhouse, Zinc Nitrate Hexahydrate (SIGMA-ALDRICH Lot # BCBM7260V, Product# 96482) (Kane et al., 2007), Distilled water prepared by water distillation apparatus (Schwarzenbek Germany) is used in purified form.

Preparation of *Punica granatum* seed extract

60g Seeds from Punica Granatum are separated and added to 120mL Distilled water and place over stirring hot plate at 80℃ temperature and stirring rpm of 300 for an hour. Then filter the solution with the help of filter paper. Reddish-colored Punica granatum extract was obtained.

Green synthesis of ZnO nanoparticles

The ZnO NPs were synthesized by the green method.1 molar Zinc Nitrate salt solution was prepared in distilled water and stirred for 15 min for uniform mixing of salt in water. 50ml Punica granatum liquid extract was introduced in the above solution dropwise with continuous magnetic stirring at 80℃ temperature for an hour. The color of the solution becomes reddish. This resultant solution was placed in a heating furnace at 80℃ for 8 hours. Reddish color of solution changes to green color which indicates the preparation of ZnO NPs in liquid phase. Heat this solution at a high temperature i.e. 300℃ for evaporation of extra water. The evolution of gases also occurs in the furnace which leads to pale

white colored fine powdered ZnO NPs (Bhandary et al., 2012).

RESULTS AND DISCUSSION

X-rays Diffraction (XRD) Investigation

The indication during synthesis is the change in color of the solution and the formation of a yellowish-white precipitate confirms that zinc nitrate has been reduced (Naveed Ul Haq et al., 2017). As displayed in Figure. 1, the X-ray diffraction pattern of synthesized ZnO NPs was obtained. The crystalline peaks sited at (2θ) angles of 31.73°, 34.39°, 36.21°, 47.48°, 56.53°, 62.77° and 66.30°correspond to crystal planes (100), (002), (101), (102), (110), (103) to (200) reflection respectively. The most intense peak corresponding to (101) planes located at 36.21° was used to derive the average crystallite size of ZnO, by using FWHM estimation and Scherrer's formula. The estimated average crystallite size to be approximately 17.11nm.

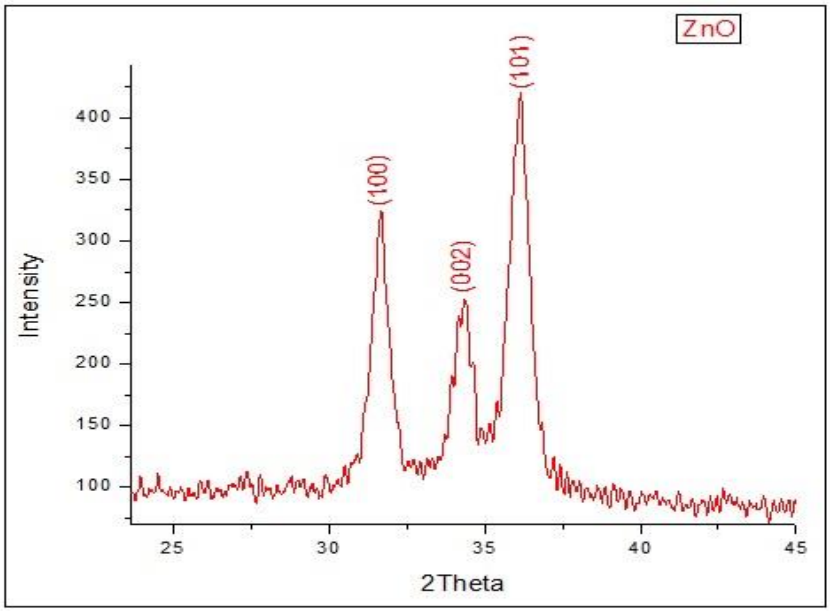


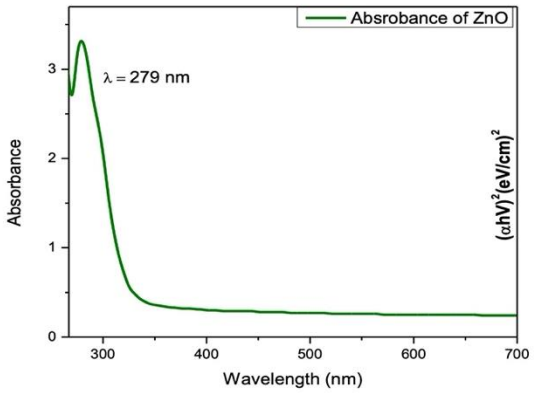
Figure 1: X-ray Diffraction Plot of ZnO NPs

U.V. Spectrophotometric Investigation

Within the range of 200–700 nm, the formation of ZnO NPs was initially confirmed by UV-visible spectroscopy. The absorption spectrum showed a characteristic peak at 279 nm of green synthesized ZnO NPs as shown in (Figure. 2). The graph of bandgap draws by the Tauc plot method. The calculated direct bandgap (Eg) was 4.0 eV and the graph is shown in (Figure 3a).

