

Green Synthesis of Iron Oxide Nanoparticle Using *Kaempferia Galanga* Extract and Its Antibacterial Activity

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ABSTRACT

Nanoscience also has significant advances in obtaining environmentally friendly and sustainable products. Iron oxide nanoparticles, one of the metal oxide nanoparticles, have different forms and properties. In recent years, iron oxide nanoparticles have been successfully synthesized from various plant species using green synthesis pathways and have been analyzed for different bioactivity properties. In this study, iron oxide nanoparticles were synthesized using a completely non-hazardous method using *Kaempferia galanga* extract. The synthesized product was characterized by UV-Visible spectroscopy, Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction pattern (XRD). In addition, the antibacterial activity of the product was analyzed, and it was recorded that the nanoparticle has remarkable antibacterial activity.

Keywords: Nanotechnology, Green synthesis, Iron oxide, *Kaempferia Galanga*, Antibacterial activity.

INTRODUCTION

In the current scenario, the nanotechnology field is fledgling daily with paramount importance due to its new developments and wide range of applications. The study of nanostructures is a large, interdisciplinary field of research and development that has grown rapidly in recent years all around the world due to their unique physiochemical properties, which include electronic magnetic, catalytic, optical, anti-corrosion, and anti-microbial activities [1-4]. It has the ability to completely transform the types and range of capabilities that can be accessible, as well as how materials and products are made. One millionth of a millimetre, or a nanometer, is 100,000 times smaller than the width of a human hair. Because at this scale, unique optical, magnetic, and electrical properties, nanomaterials are of interest [5,6]. Nanomaterials are used in nanotechnology and exhibit different physical and chemical properties from ordinary substances (i.e., silver nano, carbon nanotube, fullerene, photocatalyst, carbon nano, silica) [7]. Nanoparticles offer radical breakthroughs in areas such as materials and manufacturing, electronics, medicine and health care, environment and energy, chemical and pharmaceutical, biotechnology and agriculture, computation and information technology and national security. Nano iron oxide is used to create the magnetic material used in disk drives and audio/ video tapes.

The production of nano particles using the chemical methods has been raising concern among the environmentalists as they have an adverse effect on their ecology, hence the use of plant extract for the formation of nano particles is being favored due to salubrious nature towards the Environment. Even in the industry it produces less toxic waste. The synthesis of iron oxide nanoparticles is still in its infancy and more research need to be focused on the mechanism of nanoparticle formation which may lead to fine tuning of the process involved in the synthesis of the nanoparticle with a strict control over the size and shape parameters. Biosynthesis of nanoparticles is a kind of bottom up approach where the main reaction occurring is oxidation or reduction. Biosynthesis of nanoparticle via green synthetic route provides advancement over physical and chemical

methods as it is cost effective, environmental friendly and easily scaled up for large scale synthesis. Also, in this method there is no need to use high pressure, temperature and toxic chemicals.

EXPERIMENTAL PART

Preparation of Kaempferia Galanga extract

The rhizomes of *K. galanga* were washed to remove the adhering mud particles and possible impurities. The tubers were cut into small pieces. The extract of the *Kaempferia galanga* was prepared by taking 50g of cleaned small pieces tubers in 500ml of deionized water. The solution was heated at 100°C to get the plant extract. The extract was filtered and collected in a clean, dried beaker for further use.

Preparation of Iron oxide nanoparticles using Kaempferia Galanga extract

The synthesis of Iron oxide Nanoparticles was done by adding 0.1 M Anhydrous Ferric Chloride and the *Kaempferia galanga* extract in 1:1 proportion in a clean sterilized flask and stirred. Then 50 ml 1M freshly prepared NaOH added slowly with continuous stirring. The mixture is stirred continuously for 30 minute in shaker. Then the solution is undisturbed for a while. After the formation precipitate the solution is filtered using the filter paper Whatman no. 01. The resulting precipitate dried in an air oven. The iron oxide nanoparticle collected in a sample bottle for further characterization.

