GREEN SYNTHESIS OF ZINC OXIDE NANOPARTICLES

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ABSTRACT

Nano-sized ZnO particles of specific morphology were synthesized using the plant leaf extracts of Aloe vera. The structures, morphology, optical properties, surface area and thermal behavior of these fabricated ZnO nanoparticles were characterized by X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Ultraviolet-visible spectroscopy (UV-vis), Photoluminescence (PL)/flourescence spectroscopy, Brunauer-Emmett-Teller (BET) analysis and Thermogravimetric analysis (TGA). Photodegradation and antibacterial activity of the nanoparticles were studied.

Keywords: Zno Nanoparticles (ZNO Nps), Green Synthesis, Aloe Vera

I INTRODUCTION

The synthesis of nanoparticles with specific morphologies and properties is one of the most important aspects of nanoscience which studies materials whose size lies within the nanometer range (1 nm=10^{-9} m) [1]. Applications of these nanostructures are seen in catalysis, sensors, water purification, antibacterials and nanoelectronics. While chemical synthetic procedures can lead to the generation of toxic chemical by-products or require high temperatures and/or pressure, biosynthesis of nanoparticles using plant extracts provides a facile and 'green' method of nanoparticle synthesis.[1,2]

Zinc oxide is a semiconductor with wide band gap (3.37), high excitation binding energy (60 meV) at room temperature [1,2] and has unique optical and as well as excellent thermal and chemical stability [3]. ZnO nanoparticles have gathered the increasing interest of the scientific and industrial community due to diverse application in solar energy conversion, sensors, catalysis, cosmetics, paints, fibers, drug-delivery antibacterial and luminescence properties.

In this work we have used environmentally benign plant leaf extracts of Aloe vera which have exceptional therapeutic properties[4]. As surface stabilizing agents which act as biotemplate for the synthesis of ZnO NPs. The structural, optical, thermal, photo catalytic and anti-bacterial properties of the ZnO NPs[5] have been evaluated.

II MATERIALS AND METHODS

Zinc acetate dihydrate (Loba Chemie), sodium hydroxide pellets (Avra Synthesis Pvt.Ltd.), distilled water were used in the nanoparticle synthesis with the extracts. Aloe vera leaves were collected from the Botanical garden of Stella

Maris College, Chennai-86. Stock culture of bacteria for antibacterial studies was obtained from (Science House, Chennai). Mueller-Hinton agar, Nutrient broth, disposable sterile petri dishes, cotton swabs, sterile saline, test tubes was purchased from HiMedia Laboratories Pvt Ltd.

2.1Preparation of leaf extracts

Aloe vera leaf (50 g) were thoroughly washed, dried and then boiled in 50 ml of deionised water for half an hour. The resulting extract was cooled and used as the extract solutions.

2.2 Synthesis of ZnO nanoparticles

In this method, 0.25 g of zinc acetate was dissolved in 50 ml water. 4 ml of the extract of Aloe vera was added drop-wise and the resulting mixture was stirred for 10 minutes using a magnetic stirrer. In order to adjust the pH of the solution to pH 12, NaOH (2 M) was added drop-wise while stirring. A white crystalline precipitate of zinc oxide was obtained, which is washed repeatedly with water, filtered and dried in an oven at 60°C to obtain the ZnO nanoparticles.

2.3 Antibacterial studies

The antibacterial activity of the ZnA nanoparticles was studied by the broth inoculation method. Initially a broth is prepared by autoclaving 2.6 g of nutrient broth in 100 ml in a conical flask. The broth is divided between three test tubes –the standard, the control and the test. 1 ml of a 20 mmol suspension of the nanoparticle (ZnA) was added to the standard and the test and one loopful of bacteria were then added to the control and the test .The tubes were then incubated in an incubator for 24 hours. The growth and inhibition of the bacteria was monitored by taking absorbance readings during a period of 18 to 22 hours using a colorimeter.

