Green Synthesis of Silver Nanoparticles using Kaempferia Galanga Extract and Study of its Antibacterial Effect

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Abstract: ***Biogenic synthesis of silver nanoparticles (AgNPs) using plants has become a promising substitute to the conventional chemical synthesis method. Silver has been known to have effective bactericidal properties for centuries. Nowadays, silver based topical dressings have been widely used as a treatment for infection in burns, open wounds, and chronic ulcer. Silver nanoparticles (AgNPs) are one of the most vital and fascinating nanomaterials among several metallic nanoparticles that are involved in biomedical applications. AgNPs play an important role in nanoscience and nanotechnology, particularly in nanomedicine. This study reports a facile, eco - friendly, reliable, and cost-effective synthesis of silver nanoparticles using Kaempferia galanga extract and their antibacterial activity. The biologically synthesized silver nanoparticles were characterized by UV-Visible spectroscopy, Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction pattern (XRD).***

Keywords: Silver nanoparticles, Nanotechnology, Kaempferia galanga, Antibacterial activity

1. Introduction

Nanotechnology is an important field of modern research dealing with design, synthesis, and manipulation of particle structures ranging from approximately 1-100 nm. The use of nanoparticles is gaining impetus in the present century as they possess defined chemical, optical and mechanical properties. Amazing physicochemical, optoelectronic, and biological properties can be found in noble metal nanoparticles. They are being used for various purposes in industrial and pharmaceutical applications. Health care, cosmetics, food and feed, environmental health, mechanics, optics, biomedical sciences, chemical industries, electronics, space industries, drug-gene delivery, energy science, optoelectronics, catalysis, single electron transistors, light emitters, nonlinear optical devices, and photo-electrochemical applications are just a few of the many fields in which nanoparticles (NPs) are used. Nanoparticles exhibit new or improved properties based on specific characteristics such as size, shape and orientation. The traditional methods for synthesizing nanoparticles mostly involve physical and chemical processes. Due to dangerous compounds adhering to their surface, chemically produced nanoparticles are not suitable for medical use. Furthermore, byproducts of chemical processes are hazardous to the environment. There are several limitations to physical methods of NP synthesis as well. These techniques are expensive and demand a lot of energy and space. An alternate method of making NPs involves the utilisation of biological systems such animal cell cultures, plants, viruses, and microbes. Biosynthesis of NPs is economical, time-efficient, and eco-friendly. More importantly, the biosynthesized NPs have no toxic substance on their surface. They may also be coated with bioorganic substances, making them suitable for medical applications. Due to these, biosynthesis of NPs has considerable advantages over traditional methods. For instance, NPs are employed as a novel tool for cancer therapeutic targeting, and the key challenge is toxicity of NPs manufactured by conventional techniques. Scientists overcome this issue by coating biologically produced NPs with biomolecules that are more biocompatible.

Metallic nanoparticles are the most promising of the nanoparticles because they have remarkable antibacterial characteristics due to their high surface area to volume ratio, which is of interest to researchers due to the increasing microbial resistance to metal ions, antibiotics, and the emergence of resistant strains. Among all the metal nanoparticles, silver nanoparticles have great importance due to their application in various fields. Due to its unique properties, silver nanoparticles are widely employed in catalysis, chemical sensing, biosensing, photonics, electronics, and medicines. Biological applications, such as antibacterial activity, for silver nanoparticles are quite promising. Due to their antimicrobial properties, silver nanoparticles can be used effectively in a variety of household products, including fabrics, food storage containers, home appliances, and medical equipment. Silver is a potent antibacterial agent with low toxicity. The medical industry, such as tropical ointments to prevent infection against burn and open wounds, is where silver and silver nanoparticles are used most frequently. Because of their appealing physiochemical properties, silver nanoparticles serve an important role in biology and medicine. Silver compounds have long been known to have significant inhibitory and bactericidal properties, as well as a broad spectrum of antimicrobial activity, and have been used for centuries to prevent and cure many ailments, most notably infections. Silver nanoparticles have been found to have antifungal, anti-inflammatory, antiviral, antiangiogenesis, and antiplatelet activity.

