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Synthesis, Characterisation and Antibacterial Study of Zinc Oxide Nanoparticles

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Abstract: In recent science, Nanotechnology is a burning field for the researchers. It deals with the nanoparticles having a size of 1-100nm in one dimension used significantly concerning medical chemistry, atomic physics, and all other known fields. Metal nanoparticles have been intensively studied within the past decade. Nano sized materials have been an important subject in basic and applied sciences. Zinc oxide nanoparticles have received considerable attention due to their unique antibacterial, antifungal, and UV filtering properties, high catalytic and photochemical activity. Now a day the more interesting and attracting point in search area is synthesis of nanoparticles with specific properties. Due to unique properties of oxide of nanoparticles achieve great attention in research areas. ZnO nanostructures obtained a great attention in the research area because ZnO has large band gap. There are many different methods for the synthesis of ZnO nanoparticles. The main objective of this project is to synthesis ZnO nanoparticles by microwave assisted method and study its characterization. Nanostructures were characterized by SEM. Zinc oxide nanoparticles, such as those prepared in this study may exhibit potential antibacterial activity as their unique character. The purpose of this study was to evaluate the antibacterial activity of ZnO nanoparticles. Antibacterial study on Staphylococcus aureus, Clostridium botulinum, Bacillus cereus, E.coli, Streptococcus pneumonia, Pseudomonas aeruginosa. Antibacterial activity evaluated by agar well diffusion method.

Keyword: ZnO nanoparticles, antibacterial activity

INTRODUCTION

Nanochemistry is a branch of nano science, deals with the chemical application of nano technology. It involves the synthesis and the characterization of materials of nano scale size. The word "Nano" is derived from the Greek word for dwarf. Nanotechnology is mainly concerned with the synthesis of nanoparticles of variable sizes, shapes, chemical compositions and controlled disparities and their potential use for human benefits. Although so many physical and chemical methods may produce pure, well defined nanoparticles, these are quite expensive and potentially dangerous to the environment. Physical technique allows atoms to be manipulated and positioned to specific requirements for the prescribed use. Traditional chemical techniques arrange atoms in molecules using well characterized chemical reactions. The nanoscale usually refers to structures with a length scale applicable to nanotechnology, usually cited as 1-100 nanometers.

Zinc Oxide Nanoparticles

This presents an overview of zinc oxide nanoparticle. ZnO is described as a functional, strategic, promising and versatile inorganic material with broad range of applications. It is known as 11-1V semiconductor, since Zn and O are classified into groups two and six in the periodic table respectively. ZnO holds a unique optical, chemical sensing, semiconducting, electrical conductivity and piezoelectric properties. It is characterized by a direct wide band gap (3.8eV) in the near-UV spectrum, a high excitonic binding energy (60mEv)at room temperature and a natural n-type electrical conductivity. These characteristics enable ZnO to have remarkable applications in diverse fields

Zinc oxide nanoparticle is among one of the most researched studies conducted due to its ability to apply in varied downstream applications. Zinc oxide nanoparticle is the second most abundant metal oxide after iron and it is inexpensive, safe, and as well as it can be prepared easily. Physical and chemical behaviors of zinc oxide nanoparticle can be easily turned by changing the morphology by using different synthesis routes or different precursors or different materials to produce the nanomaterial. Zinc oxide nanoparticle is one of the inorganic compounds of group II–IV semiconductor for analytical sensing applications. Zinc oxide nanoparticle appears to be white powder and insoluble in water.

Different methods have been adopted for the assessment and investigation of antibacterial activity in vitro. These methods include disk diffusion, broth dilution, agar dilution, and the micro titer plate-based method. Other methods are different according to the investigated parameters. The most commonly used method is the broth dilution method, followed by colony count, through plating serial culture broths dilutions which contained ZnO nanoparticles and the targeted bacteria in appropriate agar medium and incubated. A number of researchers have examined the antibacterial activity of ZnO nanoparticles to determine bacterial growth through the culture turbidity and the viable cells percentage by the colony counts test.

The antibacterial properties of Zinc oxide nanoparticles were investigated using both Gram-positive and Gram-negative microorganisms. ZnO nanoparticles have a wide range of antibacterial activities towards various microorganisms that are commonly found in environmental settings. The antibacterial activity of the ZnO nanoparticles was inversely proportional to the size of the nanoparticles in S.aureus.

Experimental Work

Chemicals Required:

Zinc acetate

NaOH(4ml)

Ethyl alcohol

In this work 15 ml (1.6 $molL^{-1}$) of Zn (CH3COO)2. 2H2O were diluted in 32 ml of deionized water to obtain a Zn^{2+} solution. Afterwards 4ml of a base (3.2 $molL^{-1}$) NaOH was added drop wise into the above described solution with magnetic stirring at room temperature to get a colloid system, which was maintained under stirring for 10 min. Then the reaction mixture is kept into an microwave oven and treated at

selected temperature (80, 100, 120, or 140^{0}C) for specific time (5, 10 or 20 min) operating at different powers (300, 600, or 1200W).When the reaction was finished and cooled to room temperature, the white precipitate was collected by filtration and washed with deionized water and ethyl alcohol several times. Finally the product was dried at 65^{0}C in a vacuum oven for 3h.

Result and Discussion

SEM Analysis

SEM analysis shows the study of the surface morphology of nanoparticles. Fig-2 shows the SEM images of ZnO nanoparticles. From SEM images, observe that the size of ZnO nanoparticles is 150-170 nm.