III RESULTS AND DISCUSSION

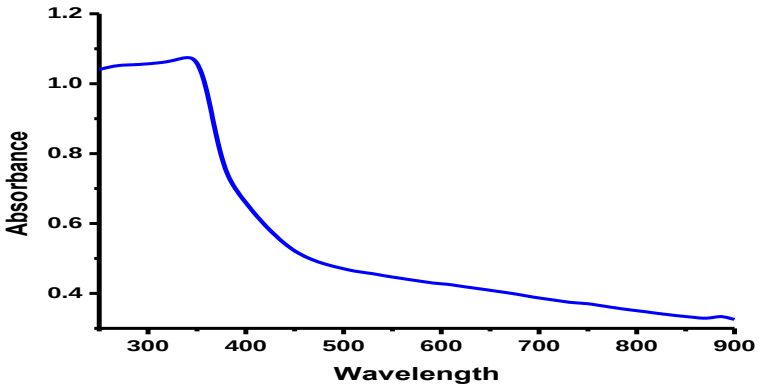


Fig 3.1 UV spectrum of ZnA

The UV-Vis spectrum of the synthesized ZnO nanoparticles carried out on carried out a JASCO UV- Vis spectrophotometer is shown in Fig. 3.1. Confirmation of the synthesised ZnO nanoparticklles was exhibited by the blue shifted absorption maximum at 340 nm. Bulk ZnO exhibits absorption maximum around 380 nm approximately

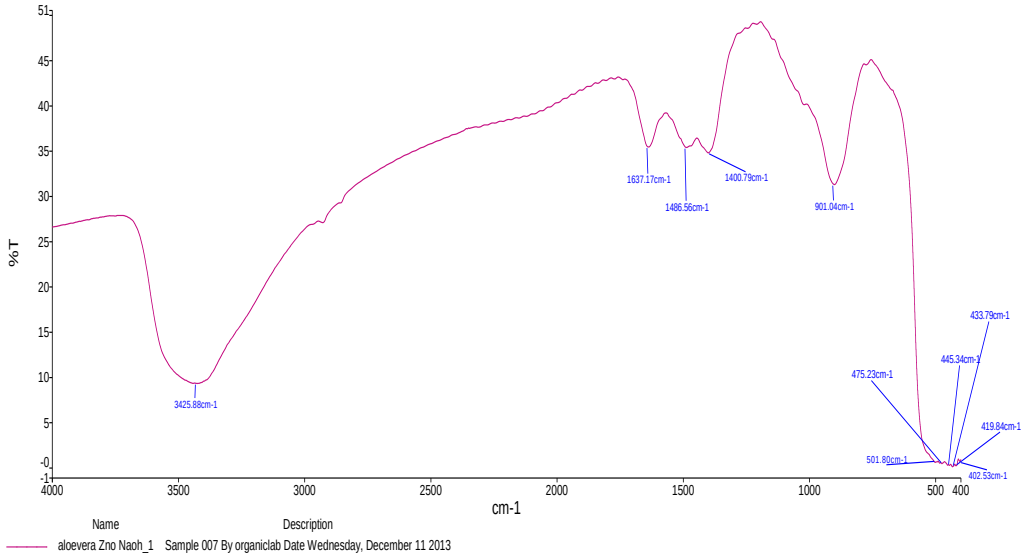
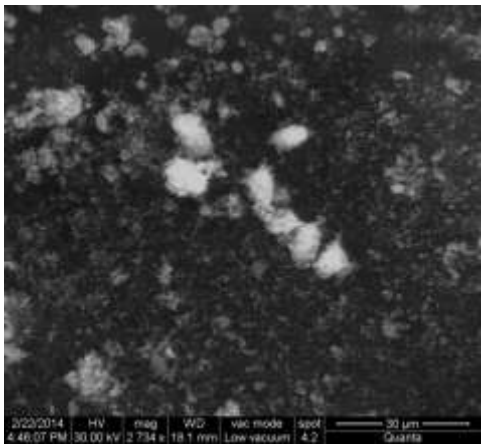
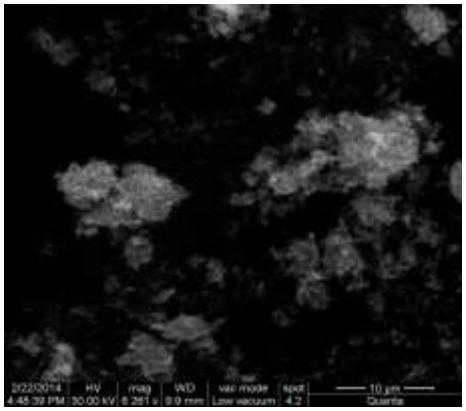


