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Spectroscopic investigation of biosynthesized nickel nanoparticles and its larvicidal, pesticidal activities

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ABSTRACT

Methanolic extract of *Cocos nucifera* (*C. nucifera*) was collected using Soxhlet apparatus. *C. nucifera* methanolic extract was used to prepare Nickel nanoparticles (Ni NPs). Eco-friendly synthesized Ni NPs were confirmed by several analytical techniques such as UV–Visible spectroscopy (UV–Vis), Fourier Transform Infrared spectroscopy (FT-IR), X-ray diffraction (XRD), Scanning Electron Microscope (SEM), Energy Dispersive X-ray analysis (EDAX), Transmission Electron Microscope (TEM) and Zeta potential. The obtained results infer that green synthesized Ni NPs are in cubical shape with an average particle size of 47 nm. Synthesized Ni NPs were subjected to pesticidal activity against agricultural pest *Callasobruchus maculates* (*C. maculates*) which resulted in 97.31% mortality. These results were compared with commercially available standard Azadirachtin. Also we have studied larvicidal activity against *Aedes ageypti* (*A. ageypti*) larvae which resulted in LC_{50} and LC_{90} value of 259.24, 446.99 ppm respectively and the result proved to be significant which were processed by ANOVA LSD Tukey's test.

1. Introduction

Across the globe, for the past few decades, nanotechnology and nanoscience have thrown lime light to the field of research and development. Recently most of the small scale industries have rapidly increased their investment towards the field of nanotechnology [1]. Nanotechnology is based on two approaches namely top-down and bottom-up approaches [2,3]. These approaches consist of three methods namely biological, chemical and physical. The physical and chemical syntheses lead to expensive and time consuming procedures which can also be toxic to the environment. But biological approach has been considered as non-toxic and a cheaper way of synthesizing nanoparticles [4,5]. This biological mediated approach is further classified into two methods namely microorganism and green source mediated synthesis. Plant mediated synthesis of metal nanoparticles has more advantages compared to micro-organism mediated synthesis [6]. The biosynthesis of nanoparticles was carried out by using the plant extracts. Where these plant extracts contain several functional group compounds which are also called as secondary metabolites having important role as reducing agent for conversion of metal precursors to metal nanoparticles [7–10].

Our research group has focused to extract the secondary metabolites from *C. nucifera* which is called as king of tropical region. Many researchers have utilized the extracts of *C. nucifera* for several biological application studies as well as for the synthesis of nanoparticles. *C. nucifera* contains various constituents are said to be most adaptable products which contain various fractions of proteins like prolamines, glutelins, albumins and globulins and is also rich in nutritional value which are mostly used in various industrial and medicinal applications like anti-bacterial, anti-viral, cytotoxicity studies, hardening the cement, and interior decorations [1]. From the literature, we have identified that Nickel possess good anti-corrosion property when compared to other transition elements [11] and also has promising biological applications such as cytotoxicity and inflammation studies [12,13]. Some of the authors have already reported on synthesis of Ni NPs with average particle size of 150 nm and its application towards blood sucking parasites which resulted in excellent larvicidal activity but they synthesized Ni NPs using Ni-hydrazine as a precursor which can act as a reducing agent for the formation of Ni NPs [14]. In another case, by using aqueous leaf extract of *Aegle marmelos* Correa, authors synthesized Ni NPs which have an average particle size of 80–100 nm of triangular shape. The synthesized triangular shaped Ni NPs were tested for *in-vitro* anti-inflammatory and larvicidal activity which resulted in enhancement while compared to crude leaf extracts of *Aegle marmelos* Correa [15]. Based on the properties and applications of Ni NPs, our research group has

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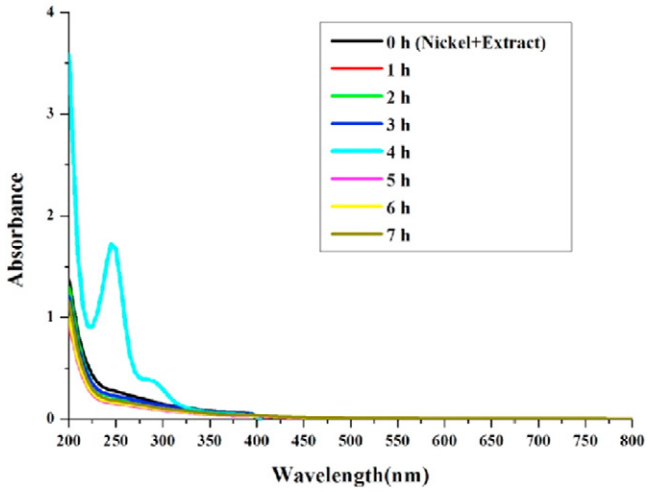

Fig. 1. UV–Visible spectral analysis of Nickel nanoparticles.

focused towards the preparation of Ni NPs by using agricultural waste *C. nucifera* coir dust extract and further checked the pesticidal activity against agricultural pest *Callasobruchus maculates* and larvicidal activity against agricultural waste breeding dengue vector *Aedes ageypti*.

