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Biomedical Potential of Zinc Oxide Nanoparticles Synthesized using Plant Extracts

Research Article

S. Rajeshkumar[1], Lakshmi T[2*]

[1] S Nanobiomedicine Lab, Department of Pharmacology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai 600077, Tamil Nadu, India.
[2] Dean -International Affairs, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai 600077, Tamil Nadu, India.

Abstract

Enhancement of plant materials based nanoparticles have various benefits over conventional physico-chemical methods. These conventional methods for example chemical reduction process, in which different chemicals hazardous are used for the synthesis of nanoparticles. Due hazardous, later converted to responsible for immeasurable health risks to environment due to their toxicity nature and threatening serious fears for human being. Plant based nanoparticle synthesis have many advantages and it will be useful to medicine and biological application. In this review, zinc oxide nanoparticles (ZnO NPs) by plants and their biomedical potential was covered. Many plants mediated (green synthesis) ZnO NPs has strong antimicrobial activity against the pathogens compared to available standard drugs and Antiviral, anticancer and free radical scavenging potential application. The plant based synthesis of ZnO NPs could be outstanding policy to develop resourceful and environmental friendly biomedical application.

Keywords: Green Synthesis; Zinc Oxide Nanoparticles; Antimicrobial; Biomedical.

Introduction

The green synthesis or biosynthesis of metal and metal oxide nanoparticles using various organic materials are vigorously growing now a days [1, 6, 12, 30, 22]. The zinc oxide nanopartilces are one of the important metal oxide nanoparticles synthesized using various microorganism (Fungi, bacteria, yeast and actinomycetes) [23, 25, 27] , plant and its various parts (seeds, leaves, flowers, root, fruits and bark) [4, 28, 29] The figure 1 and 2 clearly shows the different parts used for zinc oxide nanoparticles synthesis and different characterization techniques involved in the analysis morphology including size, shape and crystalline nature and various techniques involved.

Application of green synthesis of zinc oxide nanoparticles

The figure 3 and table 1 shows the different biomedical applications of zinc oxide nanoparticles synthesized using different parts of plants.

Zinc oxide nanoparticles synthesized from *E. crassipes* were applied with various doses on *Helianthus annus*. The shoot and root length, fresh and dry weight of *H. annus* were assessed and the results indicated that the growth of *H. annus* decreased as the concentration of nanoparticles increased [24].

The antibacterial activity of ZnO nanoparticles synthesized from *M. pulegium* against gram positive *Staphylococcus aureus* and gram negative E. coli bacteria by agar well diffusion method at different concentrations. The antimicrobial activities were excellent at all concentrations and the maximum zone of inhibition was resulted at 200 µg/ml concentration [19].

Spherical ZnO nanoparticles synthesized from *A. gomezianus* fruit and anticancer effect was evaluated by MTT assay involving breast cancer cell lines (MCF-7). The ZnO nanoparticles showed

***Corresponding Author**:
Lakshmi T,
Dean -International Affairs, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai 600077, Tamil Nadu, India.
Tel: 044-26801580
Fax: 044 -26800892
E-mail: manjaric.sdc@saveetha.com

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Figure 1. Plant mediated synthesis of zinc oxide nanoparticles.

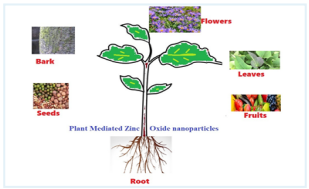

Figure 2. Characterization and its uses in plant mediated zinc oxide nanoparticles.

Figure 3. Biomedical applications of zinc oxide nanoparticles.

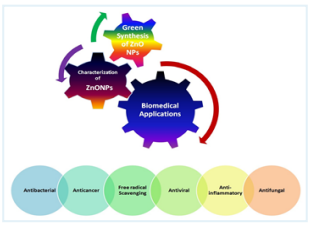

Table 1. Biomedical applications of zinc oxide nanoparticles synthesized using various plants.

S. no	Sources	Chemicals	Application	Reference
1	*A. carambola*	Zn (NO3)2·6H2O	Antibacterial activity in 0.25 to 0.0025 µg/ml range against *Bacillus subtilis*, *Staphylococcus aureus, Escherichia coli* and *Pseudomonas aeruginosa.* Antifungal effect against plant pathogenic fungi *Alternaria alternata* and *Fusarium oxysporum* in 100-700 µg/ml range.	[26]
2	*M. pulegium*	Zn (NO3)2·6H2O	Antimicrobial against gram positive *(Staphylococcus aureus)* and gram negative *(E. coli)* bacteria	[19]
3	*M. indica*	Zn(NO3)2	Free radical scavenging activity Cytotoxic effect against A549 lung cancer cell line	[21]
4	*Eclipta alba*	ZnSO4	Seed treatment with ZnO NPs significantly improved pearl millet seed germination, plant height, vigor, fresh and dry weight of seedlings. Sporangicidal assay showed that 50 ppm of NPs treatment led to plasmolysis and inhibition of spore germination of *S. graminicola zoospore.* Seed treatment and foliar spray of ZnONPs resulted in 35% reduction in incidence of downy mildew compared to untreated control. ZnO NP treated seedlings resulted in high lignification and callose deposition due to downy mildew infection. Analysis of defense enzymes showed that ZnO NPs treatment significantly improved the activities of peroxidase, lipoxygenase, phenylalanine ammonia-lyase, and polyphenol oxidase compared to untreated control. RT-PCR analysis showed differentially expressed transcripts of the defense enzymes where the genes were over expressed in treated seedlings compared to low expression in control.	[14]
5	*Hippophae rhamnoides*	Zinc nitrate hexa-hydrate and NaOH (>98%) purity	Photocatalytic activity of the ZnO NPs was studied using the Eosin Y and Malachite Green dye under UV irradiation revealed that it has ability to degrade dye about 95% & 89% respectively inferring that it can be a better photo catalyst for the treatment of polluted water through textile industry.	[16]

