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Research Article

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Green synthesis and characterization of zinc oxide nanoparticles

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ABSTRACT

ZnO nanoparticles have multiple properties that are useful for biomedical applications. Reduction of materials to nanoscale offers advantage of developing new anticancer drugs. Notable application among them is its inherent anticancer cytotoxicity actions. ZnO particles can be prepared easily by different chemical, physical, and biological approaches. But the biological approach is the most emerging approach of preparation, because, this method is easier than the other methods, ecofriendly and less time consuming. The Green synthesis was done by using the aqueous solution of Ocimum tenuiflorum(Tulsi), Phyllanthus emblica(Gooseberry), Azadirachta indica(Neem) extract and zinc nitrate. The nanoparticles were characterized by FTIR, XRD and SEM. The particles synthesized were of the size ranging from 10-30 nm.

Keywords: ZnO, Zinc oxide, FTIR-Fourier transform infrared spectroscopy, SEM- Scanning electron microscope, XRD- X-Ray diffraction.

INTRODUCTION

Nanoparticles are particles between 1 and 100 nanometers in size. In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties. Particles are further classified according to diameter. Nanoparticle research is currently an area of intense scientific interest due to a wide variety of potential applications in biomedical, optical and electronic fields.

Nanoparticles are of great scientific interest as they are, in effect, a bridge between bulk materials and atomic or molecular structures. The interesting and sometimes unexpected properties of nanoparticles are therefore largely due to the large surface area of the material, which dominates the contributions made by the small bulk of the material[1].

ZnO has been widely used in many applications such as transparent conductive films, varistors, solar cell windows, bulk acoustic wave devices, lasers and diodesabsorption spectra and electroluminescence decay parameter[2].ZnO has now become one of most studied material in the last few years as it presents very interesting properties for optoelectronics and sensing applications, in nano range synthesis. Different methods yield different particle sizes of ZnO, depending on the type of precursor, the solvent, the pH and the temperature of the reacting solution [3].

The “green” route for nanoparticle synthesis is of great interest due to eco-friendliness, economic prospects, feasibility and wide range of applications in nanomedicine, catalysis medicine, nanooptoelectronics, etc [4-6]. It is a new and emerging area of research in the scientific world, where dayby-day developments is noted in warranting a bright future for this field. The ZnO powder is widely used as an additive into numerous materials and products including plastics, ceramics, glass, cement, rubber (e.g. car tyres), lubricants, paints, ointments, adhesives, sealants, pigments, foods (source of Zn nutrient), batteries, ferrites, fire retardants, etc ZnO is present in the Earth crust as a mineral zincite; however, commercially used ZnO is produced synthetically [7]. The use of nanoparticles of silver and zinc oxide has been seen as a viable solution to stop infectious diseases due to the antimicrobial properties of these nanoparticles. The intrinsic properties of a metal nanoparticle are mainly determined by size, shape, composition, crystallinity and morphology [8].The solution phase synthesis of metal oxide nanoparticles typically involves the reaction of a metal salt with hydroxide ions [9]. The particle size is dependent on the kinetics of nucleation and growth from a supersaturated solution as well as processes such as coarsening,[10-11] oriented attachment, [12-16]and aggregation.

EXPERIMENTAL SECTION

2.1 Preparation of ZnO nanoparticles by biological method

2.1.1 Preparation of leaf extract [*Ocimum tenuiflorum*(Tulsi), *Phyllanthus emblica*(Gooseberry), *Azadirachta indica*(Neem)]

Fresh leaves were collected, washed and sun dried. 50g of the fine cut leaves were taken in a 250 mL glass beaker with 100mL of distilled water. These were boiled for60 mins, the colour of aqueous solution turned from watery to light yellow. The extract was cooled to room temperature and filtered using filter paper. The extract was stored in the refrigerator for further use.

2.1.2 Sample Preparation

For the synthesis of ZnO nanoparticles, 50mL of the leaf extract were taken and boiled at 60-80ºC using heater with magnetic stirrer. 5g of zinc nitrate were added to the solution (at 60ºC).This mixture was then boiled until it reduced to deep yellow color paste. This paste was then collected in a ceramic crucible and heated in the air heated furnace at 400ºC for 2hours. The product obtained was light yellow in color. The X-ray diffraction (XRD) pattern of the final ZnO nanoparticles was obtained with Cu Kα radiation (α = 1.5418 Å) on a Rigaku(Miniflex-II) X-ray Powder Diffractometer and the mean grain size (D) of the particles was determined from the XRD linebroadening measurement from the Scherrer equation. The size of the particles was calculated by using XRD measurements and the size was found to be in the nanoparticle range.

RESULTS AND DISCUSSION

3.1XRD Analysis

It shows a hexagonal wurtzite structure and the lattice constant values obtained from the XRD pattern of zinc oxide powders were in good agreement with the reported values [17].

