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Green fabrication of zinc oxide nanoparticles by *Anagallis arvensis* ethanolic extract and their antibacterial properties

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ABSTRACT

Green approach of zinc oxide nanoparticle fabrication is a reliable reaction that has compatibility with many biological properties. In the present study the approach of zinc oxide nanoparticle has been synthesized by *A. arvensis* aerial part using ethanol extract. The morphological, compositional and structural properties have been investigated by SEM, XRD, and FTIR studies. XRD technique demonstrated the crystallite size of 17nm with the help of Debye-Scherrer's equation which was obtained in nanorange. SEM technique demonstrated their microscopic agglomerated crystal image of green synthesizes metal in zinc oxide nanoparticle. FTIR technique represents the different types of biomolecules i.e. phenol, alkynes etc. that are responsible for good nanoparticle fabrication. These biomolecules work as encapsulation and stabilization agents for nanoparticle fabrication. These all properties of nanoparticle fabrication have been responsible for the antimicrobial activity.

Introduction

Nanotechnology is an advanced field at the present period, works with chemistry, physics, biological science, molecular and different other fields interactually. In this technology, nanomaterials play a versatile role in cosmetic, electrical, pharmaceutical, power generation, environment and textile industries. Nanomaterials moved through nanotechnology, constitute 1-100nm scale range nanoparticles. Different types of metal oxide and metal nanoparticles are already exist eg- copper oxide, copper, zinc oxide, titanium oxide, iron oxide, iron etc (Marassi *et al*., 2018; Rastogi *et al*., 2017). This metal based nanoparticle is formed from different kinds of modes such as – chemical, physical and biological. In chemical and physical modes, more energy is required and causes various side effects (Awwad *et al*., 2020; Kharissova *et al*., 2019). To over come this situation, the biological and green approach of nanoparticle synthesis is the best method by using of plant extract. This is budget-friendly, safe, and less dangerous has been fabricated by new scientists. Among already exist nanoparticles; zinc oxide is the safest, multipurpose, more ecofriendly and USDA (US administration of drug and food) approved. It is applied in many applications. For instance-photodetectors, chemical sensors, antimicrobial, wound healing and gas sensors (Chang *et al.,* 2012; Dadi *et al.,* 2019; Li *et al*., 2018). Several types of plant part like fruit, stem, flower, leaf, peel, seed etc applied in zinc oxide nanoparticle synthesis. For instance, many scientists have demonstrated ZnO NPs from leaf extract of *Echinacea angustifolia* (Iqbal *et al.,* 2021), *Camellia sinensis* (Senthilkumar & Sivakumar,2014), *Eucalyptus globulus Labill* (Barzinjy *et al*., 2020); pod extract of *Papaver somniferum*; root extract of *Rubus fairholmianus* (Rajendran *et al.,* 2021). At a recent proposal, we fabricated a green approach of zincoxide nanoparticle by *A. arvensis* aerial parts and used it for antimicrobial effect. *A.arvensis* is used by tribals people for medicinal purposes

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contain therapeutic based phytochemical substances such as triterpenoids, glucosides, flavonoids and so on substances work as encapsulating and stabilizing mediator for the fabrication of zinc oxide nanoparticle (Kawashty *et al.,* 1998) but there is lack lot of work of *A.arvensis* plant based zinc oxide nanoparticle synthesis and their properties.

Material and Methods

Aerial extract preparation

A.arvensis aerial parts were washed with water many times to clean mud, soil particle and dirt content. After that aerial part was dried. The dried part was a grind with mortar and an electric grinder. Soxhlet apparatus is used for the extraction process. 80-100g sample used in soxhlet and ethanol solvent was run in soxhlet according to the polarity. Then, the extract was filtered with filter paper 1 and the solvent was saturated with the rota evaporator, preserved at 4^0C for ahead processing (Redfern *et al.* ,2014).

Fabrication process

The precursor zinc acetate was mixed with 400mg extract in distilled water. Then, ethanolamine was added as an encapsulation mediator. Ethanolamine and precursor compound was maintained at 1 molar concentration. After that solution was vibrated for half an hour. Now, NaOH solution was added drop by drop until the endpoint of the solution is not measured, centrifuged the solution and dried the sample (Li *et al.* 2004; Perveen *et al.*, 2020).

Identification

For the identification of metal oxide nanoparticle fabrication, many systematic instruments were used. For instance- XRD depicted the size of crystallite with the help of identified phases and dimensions. Debye-Scherrer's equation was applied in the estimation of D value (where, D = crystallite size) of zincoxide preparation. FTIR spectra were applied for the functional group identification which is responsible for encapsulation in metal oxide nanoparticle preparation. These functional groups are sometimes conjugated between bioadsorbant and nanomaterial. Different groups were found in the spectra of FTIR, ranged in between (4000-500cm^{-1}), and analyzed with KBr pellet (Torres-Rivero *et al.*, 2021). SEM microscopic instrument was used in the morphology of nanomaterial respectively.

Antimicrobial effect

The microbicidal effect was conducted by agar well diffusion, which evaluated the inhibitory action of pathogens. ZnO nanomaterial (50mg) was tested against *Streptococcus pyogenes* MTCC 442 and *Klebsiella pneumonia* MTCC 4030. Muller Hinton plates were applied for bacterial strains. Then 45µl sample was added toan appropriate well of plates. After all complete procedures, plates were incubated 310K for 24h (Archana & Abraham, 2011).

