An eco-friendly synthesis of silver nanoparticles from *Jatropha curcas*, its characterization and antioxidant studies

J.Jeyapratha[1], *A.Eppi Queens[1], P.Rajeshwari[1]

[1]Department of Chemistry, Kamaraj College,Thoothukudi, Affiliated to Manonmaniam Sundaranar University, Tirunelveli.

Abstract

The purpose of this study is to minimize the negative impacts of synthetic procedures and to develop an environmentally benign procedures for the synthesis of metallic nanoparticles. In this article an eco-friendly synthesis of silver nanoparticles from *Jatropha curcas* was described. This synthesis was performed using the leaf extract of the plant *Jatropha curcas* using silver nitrate solution. The synthesized silver nanoparticles was further subjected to various studies like UV-Vis spectroscopy, IR spectra, AFM and antioxidant studies. UV-Vis spectroscopy showed the SPR peaks for AgNPs was at 440nm using *Jatropha curcas* leaves extract. IR spectral study confirmed the presence of various functional groups in the leaves extract. Surface morphology and surface roughness were studied using atomic force microscopy. Later the antioxidant activity was performed by the phosphomolybdenum method, and the leaf extract of *Jatropha curcas* was found to possess significant antioxidant activity. Thus this study revealed that biosynthesized silver nanoparticles using *Jatropha curcas* was found to be very effective as antioxidant agent.

Keywords : *Jatropha curcas*, AgNPs, UV, IR, AFM, Antioxidant

Introduction:

In recent years, nanoparticles have received particular attention for its positive impact in improving many sectors of the economy, including consumer products, energy, transportation, cosmetics, pharmaceuticals, antimicrobial agents and agriculture. The chemical methods have a low productivity, are non eco-friendly, capital intensive and toxic. However, the need for toxic solvents and the contamination from chemicals used in nanoparticle production limit their potential use in biomedical applications. The importance of biological synthesis of nanoparticles is being emphasized globally. Green chemistry is the implementation, development, design of chemical products and processes to minimize the use of subtances that are hazardous to the environment. This green synthesis method has several advantages over other methods namely cost effectiveness, simplicity, use of less temperature, the usage of less toxic materials; moreover, it is compatible for medical and food applications. Many researchers use green synthesis methods for different metal nanoparticles due to the growing need for their eco-friendly.

Among the studied nanoparticles, silver being the efficient antimicrobial agent, is attracting the researchers to design and develop the ways for its proper delivery and efficient action.

Microbes or plants can be employed for the green synthesis. However, due to various hurdles associated with the maintenance of pure microbial cultures, plants are considered as the best candidates for synthesis of AgNPs. Recent studies have highlighted the antibacterial activity of plant based AgNps against broad range of Gram-positive and Gram-negative bacteria . Although the actual mechanism of AgNps functioning is not yet clear, researchers believe that AgNps interact with thiol group of bacterial proteins and phosphorous moieties of DNA to inactivate the bacterial cell system. It was also reported that nano-silver is non-toxic to humans at low doses. Thereafter, few attempts were made to develop AgNps coated systems, especially for food preservation against lethal food borne pathogens. The developed nano-silver based food packaging was found to be effective against Escherichia coli. Therefore, green routes for AgNps synthesis and subsequent development of such systems is the need of the hour.

Methods and Materials:

Collection and preparation of extract:

Disease-free, healthy leaves of *Jatropha curcas* were collected from the rural areas of Thoothukudi district. The collected leaves were washed thoroughly with tap water and then washed well with distilled water. 20 gms of *Jatropha curcas* leaves were taken and mixed with 100 mL of distilled water in a beaker and made to boil for about 10minutes. The extract was then cooled and filtered using whatmann filter paper and stored for future use.

Bio-Synthesis of Silver Nanoparticles from the *Jatropha curcas*

About 5mL of the leaf extract was added to 0.01M silver nitrate solution for the reduction of silver ions in a Erlenmeyer flask. The reaction mixture was kept in dark room until the colour changes. The brownish-yellow colour solution indicated the formation of silver nanoparticles. The silver nanoparticles was monitored through the UV-Visible spectroscopy (200nm-900nm), the structure and components were monitored by FTIR spectroscopy. Surface morphology and surface roughness were monitored by AFM studies. Finally the antioxidant potentiality was studied by phosphomolybdenum method.

Characterization

1. UV-Spectrophotometer analysis

The synthesized silver Nanoparticles were characterized by JASCO variant 630 spectrometer within a range of wavelength 200-900nm.