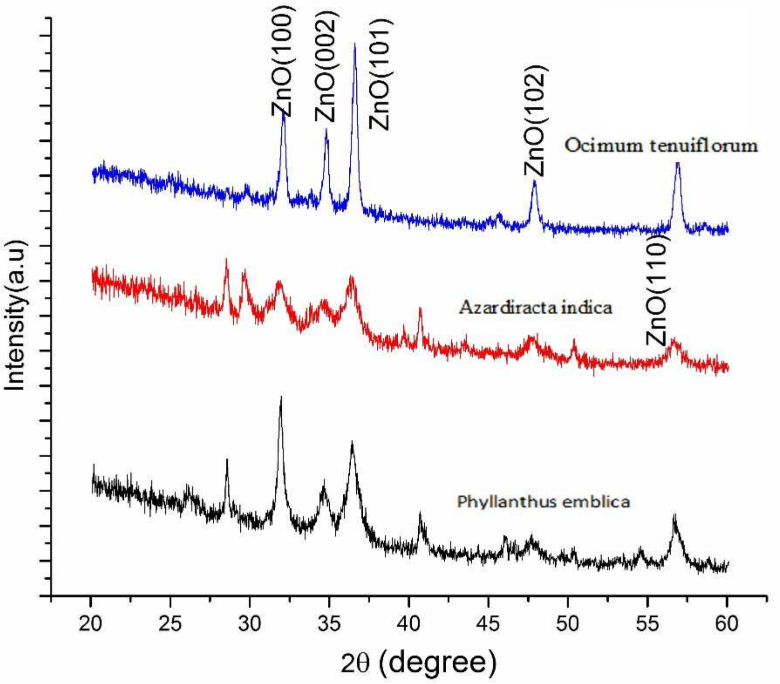

Figure 1. XRD pattern of ZnO nanoparticles synthesised from different plant extracts

The Scherrer's formula used to calculate the particle size through powder X-ray diffractometer is given as

$$P = 0.9\lambda/\beta\cos\theta \quad (1)$$

where
P is the particle size.
λ is the wavelength of source used (Cu, Kα)
β is the full width at half maximum of ZnO (101) line
θ is the diffracting angle.

The particle size of *Azadirachta Indica* Zinc oxide nanoparticles was found to be 24.7 nm
The particle size of *Ociumum Tenuiflorum* Zinc oxide nanoparticle was found to be 28.13nm
The size of *Phyllanthus Emblica* Zinc oxide nanoparticle was found to be 14.2 n

3.2 FTIR analysis
The Perkin Elmer RX1 series FTIR spectrometer was used for recording the IR spectra of the ZnO nanoparticles between 600-850cm^{-1}.

