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Environmentally Friendly Synthesis and Antimicrobial Activity of ZnONPs

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ABSTRACT

The use of nanotechnology in the textile industry has increased rapidly. This is mainly due to the conventional methods used to impart different properties to fabrics often do not lead to permanent effects, and will lose their functions after laundering or wearing. Nanoparticles can provide high durability for treated fabrics, with respect to conventional materials, because they possess large surface area and high surface energy that ensure better affinity for fabrics and lead to an increase in durability of the textile function. Various methods have been employed to improve the size and property of the Zinc Oxide Nano Particles (ZnONPs) so as to enhance the performance of ZnONPs based material. Biological methods for nanoparticle synthesis using microorganisms, enzymes, and plants or plant extracts have been suggested as possible eco-friendly alternatives to chemical and physical methods. In this work, ZnONPs have been synthesized by reduction of Zinc Nitrate in plant extract and study the antimicrobial activity of synthesized ZnONPs. FT-IR spectra peak at 483 cm^{-1} indicated characteristic absorption bands OF ZnO nanoparticles. UV-Vis absorption spectrum showed a typical spectrum for ZnO nanoparticles. The SEM and AFM image shows that ZnONPs prepared in this study are spherical in shape with smooth surface have size of minimum 16nm to maximum 36 nm and it also shows excellent inhibition to gram positive and gram negative bacteria.

Keywords: ZnONPs, FT-IR Spectroscopy, Environmental friendly method, Zinc Nitrate, Gram positive and Gram negative

I. INTRODUCTION

Nanotechnology is the study of nanoparticles, and by definition, a nanoparticle is any material measuring lessthan 100 nanometers in at least one dimension. Nano sized materials have unique optical, thermal, electrical and/or magnetic properties and have been used in cosmetics and paints.

Nanotechnology concerns with the development of experimental processes for the synthesis of nanoparticles of different sizes, shapes and controlled disparity. This provides an efficient control over many of the physical and chemical properties with various potential applications including pharmaceuticals and medicine. Most of the chemical methods used for the synthesis of nanoparticles are too expensive and are found to be responsible for various biological risks. But, synthesis of nanoparticles using plant extracts is the most adopted method as green, eco-friendly production of nanoparticles and also has a special advantage in such a way, that the plants are widely distributed, easily available, much safer to handle and act as a source of several metabolites rich in pharmacological constituents. Hence a novel approach for synthesizing ZnONPs using plants extracts. With the advent of nanoscience and technology, a new area has developed in the area of

textile finishing called Nano finishing. Growing awareness of health and hygiene has increased the demand for bioactive or antimicrobial. Nanoparticles have selective toxicity to bacteria but exhibit minimal effects on human cells. Several studies have reported the broad-spectrum antimicrobial activity for including antibacterial, antiviral, antifungal, and antimalarial activities.

In this work, ZnONPs have been synthesized by reduction of Zinc Nitrate in plant extract and study the antimicrobial activity of synthesized ZnONPs. FT-IR spectra peak at 483 cm^{-1} indicated characteristic absorption bands of ZnO nanoparticles. UV-Vis absorption spectrum showed a typical spectrum for ZnO nanoparticles. The SEM image and AFM shows that ZnONPs prepared in this study are spherical in shape with smooth surface.

II. METHODS AND MATERIAL

The Hibiscus rosa-sinensis (HRS) Leaves were washed with sterile double distilled water to remove the surface contamination and dried in oven to remove water for 60 Minutes. The dried plant material was cut into in small pieces. 10 g of plant material was taken and mixed with 100 ml of sterile double distilled water and kept in water bath for reflux at 100^0C for 1 hours. The obtained reflux solution is then filtered by Whatman No. 1 filter paper. The filtered extract was stored in refrigerator at 20^0 C for further studies.

The solution of plant extract having pH 5 was mixed with 10mm concentration of Zinc Nitrate, time for sonication and temperature maintained 30 minutes and 80^0C respectively.

The bio-reduction of the Zinc ions in the solution was monitored periodically by measuring the UV–Vis spectroscopy (200–800 nm) of the solutions. The formation of a yellowish brown-colored solution indicated the formation of the ZnONPs. The ZnONPs obtained was centrifuge and then obtain ZnONPs were purified by sterile deionized water three times to remove the water-soluble biomolecules such as proteins and secondary metabolites. After that dried ZnONPs were used to characterize the structure and composition.

III. CHARACTERIZATIONS

1. FT-IR Analysis:

Two milligram of ZnO NPs was mixed with 200 mg of potassium bromide (FTIR grade) and pressed into a pellet. The sample pellet was placed into the sample holder and FTIR spectra were recorded in FTIR spectroscopy. To validate again the nature of the synthesized nanoparticles and their purity Fourier Transform Infrared spectroscopy (FTIR) (Jasco) studies were performed. A reports the typical FTIR spectrum of the pressed powder in the spectral range of 200-4000 cm^{-1}. The IR transmission is plotted so to single out the major absorptions observed at lower wave numbers.