2. Fourier Transform Infra-red Spectroscopy (FTIR)

The silver nanoparticles were analysed by for the detection of different functional groups using Thermo scientific Nicolet iS5ATR-iD1 Spectrometer.The FTIR was recorded in the range of 400–4000 cm^{-1}.

Phytochemical screening:

The preliminary phytochemical screening tests were carried out to identify the leaves constituents by standard methods.

AFM Analysis:

Further to analyze the surface morphology and surface roughness was studied using Nanoeasy scan 2 AFM (BT02218).

Antioxidant studies:

The total antioxidant capacity (TAC) of *Jatropha curcas* leaf extract was spectrophotometrically determined by the phosphomolybdenum assay method.

Results and Discussion:

UV-Visible spectroscopy:

It is well known that AgNPs exhibit a reddish brown colour in aqueous solution due to excitation of surface plasmon vibrations. Reduction of silver ions to AgNPs could be followed by a colour change from pale brown to reddish brown and which was noted by visual inspection.

The UV/Vis spectrum of AgNPs showed a surface plasmon absorption band with maximum absorbance at 440 nm (fig. 1) indicating the presence of stable and well dispersed AgNPs. Surface plasmon resonances are clearly featured in the optical spectra and were located in visible region. Since the intensity of the plasmon resonance band depends on particle size, shape, metallic material and its surrounding environment.

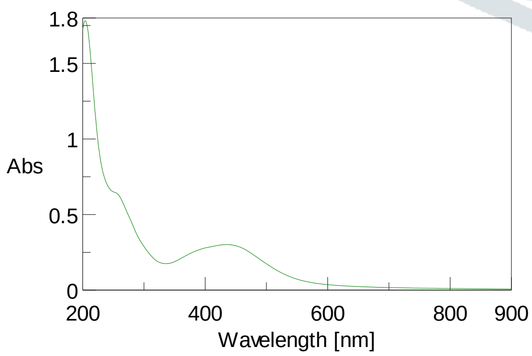

Figure :1 UV-Vis spectrum of AgNPs

FTIR spectroscopy:

The aim of the FTIR analysis was to check the existence of functional groups. The FTIR analysis (fig :2) showed different stretches of bond as follows: It exhibits intense absorption peaks at 3346.70 cm−1 corresponding to N–H stretching of primary amine. The weak band observed at 2112.74 cm−1 indicates the H–C–H symmetric stretching of alkanes. The intense peak at 1638.73 cm^{-1} may be due to the presence of alkenes.The peaks at 1335.36 cm^{-1} was due to terminal CH_3 group.

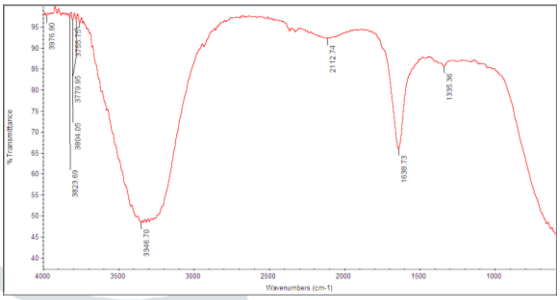

Figure: 2 FTIR spectrum of AgNPs

Phytochemical screening:

The phytochemical active compounds of *Jatropha curcas* were qualitatively analysed and the results were mentioned in Table 1.

Table:1 Qualitative Phytochemical screening of *Jatropha curcas* flower extract

S.No.	Phytochemicals	*Jatropha curcas* leaf extract
1	Flavanoids	Detected
2	Phenols	Detected
3	Saponins	Detected
4	Tannins	Detected
5	Alkaloids	Detected
6	Phytate	Detected
7	Steroids	Not detected
8	Carbohydrates	Not detected
9	Oils & Resins	Not detected

AFM studies

Topography of the silver nano particles synthesized from *Jatropha curcas* leaf extract were given in the Fig.2

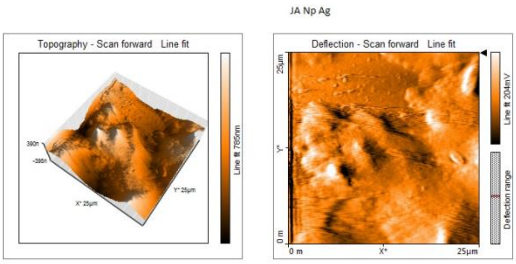

Figure :3 Topography of AgNPs

Surface morphology was measured using an AFM and are shown in figure 3. The silver nanoparticles showed a smoother and porous surface. The average surface roughness was found to be 32.483nm.