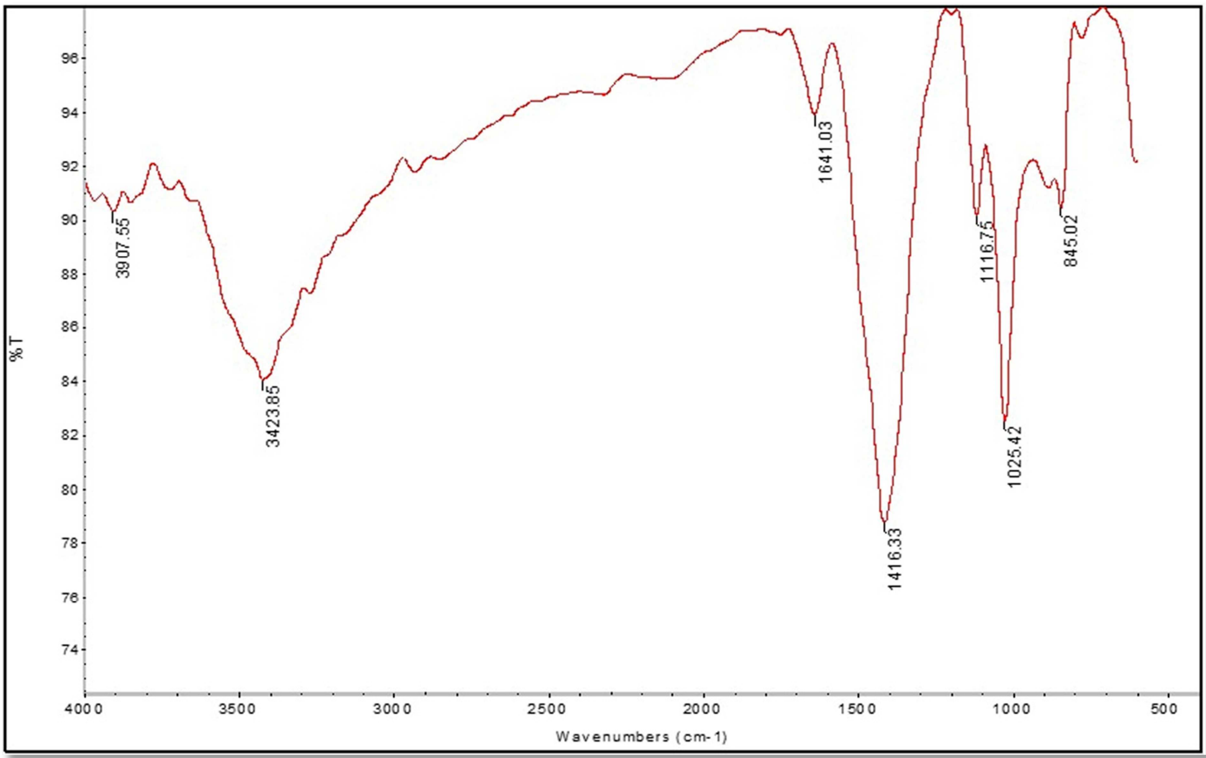

Figure 2. IR Spectra obtained for *Phyllanthus emblica*

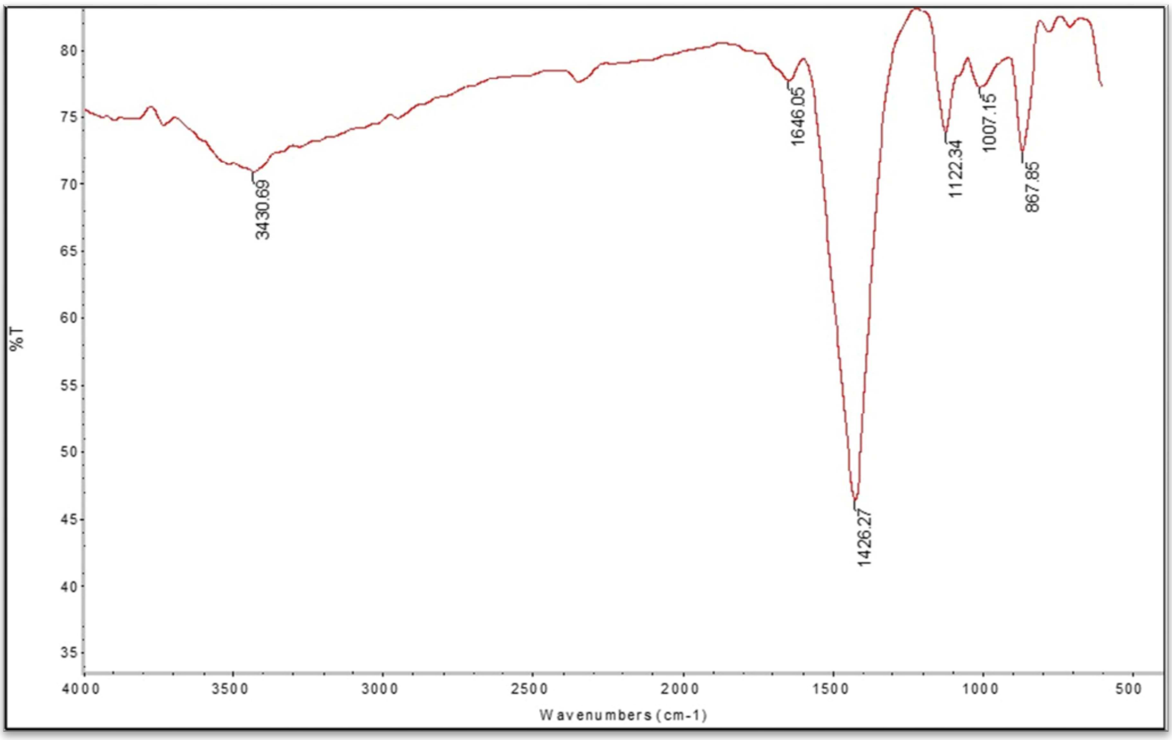

Figure 3.IR Spectra obtained for *Azardiracta indica*

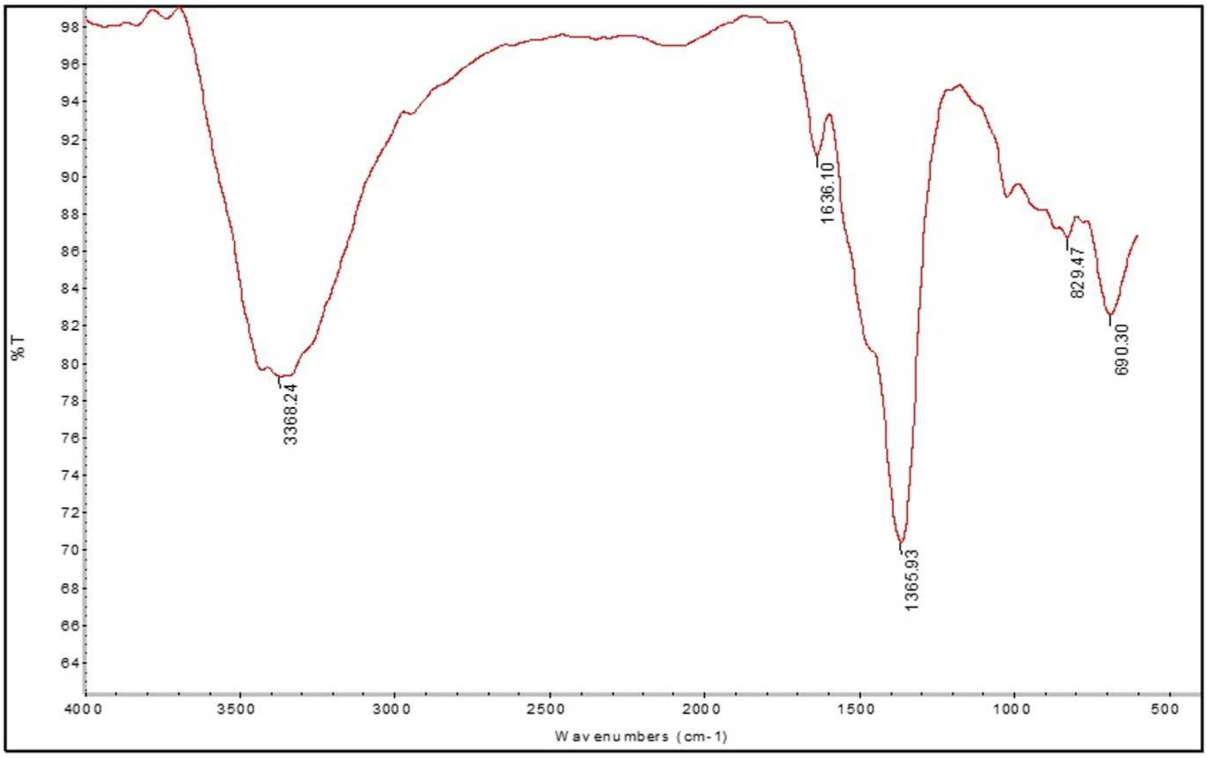

Figure 4.IR Spectra obtained for *Ocimum tenuiflorum*

3.3 Antimicrobial activity

Many microorganisms exist in the range of tens of micrometres & hundreds of nanometres to. ZnO-NPs of smaller sizes can easily penetrate into bacterial membranes due to their large interfacial area, thus enhancing their antibacterial efficiency. A large number of studies investigated on the considerable impact of particle size on the antibacterial activity, and the researchers found that controlling ZnO-NPs size was crucial to achieve best bactericidal response, and ZnO-NPs with smaller size (higher specific surface areas) showed highest antibacterial activity [18-20].Release of Zn^{2+} ions is responsible for the antimicrobial activity. It was found out that smaller sized, 14 nm showed best efficiency compared to 28 nm.

