GREEN SYNTHESIS OF ZINC OXIDE NANOPARTICLES AND THEIR BIOLOGICAL INVESTIGATIONS

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Abstract

Nanoparticles synthesis has its great impact in recent times due to their advantageous properties and varied applications. Green synthesis procedures have several merits such as, simple, inexpensive, suitable, less time consumption, non-toxic byproducts and large-scale synthesis. In this present work, green methods are adopted for the synthesis of ZnO nanoparticles. The synthesized ZnO nano particles are characterized by UV-Visible absorption spectroscopy, Fourier transform infrared spectroscopy (FT-IR), X-ray diffraction (XRD) and Scanning electron microscopy (SEM) techniques. The antimicrobial assays are demonstrated against some bacterial and fungal growth.

Keywords: *Green synthesis, zinc sulphate, ZnO nanoparticles, characterization and antimicrobial investigation*

1. Introduction

Nanotechnology refers to the branch of science dedicated to materials, having dimensions in the order of 100^{th} of nm or less [1, 2]. Nanoparticles possess the unique size dependent property depends on aspect ratio which is the ratio of the surface area to volume. Smaller the size of the particles greater will be the aspect ratio [2]. The size of nanoparticles is reasonable for tremendous applications in various fields such as medicine, electronics, diagnostics, therapeutics, bio-technology, optical devices, etc. [2, 3].

Nano sized particles may be synthesized by physical, chemical, irra and biological methods [4]. Green synthesis procedures have several meri as, simple, inexpensive, suitable, less time consumption, non-toxic byp and large-scale synthesis [3,4]. In recent times, researchers prefer an eco-f green synthetic approach for the nanoparticles synthesis [5,6, and 7 interesting aspect of green synthetic methods is the utilization of pollut chemicals and benign solvents [8].

Zinc oxide nanoparticles have several unique properties such a transparency, high electron mobility, wide band gap and strong room temp luminescence [9,10]. ZnO nanoparticles due to their nontoxic natu extensive application in diagnostics, microelectronics, water puri galvanization process, etc. It possesses considerable attention due t antimicrobial UV blocking, high catalytic and photochemical activities [11

Recently green synthesis of ZnO nanoparticles are reported by rese Gnana Sangeetha et al. reported the bio-synthesis of Zinc oxide nanop using *Corriandrum Sativum* as reducing medium [12]. ZnO nanopartic synthesized using *Hibiscus Rosa Sinensis* by Divya M.J. et al. [13]. *Aloe* used by Srinivasa et al. for the preparation of ZnO nanoparticles [14]. The physiochemical properties of the nanoparticles combined with the inhibitory capacity against microbes lead to their potential applica antimicrobials [15].

In this present investigation we demonstrate the use of the plant e as reducing agents for synthesizing zinc oxide nanoparticles. The techniq as UV-Visible, FT-IR, XRD and SEM are adopted for characterizati nanoparticles are screened against some bacteria and fungi.

2. Experimental

2.1. Materials

Tamarindus Indica (Tamarind) leaves, *Musa Acuminata* (Banan *Foeniculum Vulgare* (Sombu) *seeds* and *Piper Nigrum* (Pepper) *se* collected, purified and used for synthesis process. 1×10^{-3} M zinc sulphate s is prepared by weighing the required amount of $ZnSO_4$ accurately and di in double distilled water.

2.2. Methods

2.2.1. Preparation of plant extracts

First step involves the preparation of plant extracts. The fresh leaves / seeds / peel of the required plants are collected and washed with double distilled water. They are dried in the absence of sunlight and crushed to powder. 2g of the powdered sample is weighed accurately and mixed with 100 ml double distilled water. The contents are boiled for about 5-10 minutes. The extract is cooled and filtered using Whatman No.1 filter paper. The same method is followed for the preparation of extract from all the other chosen species.

