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Efficacy of synthesized ZnO nanoparticles and their application in antibacterial activity against pathogenic bacteria

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Abstract

The increasing number of MultiDrug-Resistant (MDR) bacteria and the need to synthesize new antimicrobials, nanoparticles have attracted interest in the scientific community. This study aimed to evaluate the synergistic effect of nanoparticles with some antibiotics against MDR pathogenic bacteria. An interesting biological method for synthesis of Zinc Oxide NPs involves the use of enzymes, micro-organisms (bacteria and yeasts), and plant extracts. Antibacterial effects observed against bacterial strains which includes Staphylococcus Aureus, Streptococcus Mutans, Escherichia Coli, and Pseudomonas Aeruginosa. Based on the outcomes, the nanoparticles displayed stronger antibacterial activities towards the gram-positive bacteria while compared with gram negative bacteria.

Keywords:- Antimicrobial, pathogenic, micro-organisms, Escherichia coli , Anti-bacterial ,Gram-negative bacteria.

1.1. Introduction

Nanotechnology is a research trend in modern materials science. Nano technology is capable of providing miscellaneous novel applications which include sophisticated medicinal techniques. It is synthesis, characterization, and exploration of materials in the nanometre region (1-100nm). At this region, the properties and functions of living and anthropogenic systems are determined. In this technology, the pertinent materials are those whose structures exhibit new and considerably enhanced physical, chemical and biological properties as well as distinct phenomena as an outcome of the nano-scale size . This nano-scale size generally confers larger surface areas to nano particles (NPs) compared with macro-sized particles . This particular property allows it possible for applications in many fields such as nanomedicine, bio-sensors, and bio-nanotechnology . The Intrinsic properties of metal NPs such as Zinc Oxide (ZnO) is mostly characterized by their Size, Composition, Morphology and Crystalline structure. Reduced size can change their chemical, mechanical, electrical, structural, morphological, and optical properties. These modified characteristics make the NPs to interact in a particular manner with biomolecules cell and thus facilitates the physical transfer of nanoparticles into the inner cellular structure. Nanostructured materials have a larger percentage of surface atoms and hence surface reactivity is high. Thus, nanomaterials have recently witnessed significant importance in applied sciences as well as in bionanotechnology.The Intrinsic properties of metal NPs such as Zinc Oxide (ZnO) is mostly characterized by their Size Composition,Morphology and Crystalline structure. Reduced size can change their chemical, mechanical, electrical, structural,morphological, and optical properties .These modified features allows the NPs to interact in a particular mannerwith cell bio-molecules and easy physical transfer of nanoparticle into the internal cellular structures

.Nanostructured materials have a larger percentage of surface atoms and hence surface reactivity is high. Thus, nanomaterials have recently witnessed significant importance in applied sciences as well as in bionanotechnology. Nanosized ZnO exhibits variations in morphologies and exhibit significant antibacterial activity over wide spectrum of bacterial species.Bacterial contagious conditions are dangerous health problem that has drawn the public attention in worldwide as a mortal health trouble, which extends to profitable and social complications. Growing outbreaks and infections due to pathogenic strains.In this studies, an extense reviewed idea is given about the antibacterial activity of ZnO-NPs covering techniques of evaluating bacteria viability and the factors that affect the antibacterial activity.

1.2. ZincOxide Nanoparticles

Zinc Oxide is a functional, strategic and versatile inorganic material with a wide range of applications. ZnO holds a unique optical, chemical sensing, semiconducting, electric conductivity, and piezoelectric properties .These characteristics enable ZnO to have efficient applications in diverse fields . High temperature excitonic stimulated emission at room temperature and increased conductivity results when ZnO doped with other metals . Zn-O shows strong ionic bonding due to optical covalent characteristics. Its parameters like durability, selectivity, and heat resistance are preceded over other organic and inorganic materials . The synthesis of nano-sized ZnO has led to the research of its use as fruitful antibacterial agent. Along with its unique antibacterial and antifungal activities, ZnO-NPs possess high catalytic and high photochemical properties. ZnO shows high light absorption in the Ultraviolet A ,UVA (315–400 nm) and Ultraviolet B,UVB (280–315 nm) regions which are beneficial in antibacterial response and used as a UV protector in cosmetics

1.3. Antibacterial Activity of ZincOxide Nanoparticles

In a study, Azam et al. it was reported that the anti-microbial properties against both gram-negative (E.coli and P.aeruginosa) and gram-positive (S. aureus and Bacillus subtilis) bacteria will increase with increase in Surface- to-Volume Ratio as there is decrease in particle size of ZnO nanoparticles. And also, in this reports, Zinc oxide nanoparticles have shown maximum (25 mm) bacterial growth inhibition against B. subtilis (Fig.1).