Antibacterial activity of the silver containing materials is used in medicine to reduce infections in burn treatment and arthroplasty, as well as prevent bacteria colonization on prostheses, catheters, vascular grafts, dental materials, stainless steel materials, and human skin. Researchers

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predicts that bio – reduction of metal compounds by plants is due to the presence of phytochemicals. Water soluble phytochemicals such as polyphenols, flavonoids, organic acids and quinones are responsible for immediate reduction.

2. Experimental Part

2.1 Preparation of Extract of Kaempferia Galanga

About 65 g of rhizomes of *Kaempferia Galanga* is washed and cleaned properly out of mud and soil. It is chopped into small pieces and taken in a vessel and then boiled in about 400 ml of water for about 1 hour till the solution turns into pale brown color indicating that the essence of the aromatic ginger is dissolved in water. The solution is left to cool and then filtered properly used filter paper and funnel. The filtrate is the required extract and is stored in a bottle which is to be stored in cold.

2.2 Preparation of Silver Nanoparticles

100 ml of the above prepared extract was challenged against 100 ml of 100 mM $AgNO_3$ solution and warmed enough. The synthesis of silver nanoparticles was indicated by development of its characteristic brown colour. Treatment of acetone to silver colloids leads to precipitation of silver nanoparticles. The obtained precipitate is filtered carefully using a Whatmann no. 1 filter paper and later dried in air oven.

3. Results and Discussion

Characterization of AgNPs is important in order to evaluate the functional aspects of the synthesized particles. Characterization is performed using a variety of analytical techniques, including UV-vis spectroscopy, X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM).

3.1 UV-visible spectral analysis

The absorbance spectra of sample were measured in wavelength within the range from 200-900 nm using a UV-Vis UVD-3500 spectrophotometer. Reduction of silver ions into silver nanoparticles during exposure of plant extracts was observed as a result of the colour change. The colour change is due to Surface Plasmon Resonance. In the UV-Visible region of the electromagnetic spectrum, molecules undergo electronic transitions. It is based on the principle that molecules containing π electrons or nonbonding electrons can absorb the energy in the form UV or Visible light to excite these electrons to higher antibonding molecular orbital. The more easily excited the electrons (i.e., lower energy gap between HOMO and LUMO), the longer wavelength of light it can absorb. The sharp bands of silver nanoparticles were observed around 420 nm. It is accounted with the presence of loosely bound conduction electron present in AgNPs. From different literatures it was found that silver nanoparticles show peak around 420 nm. So we confirmed that *Kaempferia galanga* has more potential to convert silver ions into silver nanoparticles.