2.2.2. Synthesis of zinc oxide nanoparticles

20 ml of the plant extract obtained from the first step is mixed with 40 ml of 1×10^{-3}M $ZnSO_4$ solution. There is notable colour changes observed immediately. This colour change indicates the formation of nanosized materials (**Figure 1**). The contents are kept aside for 24 hours. Zinc oxide nanoparticles are settled down. It is centrifuged and filtered using Whatman No.1 filter paper. The nanoparticles are dried and used for further studies.

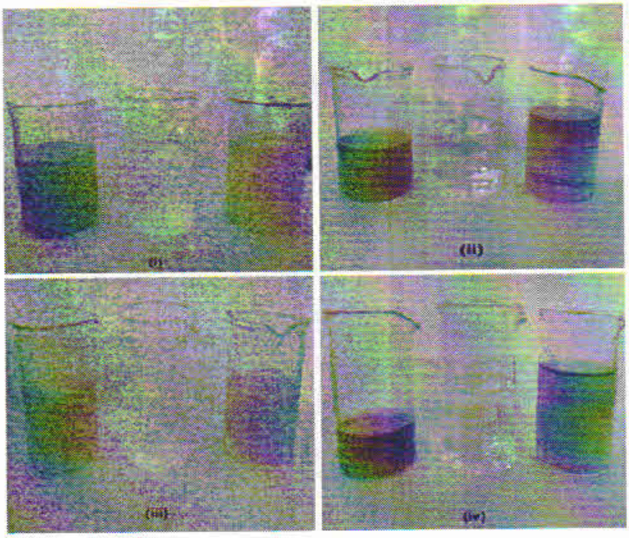


Figure 1. Color changes observed when 1×10^{-3} $ZnSO_4$ mixed with (i) *Tamarindus Indica* leaves extract (ii) *Musa Acuminata* peel extract (iii) *Foeniculum Vulgare* seeds extract (iv) *Piper Nigrum* seeds extract

2.3. Instrumental analysis

UV-Visible Spectrophotometric techniques are adopted for struc characterization of zinc oxide nanoparticles. A small aliquot is drawn from reaction mixture and a spectrum is recorded between wavelengths from 20 to 900 nm using Shimadzu 1800 Double beam spectrophotometer. The synthe ZnO nanoparticles are characterized by FT-IR spectrophotometer.

XRD measurements are performed by X-Ray diffractometer with C (λ=1.54060 Å) radiation. Particle size is determined from the width of XRD p using Scherrer's formula, **D (nm) = 0.9λ / $\beta_{1/2}$Cos** θ. SEM is recorded by J Model 6390 computer-controlled microscope.

The disc diffusion method was followed for antibacterial and antifung susceptibility tests.

3. Results and Discussion

3.1. UV-Visible Spectral analysis

Confirmation of the synthesized ZnO nanoparticles in nano-sc revealed by the highly blue shifted absorption maximum occurring a 268 nm, 215 nm, 264 nm and 327 nm respectively. Sample pictures are sh **Figures 2 and 3**

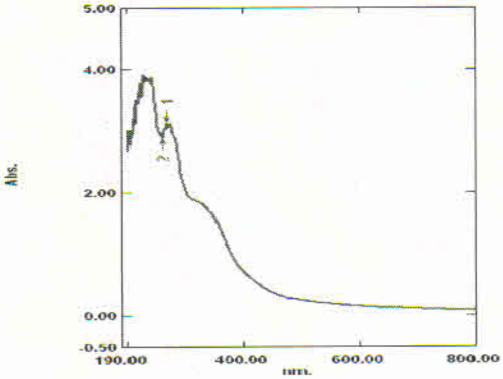


Figure 2. Absorption Spectrum of ZnO nanoparticles formed usi ***Tamarindus Indica***