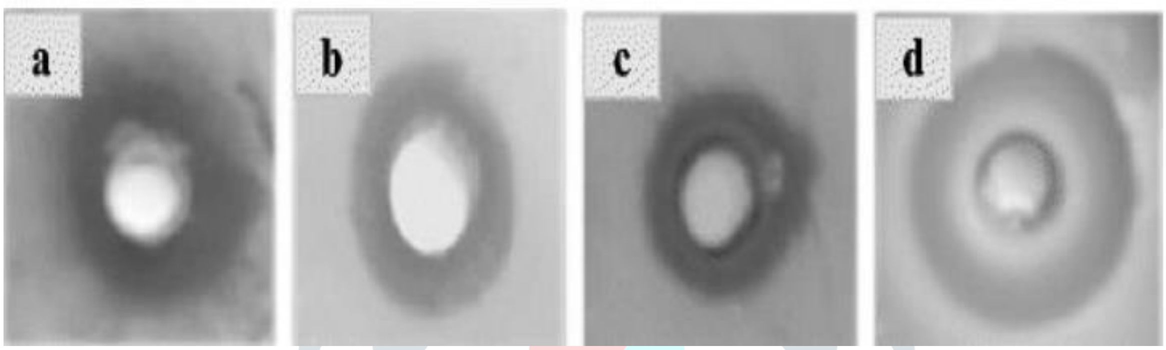

Figure 1. Antibacterial activity and/or Zone of Inhibition produced by ZnO nanoparticles against G-positive and G- negativebacterial strains namely a) Escherichia coli, b) Staphylococcus aureus, c) Pseudomonas aeruginosa, and d)Bacillus subtilis .It has been reported that as the size of zinc oxide nanoparticles decreases it exhibits more antibacterial activity than microscale particle.

2. Chemical synthesis of metal nanoparticles 2.1.Synthesis of ZnO-

NPs by precipitation method:

ZnO NPs is synthesized using precipitation method . Zinc Nitrate Hexahydrate (Zn (NO3)2.6H2O) [0.1 M, solution A]and Sodium Carbonate (Na2CO3) [0.12 M, solution B] were prepared and then solution A was added to solution B drop by drop under continuous stirring. The white precipitate formed which was collected by filtration method and then rinsed with distilled water atleast three times. The resultant solid was then washed with ethanol and dried at 100°C for 6hours.

2.2. Characterization of the chemically synthesized nanoparticles

Visual review : The formation of white precipitate from the precipitation of Zinc Nitrate indicates the formationof ZnO nanoparticles**.**

Figure 2. ZnO-NPs synthesized by the precipitation method as solid dry precipitate .

2.3. UV-Vis Spectroscopy:

The UV-Vis absorption spectrum of the synthesized ZnO-NPs is shown in Fig 3. The broad absorption peak for ZnO-NPs is noticed in spectrum at 360-380 nm which is a characteristic band for the pure ZnO nanoparticles.

