

Green Synthesis of Silver Nano Particles From Carica Papaya Plant Leaf Extract and their Antimicrobial Activity

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Abstract: *Green synthetic methodology is now days emerged as most profound strategy in synthetic chemistry as it is environment friendly. Nano technology is not exception to that as it involves synthesis of various Nano-materials by using biological extract and their applications in various fields. Among the several metal nanoparticles, due to their distinct properties like chemical stability, favorable electronic conductivity and catalytic activity, Silver nanoparticles have attracted special attention. The present work explores the simple and green method for the synthesis of silver nanoparticles (Ag-NPs). To become free from toxic chemical components, Synthesis involves use of leaf extract of Carica papaya, prepared in water as green solvent and the physicochemical properties of prepared nanoparticles were studied using several characterization techniques involving UV-Visible, and FTIR Spectroscopy. The highest peak of absorption at 428 nm in Uv-Visible spectra clearly supports the formation of Ag-NPs. The FT-IR analysis shows different peakswchich clearly indicates presence of the polyphenolic and alcoholic functional groups in carica papaya leaf extract which acts as capping and stabilizing agents on the surface of synthesized Ag-NPs. Face-centered-cubic (FCC) structure of crystalline silver nanoparticles was determined from XRD analysis. In addition to that the antimicrobial activity was evaluated against pathogenic bacteria Staphylococcus aureus and Escherichia coli. The results revealed that synthesized nanoparticles exhibits prominent biological activity. The present study provides cost effective, better green approach having capability of supporting large scale synthesis of silver nanoparticles, free from toxic chemicals which can be used for medicinal purpose as antimicrobial agents.*

Keywords: Nanoparticles, Caricapapaya plant, Leafextract, Reducing agent, Biological activity

I. INTRODUCTION

In last few decades a new synthetic strategy has been developed and emerged as promising, sustainable method called as nanotechnology, which is found to be fastest growing branch of science and technology[1-3]. There is large difference in the properties in macro and micro molecules of same substance, which leads to create scientific interest about the nanoparticles. Nanostructured (1-100 nm in size) materials of metals and non-metals have been prepared and are differ in their structure, material and size[4-5]. Due to the smaller size they have larger surface area to volume ratio, which significantly improves their physical, chemical and biological properties including thermal conductivity, catalytic reactivity, chemical stability etc.[6-7]. Because of their simpler synthetic strategies and versatility, metal nanoparticles are one of the most researched type of nanoparticles and are used in both industry and medicine. Most



commonly they are used for the purpose of biosensors, DNA analysis, solar energy, drug delivery and in cancer therapy[8-13]. As per the requirement and specific use of nanomaterials, different researchers adopted different synthetic methods but synthesis by using plant extract is most adopted method [14-17]. Silver nanoparticles (Ag-NPs) are one of the widely used nanoparticles in last few decades. There are several synthetic approaches like chemical, physical and biological and synthesizes variety of nanoparticles with their own specialty. In case of chemical synthetic approach though it requires short reaction time for the synthesis of large scale nanoparticles, chemicals used for the synthesis are toxic and leads to generate non ecofriendly by-products. Also for the size stabilization capping agents are required which are again toxic chemicals. To compensate such drawbacks physical and chemical methods of synthesis are increasingly replaced by eco-friendly green methods which overcomes the difficulties like low yields, high energy consumption, long tedious procedure, requirements of sophisticated equipment's and production of hazards chemical substances as by-product as in case of chemical and physical synthetic methods.

On the other side, alternative green synthesis of silver nanoparticles follows biological process involving plant extracts, waste products, enzymes, molds, yeast etc. synthesis of nanoparticles using plant-mediated green approach is a simple, reliable, fast, economical as well as environmentally friendly single step method [18-20]. The phytochemicals present in plant extract are capable of significantly reducing environmental contamination and has the capability to adsorb, hyper-accumulate and degrade certain inorganic metallic ions from their surroundings. Such type of green methods involves the mixing of silver nitrate solution with reducing substances extracted from plants parts like roots, leaves, bark, stem, latex and seeds. The phytochemicals present in plant extract acts as alternatives to chemical reducing, stabilizing and capping agents[21-22]. Previously reported silver nanoparticles were used in biology, medicine, engineering and found to be inhibiting the growth and activities of both gram positive and gram negative bacteria[23-28]. In this context, we also screened our synthesized silver nanoparticles for their antimicrobial activity.

II. EXPERIMENTAL SECTION

2.1 Materials

The silver nitrate required for this experiment was purchased from Sigma-Aldrich and used as received without any further purification.

