Research Article

Journal of Environmental Nanotechnology

# Fabrication and Characterization of Nickel Nanoparticles using *Calotropis gigantea* for Antimalarial Applications

S. Peer Mohamed*

Department of Zoology, Sadakathullah Appa College (Autonomous), Rahmath Nagar, Tirunelveli, TN, India

Received: 04.02.2023 Accepted: 15.02.2023 Published: 30-03-2023

*peerjamal38@gmail.com

## ABSTRACT

Malaria diagnosis using sophisticated methods is highly expensive and time-consuming. The development of sensitive, selective, robust, accurate, fast and low-cost clinical diagnosis techniques has been a major focus of researchers in recent years. In this work, nickel nanoparticles have been synthesized successfully using *Calotropis gigantea* leaf extract, by Co-precipitation method and then characterized by Scanning Electron Microscope (SEM), X-ray Diffraction (XRD), Energy Dispersive X-ray (EDX), Fourier transform infrared spectroscopy (FT-IR) and Ultraviolet-visible (UV-Vis.) spectroscopic techniques. FT-IR spectra showed a sharp peak at 699 $cm^{-1}$ and a broad peak ranging from 2500 - 3500 $cm^{-1}$ ensuring the construction of nickel nanoparticles. X-ray Diffraction pattern revealed a face-centered cubic structure. The SEM image has shown the spherical structure with a rough area. The results obtained were satisfactory in terms of antimalarial applications of the nickel nanoparticles.

**Keywords:** Ni nanoparticles; Malaria diagnosis; Detection technique; Antimalarial features.

## 1. INTRODUCTION

Medicinal plants are a local heritage with global importance playing a vital role in the world health care system of developing countries. *Calotropis procera* (Asclepiadaceae), a giant milkweed, is known for its pharmacological importance for centuries (Alencar *et al.* 2004). The coarse shrub is a very promising source of anti-cancerous, acaricidal, schizonticidal, anti-microbial, anthelmintic, insecticidal, anti-inflammatory, anti-diarrhoeal, larvicidal and many other beneficial properties. It is described as a golden gift for mankind as it contains calotropin, calotropagenin, calotoxin, calactin, uscharin, amyrin, amyrin esters, uscharidin, coroglaucigenin, frugoside, corotoxigenin, calotropagenin and voruscharine with many therapeutic applications (Arya and Kumar, 2004). Different compounds like norditerpenic esters, organic carbonates, cysteine, protease, procerain, alkaloids, flavonoids, (Basu and Chaudhuri, 1991) sterols and numerous cardenolides made this plant a scientific attraction for centuries. The plant is not only a great source of natural hydrocarbons; it also contains several metabolites used as a folk medicine for the treatment of leprosy, elephantiasis, fever, menorrhagia, malaria and snake bite (Bhaskar and Ajay, 2000).

Nature has provided plant wealth for all living creatures, which possesses medicinal virtues (Bhatti *et al.* 1998). Medicinal plants are important sources of drugs in the traditional system of medicine and are being used since the prehistoric period for the cure of various diseases. Since these are in common use by the local people and are of great importance that is why a lot of people are engaged in the trade of important medicinal herbs throughout the world (Chatterjee and Chandra, 1995). Especially, people living in villages have been using indigenous plants as medicines based on life-long experiences; besides, the villages are far away from cities and mostly lack proper health facilities (Elisabetsky and Castilhos, 1990).

Metal nanoparticle-based formulations have wide-spectrum applications in the biomedical area due to their exceptional physicochemical properties. The nanostructures have promising plasmodial efficacies and proved to be the right choice for treating malaria.

## 2. MATERIALS AND METHODS

### 2.1. Materials

Nickel (II) Nitrate hexahydrate ($Ni(NO_3)_2 6H_2O$), Sodium borohydride ($NaBH_4$) and ethanol were purchased from Hi Media, India and were used without extra purification. All chemicals used in this examination were of analytical grade. Double distilled water was used throughout the investigation.

## 2.2. Collection of Extract

20 g of *Calotropis gigantea*, a giant milkweed, were collected from the local region. They were washed and cleaned with distilled water and dried with water-absorbent paper. Then they were crushed with mortar and pestle, soaked in water and dispensed in 100 ml of sterile distilled water and boiled for 5 minutes and then kept for 2-3 minutes. The extract was then filtered using Whatman's No.1 filter paper. The filtrate was collected in a clean and dried conical flask; the fresh extract thus obtained was used for the preparation of nickel nanoparticles (Ni-NPs).