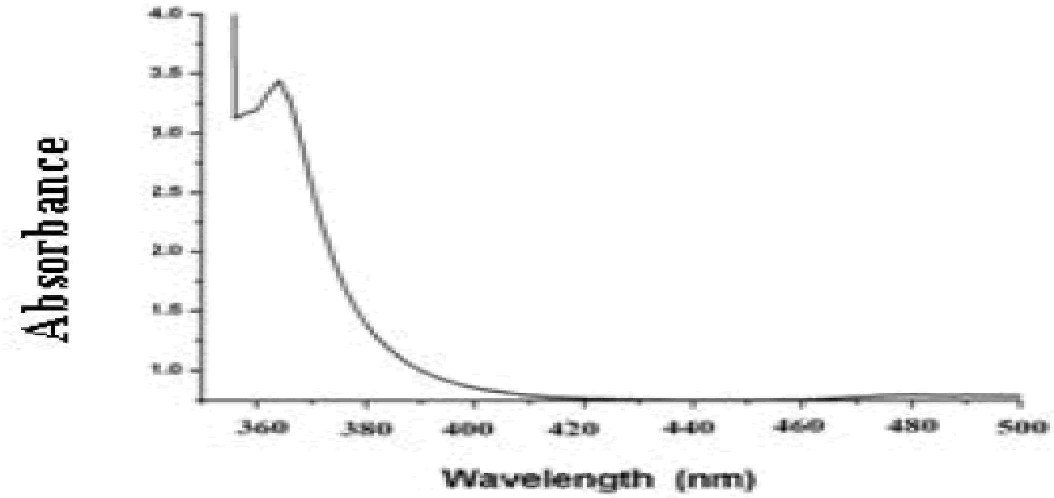

Figure 3 .Ultraviolet visible (UV-Vis) spectrum of synthesized ZnO-NPs

2.4. Energy Dispersive X-Ray Analysis (EDX):

The ED X-ray profiles which is obtained in the study confirms the presence of ZnO NPs with strong energy peaksignals for Zn atoms in the standard range as shown in Figure 4 .

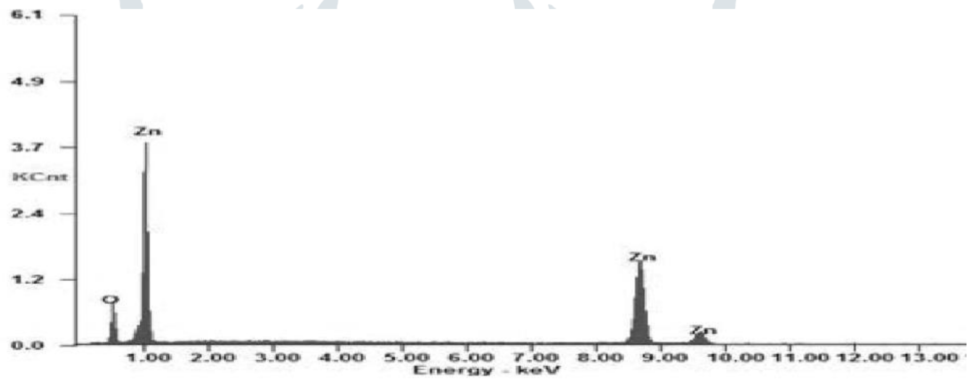

Figure 4 . Energy dispersive X-Ray analysis of the synthesized ZnO-NPs

2.5. Transmission Electron Microscopy(TEM):

The morphology and the average size of the synthesized nanoparticles were analyzed by Transmission ElectronMicroscopy (TEM).The average size for the particles was calculated and found to be 7.6 ± 0.5 nm for ZnO-NPs, figure 5.