Results and Discussion

Determination of functional biomolecules

Various types of biomolecules illustrated peaks in FTIR spectrum of extract and biosynthesized ZnO NPs shown in figure 1. Figure 1 demonstrated a comparison spectrum of extract (a) and bio reduced ZnO NPs(b). Many peaks were identified as the spectrum of FTIR at 2335, 1560, 1424 and 640cm^{-1}. 640cm^{-1} peak represents ZnO NPs which is found inrange 800-400cm^{-1} (Degefa *et al.,* 2021). The peak at 1424 corresponds to C=C–C stretching. Different intensities at 1560 and 2335cm^{-1} originatedue to the polyphenol aromatic ring of C=C stretching and internal alkynes (Rahman *et al.*, 2022).

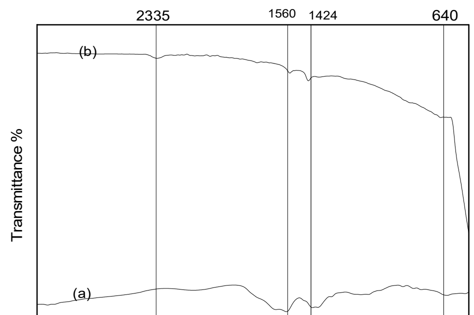

Figure 1: Functional group identification spectra of FTIR

Determination of crystallite size

Different intensity peaks of XRD spectra demonstrated the wide range of phases which indicates the fabricated nanomaterial was found in nano dimension range (figure 2). XRD value of plant mediated zincoxide nanoparticles demonstrated the different angle 31.87, 34.53, 36.36, 47.67, 56.73, 63.00, 68.09, 69.20 correspond to the reflection of 100, 002, 101, 102, 110, 103, 112 planes sequentially. The large identified peak 36.36 present on 101miller indices showed a crystallite size of about 19nm and the average crystallite size of all identified peaks was found to be 17nm. Previously studies have been found similar at these studies demonstrated by Degefa *et al.,* 2021; Senthilkumar & Sivakumar, 2014.

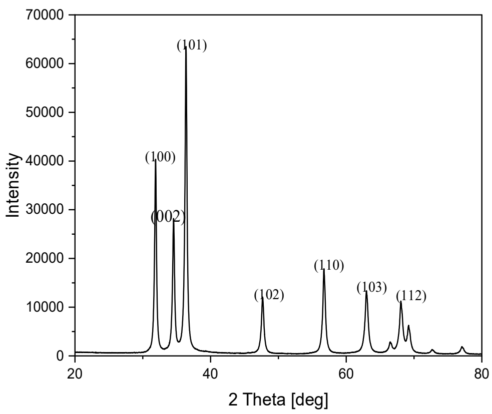

Figure 2: Identified phase and dimension of crystallite of zinc oxide nanoparticle *A. arvensis*aerial part ethanol extract

Determination of morphology

The morphology of nanomaterial was determined by FESEM microscopic instrument. Figure 3 demonstrated the agglomerated form of small nanomaterial which becomes aligned and forms spherical shape structure (RSC). These agglomerated shape of nanomaterial showed spherical structure of zincoxide nanoparticle which was similar from previous studies. These agglomerations indicate the presence of encapsulating agent (Muhammad *et al.,* 2019).

Antimicrobial property

This study was conducted against two pathogens *Streptococcus pyogenes* MTCC 442 and *Klebsiella pneumoniae* MTCC 4030 respectively. The outcomes of the study were found 14mm and 16mm towards ZnO NPs, 18mm zone of inhibition toward antibiotic clindamycin against these pathogens. Thus, ZnO NPs showed the satisfied results of the antimicrobial towards MTCC pathogens, enter in the cell wall generated the ROS, and causes the cell destroy (Jiag *et al.,* 2020).

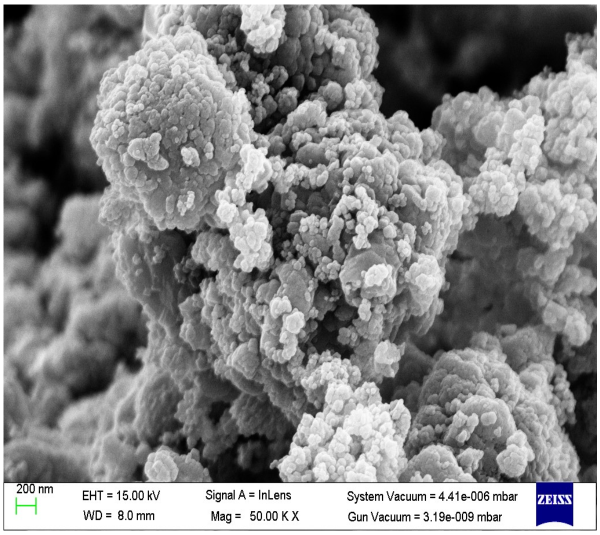

Figure 3: Microscopic photograph of SEM of zinc oxide nanoparticle *A. arvensis* aerial part ethanol extract

Conclusion

We have designed successfully appropriate ZnO NP fabrication from *Anagallis arvensis* aerial part by green synthesis. All characterizations have an important role in the designed study of the therapeutic field. FTIR studies showed organic functional group act as an encapsulation of ZnO NP fabrication. Morphological studies demonstrated by SEM showed nano particle fabrication. These all properties of prepared ZnO NPs impact on the antimicrobial study. The antimicrobial study indicates zinc oxide nanoparticle as a drug indicator. Thus it has been applied for pharmaceutical and medicinal applications.

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Conflict of interest

The authors declare that they have no conflict of interest.

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