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Characterization and Antimicrobial Study of Nickel Nanoparticles Synthesized from Dioscorea (Elephant Yam) by Green Route

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Abstract: ***In the present study Nickel nanoparticles (NiNPs) are synthesized by green technique using aqueous tuber extract of Dioscorea (elephant yam) as a reducing, stabilizing and capping agent. Nickel nanoparticles were confirmed by UV-Visible studies. The synthesized NiNPs are characterized by UV-VIS, XRD, and SEM with EDAX. The EDAX pattern shows the 2.33 weight percentage of Nickel present in the synthesized sample and XRD studies shows that the particles are mostly crystalline in nature. Further these biologically synthesized nanoparticles were found to be highly toxic against different multi drug resistant bacteria pathogens. This is the first report on the synthesis of NiNPs from tuber extract of Dioscorea was used for synthesis of NiNPs and its antimicrobial studies.***

Keywords: *Dioscorea*, NiNPs, UV-VIS, XRD, SEM with EDAX and antimicrobial activity.

1. Introduction

Nanoparticles are ultrafine particles with their size ranging from 1-100nm. Nanoparticles (NP) have attracted considerable attraction due to their un usual and fascinating properties, with various applications, over their bulk counter parts (Daniel and Astruc, 2004**;** Kato, 2011). Nanotechnology can be defined as the manipulation of matter through certain chemical and/or physical processes to create materials with specific properties, which can be used in particular applications [2]. Nanotechnology is a field that is burgeoning, making an impact in all spheres of human life. A variety of methods have been reported for the preparation of metallic nanoparticles [3] [4]. Notable examples include, reverse micelles process [5][6], salt reduction [7], microwave Dielectric heating reduction [8], ultrasonic irradiation [9], radiolysis [10] [11], solvothermal [l2] synthesis [13] [14], electrochemical synthesis[15] [16], template synthesis[17], hydrothermal synthesis [18] chemical route etc[19][20]. Nickel is an important metal in modern infrastructure with major uses in stainless steel (~65%) metal alloys (~20%) and plating (~90%) as well as electric batteries and chemicals. In recent years nickel nanosized material has become one of the interesting material in research communities due to the diverse promising application in the field of catalysis and magnetism [Chang & Su 2008]. It is used to identify the anticancer mechanism of the synthesized nickel and Nio nanoparticle that may use for cancer therapy (Ayesha mariama, S.Arokiaraj; 2011). They have wide range of application including batteries, hard alloys, catalyst, and electricity and so on. Nickel nanoparticles have important applications in catalysis and magnetic material (N.R.Nik Roslin, A.Azizan.2012). Elephant yam is one of the major stable food crops. The crop is of great nutritional and economic importance to mankind. Elephant yam is medicinally a heart stimulant. Moreover, elephant yam is also a source of industrial starch the quality of which varies with the species with some of them producing starch (Jonathan Roben and Antony; 2012). Elephant yam has been used as a traditional medicine in china, Korea and Japan since centuries. It contains allantoin cells proliferate that expedites the healing process when applied topically on ulcers, boils and other skin disease. In the present research paper, such an ecofriendly synthesis method for Nickel nanoparticle has been reported using the solution of Nickel sulphate by the aqueous extract of a natural material Dioscorea. The nanoparticles synthesized by the mentioned ecofrienly method found toxic for bacteria like *Escherichia coli, Klebsiella pneumoniae, (Gram negative) Bacillus cereus* and *Staphyloccocus aureus(Gram positive).*

2. Materials and Methods

Nickel sulphate is obtained from Sigma-Aldrich chemicals. Dioscorea has been collected from a local supermarket in Kanyakumari District, Tamil Nadu, India.

2.1 Preparation of Dioscorea Extract

Healthy roots of Elephant yam collected from the local market and washed thoroughly with tap water for 5-8 minutes. The root tuber vegetables (200g) was again washed with sterile water and smashed inside a grinder. The smashed root was then filtered to remove debris. At the end filtered extract was centrifuged at 5000 rpm for 15minutes to obtain the liquid extract and it was preserved inside a refrigerator for future use.

2.2 Synthesis of Nickel Nanoparticle (Dioscorea)

5 ml of *Dioscorea* extract was treated to the 1N of 5ml aqueous solution of Nickel sulphate and stirring continued for 1 minute at room temperature. The solution changed from blue to Yellow which indicates the formation of Nickel nanoparticles. The procedure was repeated for 10ml, 15ml, 20ml, 25ml extract but the metal used only 5ml Nickel sulphate throughout the experiment. Then the P^H was noted using the Eutech P^H meter. The prepared Nickel nanoparticles were centrifuged at 15 minutes at 10,000 rpm and dried at room temperature for two weeks. The dried powders were taken for further characterization study.