Fig 3.2 IR spectrum of ZnA

The IR spectrum was taken using a Perkin Elmer FT –IR instrument operating at a resolution of 4000-400 cm^{-1} in the percent transmittance mode. In addition to the absorption bands of the biomolecules used as reduction and stabilization(capping) agents, the absorption peak at 437 cm^{-1} indicate the presence of ZnO nanoparticles (ZnA). The physicochemical properties of Aloe vera acts as a bio template which prevents the particles formed from aggregating. SEM image by green synthesis method explains the external morphology of the ZnO nanoparticle (ZnA) The SEM images of ZnA (Fig. 3.3) indicate a small amount of agglomeration of the nanoparticles with a possible networked structure.





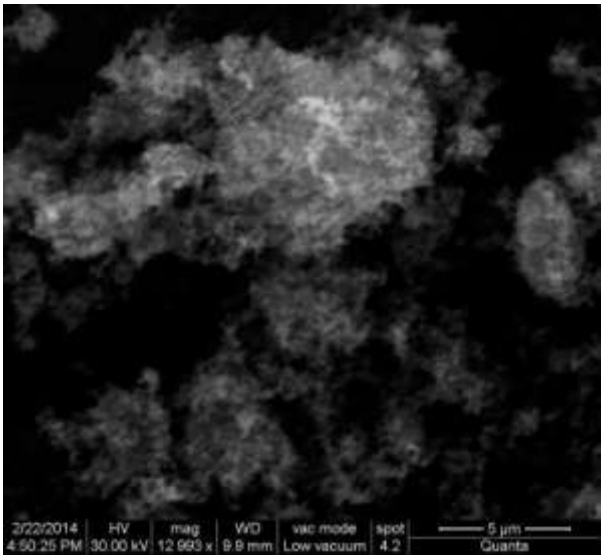


Fig. 3.3 SEM images of ZnA

XRD spectrum of the as prepared ZnA nanoparticles was carried out using XRD (Bruker AXS D8 Advance) for 2θ values ranging from 10 to 80° using CuKα radiation at λ = 1.5406Å. In ZnA, the 2θ values with (hkl) plane at 31.5°(100), 34.2°(002), 36.1°(101), 47.4°(102), 56.5°(110), 62.8°(103), 67.8°(200), 68.9°(112) and 76.9°(004) were observed. The spectrum (Fig.3.4) confirmed the hexagonal zinc oxide structure for ZnA. The average particle size (D) of synthesised nanoparticles was calculated using the well known Scherrer formula. The calculated value of D was 22.18 nm.