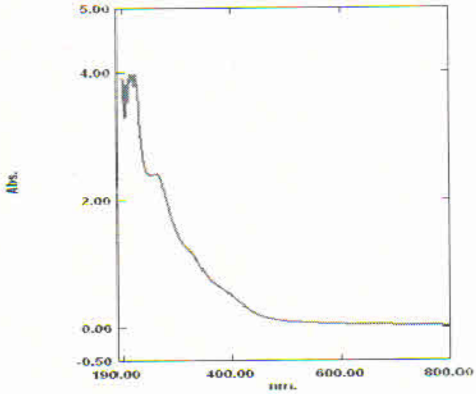


Figure 3. Absorption Spectrum of ZnO nanoparticles formed using *Foeniculam vulgare*

3.2. FT-IR Analysis

FT-IR measurements are carried out to identify the possible biomolecules responsible for capping and efficient stabilization of the metal nanoparticles synthesized by the plant extracts. The peaks obtained confirm the reduction of metal oxide nanoparticles. The data for the FT-IR analysis is given in **Table 1.**

Table 1. FT-IR Analysis

S.No.	Plant extract	ZnO peak cm^{-1}	>C-O stretching cm^{-1}
1.	*Tamarindus Indica*	629 and 449	1099
2.	*Musa Acuminata*	397	1105
3.	*Foeniculum Vulgare*	610 and 484	1107
4.	*Piper Nigrum*	625 and 447	1101

The observed peak around 1320 - 1000 cm^{-1} corresponds to >C–O stretching of alcohols, carboxylic acids, esters and ethers. The stretching frequency around 1500 - 1400 cm^{-1} infers >C–C stretch (in-ring) aromatics. Thus, the synthesized ZnO nanoparticles are surrounded by metabolites like proteins and terpenoids with the attachment of the various functional groups. The biomolecules have the capability to perform dual functions of formation and stabilization of ZnO

nanoparticles. The values obtained are comparable with the literature availabl
Figures 4 and 5 show FT-IR peaks of the sample.