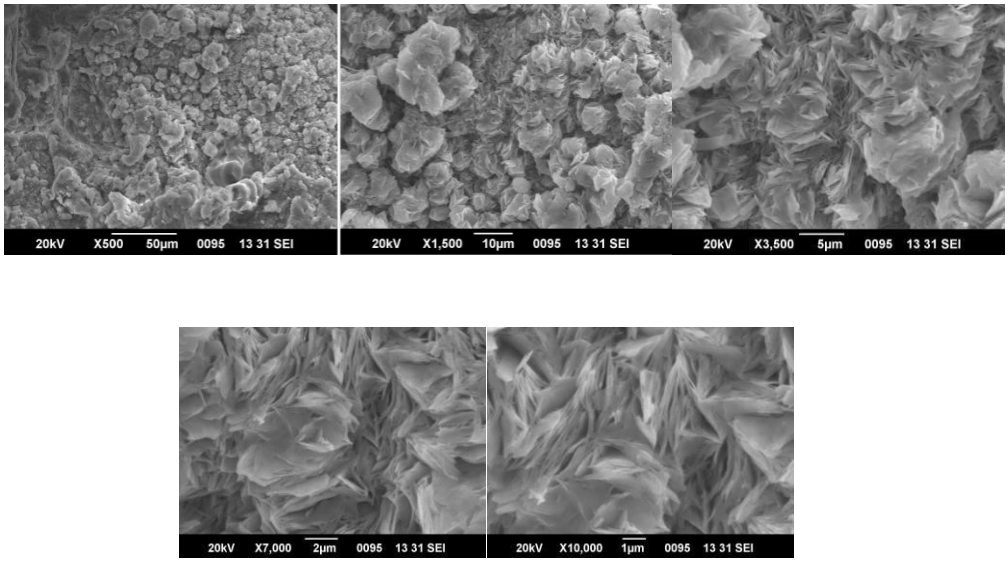


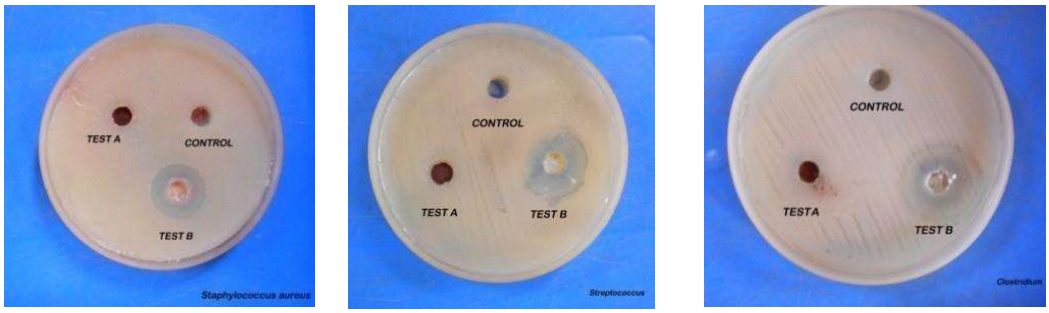
Figure 2: SEM images of Zinc oxide nanoparticles synthesized.

Antibacterial activity was determined using agar well diffusion method. The presence of an inhibition zone clearly indicated the antibacterial effect of ZnO nanoparticles. The cultures were swabbed on nutrient agar plates and wells were prepared on each plate using sterile Cork borer. 100µl of samples were loaded into respective wells and six replications were maintained for each sample. The plates were incubated at 37°C for 24-48hrs. After incubation, the zone of inhibition around well was measured.

Antibacterial activities studied against Staphylococcus aureus, Clostridium botulinum, Streptococcus pneumonia, Pseudomonas aeruginosa, Bacillus cereus and E.coli strains in the figure.

ANTIBACTERIAL ACTIVITY

Staphylococcus aureus **Clostridium botulinum** **Streptococcus pneumonia**



Pseudomonas aeruginosa **Bacillus cereus** **E.coli**

Figure 3: Antibacterial activity of Zinc oxide nanoparticles

ZnO nanoparticles were found to be active against Staphylococcus aureus, Clostridium botulinum, Streptococcus pneumonia, Bacillus cereus, E.coli and inactive against Pseudomonas aeruginosa,

Zinc oxide nanoparticles show a zone of inhibition of 2.6 cm to Staphylococcus aureus, 2.5 cm to Clostridium botulinum, 2.6 cm to Streptococcus pneumonia, 2.7 cm to Bacillus cereus and
2.1 cm to E.coli.

CONCLUSION

ZnO nanoparticles have been successfully synthesized by microwave irradiation method, which holds many advantages over the traditional process as it follows rapid initial heating, homogeneous reaction medium, the increased reaction kinetics, clear reaction products with higher yields.

In the present study we report a simple, low cost, and environmentally benign and microwave assisted chemical method for the synthesis of zinc oxide nanoparticles. The ZnO nanoparticles obtained successfully via microwave synthesis. The synthesized Zinc oxide nanoparticles have been characterized by SEM. The average particle size was found to be 150- 170 nm obtained from SEM measurement for ZnO nanoparticles dried at 65^0C.

Antibacterial activity of ZnO nanoparticles against Staphylococcus aureus and Clostridium botulinum strains were also determined using Agar well diffusion method thus analyzed that it was found to be ZnO nanoparticles active against Staphylococcus aureus and Clostridium botulinum, Streptococcus pneumonia, Bacillus cereus, E.coli and inactive against Pseudomonas aeruginosa.

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