An IR spectrum of synthesized zinc oxide shows the characteristic bands corresponding to M-O (Zn-O) stretching at 483 cm^{-1}. Peaks at 3404cm^{-1} and 1651cm^{-1} may be due to presence of moisture and carbon dioxide present in atmosphere. The presents of diagnostic bands at 1384 and 1107 cm^{-1}, related to the symmetrical and asymmetrical stretching modes of the carboxylate groups of plant extract. The IR spectrum of the ZnONPs powder collected after washing with water treatment of the original ZnONPs shows a slight shift and a decrease in the intensity of the characteristic bands shows in figure 1.

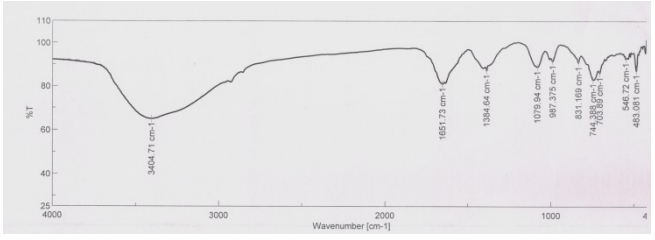

Figure 1. FT-IR spectra of ZnONPs

2. XRD Analysis:

X-ray diffraction (XRD) analysis (MiniFlex) with Cu-Ka radiation (k = 1.54178 Å) with 40 kV, 15 mA was used to examine the crystalline structure of the products. Fig. 2 XRD patterns of all prepared powders. All of the diffraction peaks are well matched with the standard hexagonal structure of ZnO (JCPDS card No. 00-079-0207). Both samples show wurtzite crystal structure of ZnO, For three curves, the average crystalline sizes were calculated using the Debby–Scherer equation (d= kλ / βCosθ), where d is the mean crystalline size of the powder, k is the wavelength of Cu-Ka (k = 1.54178 Å), B is the full width at half maximum (FWHM) intensity of the peak in radian, the Bragg's diffraction angle and k is a constant usually equal to ~ 0.9). The average crystallite size of samples I and II were determined to be about 16, 18 and 36 nm, respectively. Diffraction peaks corresponding to the impurity were not found in the XRD patterns, confirming the high purity of the synthesized products.

The X-Ray diffraction (XRD) pattern reveals the formation of ZnO NPs, which attributes to the crystalline nature of nanoparticle (Fig 2). XRD spectra showed strong diffraction peaks at 31, 34, 36, 47, 56, 62, 66, 67 and 68 degrees of 2θ which corresponds to (100), (002), (101), (102), (110), (103), (200), (112) and (201) crystal planes, which were in significant agreement with the JCPDS file 361451 (a = b = 3.249 Å, c = 5.206 Å) and indexed as the hexagonal wurtzite structure of ZnO NPs. This indicates the crystalline nature of synthesized nanoparticle.

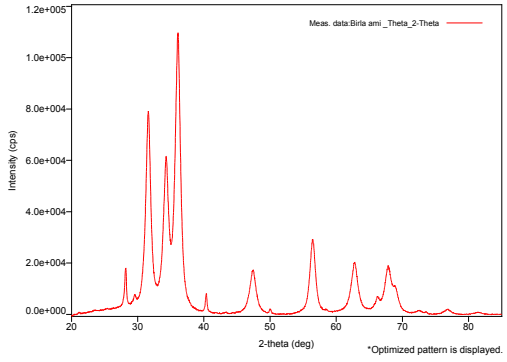

Figure 2. XRDspectra of ZnONPs

3. UV-Vis Spectroscopy analysis:

Initially, the solution turned yellow, characteristic of the spherical particles, but over 30 hours the solution turned Yellowish brown.We observed a decrease in intensity of the characteristic surface plasmon band in the ultraviolet-visible (UV-Vis) spectroscopy for the spherical particles at λ max 358-372 nm appeared. The absorption band is observed at 280 nm and a small but sharp peak at 380 nm for spherical ZnO nanostructure. In this case, the first and second band gaps were calculated 4.43 and 3.27 eV, respectively. It has been concluded that both morphologies have nearly similar band gaps, which may be due to having similar particle sizes.

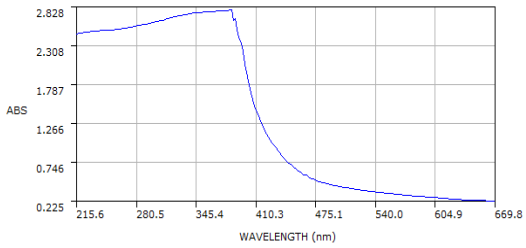

Figure 3. UV-visible spectra of ZnONPs

4. SEM Analysis :

The SEM image was taken at X 25,000 magnification. The image shows ZnO particles are spherical in shape with smooth surface and the size of the particles around 16-36 nm.