2.3 Characterization of Synthesized Nanoparticles

The reaction of Nickel sulphate solution with Dioscorea extract was optically measured using Thermo scientific UV.Visible Spectrophotometer. A different Wavelength range was observed from 200 nm to 350nm. The synthesized Nickel nanoparticles were centrifuged at 10,000 rpm for 20 min, and the pellets were collected. The pellets were washed with distilled water for several times to remove impurities and dried to get power. The X-Ray diffraction assay was performed for detection of crystalline nature of the metal nanoparticles and it was done by using powder X-Ray diffractometer. Shape and size of the Nickel nanoparticles were studied by using Scanning Electron Microscope. The main element in the synthesized materials was determined using the energy dispersive X-ray spectroscopy (EDX). p^H range for Nickel nanoparticle was determined using Eutech p^H meter Systronics.

Antimicrobial Activity

By disc diffusion method, the antibacterial activities of the root tuber extract reduced Ni NPs were studied. LB (Luria bertoni) media was used, sterilized and solidified. Then four bacterial strains (*Escherichia coli, Klebsiella pneumoniae, Bacillus cereus* and *Staphyloccocus aureus)* were swabbed on the plates. Sterile discs were dipped in Nickel nanoparticles solution (50µg/ml) and placed in the nutrient media plate and kept for incubation at 37ºC for 24 hrs. Zones of inhibition for control and Nickel sulphate were measured and the mean values of zone diameter were presented.

3. Results and Discussion

3.1 UV-Vis Absorbance Study

The addition of Dioscorea extract to Nickel sulphate solution resulted in colour change of the solution from blue to yellow due to the production of Nickel nanoparticles. The colour change arised from the excitation of surface Plasmon vibrations (SPR) with the Nickel nanoparticles. The SPR of Nickel nanoparticles produced a peak centered near 207nm. UV-Vis absorbance of the reaction mixture was taken from 0 to 2min (Fig 1). It was observed that the absorbance peak was centered at 207nm, indicating the reduction of Nickel sulphate into Nickel nanoparticles. It was also observed that the reduction of Nickel ions into Nickel nanoparticles started at the begining of reaction and reduction was completed at almost 2min at room temperature, indicating that the rapid biosynthesis of Nickel nanoparticles.

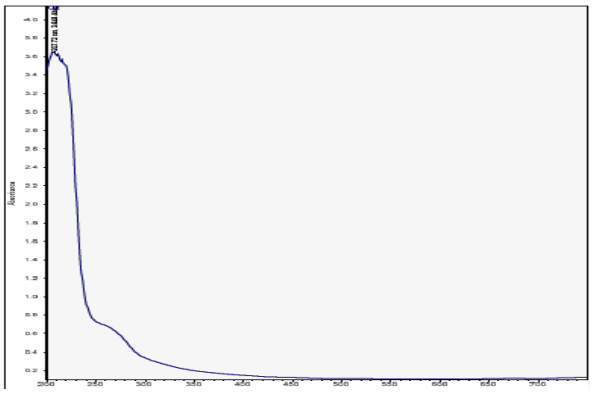

Figure 1: UV-Vis spectram of Nickel nanoparticles using Dioscorea tuber extract

3.2 XRD Studies

The phase identification and crystalline structures of the nanoparticles was characterized by X-ray diffraction. The crystalline structure of the biosynthesized Nickel nanoparticle was investigated by using *Dioscorea* extract. The obtained strongest diffraction peak for Nickel nanoparticles are 18.30^0, 30.81^0 and 22.80^0 which assigned to (111) (202) (110) planes (Figure 2). X-ray diffraction results clearly showd that the Nickel nanoparticles formed by the reduction of Ni^{2+} ions by the Dioscorea tuber extract are crystalline nature. (25)

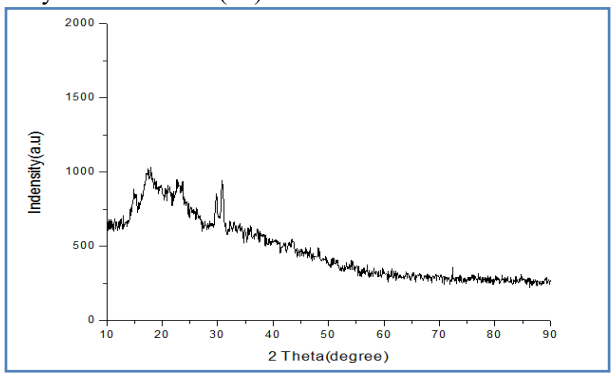

Figure 2: X- ray diffractogram of Nickel NPs Synthesized from *Dioscorea* extract

Using Debye-Scherer's formula the crystalline size for the nanoparticles was calculated.

$$D = K\lambda / \beta \cos\theta$$

Where D is the average particle size in nm, λ is the wave length of the X-ray (0.15406nm), β is the full width at half maximum of the diffraction peak, K, is the Scherrer constant with the value of 0.9 to 1 and θ is the Bragg angle. In *Dioscorea* the average particle size for Nickel nanoparticle are found in the range of 2.31 nm.