## 2.3. Taxonomic Classification

| | |
|---|---|
| Kingdom | Plantae |
| Sub-kingdom | Tracheobionta |
| Super division | Spermatophyta |
| Division | Magnoliophyta |
| Class | Magnoliopsida |
| Order | Gentianales |
| Family | Asclepiadaceae |
| Genus | *Calotropis* |
| Species | *gigantea* |

### 2.3.1 Botanical Description

*Calotropis gigantea* Linn is an erect, tall, large, branched and perennial shrub that grows to a height of 5.4 m, with milky latex throughout the plant. The bark is soft and corky. Branches stout, terete with fine appressed cottony pubescence. Leaves are sub-sessile, opposite, decussate, elliptic or obovate, acute, thick, glaucous, green and covered with fine cottony pubescent hair on young but glabrous later and base cordate. Flowers are umbellate and tomentose when young and the calyx is glabrous, ovate and acute (Ghosh, 1998). Corolla is glabrous, lobes erect, ovate, acute, coronal scales 5-6, latterly compressed and equally exceeding the staminal column. Follicles are sub-globose or ellipsoid or ovoid. Seeds are broadly ovate, acute, flattened, minutely tomentose and brown-colored and silky coma is 3.2 cm long (Dewan *et al.* 2000).

**Fig. 1:** ***Calotropis Gigantea*** **images**

## 2.4. Synthesis of Ni-NPs

Ni-NPs were prepared by using Co-precipitation method. 50 ml of aqueous solution 0.5 mm of ($Ni(NO_3)_2 6H_2O$) and 50 ml of *Calotropis gigantea* extract was added and the reaction was kept constant by stirring for 3 h at room temperature; then, 1.5 g of sodium borohydride was added in portions with constant stirring till the temperature elevates to 50 °C and the precipitate was obtained after cooling to room temperature; the precipitate was obtained by centrifugation followed by water and ethanol washing, drying and calcinating the precipitate.

## 3. RESULT AND DISCUSSION

## 3.1. UV-Visible Spectroscopy

The optical property of Ni-NPs was recorded with respect to high purity, and its crystallinity was confirmed with the help of UV-DRS by observing an excitonic absorbance band at 300 nm with a tail extending towards a longer wavelength (Harne, 2012) due to their quantum size effects as shown in Fig. 2. The absorption peaks exhibit a broad peak due to the particle size. The stability of Ni-NPs can be attributed to symmetrical polarity structure which depends on the weak interaction of Van der Waals forces within the particle regime.

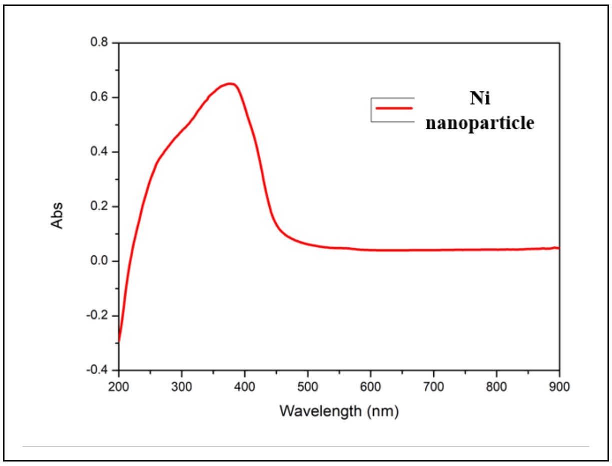


**Fig. 2: UV-Visible Absorption spectra of Ni-NPs**

### 3.2. FT-IR Spectroscopy

FT-IR absorption band in the range of 4000 - 400 $cm^{-1}$ are usually assigned to the vibration of ions in the crystal lattice, recorded using K-Br disc method. The FT-IR spectra of Ni-NPs (Fig. 3) reveals a peak at 669 $cm^{-1}$ corresponding to vibration in Ni in the octahedral hole and 663.51 $cm^{-1}$ stretching vibrations in Ni in the tetrahedral hole; it shows the presence of single-phase face-centred cubic structured nanoparticles. Annealing at 500 °C for two hours leads to the change from amorphous to crystalline state with narrow particle size distribution with well-defined particle size, shape and phase purity (Mukherjee *et al.* 2010).