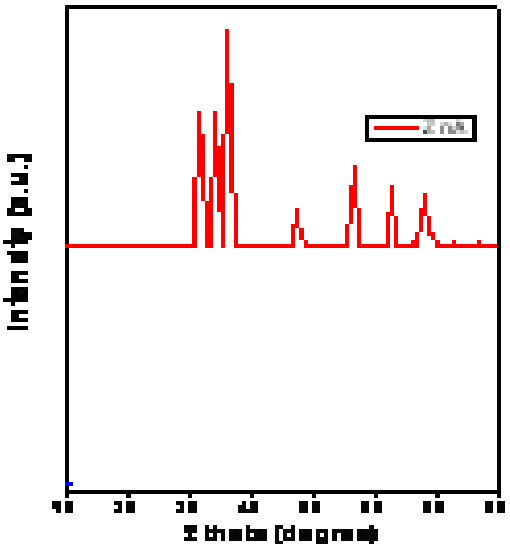


Fig 3.4 XRD of ZnA

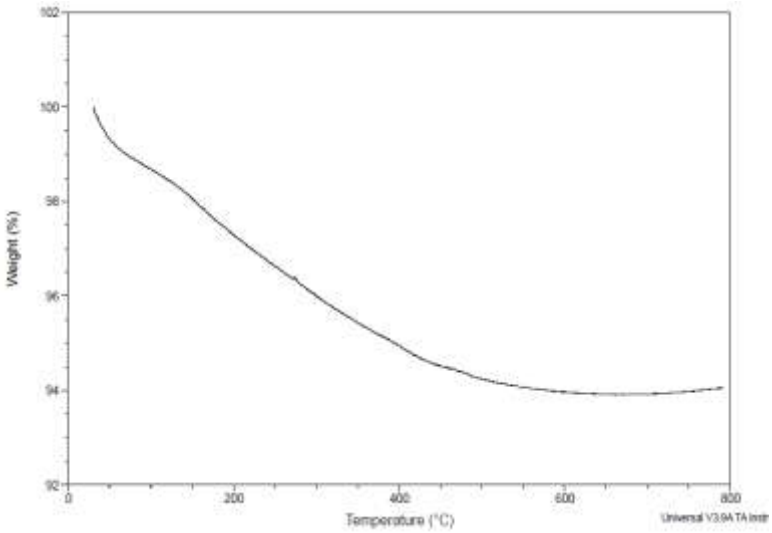


Fig. 3.5 Thermogravimetric curve of ZnA

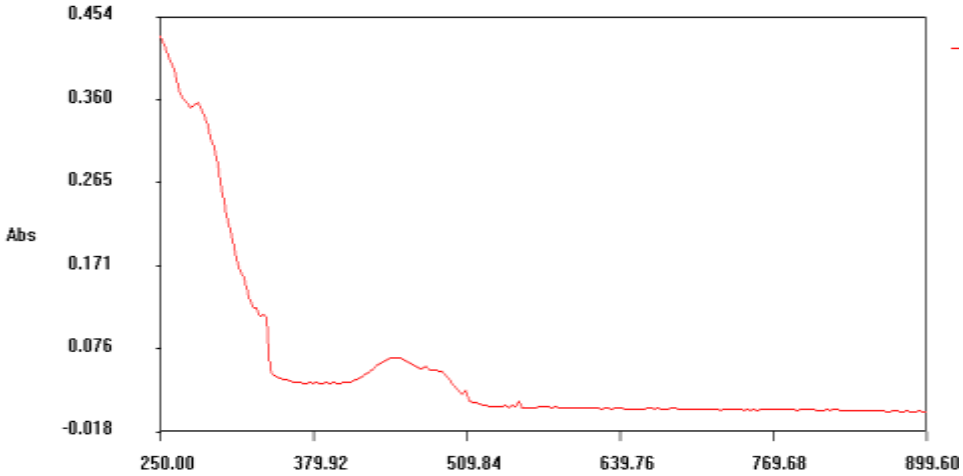


Fig. 3.6 a UV absorption spectrum of fluorescein

The thermogravimetric analysis of ZnA (Fig. 3.5) was performed on a Perkin–Elmer Thermo gravimetric analyser and showed a 12% loss of weight at 100°C due to the loss of water and a continuous loss of weight from 200°C for ZnA nanoparticles indicating the loss of other volatile components in the plant extracts used as reduction and stabilization (capping) agent.