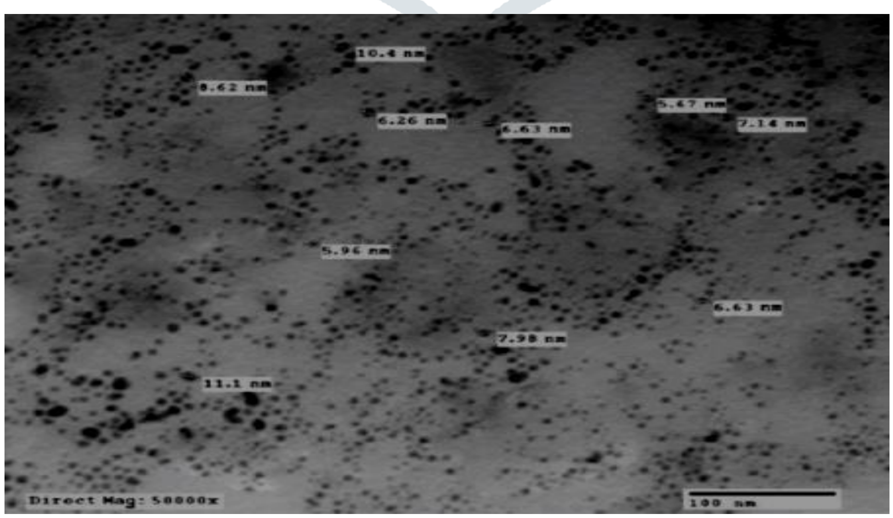

Figure 5: Transmission electron micrographs showing spherical well separated and dispersed synthesizedZnO-NPs with average size 7.6 ± 0.5 nm.

3. The antibacterial efficacy of ZnO-NPs against E. coli and K. pneumoniae isolates

The antibacterial efficacy of nanoparticles were tested and evaluated against two E. coli and four K. pneumonia (Klebsiella pneumoniae) isolates. According to the results obtained, two isolates (E2 and K1) were sensitive to ZnO-NPs .Generally, the diameter of inhibition zones obtained by 50 and 100 µl 0f ZnO-NPs shows no difference.

Mean of inhibition zone diameter (mm) ± SD

Isolates Code	**ZnO-NPs**	
	50 µl	**100 µl**
E1	0 ± 0.00	0 ± 0.00
E2	12 ± 0.17	12 ± 0.35
K1	13 ± 0.15	13 ± 0.29
K2	0 ± 0.00	0 ± 0.00
K3	0 ± 0.00	0 ± 0.00
K4	0 ± 0.00	0 ± 0.00

*E: *E. coli*; K: *K. pneumonia*; SD: Standard deviation. Each result were in triplicate.

Figure 9: The enhanced efficacy of ZnO-NPs on the antibacterial activity of Amoxicillin/clavulanic on one of K.pneumonia isolates where; the effect of antibiotic disc alone on the left and the effect of the antibiotic disc upplemented with ZnO-NPs on the right.

CONCLUSION

Zinc Oxide is an inorganic material which promises a wide range of applications in various sectors. It is much adaptable for electronic configuration and bio-compatible properties to act as an anti-bacterial active material. Improvement such as heterojunction, doping and optimizing various properties resultant in enhancement of antibacterial activity. The growing antimicrobial resistance among different bacterial strains is a great threat that requires rapid and serious actions to be taken. Due to their unique antibacterial properties ,Nanoparticles could be evaluated as substitute to the traditional antibiotics or used to enhance the efficacy of certain antibiotics.

References

1. Health Policy Brief (2015) Antibiotic Resistance. Health Affairs 12: 1-7.
2. Melakea NA, Eissaa NA, Keshkb TF, Sleema AS (2015) Prevalence of multidrug-resistant bacteria isolated from patients with burn infection. Menoufia Med J 28: 677-684.
3. Silver LL (2011) Challenges of antibacterial discovery. Clin Microbiol Rev 24: 71-109.
4. Naqvi SZH, Kiran U, Ali MI, Jamal A, Hameed A, et al. (2013) Combined efficacy of biologically synthesized silver nanoparticles and different antibiotics against multidrug- resistant bacteria. Int J Nanomedicine 8: 3187-3195.
5. Singh R, Nawale LU, Arkile M, Shedbalkar UU, Wadhwani SA, et al. (2015) Chemical and biological metal nanoparticles as antimycobacterial agents: A comparative study. I J Anti Mic Ag 46: 183-188.
6. Ohira T, Yamamoto O, Iida Y, Nakagawa ZE (2008) Antibacterial activity of ZnO powder with crystallographicorientation.
7. Jalal R, Goharshadi EK, Abareshi M et al (2010) ZnO nanofluids: Green synthesis, characterization, andantibacterial activity.
8. Gordon T, Perlstein B, Houbara O et al (2011) Synthesis and characterization of zinc/iron oxide composite nanoparticles and their antibacterial properties. Colloids Surfaces A Physicochem Eng Asp 374:1–8. https://doi.org/10.1016/j.colsurfa.2010.10.015
9. Raghavan, Y. S. (2010). Nanostructures and nanomaterials: synthesis, properties and applications.