A stretching frequency at 3388 $cm^{-1}$ and a weak asymmetric band at 1443 $cm^{-1}$ support the presence of the OH- group due to the absorption of water by nanoparticles during sample preparation (Kumar and Arya, 2006). The two strong M-O stretching and bending frequencies at 663.51 $cm^{-1}$ and 570.93 $cm^{-1}$, respectively (Oudhia, 2001) support the presence of phase purity (monodispersed) in the face-centered cubic structure. A stretching frequency at 3788 $cm^{-1}$ was assigned to the presence of an amino group of proteins and a stretching frequency at 1788 $cm^{-1}$ was assigned to the presence of a carbonyl group of flavonoids and other biomolecules (Quaquebeke *et al.* 2012).

Fig. 3 shows the absorbance at 250-350 $cm^{-1}$ and 550-700 $cm^{-1}$; the first absorption was due to the Ni ligand to metal charge transfer and the band at 580 $cm^{-1}$ corresponds to Ni charge transfer. The cubic phase behaves as a p-type semiconductor.

### 3.3. XRD

The X-ray diffraction pattern of the synthesized Ni-NPs was analyzed to investigate the phase structure along with its crystallinity, as illustrated in Fig. 4. This shows a crystalline structure with 8 peaks. The XRD pattern shows a significant amount of line broadening, a characteristic of nanoparticles. The XRD pattern exhibits prominent peaks at 21.4, 23.26, 31.23. 35.1, 36.84, 44. 62 and 65.12°. The peaks positions appearing at 2θ = 19, 23.26, 31.23,,35.1, 36.84, 44.62 and 65.12° can be readily indexed as (111), (220), (311), (222), (220), (400) and (440) crystal planes. The peaks were indexed to pure phase with a face-centered cubic structure, which corresponds to JCPDS file (76–1802) after annealing the sample and by matching Bragg reflection peaks.

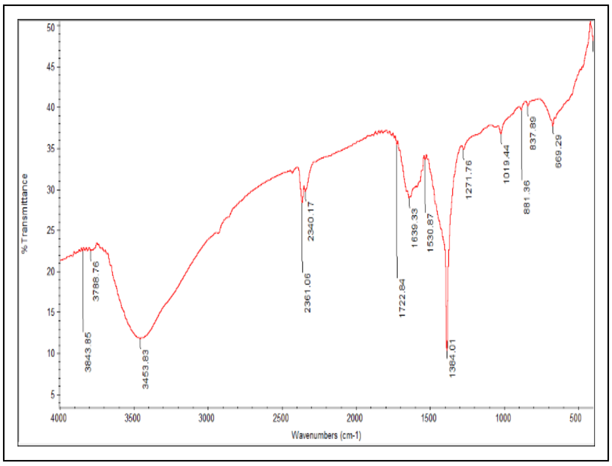


**Fig. 3: FT-IR spectra of Ni-NPs**

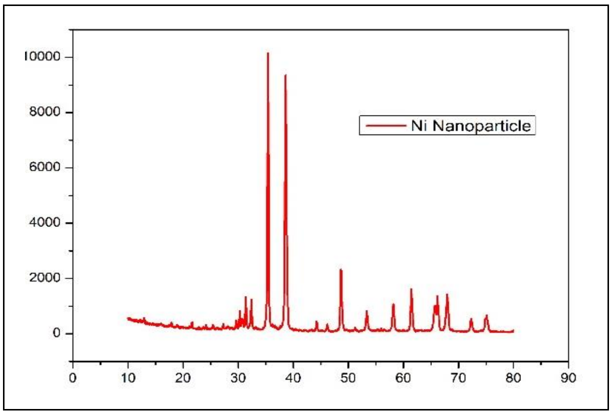


**Fig. 4: XRD patterns of Ni-NPs**

### 3.4. Morphological Studies

The surface morphological features of synthesized nanoparticles were studied by scanning electron microscope. Fig. 5 reveals the microcrystalline nature of the particle after calcination with the least degree of agglomeration. Particles seem to have an irregular shape with chemical homogeneity with uniform morphology due to the presence of inter-particle surface connectivity. It was observed that the annealing temperature increases the crystalline nature of the particle that changes due to nucleation. The Ni-NPs were like the needle-shaped petals of a flower. The microstructural characterization studies were used to determine the size of nanoparticles and examine the homogeneity and size distribution.

