International Journal of Botany Studies
ISSN: 2455-541X; Impact Factor: RJIF 5.12
Received: 06-12-2020; Accepted: 06-01-2021: Published: 19-01-2021
www.botanyjournals.com
Volume 6; Issue 1; 2021; Page No. 197-200

Plant mediated green synthesis of zinc ferrite nanoparticles and its biological applications

Ashwini Karthikeyan[1], Raja Naika Hanumanaika[1*], Gurushantha K[2], Krushitha Shetty[3]

[1] Department of Studies and Research in Biotechnology, Tumkur University, Tumkur, Karnataka, India

[2] Department of Chemistry, Sapthagiri College of Engineering, Bengaluru, Karnataka, India

[3] Department of Nanotechnology, Visvesvaraya Technological University, VIAT, Muddenhalli, Chikkaballapur, Karnataka, India

Abstract

Zinc ferrite ($ZnFe_2O_4$) nanoparticles were prepared using a bio-mediated, environmental friendly and a less expensive route using *Phyllanthus acidus* as fuel. The nanoparticles were examined by Powder X-ray diffraction and Scanning Electron Microscopy techniques. The scanning electron micrographs of the synthesized $ZnFe_2O_4$ nanoparticles synthesized by this plant based method demonstrates irregularly shaped thin flakes of crystallites, showing voids and pores due to the escaping gases during the process. The synthesized nanoparticles were found to be in the range 11-20 nm. The antimicrobial activity was observed by the zone of inhibition induced by the plant mediated synthesis of the ferrite nanoparticles.

Keywords: ferrite nanoparticles; plant based synthesis route; *Phyllanthus acidus*; antimicrobial activity.

Introduction

Nanotechnology is one of the promising approaches in controlling the microbial activity. Many metallic nanostructured particles are under investigation for its potency in inhibiting the microbial growth or biofilm formation. Research works in this area have shown that the antimicrobial activity of the nanomaterials could be due to the generation of reactive oxygen species (ROS) which damages the microbial cell by reducing the cellular adhesion due to the neutralization of electrostatic forces rendered by nanostructured surfaces. The degree of antimicrobial activity of any nanomaterial could be attributed to some of its unique features like high surface area, reactive sites and unusual crystal morphologies [1]. Metallic NPs such as silver, zinc, copper, aluminium, gold, titanium with suitable surface coatings have been studied extensively for antimicrobial activities. Metal oxide NPs such as zinc oxide, magnesium oxide, silver oxide have been tested for their antimicrobial activity against several bacterial and fungal strains. The issue of low colloidal stability in metal oxide NPs can be overcome by the use of ferrofluids in combination.

The suspensions of magnetic iron oxide NPs such as Zinc ferrite have been reported to show less agglomeration in the aqueous suspension form. Such iron oxide NPs serve as Fenton's reagent and reacts with hydrogen peroxide to produce hydroxyls and peroxide radicals. This radical formation may act synergistically with metal oxide NPs to enhance their antibacterial effect [2]. The performance of magnetic NPs mainly depends on their physical and chemical properties and also its surface characteristics which can be greatly influenced by the method of synthesis chosen for their preparation [3].

Recently, Zinc ferrite nanoparticles have gained lots of attention because of their numerous biomedical applications. Zinc ferrite nanoparticles are widely studied for their antimicrobial properties as well as contrast agents in Magnetic Resonance Imaging (MRI). The effectiveness of the nanoparticle as an antimicrobial agent can be determined by using experimental techniques that measure viable microbial cells after their exposure to it. Numerous Techniques are available to check the antibacterial activity of nanomaterials. Usually multiple methods such as bacterial plating, live/dead cell staining and tetrazolium salt reduction assays are used in a study to compare and get accurate results [4].

The regular routes of nanoparticle synthesis including solution combustion, hydrothermal or sol-gel methods involves hazardous chemicals that are expensive, laborious to handle and harmful to the surrounding environment [5]. To overcome such issues, Plant mediated method of synthesis involving the extracts from the leaf, pulp, bark or flower can serve as a good alternative. Plant extracts act as biofuel to run the synthesis combustion there by being cost effective as well as eco-friendly method.

Several plants including Aloe vera, Hibiscus, Fruit pulps have been demonstrated to be as good fuels in synthesis of nanoparticles [7]. In this study, *Phyllanthus acidus*, commonly known as Gooseberry, a small glabrous tree and their leaf extract has been used as a fuel to the combustion process.

The antibiotic efficacy of the synthesized nanomaterials is generally assayed using at least one Gram-positive species and one Gram-negative species to compare the results [8]. Some of the widely used bacterial strains to determine the antibacterial activity of the synthesized nanomaterials are Staphylococcus aureus, Bacillus subtilis (Gram-positive type).