Figure 5.Antimicrobial activity of ZnO nanoparticles of size 14 nm

3.4 SEM analysis

The scanning electron microscope images of the Zinc oxide nanoparticles were recorded using JEOL JSM – 6380 LA analytical scanning electron microscope and FEI Quanta 400 environmental scanning electron microscope.

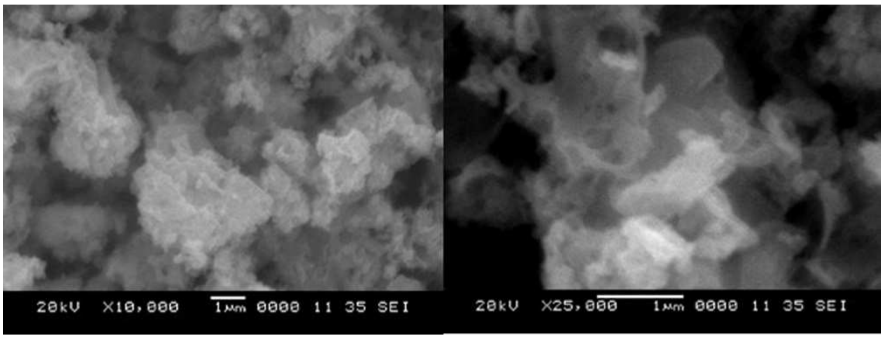

Figure 6. SEM images of ZnO nanoparticles

CONCLUSION

The XRD of all the prepared samples showed a characteristic peak indicating the presence of Zinc oxide in the nanosize. SEM image of Zinc oxide nanoparticles indicated that the structure is elongated giving a floral appearance. The IR spectra showed the presence of ZnO nanoparticle. The synthesized samples also showed antimicrobial activity.

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