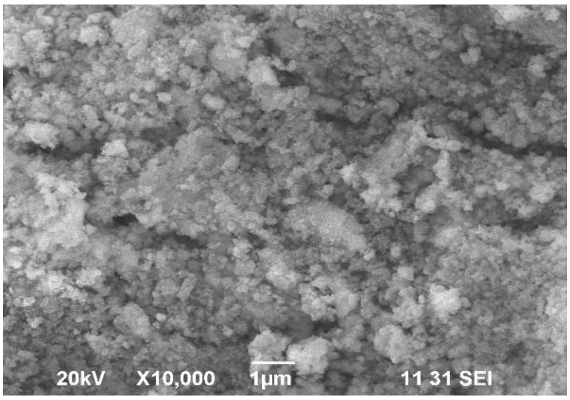


**Fig. 5: SEM images of Ni-NPs**

## 4. ANTIMALARIAL ACTIVITY

The ethanolic extracts of Nickel nanoparticles using the different parts of *Calotropis gigantea* showed antimalarial activity against *Plasmodium falciparum* (Ramos *et al.* 2012). These extracts deserve further study aimed at the identification of the active constituents. The results obtained support the ethnobotanical use of this plant (Sharma and Sharma, 2000). Schizonts are protozoan cells that divide by schizogony and *Calotropis gigantea* acts an agent (schizonticide) to kill these schizonts (Sameer, 2010). Good record keeping of subjective and objectively recorded cures by practitioners of the traditional medicinal system will help in the establishment of the use of *Calotropis gigantea* as an antimalarial plant. Researchers attempted to see the effect of crude fractions of its leaf against a chloroquine (CQ)-sensitive strain, MRC 20 and a chloroquine-resistant strain, MRC 76 of *Plasmodium falciparum* (Sangraula, 2002) using the Desjardins method; the effectiveness of its fractions were better with the CQ-sensitive strain than the CQ-resistant strain *in vitro*. The scientists evaluated the ethanol extracts of the plant leaves screened *in vitro* for schizonticide activity against CQ-sensitive and CQ-resistant *Plasmodium falciparum* strains (Saxena, 1979).

## 5. CONCLUSION

*Calotropis gigantea* has been used as traditional folk medicine by many countries and it has been the subject of wide phytochemical and bioactive investigations (Sharma and Sharma, 2000). It had shown significant pharmacological importance representing a strong contender in the medical area (Shinwari and Khan, 2000). In Ayurveda, *Calotropis gigantea* is described as Aakra and is widely used for its medicinal applications and therapeutic properties; it has its importance in Ayurvedic preparations due to its wide variety of pharmacological properties. Ayurvedic proactiveness recommends (Taylor, 2013) the use of the root and leaf of *Calotropis gigantea* in asthma and shortness of breath, and stem and bark in liver and spleen diseases (Ghosh, 1988). The plant is also effective in treating skin, digestive, respiratory, circulatory and neurological disorders and is used to treat fevers, elephantiasis, nausea, vomiting and diarrhoea (Upadhyay, 1979, Yelne *et al.* 2000). Hence, this plant is in need to a greater research emphasis for better utilization of this plant for the mankind.

## FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.



## REFERENCES

Alencar, N. M., Figueiredo, I. S., Vale, M. R., Bitencurt, F. S., Oliveira, J. S., Ribeiro, R. A., Ramos, M. V., Anti-inflammatory effect of the latex from Calotropis procera in three different experimental models: Peritonitis, paw edema and hemorrhagic cystitis, *Planta Med.*, 70(12), 1144-1449 (2004). https://doi.org/10.1055/s-2004-835842

Arya, S. and Kumar, V. L., Interleukin 1 beta inhibits paw edema induced by local administration of latex of Calotropis procera extracts, *Inflammopharmacology*, 12(4), 391-398 (2004). https://doi.org/10.1163/1568560043696254

Basu, A. and Chaudhuri, A. K. N., Preliminary studies on the anti-inflammatory and analgesic activities of Calotropis procera root extract, *J. Ethnopharmacol.*, 31(3), 319-324 (1991). https://doi.org/10.1016/0378-8741(91)90017-8

Bhaskar, V. H., and Ajay, S. S., Antimicrobial Activity of Calotropis procera Seeds. Asian journal of chemistry, 21(7), 5788-5790 (2000).

Bhatti, G. R., Qureshi, R. and Shah, M., Ethnobotany of Calotropis procera with especial reference to the people of Nara Desert, Scientific Sindh., 5, 13-22 (1998).