Total Antioxidant Capacity:

Table:2 Total antioxidant capacity

Sample	Concentration µg/ml	OD at 695 nm	TAA mg/g equivalents of ascorbic acid
Standard Ascorbic acid	200	0.050	
	400	0.350	
	600	0.380	
	800	0.630	
	1000	0.740	
Jatropha curcas	200	0.600	8
	400	1.040	27.733
	600	1.480	59.200
	800	1.690	90.128
	1000	2.000	133.333

The total antioxidant capacity of the leaf extract was shown above (Table:2). The leaf extract possessed greater antioxidant potential .

Conclusions:

The biological reduction of metals by plant extracts has been known since the early 1900s; However, the reduction products were not studied. The synthesis of silver nano particles is still in its infancy and more research needs to be focused on the mechanism of nanoparticle formation which may lead to fine tuning of the process ultimately leading to the synthesis of nanoparticles with a strict control over the size and shape parameters. The UV absorption peak at 440nm clearly indicates the synthesis of AgNPs. FTIR studies confirmed the biofabrication of the AgNPs by the action of different phytochemicals with its different functional groups present in the extract solution. The AFM studies were helpful at deciphering their morphology and surface roughness. The total antioxidant capacity revealed a high antioxidant value for the leaves *Jatropha curcas*.

References:

1. J. Das, M. Paul Das, and P. Velusamy, Spectrochimica Acta—Part A: Molecular and Biomolecular Spectroscopy 104, 265 (2013).
2. R. M. Gengan, K. Anand, A. Phulukdaree, and A. Chuturgoon, Colloids and Surfaces B: Biointerfaces 105, 87 (2013).
3. M. Klekokto, K. Matczyszyn, J. Siednienko, J. Olesiak-Banska, K. Pawlikb, and M. Samoca, Physical Chemistry Chemical Physics 17,1 (2015).
4. R. Hamid, Y. Rotshteyn, L. Rabadi, R. Parikh, and P. Bullock, Toxicology In Vitro 18, 703 (2004).
5. Narayanan, R., and E1-Sayed., (2003) M.A. Journal of the American Chemical Society., 125:8340.
6. Khan, H., M.A. Khan, and T.Mahmood. (2008) Antimicrobial activities of *Gloriosa superba Linn* extracts. *Journal of Enzyme Inhibition and Medicinal Chemistry* 6: 855-859.
7. Vasudev, D., Kulkarni, Pramod, S., Kulkarni. (2013).Green Synthesis of Copper Nanoparticle Using Ocimum Sanctum Leaf Extract. *InternationalJournal of Chemical Studies*,1(3):2321-4902.

8. Akl M Awwad1, Nidà M. Green Synthesis of Silver Nanoparticles by Mulberry Leaves Extract Nanoscience and Nanotechnology. 2012; 2(4): 125-128.
9. P.K. Khanna P.K, Gaikwad. S, Adhyapak P.V, Singh N, Marimuthu R. Synthesis and characterization of copper nanoparticles: Materials Letters 61 2007; 4711–4714.
10. Mallikarjunaa K, Narasimhab G, Dillipa GR, Praveenb B, Shreedharc B, Sree Lakshmic C et al. Green Synthesis of Silver Nanoparticles Using *Ocimum*Leaf Extract and Their Characterization.Digest.J.Nanomat.Biostruct. 2011; 6(1): 181–186.
11. Mosmann T, Rapid colorimetric assay for cellular growth and survival:application to proliferation and cytotoxicity assays, J of Immunological Methods 1983;65:55-63.
12. Jeong S.H., Yeo S.Y., Yi S.C., The effect of filler particle size on the antibacterial properties of compounded polymer/ silver fibers, J. Mat.Sci, 2005, 40, 5407-5411.
13. Lopez-Alarcon, C.; Denicola, A. Evaluating the antioxidant capacity of natural products: A review on chemical and cellular-based assays. Anal. Chim. Acta 2013, 763, 1–10.
14. Cekic, D.; Cetinkaya, A.; Avan, A.; Apak, R. Correlation of total antioxidant capacity with reactive oxygen species (ROS) consumption measured by oxidative conversion. J. Agric. Food Chem. 2013, 61, 5260–5270.
15. C. Vidya et al., Green Synthesis of Zinc Oxide Nanoparticles by *Calotropis gigantea,* Int. J. Curr. Eng. Tech., 118-120 (2013).