3.3 SEM

Scanning electron microscope is one of the powerful tools to identify the shape of the nanoparticles. SEM image provided the morphology of the nanoparticles (figure 3). The scanning electron microscopic (SEM) image showed the high density of Nickel NPs synthesized by *Dioscorea* tuber root extract. The Nickel nanoparticles were relatively spherical and also individual nanoparticle was aggregated shows large nanoparticles. This aggregation took place due to the

presence of cell component and the surface of nanoparticles act as a capping agent.

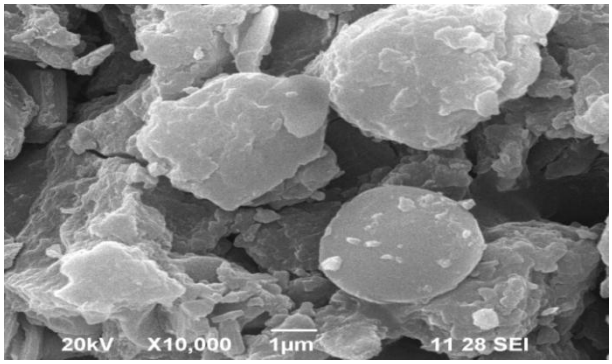

Figure 3: SEM image of Nickel nanoparticle synthesised from *Dioscorea* tuber extract

3.4 Energy dispersive X-ray spectroscopy

To confirm the presence of the main elements in the synthesized materials an elemental composition analysis was done by energy dispersive X-ray spectroscopy (EDX). Using this technique the elemental composition of the materials was obtained with high resolution. EDX analysis data confirms that the main components of the materials. *Dioscorea* tuber extract have the weight percentage of Nickel as 2.33%(Figure 4).

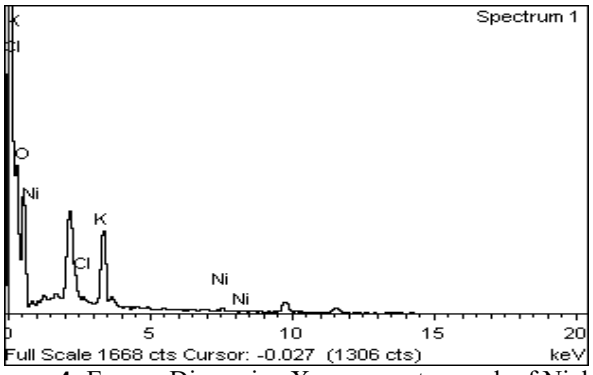

Figure 4: Energy Dispersive X-rays spectrograph of Nickel NPS from *Dioscorea* tuber

3.5 Antibacterial Activity

The Nickel Nanoparticles pretence to have an good bactericidal activity. The synthesized Nickel nanoparticles from Dioscorea tuber extract were tested against four different pathogenic microorganisms such as Escherichia *coli, Klebsiella pneumoniae Staphylococcus aureus* and Bacillus *cereus. Dioscorea* tuber extract showed the zone of inhibition for Nickel nanoparticles in *Staphylococcus aureus* is (14mm), *Escherichia coli (13mm), Bacillus cereus (10mm*) and the lowest value is (9mm) for *Klebsiella pneumoniae* (Figure 5).

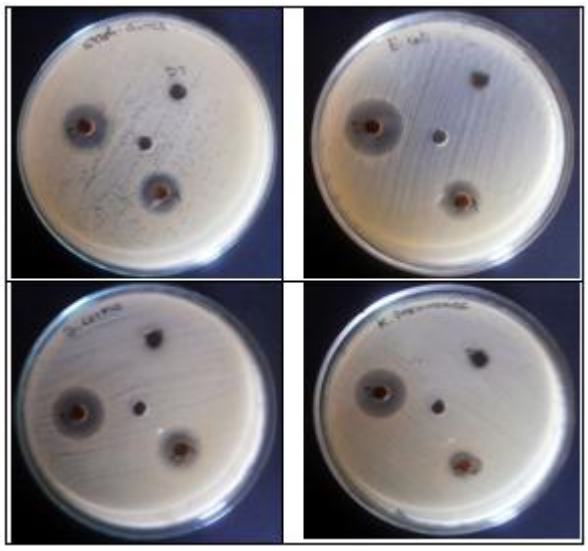

Figure 5: Antibacterial activity against *S.aureus, E.Coli, B.cereus, and K.pneumonia for Nickel NPs from Dioscorea root extract.*

4. Conclusion

In this study we have developed an eco friendly and environment safe green method for the synthesis of Nickel nanoparticles using *Dioscorea* tuber extract with rapid speed. The tuber extract very much suitable for the synthesis of small Nickel nanoparticles. The colour change from light blue to yellow indicates the presence of stabilization and capping of Nickel nanoparticles, which is confirmed by UV-VIS spectroscopy. The nanoparticles are very small in the range between 2-3 nm confirmed by XRD, SEM, and analysis of total content Nickel nanoparticles by EDAX instrument. Further the antimicrobial studies indicated that the nanoparticles are toxic to different types of drug resistant microorganisms. Finally we conclude that the tuber extract of *Dioscorea is* ideal material for the rapid synthesis of NiNPs and act as a potential antimicrobial agent.

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