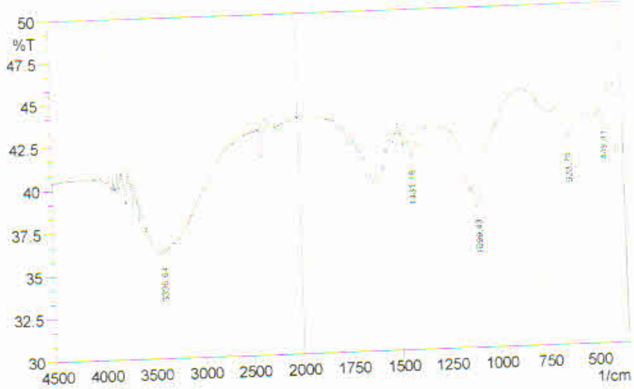


Figure 4. FT - IR Spectrum of ZnO nanoparticles formed usin
Tamarindus Indica

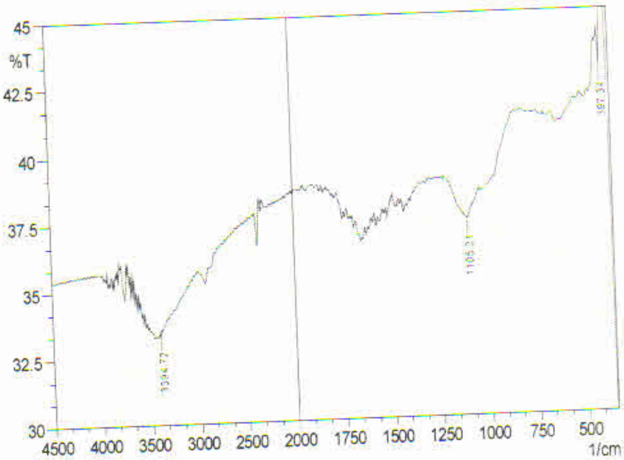


Figure 5. FT- IR Spectrum of ZnO nanoparticles formed using of
Acuminata

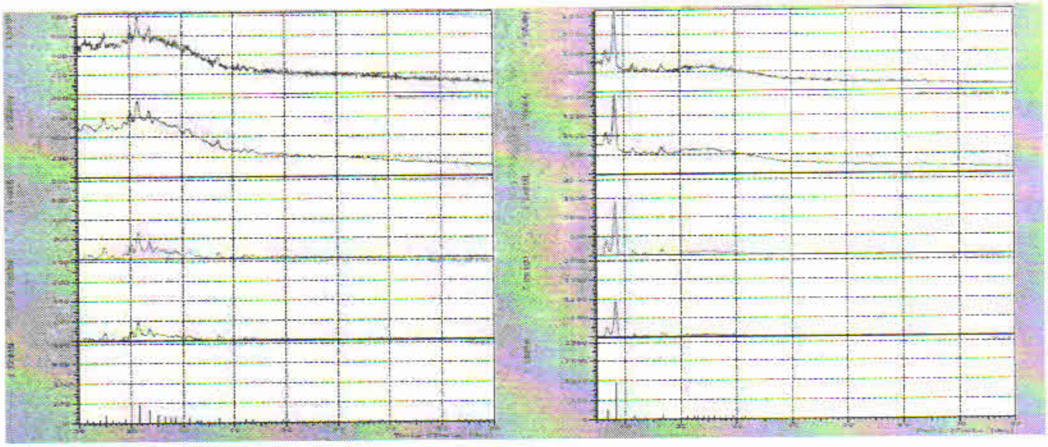
3.3. X-Ray Diffraction studies

XRD studies for the synthesized zinc oxide nanoparticles are carr
The XRD pattern showed three intense peaks in the whole spectrum of
diffraction peaks indicate that the dimensions of the resultant nanopart
appreciable. ZnO nanoparticles size is determined from the width of XR

using Scherrer's formula and the values in nm are tabulated in **Table 2.** XRD pattern for samples are shown in **Figures 7 (a) and (b).**

Table 2. Size determination from XRD calculations

S.No.	Plant extracts used	Size of ZnO nanoparticles in nm
1	Tamarindus Indica	1.4
2	Musa Acuminata	4.0
3	Foeniculum Vulgare	2.0
4	Piper Nigrum	4.0

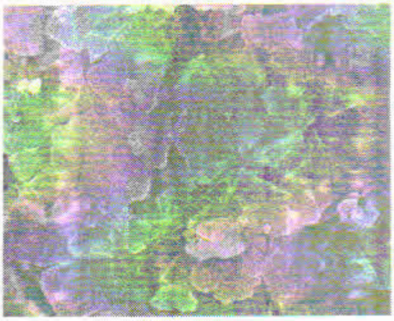


(a) (b)

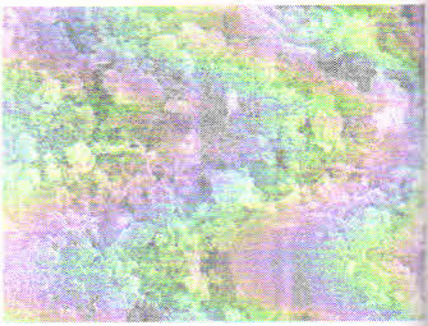
Figure 7. XRD pattern of ZnO nanoparticles formed using (a)*Tamarindus Indica* (b)*Foeniculum Vulgare*

3.4. SEM Analysis

Figures 8 (c) and (d) show sheet like and sphere like shapes of zinc oxide nanoparticles synthesized using *Musa Acuminata* and *Foeniculum Vulgare* plant extracts. The ZnO nanoparticles are distributed within the range of 1 - 100 nm.