2. Experimental Section

2.1. Materials

We have collected *C. nucifera* coir dust ample from Gudiyatham region, Vellore district, Tamilnadu, India and its co-ordinates are 12.9397° N, 78.8644° E. Further the collected specimen was subjected for authentication in Tamilnadu Agricultural University (TNAU), Coimbatore, Tamilnadu, India and the authenticated number is BSI/SRC/5/23/2013–14/Tech 1118 which is kept for future reference. Nickel acetate salt was procured from Alfa Aesar, Chennai, India and Methanol was procured from Sisco Research Laborites, Mumbai (SRL-India) and for the entire experimental process, we have utilized double distilled water.

2.2. Methanolic Extract Preparation of C. nucifera

The authenticated samples were air dried, grinded and sieved into fine particles. About 300 g of authenticated *C. nucifera* coir sample was packed into soxhlet apparatus for extraction process. The powdered *C. nucifera* was initially extracted with petroleum ether to remove the hydrocarbons present in it. This extraction process was continuously monitored by Thin Layer Chromatography. Once the hydrocarbons were removed, solvent system was changed to methanol for collection of *C. nucifera* methanolic extract. The extracted samples were condensed using distillation apparatus for getting our desired product and further extracted sample was used as secondary metabolites for nanoparticle synthesis.

2.3. Ni NPs Synthesis Using Methanolic Extract of C. nucifera

We synthesized Ni NPs by the methodology already reported by Elango et al. [16] with slight modifications. Initially 100 mL of 1 mM Nickel acetate solution (Solution 1) and 20 mg of *C. nucifera* methanolic extract (Solution 2) in 20 mL of double distilled water were prepared separately. Now 80 mL from the solution 1 and 20 mL from the solution 2 were mixed with stirrer and placed in water bath maintained at 60 °C and samples were collected for every 1 h interval for 7 h which were subjected for UV–Visible spectroscopy to identify the highest absorbance range and time. After confirmation of the highest absorbance, the resultant liquid sample was centrifuged at 3000 rpm for 30 min for removing impurities. The resultant pellet sample was collected and placed for calcination process using furnace at 400 °C for 3 h [16].

2.4. Ni NPs Characterization Techniques

After calcination process, collected powder sample was characterized using various techniques like UV–Visible spectroscopy (Schimadzu UV–Visible spectrophotometer, model UV-1800), XRD-analysis (Advance Powder X-ray diffractometer, Bruker, Germany, model D8), FT-IR (Alpha T Bruker), TEM (Philips, CM 200, Operating voltages: 20–200 kv Resolution: 2.4 A°), Zeta potential (Horiba Nanoparticle Analyzer) to study the various physical and chemical properties of green synthesized Ni NPs and also we subjected our *C. nucifera* methanolic extract for Gas chromatography–mass spectrometry (GC–MS) for the identification of chemical constituents present in the extract.

2.5. Larvicidal Activity of Green Synthesized Ni NPs

The larvae of dengue causing vector known as *Aedes ageypti* were collected from Cooum river, Saidapet, Chennai and its co-ordinates are 13.0681° N, 80.2858° E. Further it was identified by a zoologist Dr. Kuppusamy Elumalai, Government Arts College (Autonomous), Nandanam, Chennai. 14–20 days old larvae's were used for the bioassay [17]. We performed larvicidal activity with the help of the collected larvae against the green synthesized Ni NPs. 20 larvae's were placed in 10 mL of distilled water with various concentrations ranging from 100 to 500 ppm. This whole experimental setup was processed under laboratory conditions using reusable paper cups with five replicates [18]. Larvae present in distilled water were considered as control. Mortality percentage was identified after 24 h of exposure and we calculated LC_{50} and LC_{90} by using ANOVA LSD Tukey's test.

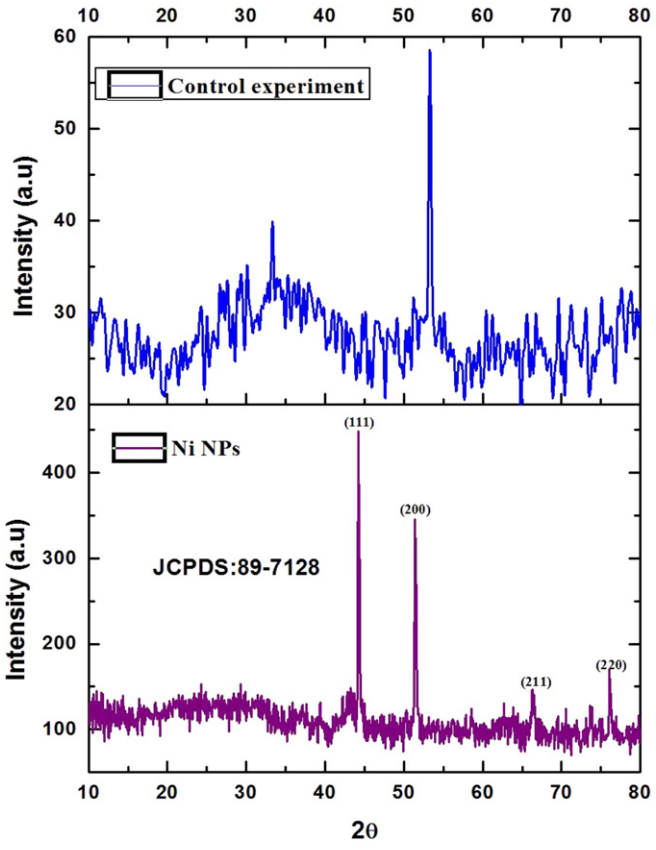

Fig. 2. XRD pattern of control and Nickel nanoparticles.