6	*Cucurbita pepo*	Zinc acetate	MTT assay performed by treatment with MG63 osteoblast-like cells with or without different concentrations of ZnO NPS revealed a significant level of reduction in cell proliferation in ZnO NPs treated samples compared to control dose-dependently (~50-65% growth inhibition at 20ppm, 40ppm and 60ppm, whereas ~75% at 80ppm) FDA staining showed reduction in fluorescence intensity with an increase in the concentration of ZnO NPs.	[8]
7	*Tabernaemontana divaricata*	Zn(NO3)2 .6H2O	ZnO NPs revealed higher antibacterial activity against *S. aureus* and *E. coli* and lesser activity against *S. paratyphi* compared to the standard pharmaceutical formulation. Photocatalytic activity analyzed for methylene blue (MB) dye degradation with sunlight. Almost complete degradation of dye occurred in 90min.	[20]
8	*Cardiospermum halicacabum*	Zn (NO3)2•6H2O	Antibacterial activity against gram positive bacteria (*Staphylococcus saprophyticus* and *Bacillus subtilis*) and gram negative bacteria (*E. coli* and *Pseudomonas aeruginosa*) bacteria	[15]
9	*Eucalyptus globus*	Zn (NO3)2•6H2O	High antioxidant activity against DPPH free radicals scavenger and photocatalytic activity degrading Methylene blue and Methyl orange exhibiting 98.3 % of maximum degradation efficiency	[18]
10	*Artocarpus heterophyllus*	Zn (NO3)2•6H2O	Photocatalytic activity proved efficient degradation of rose Bengal dye	[5]
11	*Mimusops elangi*	Zn (NO3)2•6H2O	Agar- ZnO nanocomposite films as a packaging material to enhance shelf life of fresh fruits like green grapes	[10]
12	*Punica granatum*	Zn (NO3)2•6H2O	Antibacterial activity against *E. coli and Enterococcus faecalis.* Cytotoxic activity against human colon normal and cancerous cells.	[13]
13	*Artocarpus gomezianus*	Zn (NO3)2•6H2O	Anticancer activity against breast cancer cell lines Antibacterial activity against *S. aureus* and antifungal activity against *Aspergillus niger*	[3]
14	*Trifolium pratense*	ZnO	Antibacterial activity against clinical and standard strains of S. aureus and *P. aeruginosa* and standard strain of *E. coli*	[7]
15	*Bougainvillea glabra*	ZnC4H6O4	Antimicrobial activity against *E. coli, P. aeruginosa, S. aureus* Anticancer activity against MCF- 7 which was mechanically confirmed by ROS generation by the ZnO nanoparticles	[2]
16	*Prosopis farcta*	ZnC4H6O4	Antibacterial activity against *Acinetobacter baumanni* and *P. aeruginosa*	[9]

toxicity at 100 µM approximating that of the drug camptothecin whose toxicity levels were at 50 µM. CAM assay was performed by implanting the experimental drug on the blood vessels of a chick embryo which resulted in the thinning/ disappearance of blood vessels indicating its tumour destruction action. Inhibition of the formation of new blood vessels showed its anticancer properties [3].

The antibacterial activity was evaluated for the ZnO nanoparticles synthesized from *Olea europaea* against *Xanthomonas oryzae* pv. Oryzae (Xoo) strain GZ 0003 showed zone of inhibition of 2.2 cm at 160 µg/ml with significant differences compared to ZnO nanoparticles synthesized from *Matricaria chamomilla* and *Lycopersicon esculentum* [17].

Green synthesis of ZnO nanoparticles from *Syzygium aromaticum* flower bud extracts were prepared and the antifungal action on F. *graminearum* were analysed by intracellular reactive oxygen species (ROS). The results showed accumulation of ROS effectively and in dose-dependent manner. The effect of ZnO nanoparticles on ergosterol biosynthesis of *F. graminearum* revealed reduced ergosterol. These ZnO nanoparticles were also reported to enhance lipid peroxidation and bring about detrimental effects to the membrane integrity of fungi [11].

Conclusion

Plant extract based NPs are highly potential than other synthesis NPs and their biological activities also will diverse due to typical biochemical compositions. Their structural and optical studies us-

ing UV, FTIR, XRD and SEM analysis also more important to prove the capable of plant based ZnO NPs. From this present reviews, it is deliberated that synthesis of plant based green ZnO NPs is highly safer and eco-friendly than the chemical and physical methods. In conclusion, synthesis of ZnO NPs using plants could have suitable medicinal applications in cure of various human diseases. Nevertheless, further detailed studies including characterization of bioactive compounds and NPs will be necessary to validate the ability of these NPs in medical applications and their capability to overwhelm the risks related with predictable drugs.

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