(c) Using *MusaAcuminata*

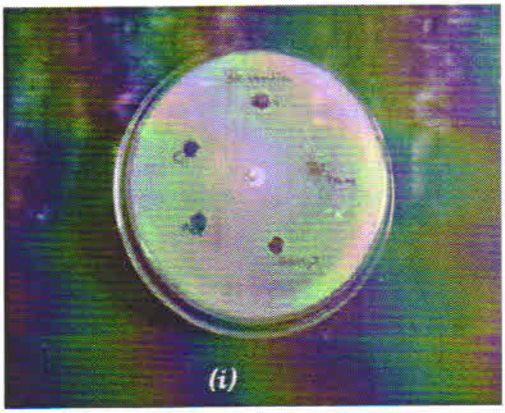


(d) Using *Foeniculum Vulgare*

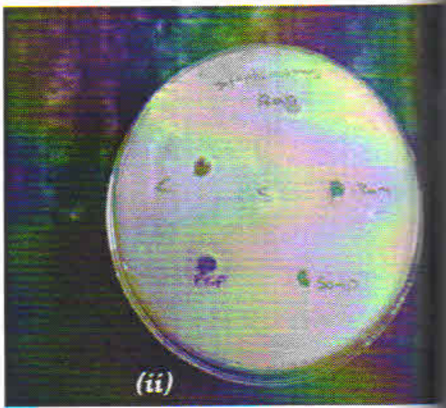
Figure 8. SEM images of ZnO NPs

3.5. Antimicrobial Activity:

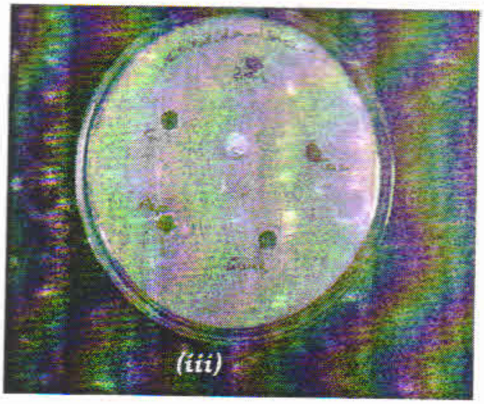
The antimicrobial activity of synthesized zinc oxide nanoparticl investigated against Serratia, Staph aureus, Candida albicans and Asper niger. The antimicrobial activity is estimated by the zone of inhibitio sample pictures are shown in **Figure 9**.



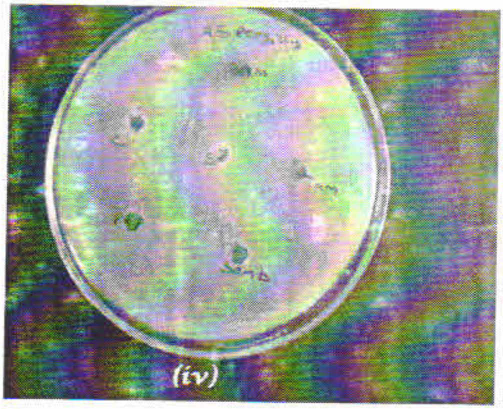
(i)Serratia strain with ZnO NPs



(ii)Staph. Aureus strain with Zn



(iii) Candida albicans strain with ZnO NPs



(iv) Aspergillus niger Strain with ZnO NPs

Figure 9. Antibacterial and antifungal activity

The synthesized ZnO nanoparticles using *Piper Nigrum* exhibit good antibacterial and antifungal sensitivity against serratia, staphylococcus aureus, candida albicians and aspergilus niger. ZnO nanoparticles formed using *Foeniculum Vulgare* are sensitive towards the bacteria, serratia and the fungus, candida albicians.

4. Conclusion

The greener route using plants extract is followed for the synthesis of zinc oxide nanoparticles. The chosen plant species are *Tamarindus Indica, Musa Acuminata, Foeniculum Vulgare* and *Piper Nigrum*. The synthesized ZnO nanoparticles are characterized by UV-Visible, FT-IR, XRD and SEM instrumental techniques. The activity against bacteria and fungi are scrutinized. The synthesized ZnO nanoprticles are sensitive towards the micro organisms. This green method of synthesis of ZnO nanoparticles are environmentally benign, cost effective, simple and safe to handle. The study reveals that the chosen plant species are good source for synthesis of ZnO nanoparticles.

5. Acknowledgements

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