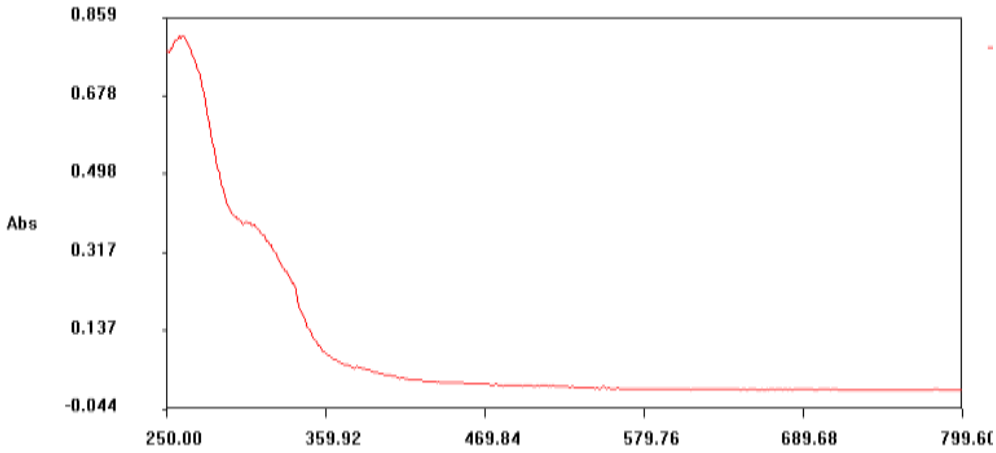


Fig. 3.6 b UV absorption spectrum of fluorescein after photocatalytic degradation

The photodegradation activity of the ZnA nanoparticles was studied with fluorescein dye

The absorption maximum of fluorescein is about 494 nm as seen in Fig.3.6 a After the irradiation of the dye (1 ppm) for 24 hours with UV light , the peak at 494 nm diminished as seen in Fig 3.6 b. This proves that the ZnA nanoparticles prepared have significant photocatalytic degradative ability. This photocatalytic degradation is shown in Fig. 3.6 (c).

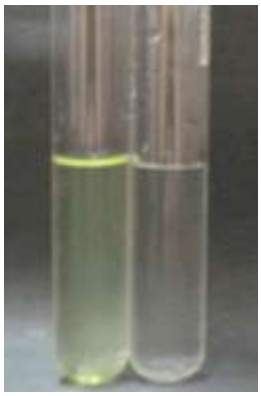


Fig. 3.6 c Photocatalytic degradation of flourescein

The presence of antibacterial activity on the synthesized ZnO nanoparticles was first detected by the surface inoculation method. In order to obtain more accurate information of the antibacterial property of ZnA via a time-dependent study , the broth inoculation method was carried out using five bacteria : *E.coli, S.aureus ,K.pneumoniae ,P.mirabilis* and *B.cereus* .This method was used to determine the antibacterial properties of the synthesized nanoparticles by comparing the growth of the bacteria in the control tube (containing the broth and bacteria) and that in the test(containing the broth, bacteria and nanoparticle suspension). The growth of the same was studied colorimetrically for a period of 18 -22 hours.