RESULTS AND DISCUSSION

Various properties of nano particles are characterized by using different techniques. In this work we used UV – visible spectroscopy, IR spectroscopy, X-Ray Diffraction Technique (XRD). The absorbance spectra of sample were measured in wavelength within the range from 200-900 nm using a UV-Vis UVD-3500 spectrophotometer. Particle Structure and crystalline size of nanoparticles were determined by XRD. The functional groups of nanoparticles were recorded by FT-IR spectroscopy (Perking Elmer), with a scan range from 4000 to 400 cm^{-1} .

UV-Visible Spectral Analysis

UV-Vis analysis is one of the most important characterization methods to study nanoparticles. The absorption of visible radiations due to the excitation of SPR, imparts various colours to nanoparticles. As the nanoparticles size changes, colour of the solution also changes. So UV-Vis absorption spectrum is quite sensitive to the formation of nanoparticles. The nanoparticle sample (Green method) is subjected to UV-Vis study. The nanoparticles synthesized by green method shows maximum absorption at 370 nm confirming that the synthesized product was iron oxide nanoparticles [8]. Iron oxide nanoparticles have been reported to exhibit a characteristic broad absorption band in the range of 330-400 nm. The spectra recorded for the samples synthesized by green method also shows a small band around 400-450 nm that may be due the components present in the plants.

Infrared Spectroscopy

The prepared iron oxide nanoparticles were subjected to FT-IR spectroscopy measurements. It was recorded by using a Perking Elmer, spectrometer in the range 400-4000 cm^{-1} . It was used to identify the possible biomolecules responsible for the reduction and capping of the nanoparticles. Strong bands around 3345 cm^{-1} , 1745 cm^{-1} , and 540 cm^{-1} are related to those reported for Fe_2O_3 [9]. The band at 3570 cm^{-1} is attributed to the O-H stretching vibration of alcohol and phenol compounds. During the formation of IONPs, band at 572 cm^{-1} is attributed to FeO, as reported in the literature [10]

X-Ray Diffraction (Xrd)

XRD is an effective technique to identify the phase and to confirm the crystal structure of the synthesized iron oxide nanoparticles. The X-ray diffraction patterns obtained for the iron oxide nanoparticles synthesized using the root extract of *Kaempferia galanga* is shown in Figure 4.1. The exhibited peaks correspond to the (012),

(104), (110), (113), (024), (116), (018), (214) and (300) of a rhombohedral structure of α - Fe_2O_3 is identified using the standard data. The results are in agreement with the standard XRD pattern of Fe_2O_3 (JCPDS 76-0958).