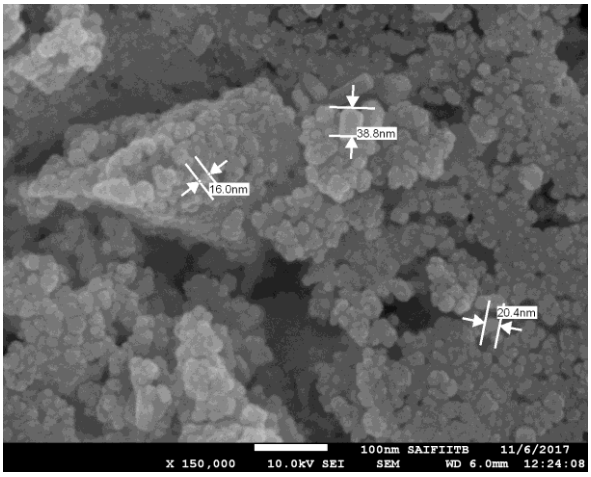

Figure 4. SEM Image of ZnONPs

5. AFM Analysis:

Size and shape of the nanoparticles which obtained directly from tip-corrected AFM measurements, and the shape of the nanoparticles is estimated on the

basis of AFM images and line scans. The ZnOPs obtained using green method gave size in the range of 20–36 nm and elongated in shape.

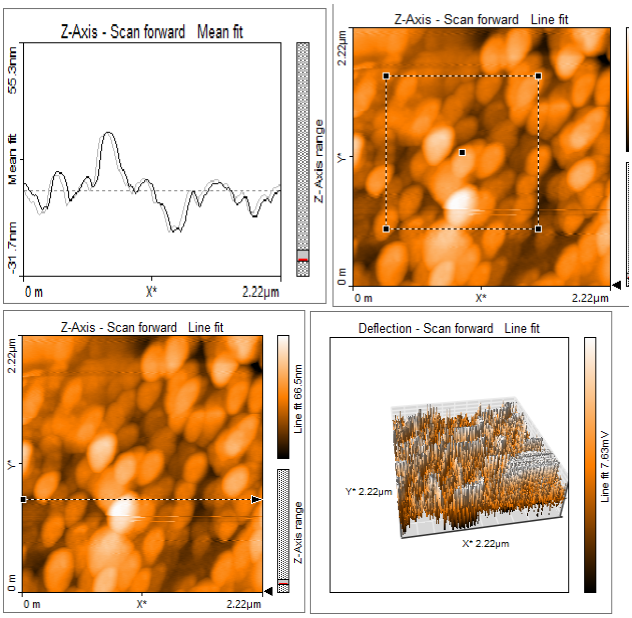

Figure 5. AFM Image of ZnONPs

6. Antimicrobial properties:

The antibacterial activities of ZnONPs were measured by Agar well diffusion method. The test was done against Gram positive and negative bacteria. It was proved that this ZnONPs has excellent antibacterial activity and could be used as anti-microbial agents.

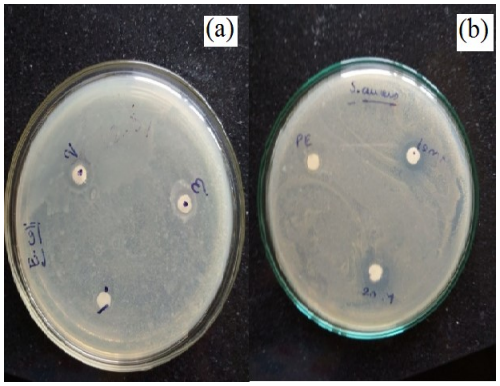

Figure 6. (a) Antibacterial activity against *E.Coli* (b) Antibacterial activity against *s.aureus*

IV.RESULTS AND DISCUSSION

Several approaches have been employed to obtain a better synthesis of ZnONPs such as chemical and biological methods. Recently, synthesis of ZnONPs using plant extracts getting more popular. The development of easy, reliable and eco-friendly methods helps to increase interest in the synthesis.

The present work addresses the synthesis and characterization of ZnO nanoparticles obtained through a homogeneous phase reaction between zinc nitrate and plant extract Solution having pH = 5 at 10mm in concentration with constant sonication time and temperature. The particles were then characterized, by evaluating their chemical composition through FTIR spectroscopy; their crystallinity through X-ray diffractometryand partical size by AFM and SEM Analysis.

V. CONCLUSION

The present work shows rapid biological synthesis of ZnONPs using Plant extract which provides an environmental friendly, simple and efficient route for synthesis of nanoparticles and characterization of ZnONPs obtained through a homogeneous phase reaction between zinc nitrate and plant extract Solution having pH 5 at change in concentration with constant sonication time and temperature.

FTIR shows that peak at 533 cm^{-1} is the characteristic absorption of zinc oxide bond which confirms formation of zinc oxide nanoparticles.

X-ray diffraction confirms the formation of a hexagonal wurtzite phase which is the most stable form of zinc oxide at ambient conditions. . The average crystalline sizes were calculated using the Debby–Scherer equation to be about 16 nm.

AFM measured nanoparticles 20–36 nm and spherical in shape.
SEM image showed that most of the nanoparticles are spherical in shape formed within diameter range of 10-40 nmZnO NPs have been economically synthesized by Bio-Reduction of Zinc nitrate using plant extract.

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