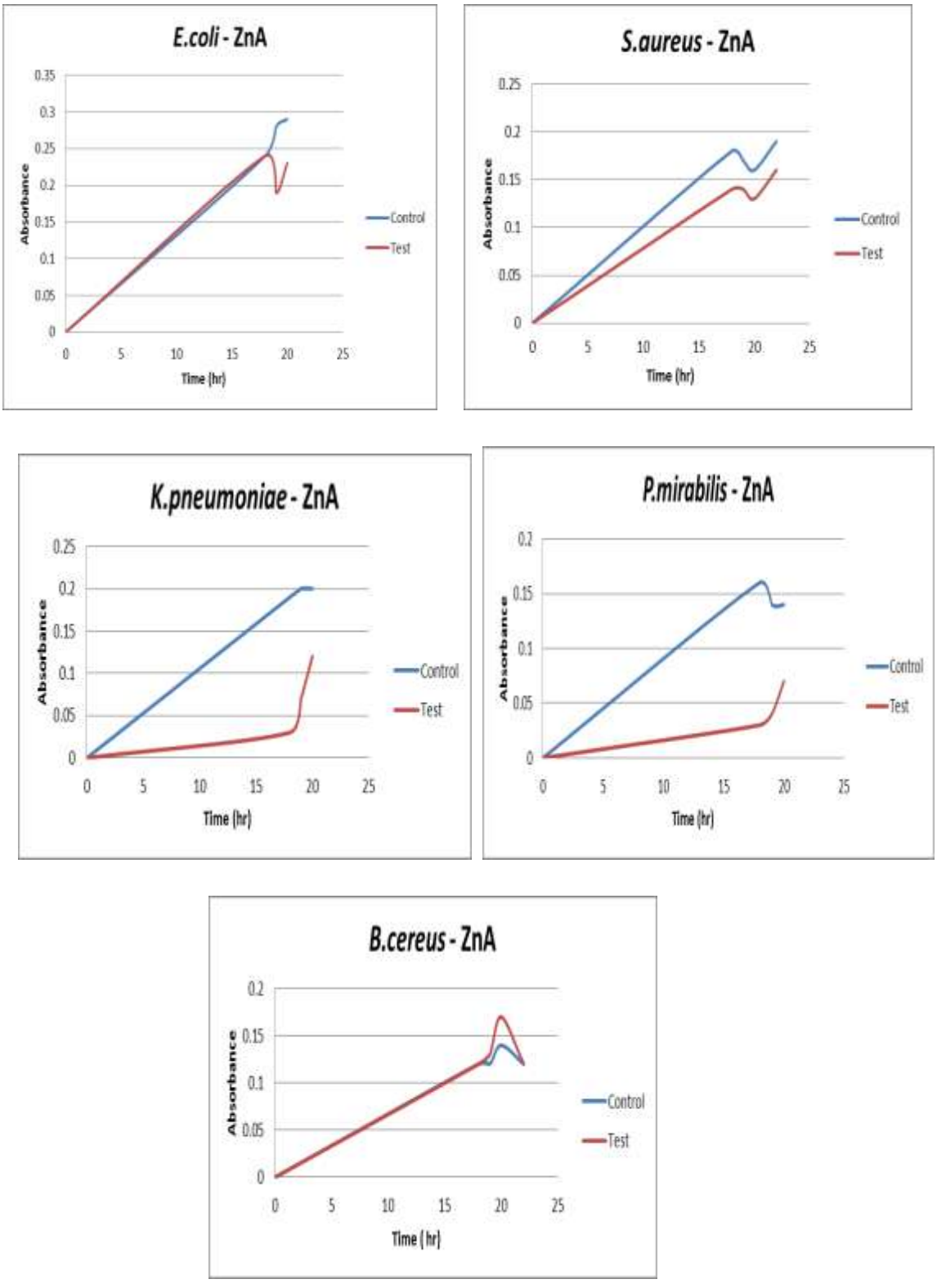


Fig 3.7 Antibacterial studies of Zn A

The antibacterial studies of ZnA (Fig.3.7) exhibited sensitivity to both Gram positive and Gram negative bacteria. CuGT showed antibacterial action towards *S.aureus, K.pneumoniae, P.mirabilis* .

IV CONCLUSION

ZnO NPs was synthesized by the green synthesis method using *Aloe vera* extract is simple and cost effective. The as prepared ZnO NPs were characterized using several techniques such as XRD, SEM, FTIR, Solid UV –Vis and TGA. The blue shifted UV-Vis absorption peak at 340 nm confirmed the presence of ZnO in the nano scale. The FT-IR studies showed an absorption peak at 437 cm^{-1}(Zn-O linkage) which indicated the formation of zinc oxide nanoparticles. XRD analysis confirmed the hexagonal zinc oxide structure for ZnA with average particle size of 22.18 nm. The SEM analysis of ZnA showed the morphology of the samples to be networked with some agglomeration. The antibacterial studies of the as synthesized nanoparticles showed sensitivity to both Gram positive and Gram negative bacteria. ZnA nanoparticles showed significant photo catalytic degradative ability with fluorescein dye. Thus the as synthesised ZnO nanoparticles (ZnA) find use for medical applications and environmental science.

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