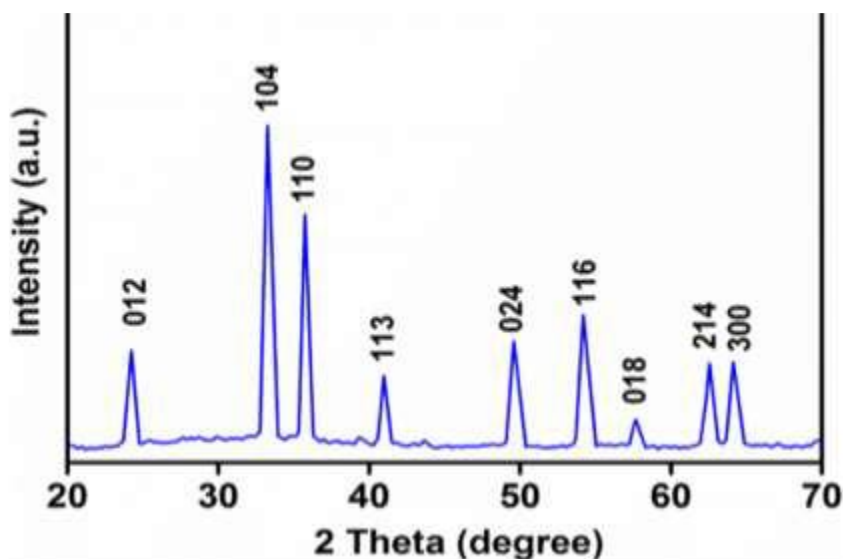


Fig 1: XRD pattern of green synthesized Fe_2O_3 nanoparticles

Anti-bacterial Activity

Fe_2O_3 nano particles have antimicrobial activity at relatively very high concentrations. The activity can be further moderated by changing the surface potential and accessible surface functional groups. The changes cause change in interaction pattern at the nano-bio interface, hence play crucial role in determining the antimicrobial propensity of Iron oxide nanoparticles. However, the enhanced production of ROS because of the interaction potential at the interface is the principal cause for antimicrobial propensity of the NPs. In this study, Extract of *Kaempferia Galanga* mediated synthesized Fe_2O_3 nanoparticles were examined for possible antibacterial activity. The synthesized Iron oxide nanoparticles were tested for antibacterial activity against both Gram's positive (*Bacillus cereus* and *Staphylococcus aureus*) and Gram's negative (*Escherichia coli* and *Shigella flexneri*) bacteria. Table 1 and Figure 2 and 3 show the results of antibacterial activities of synthesized Iron oxide nanoparticles evaluated from the well diffusion method.