2.2 Preparation of Carica Papaya plant leaf extract:

The plant leaves of Carica Papaya were collected from local field. The leaves first washed, dried the at room temperature. By weighting, 20 g of Carica Papaya plant leaves were crushed into a fine powder, and it was mixed with 100 ml sterile distilled water in a beaker. The solution was then boiled for 30 min. at 80⁰ C and kept overnight at room temperature in order to extract the phytochemicals (reducing agent) present in the leaves into the water. Finally, the solution was filtered through Whatman filter paper No. 1 to collect the fresh plant leaf extract. The extract was then stored in refrigerator at ice cold condition and used further for the synthesis of silver nanoparticles.

2.3 Synthesis of Silver nanoparticles (Ag-NPs):

For the synthesis of silver nanoparticles (Ag-NPs), 50 mL, solution of silver nitrate (0.01M in water) was taken in 250 ml beaker and 50 mL of plant leaf extract was added to this solution. The mixture was then stirred at 60°C for 30 min on magnetic stirrer equipped with hot plate. Initial green color of silver nitrate solution changes to dark brown colored precipitate (due to reduction of silver ions by reducing agent present in extract), clearly indicates the formation of silver nanoparticles. The precipitate was then filtered and washed repeatedly with deionized water followed by ethanol to remove the impurities in the final product which was then dried at 60 °C in vacuum oven for overnight.

After synthetic confirmation by various analytical techniques, the synthesized nanoparticles then used for their catalytic applications. The method of preparation of Ag NPs represented in **Figure 1**.



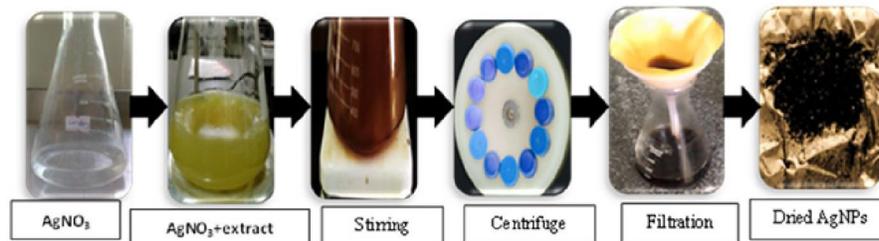


Figure 1: Ag-NPs synthesis from silver nitrate solution and plant extract.

2.4 Characterization of Ag-NPs:

The physicochemical properties of Bio catalytically synthesized silver nanoparticles were determined by using various analytical techniques. The UV-Vis absorbance spectra was measured using A Shimadzu double beam UV-visible spectrophotometer in the range of 250–800 nm. The FTIR performed recorded using Lambada 7600 PC with wavelength range between 4000 cm^{-1} to 400 cm^{-1} . X-ray diffraction (XRD) measurement was performed using Bruker Ltd Germany, D2 Phaser X-ray diffractometer instruments.

2.5. Biological activity:

The well-diffusion method was utilized to confirm the bioactivity analysis of Ag-NPS against two bacterial strains, *Staphylococcus aureus* and *Escherichia coli*. Microorganisms were cultured overnight on nutrient agar plates. A sterile glass spreader was used to dispense 100 μL of microbial suspension. Subsequently, Ag-NPs 50mg/ml was prepared and used further for antibacterial studies. The plates were incubated for one day at 30 °C for the bacterial strains. The DMSO is used as negative control. The inhibitory zones in millimeters on the agar surface surrounding the well was used to calculate the antimicrobial response. The inhibition zone by Ag-NPs was compared with conventional antibioticskanamycin.

III. RESULT AND DISCUSSION

The various plant parts such as leaves, roots, latex, bark, stem, and seeds have been considered the best candidates for the synthesis of Ag-NPs. This is due to the presence of phytochemicals like proteins, alkaloids, starch, tannins, sterols, etc. in its extract, which acts like stabilization, capping or reducing agents. In addition to that also these phytochemicals exhibit various biological activities. As a result, for more exploration of therapeutic and catalytic applications of plant extract, we synthesized silver nanoparticles, studied for their antimicrobial applications against *Staphylococcus aureus* and *Escherichia coli*.

3.1. Characterization of silver Nanoparticles:-

3.1.1. UV-Visible Spectroscopy

The biosynthesized silver nanoparticles (Ag-NPs) were isolated by filtration followed by repetitive washing with deionized water to remove the impurities. Finally, the oven dried (at 60 °C overnight) silver nanoparticles shown absorption peak at 428 nm clearly supports the formation of Silver nanoparticles. A UV-Visible spectrophotometer was used to characterize the silver nanoparticles.