FTIR Spectroscopic Investigation

The most confirmatory technique used for nanoparticle formation is FTIR as it offers an impression of the vibrational and rotational modes of the prevailing molecules. Functional and possible phytochemical molecules involved in the reduction and stabilization of ZnO NPs are hence identified by FTIR. The peak at 442 cm^{-1} which is corresponding to the hexagonal ZnO symmetric bending vibration as shown in the Figure. 3(b) representing the FTIR spectra of ZnO NPs synthesized by the green approach. Due to weak vibration of ZnO peak located at 878



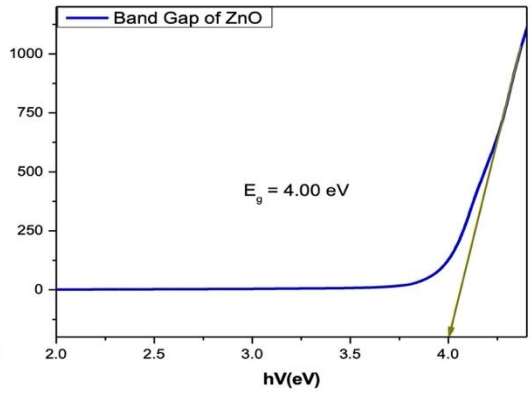
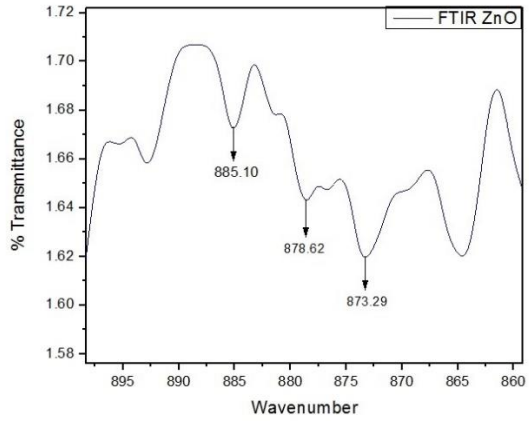


Figure 2(a): Absorption Spectrum of ZnO NPs **Figure 2(b): Band Gap E_g of ZnO NPs**

cm−1 in the Figure. 3(a). Other peaks of smaller bond vibration including 2925.48 cm^{-1} which denotes the C—H stretching vibration, 2352.73, 1630.52, and 1445.39 cm^{-1} are due to the existence of primary and secondary amines that have features of proteins/enzymes and stretching regions of C–O phenolic and polysaccharides groups.



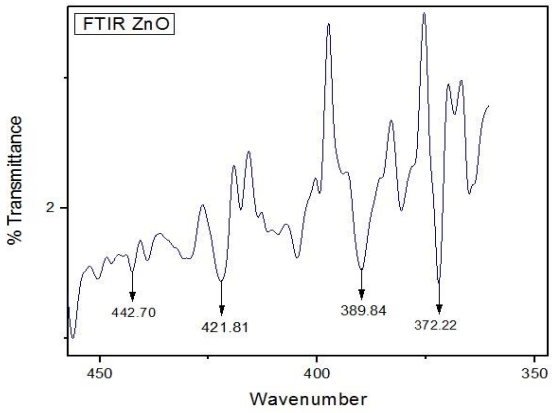


Figure 3(a): FTIR Spectra of ZnO NPs **Figure 3(b): FTIR Spectra of ZnO NPs**

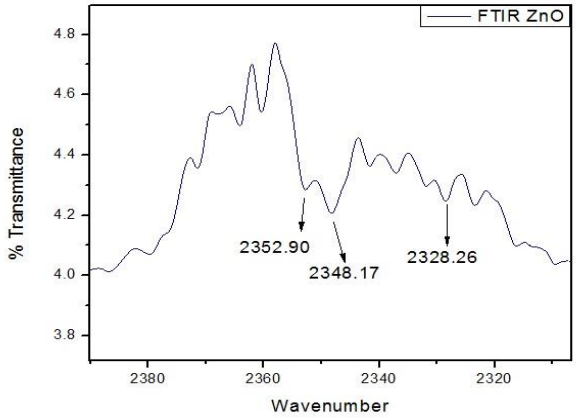


Figure 3(c): FTIR Spectra of ZnO NPs

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