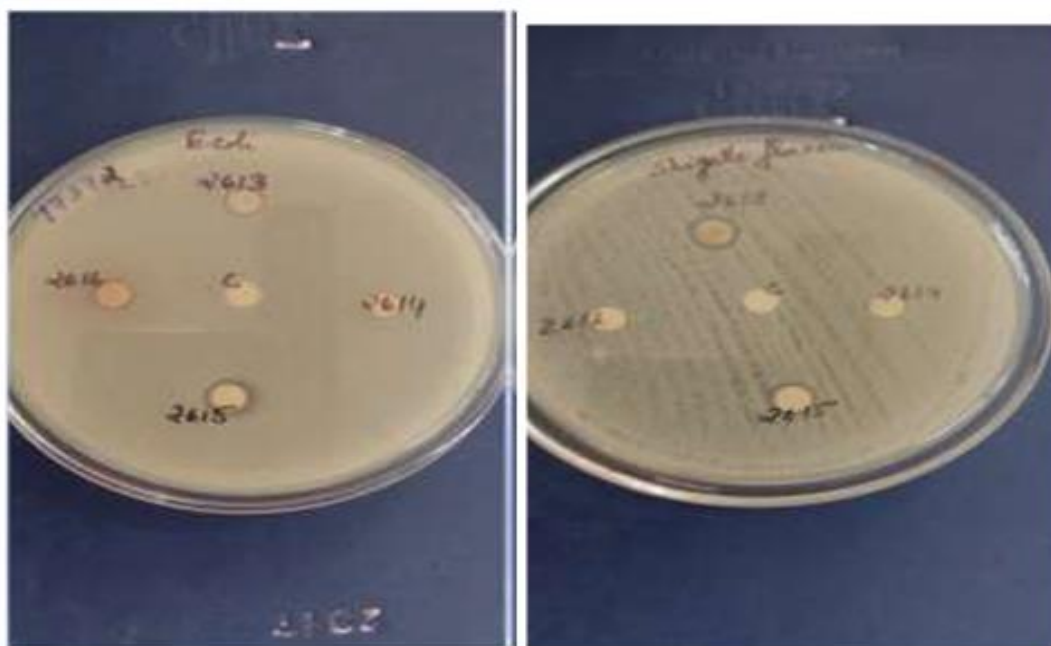


Figure 2: Photographic images of sample 1 and 2

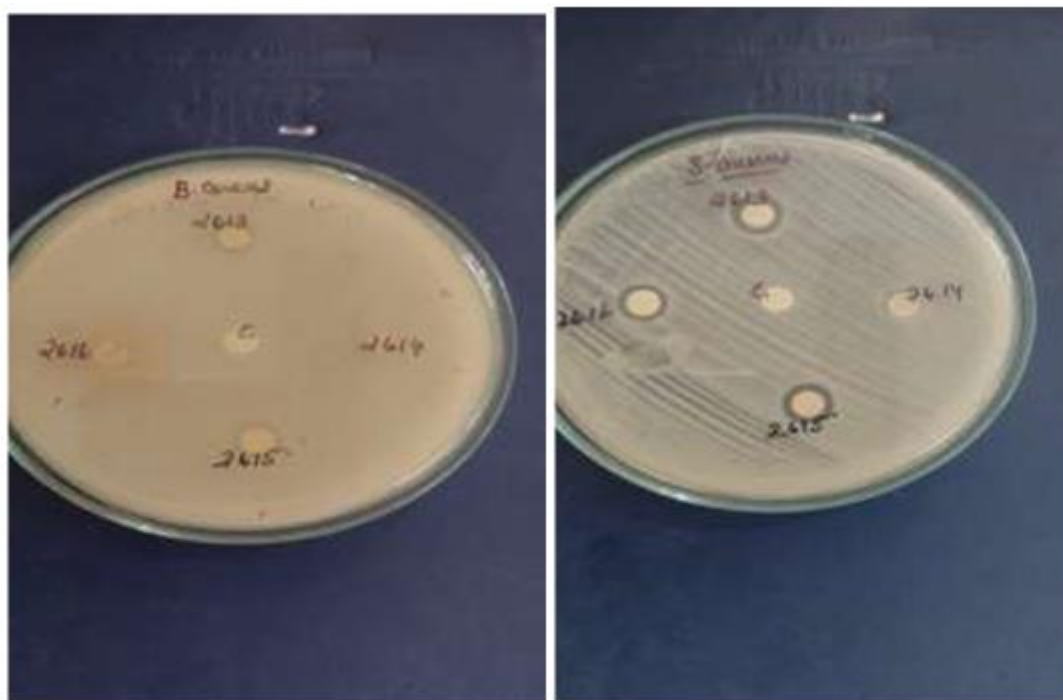


Figure 3: Photographic images of sample 3 and 4

Table 1

SL. NO	PARAMETER	RESULT	UNIT
1	Shigella Flexneri	Sample 7 mm control NZ	Dia(mm)
2	Bacillus Cereus	Sample 7 mm Control NZ	Dia(mm)
3	Staphylococcus aureus	Sample 7 mm Control NZ	Dia(mm)
4	Escherichia coli	Sample 7 mm Control NZ	Dia(mm)

Table 1: Antimicrobial activity of Iron nanoparticle

The synthesized Fe₂O₃ nanoparticles tested for antibacterial activity showed inhibition zones against the studied bacteria. The nanoparticles showed antibacterial activity due to their large surface area that provides better contact with cell wall of bacteria.

CONCLUSIONS

Green synthesis of iron nanoparticles using plant extracts is a promising method for obtaining environmentally friendly nanomaterials for biological applications. Iron oxide nanoparticles (α - Fe₂O₃) were synthesized using Kaempferia galanga extract as a reducing and stabilizing agent. These include rapid heating, environmentally friendly and low cost, higher yield and shorter reaction time, and size and shape distribution control. FTIR measurements confirmed the attachment of compounds present in the extract to the iron nanoparticles' functional groups found in phenolic compounds can help in the formation of metallic nanoparticles. Particle morphology and size were studied using XRD techniques. The synthesized nanoparticles were tested for their effect as antimicrobial agents against various bacteria such as Escherichia coli, Staphylococcus aureus, Shigella Flexneri, and Bacillus cereus. The synthesized Fe₂O₃ nanoparticles exhibited antibacterial activity against Bacillus cereus, Staphylococcus aureus Escherichia coli and Shigella flexneri strains. The synthesized Fe₂O₃ NPs were used for antibacterial activity due to their high stability, less toxicity, and biocompatibility.

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