Materials and method

The chemicals used in the present investigation such as Zinc Nitrate, Ferric Nitrate, Ethanol were purchased from Merck, India.

The leaves of *Phyllanthus acidus* were collected, washed thoroughly with a final ethanol rinse to remove dust particles. The leaves were sun-dried and powdered. The stoichiometric amount of Zinc Nitrate, Ferric Nitrate and the powdered leaves were placed in a cylindrical Pyrex and introduced into a muffle furnace. On heating, the decomposition of metal nitrates takes place, resulting in a white foamy material consisting of the nanoparticles along with the release of gaseous fumes.

Biosynthesis method

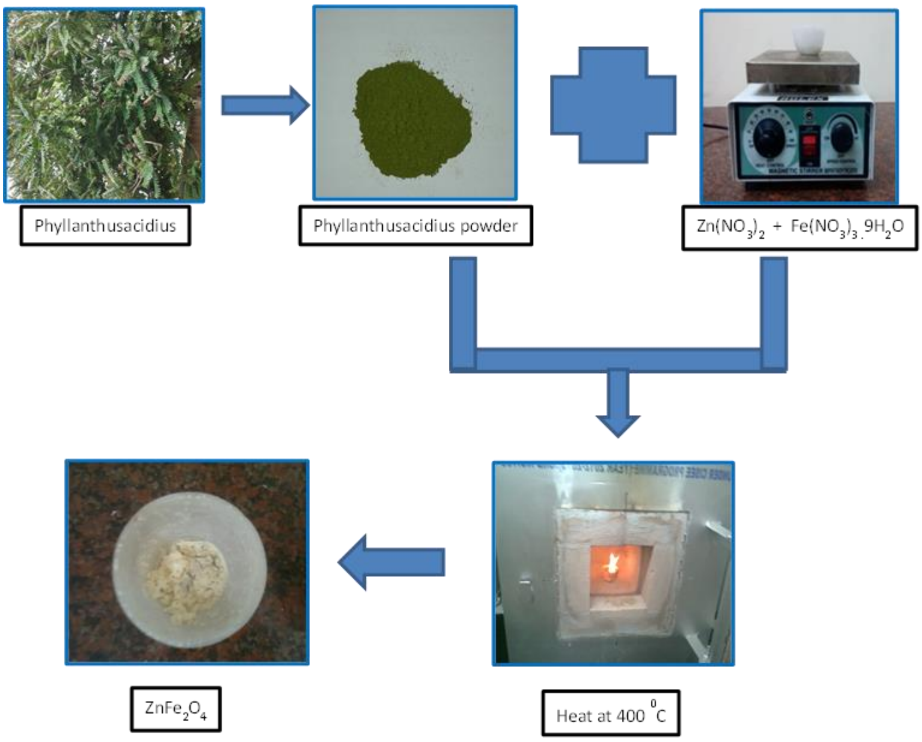

Fig 1

Instruments Used

The phase purity was examined using powder X-ray Diffractometer (PXRD) (PANalytical X′Pert Pro) using Cu $K_\alpha$radiation with a nickel filter. The morphology of the nanoparticles had been studied with the help of Scanning Electron Microscope (SEM) (JOEL JSM 840 A) by sputtering technique using gold as a coating contrasting material [9].

Results and Discussion

The crystalline phases of $ZnFe_2O_4$ obtained through both the methods exhibit similar PXRD patterns. The diffraction patterns of the samples show a very good match with the standard pattern of face – centered – cubic $ZnFe_2O_4$ with a spinel structure [JCPDS No- 22-1012] [10]. The $ZnFe_2O_4$ sample demonstrates few minor peaks at diffraction angle 31.9 and 50.3° which corresponds to Fe_2O_3 [JCPDS No- 33-0664].