3.1.2. FTIR analysis

The functional groups present on the surface of the Ag-NPs derived from carica papaya leaf extract were determined by using FT-IR technique and the observed peaks at $3300\text{-}3500\text{ cm}^{-1}$ (O-H stretch in alcohols and phenols), $1600\text{-}1650\text{ cm}^{-1}$ (C=C stretch in flavonoids, proteins) and $1000\text{-}1050\text{ cm}^{-1}$ (C-O stretch in carbohydrates and alcohols) clearly indicates that the biomolecules present in carica papaya leaf extract acts as reducing agents or capping agents and also acts as stabilizing (binding) agents on the surface of synthesized silver nanoparticles.



3.1.3 X-ray Diffraction (XRD):

XRD analysis of silver nanoparticles from Carica Papaya leaf extract typically shows peaks (patterns) at 2θ values approximately at 38.57° , 40.40° , 64.87° , 77.70° corresponding to (111), (200), (220), and (311) planes which indicates face-centered-cubic (FCC) structure of crystalline silver nanoparticles and supports the successful green synthesis. The XRD data were compared with the pure crystalline structure database of the JCPDS (JCPDS card number, 04-0783). The diffraction peak at 38.57° had a robust diffraction intensity indicating the preferential orientation of Ag crystal along the (111) plane. The other peaks shown in the figure might be due to metabolites of carica papayathat were still attached to the surface of silver nanoparticles. The XRD graph of Ag-NPS shown in **Figure 2**.

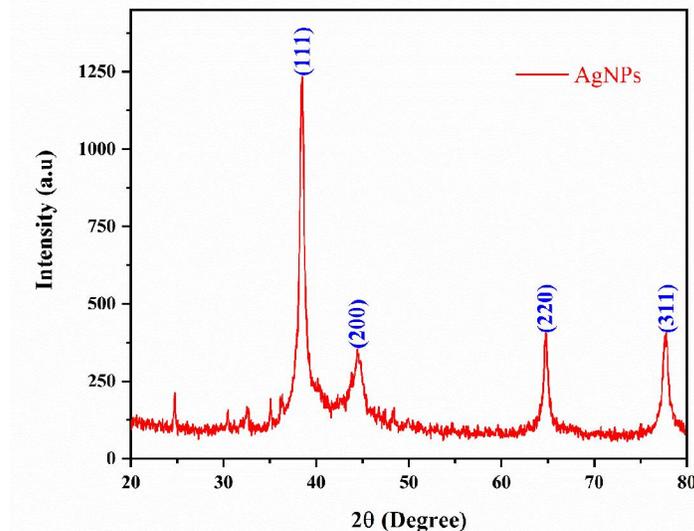


Figure 2 – Characterization of Silver nanoparticles (Ag-NPs) by XRD.

3.2. Biological Activity:-

The antibacterial activity of these Ag-nanoparticles was investigated against *Staphylococcus aureus* and *Escherichia coli* using the well diffusion method. The diameter of inhibition zones (in millimeters) around the different antibiotic disks with or without Ag-NPs against test strains are shown in **Table 1**. The effects of Ag-NPs on the antibacterial activity of the aforementioned antibiotics for *E. coli* were lower than *S. aureus*.

Compounds	Inhibition zone (in mm)	
	Gram +ve (<i>Staphylococcus aureus</i>)	Gram -ve (<i>Escherichia coli</i>)
1. Ag NPs	12	11
2. Kanamycin	21	20

Table-1. Bioactivity information of synthesized compounds (1-4) and Reference Compounds

IV. CONCLUSION

The biological synthesis of silver nanoparticles using leaf extract of carica papaya is a simple, eco-friendly, cost effective, and rapid method. Instead of toxic, harmful chemical reducing or capping agents, use of aqueous plant extracts as stabilizing agent is a green protocol. The structure of Ag-NPs was validated by using different validation techniques to describe its physico-chemical properties. In addition, the antibacterial activity of carica papaya leaf extract mediated Ag-NPs was screened by using well diffusion method. The maximum zone of inhibition was observed against *S. aureus*. The results conclude that the Ag-NPs have excellent biocompatibility and broad-spectrum antibacterial activity against selected bacteria. The synthesis of bio-catalyzed silver nanoparticles is still in its infancy



and to explore the synthetic routes and their applications, more research needs to be focused on the mechanism of nanoparticle formation, targeting the specified applications, which may lead to designing of the process ultimately leading to the synthesis of nanoparticles with a strict control over the size and shape parameters.

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