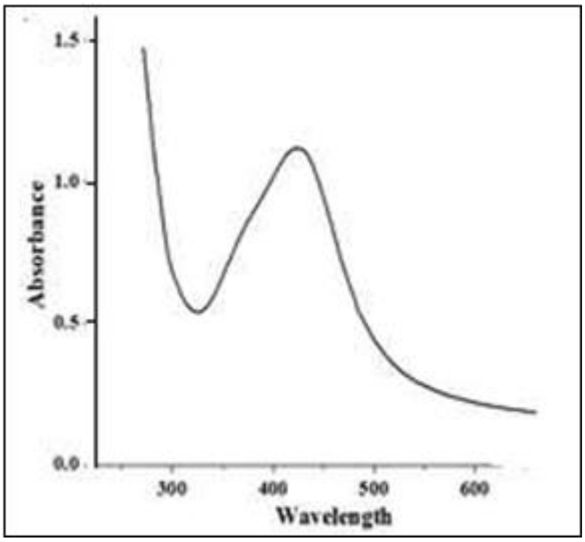

Figure 1: UV spectrum of AgNPs prepared using plant extract

3.2. Infrared spectroscopy

FTIR measurements were carried out to identify the possible biomolecules responsible for the capping and efficient stabilization of the silver nanoparticles synthesized by the plant extracts. Peak at 3309 cm-1 and 1601 cm-1 corresponds to N–H stretching and bending vibrations, respectively in amines from proteins of plants. The two bands observed at 1223 and 1075 $cm{-1}$ can be assigned to C-N stretching vibrations of the aromatic and aliphatic amines respectively. These observations indicate the presence and binding of proteins with silver nanoparticles which can lead to their possible stabilization. 655.75 cm−1 assigned to C–H alkenes stretch. Peak at 537 cm–1 is attributed to OH group of phenols.

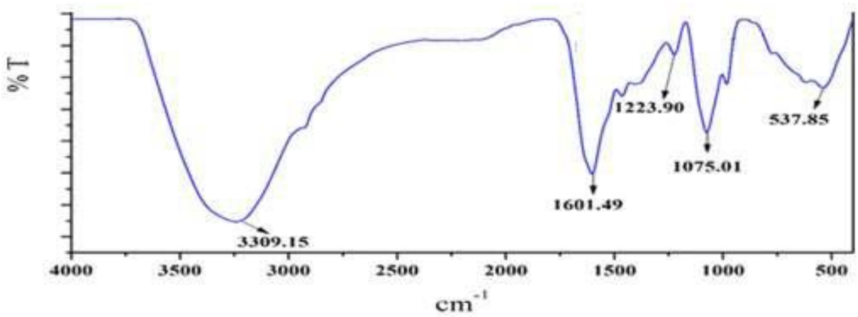

Figure 2: IR spectra of silver nanoparticles synthesized using plant extract

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3.3. XRD analysis

Analysis of structure and crystalline size of the synthesized silver nanoparticles were carried out by XRD. The XRD analysis of synthesized silver nanoparticles showed diffraction peaks at 32.5°, 36.3°, 44.4°, 64.6°, and 76.8°. When compared with the standard, the obtained XRD spectrum confirmed that the synthesized silver nanoparticles were in nanocrystal form and crystalline in nature. The peaks can be assigned to the planes (122), (111), (200), (220), and (311) faces of silver crystal, respectively. The high peaks in the XRD analysis indicated the active silver composition with the indexing. This indicates that the silver nanoparticles are face centred, cubic, and crystalline in nature (correlated to JCPDS card: number 04-0783).

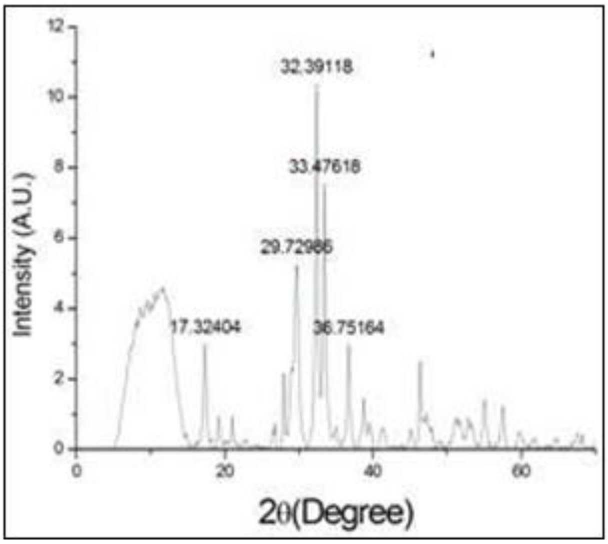

Figure 3: XRD patterns of AgNPs prepared using plant extract

Antibacterial Activity

Silver nanoparticles have been widely used in health, medicine, and environmental applications. In this study, extract of *Kaempferia Galanga* mediated synthesized silver nanoparticles were examined for possible antibacterial activity. The synthesized silver nanoparticles were tested for antibacterial activity against both Gram's positive (*Baciilus cereus* and *Staphylococcus aureus*) and Gram's negative (*Escherichia coli and Shigella flexneri*) bacteria. Figure 4 and 5 show the results of antibacterial activities of synthesized silver nanoparticles evaluated from the well diffusion method. The synthesized silver nanoparticles tested for antibacterial activity showed inhibition zones against the studied bacteria. Maximum zone of inhibition 11 mm was produced against *Staphyiococcus aureus*. The least zone of inhibition was observed in *Baciilus cereus* species. This may be due to the variation in the cell wall composition between bacteria. The silver nanoparticles showed antibacterial activity due to their large surface area that provides better contact with cell wall of bacteria. Several similar results were obtained in previous studies.