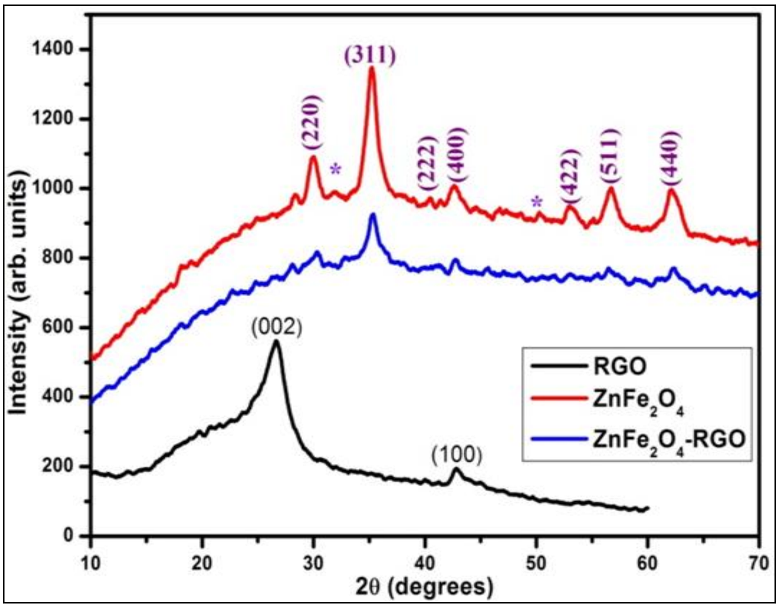

Fig 2: PXRD pattern of synthesized Zinc ferrite Nanoparticles

The SEM analysis of $ZnFe_2O_4$ nanoparticles shows the irregular thin flakes of crystallites containing several voids as well as pores. Non-uniform distribution of temperature and mass flow in the combustion flame can be the cause of agglomeration of the NPs [10]. The nanomaterials with highly porous network are significant of combustion synthesized powders [11]. The pores and void frame network of the NPs facilitates the entrance and multiple light reflection within the interior cavity, leading to a better use of the light source [12].

The average crystallite size of $ZnFe_2O_4$ was calculated using Debye-Scherrer formula [13] was found to be 20 and 11 nm.

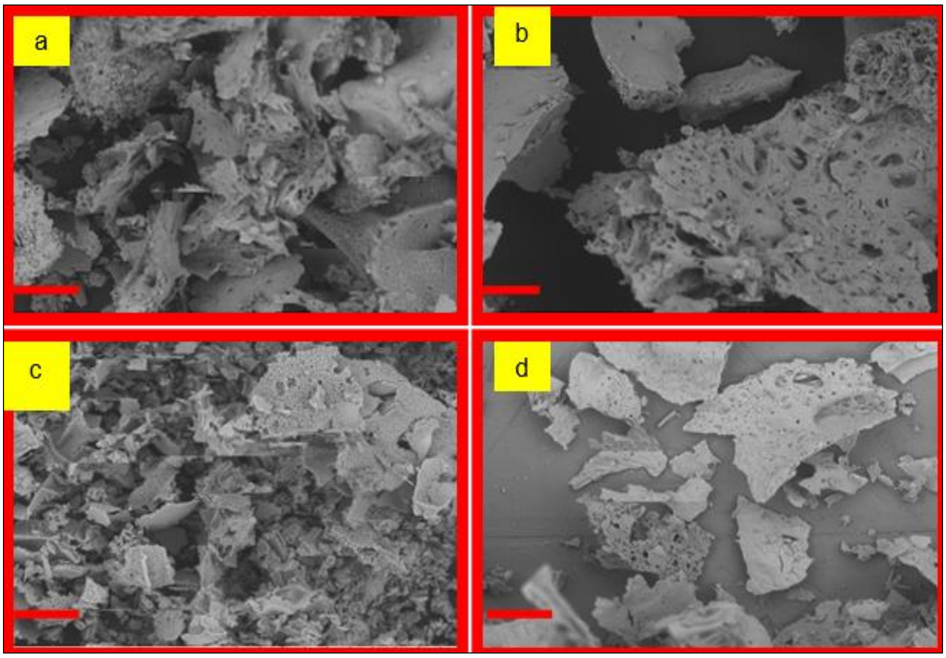

Fig 3: SEM images of the synthesized Zinc Ferrite Nanoparticles

Antimicrobial studies

The agar well diffusion method utilizing the bio mediated route of synthesized Zinc ferrite nanoparticles studied at different concentrations showing the clear zone of inhibitions [14]. Antibacterial activity of the nanomaterial against Gram – positive and Gram – negative bacterium E.coli, Staphylococcus aureus, Aeromonas hydrophila, Rhodococcus rhodochrous, Vibrio cholerae, Salmonella typhi and Proteus mirablis - (1) Standard antibiotics, (2) Zinc ferrite 25µg/mL, (3) Zinc ferrite 50µg/mL, (4) Zinc ferrite 75µg/mL, (5) Zinc ferrite 100µg/mL and (6) Distilled water (negative control).