Chatterjee, A. and Chandra, P. S., The treatise of Indian medicinal plants, CSIR, Volume 4, 130 (1995).

Dewan S., Kumar, S. and kumar, V. L., Antipyretic effect of latex of Calotropis procera, *Indian J. Pharmacol.*, 32(3), 252-253 (2000).

Elisabetsky, E., Castilhos, Z. C., Plants used as analgesics by Amazonian cabocols, *Int. J. Crude Drug Res.*, 28(4), 309-320 (1990). https://doi.org/10.3109/13880209009082838

Ghosh, N. C., Comparative Materia Medica, *Calcutta: Hannemann Publ. Co. Pvt. Ltd*, (1988).

Harne, S., Sharma, A., Dhaygude, M., Joglekar, S., Kodam, K. and Hudlikar, M., Novel route for rapid biosynthesis of copper nanoparticles using aqueous extract of Calotropis procera L. latex and their cytotoxicity on tumor cells, *Colloids Surf B: Biointerfaces*, 95, 284-288 (2012). https://doi.org/10.1016/j.colsurfb.2012.03.005

Kumar, V. L. and Arya, S., Medicinal uses and pharmacological properties of Calotropis procera, *Recent Prog. in Med. Plants*, 373-388 (2006).

Mukherjee, B., Bose, S. and Dutta, S. K., Phytochemical and pharmacological investigation of fresh flower extract of Calotropis procera Linn, *Int. J. Pharm. Sci. Res.*, 1(2), 182-187 (2010). http://dx.doi.org/10.13040/IJPSR.0975-8232.1(12).182-87

Oudhia, P. C., Useful weed, society for panthenium management, Geeta nagar, India (2001).

Quaquebeke, V. E., Simon, G., Andre, A., Dewelle, J., Yazidi, M. E., Bruyneel, F., Jerome, T., Odile, N., Pierre, G., Christine, D., Jean-Claude, B., Robert, K., Francis, D., Identification of a novel cardenolide (2-oxovoruscharin) from Calotropis procera and the hemi-synthesis of novel derivatives displaying potent in vitro antitumor activities and high in vivo tolerance: Structure-activity relationship analyses, *J. Med. Chem.*, 48, 849-856 (2005). https://doi.org/10.1021/jm049405a

Ramos, M. V., Viana, C. A., Silva, A. F., Freitas, C. D., Figueiredo, I. S., Oliveira, R. S., Alencar, N. M., Lima-Filho, J. V., Kumar V. L., Proteins derived from latex of C. procera maintain coagulation homeostasis in septic mice and exhibit thrombin and plasmin-like activities, *Naunyn Schmiedebergs Arch Pharmacol.*, 385(5), 455-463 (2012). https://doi.org/10.1007/s00210-012-0733-3

Sameer, H. Q. M., DNA-RAPD Fingerprinting and Cytogenetic Screening of Genotoxic and Antigenotoxic Effects of Aqueous Extracts of Costus Speciosus (Koen.), *JKAU: Sci.*, 22(1), 133-152 (2010).

Sangraula, H., Dewan, S., Kumar, V. L., Evaluation of the anti-inflammatory activity of latex of Calotropis procera in different models of inflammation, *Inflammopharmacology*, 9, 257-64 (2002).

Saxena, V. K. and Saxena, Y. P., Isolation and study of triterpenoids from Calotropis procera, *J. Res. Indian Med. Yoga Homeopathy.*, 14, 152-154 (1979).

Sharma, P. and Sharma, J. D., In-vitro Schizontocidal screening of Calotropis procera, *Fitoterapia*, 71(1), 77-79 (2000). https://doi.org/10.1016/s0367-326x(99)00121-5

Shinwari, M. I. and Khan, M. A., Folk use of medicinal herbs of Margalla hills national park, Islamabad, *J. Ethnopharmacol.*, 69(1), 45-56 (2000). https://doi.org/10.1016/s0378-8741(99)00135-x

Taylor, P., Arsenak, M., Abad, M. J., Fernández, A., Milano, B., Gonto, R., Screening of Venezuelan medicinal plant extracts for cytostatic and cytotoxic activity against tumor cell lines, *Phytother Res.*, 27, 530-539 (2013). https://doi.org/10.1002/ptr.4752

Yelne, M. B.,Sharma, P. C. and Dennis, T. J., Database on Medicina Plants used in Ayurveda, *Central Council for Research in Ayurveda and Siddha*, New-Delhi., 2, 69-73 (2000).