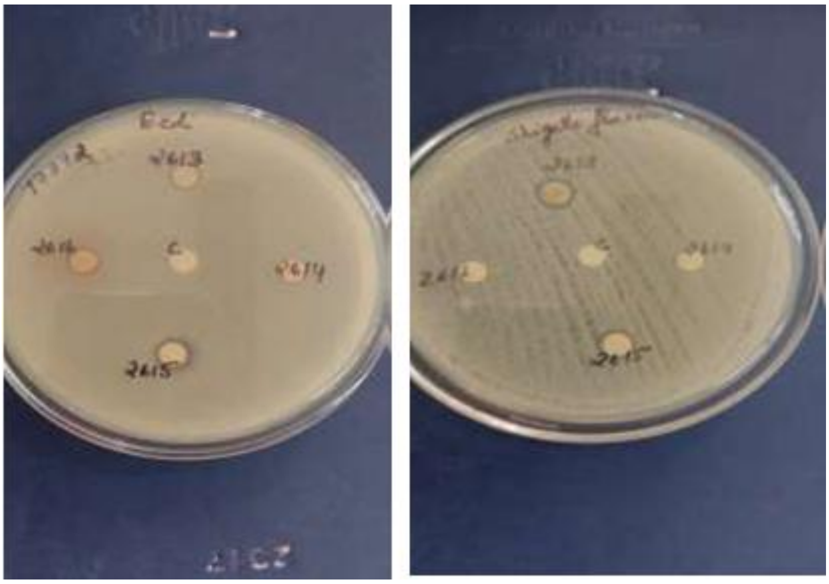
Figure 4: Photographic images of sample 1 and 2

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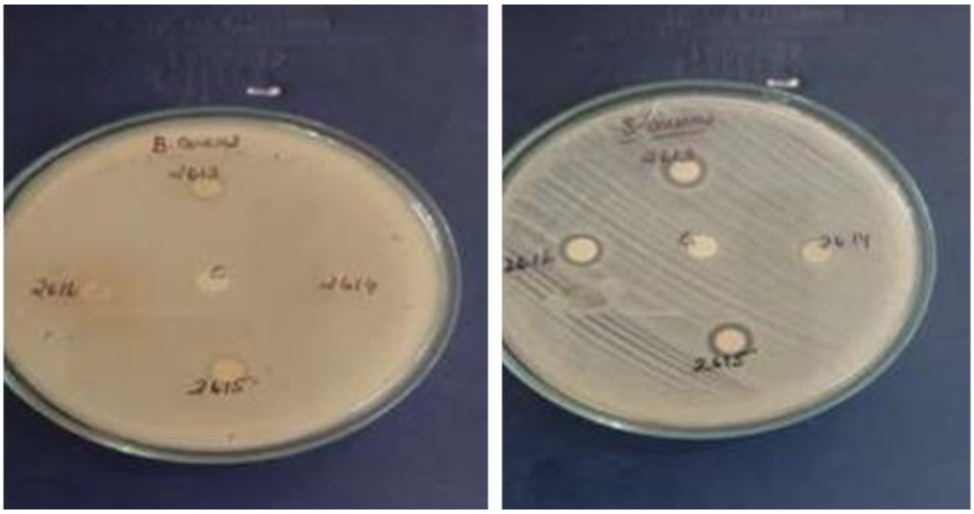

Figure 5: Photographic images of sample 3 and 4

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