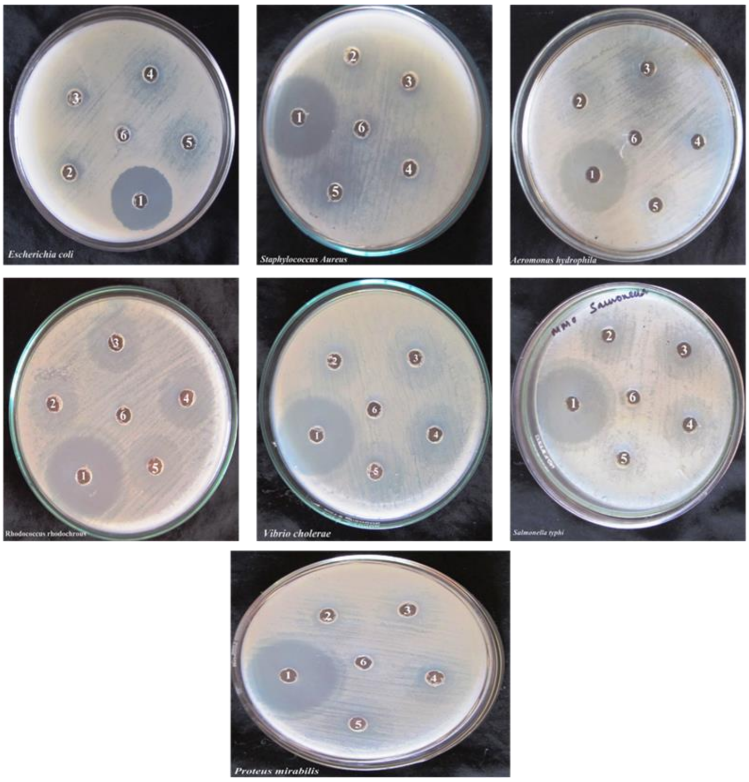

Fig 4: Anti-bacterial activity of Bio synthesized Zinc ferrite nanoparticles

Conclusion

In the present work, $ZnFe_2O_4$ nanoparticles were examined for their application as a antimicrobial material. The nanoparticles were synthesised by bio mediated methods and characterized by powder XRD and SEM analysis [15]. A nanoparticle size of about 11 nm obtained showing good pathogenicity against several bacterial strains.

Acknowledgements

The authors would like to acknowledge Department of Chemistry, East West College of Engineering, Bengaluru and Department of Physics, Tumkur University, Tumkuru for their technical support for biosynthesis and characterization of nanomaterials.

References

1. Z Karimi, Karimi L, Shokrollahi H. Mater Sci Eng C Mater Biol Appl. 2013; 33:2465-2475.
2. Ghasemian Z, Shahbazi-Gahrouei D, Manouchehri S. Avicenna J Med Biotechnol., 7 thed. 2015; 2:64-68.
3. Sophie Laurent, Morteza Mahmoudi. Int J Mol Epidemiol Genet. 2011; 2(4):367-390.
4. Barcena C, Amandeep K, Sra Girija S, Chaubey C, Khemtong J, Ping Liu, *et al*. Chem. Comm, 2008, 2224-2226.
5. Maria M, Angelin Sinthiya, Ramamurthi K, *et al*. IJCRGG. 2015; 7(5):2144-2149.
6. Vidya YS, Anantharaju KS, Nagabhushana H, Sharma SC. J. Alloys Compd, 2015, 760-770.
7. Vidya YS, Gurushantha K, Nagabhushana H, *et al*. J. Alloys compd, 2015, 86-96.
8. Li H, Bian Z, Zhu J, *et al*. Journal of the American Chemical Society, 2007, 8406-8407.
9. Zhuang J, Tian Q, Zhou H, Liu Q, Liu P, Zhong H, *et al*. Journal of Materials Chemistry, 2012, 7036-7042.
10. Fa-tang Li, Jingrun Ran, Mietek Jaroniecand, Shi Zhang Qiao. Nanoscale: The Royal Society of Chemistry, 2015.
11. Bing-Lei Guo, Ping Han, Li-Chuan Guo, Yan-Qiang Cao, Ai-Dong Li, Ji-Zhou Kong, *et al*. Nanoscale Research Letters. 2015; 10(336):1-10.
12. Hong Yang a, Cuixia Zhang a, Xiangyang Shi b, He Hua, Xiaoxia Du c, Yong Fang d, *et al*. Biomaterials. 2010; 31:3667-3673.
13. Tamar Gordon, Benny Perlstein, Ofir Houbara, Israel Felner, Ehud Banin, Shlomo Margel, *et al*. A: Physicochem. Eng. Aspects. 2011; 374:1-8.
14. Teresa Valde´s-Solı´s, Patricia Valle-Vigo´n, Sonia A´ lvarez, Gregorio Marba´n, Antonio B. Fuertes, Catal. Commun. 2007; 8:2037-2042.
15. Roca AG, Morales MP, O'Grady K, Serna CJ. Nanotechnology. 2006; 17:2783-2788.