Maqui Plant Leaf Extract Produces CdS Nanoparticles: A Report

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Abstract—**Maqui plant leaf extract has been shown the potentiality of biogenic production of CdS nanoparticles from cadmium nitrate salt. Probably the synthesis of CdS nanoparticles is due to the plant extract contains phenolic compounds, antioxidants, which are also responsible for the nanoparticles stabilization. Therefore, it presents a convenient and eco-friendly approach for the biosynthesis of stable CdS nanoparticles compared to the other conventional approaches.**

Keywords—Biosynthesis; CdS; leaf extract; Maqui plant; Nanoparticle.

I. INTRODUCTION

It is a recent trend that scientists are following biological process for nano-synthesis. Actually it serves several advantages over the chemical synthesis, mainly in terms of economic as well as eco-friendly. Most of such methods are single stepped bioreduction method and sometimes it is not necessary to add external stabilizers [1]. Various types of bioorganism or biomolecules and plant extracts are used in the biological process, therefore it's called the 'green-synthesis' [2,3]. The biological method would give us a new pathway to minimize the chemical hazards to health and environment, reducing waste and prevents the pollution [1, 4]. The crude extract of plant from various plant parts contain secondary metabolites such as phenolic acid, flavonoids, alkaloids and terpenoids. These compounds are said to be responsible for the reduction of ionic metals to nanoparticles [5]. Different parts of plant such as stem, root, fruit, seed, callus, peel, leaves and flowers have been reported to synthesize the nanoparticles with various shape and size. Further advantages of plant sources are it free from toxic chemicals; moreover, natural capping agents are readily supplied by the plants [6,7]. There are neumerous nanoparticles such as gold, silver, platinum, zinc, copper, titanium oxide and sulfide nanoparticles are synthesized using plant extracts. Recently, Jose-Yacaman and co-workers have shown that gold and silver nanoparticles are synthesized in live alfalfa plants by gold and silver uptake from solid media [8]. Another report also available on the gold and silver nanopartciles that have been synthesized by using alovera plant extracts and boiling of fresh plant leaves [9]. The mechanism of biosynthesis of nanoparticle crystals is complex and not yet fully understood. But it has been reported that the aldehyde, carboxyl, amine and phenolic compounds of the extract are involved in the reduction of silver ions into metallic Ag nanoparticles [10, 11]. The aqueous extract of *Trigonella foenumgraecum* contains high flavonoids and other natural bioactive products such as lignin, saponin and vitamins. They are responsible for nanoparticles synthesis and COO^- and C=C functional groups of the extract helps in the stabilization of synthesized gold nanoparticles. The plant extract acts as a reducing and protecting agent in nanoparticles synthesis process [12, 13]. Maqui tree is widely distributed in Chile. It has long been used as traditional herbal for the treatment of diseases related to throats, kidney, stomach, digestive system, scarring injuries as well as an anti-inflammatory agent. Maqui plants are also enriched with phenolic acid, flavonoids and alkaloids like secondary metabolites [14, 15]. However, such Maqui plant mediated biosynthesis of CdS nanoparticle has not been reported yet. In view of the above present study is undertaken.

II. METHODS

A. Preparation of plant extract

1gm of crushed dried Maqui plant leaf was suspended in 100 ml of Milli-Q water. The suspension was heated at 55-60 ˚C temperature for 30 min, and sonicated for 20 min under cooling condition. The mixture was filtered and centrifuged at 8000 r.p.m. for 30 min at 4 ˚C. The obtained extract was used for the synthesis of CdS nanoparticles. Another part was used for biochemical assay such as phenolic content assay, DPPH assay and FRAP assay.

B. Biosynthesis of CdS nanoparticles

For biosynthesis of CdS nanoparticles, cadmium nitrate (2mM) was added in 0.5% of plant extract and after that sodium sulfide was added (2mM). The pH of the reaction mixture adjusted to pH 8.5. The reaction mixture was kept in shaker at 200 r.p.m. at 36 ˚C for 18-20 hours for continuous stirring.

C. Phenolic Assay

The total phenolic content was determined by Folin-Ciocâlteu method [16] using Gallic acid as standard. In this method 5µl of 0.5% plant Maqui extract was mixed with135 µl Folin reagent and O.D. was measured at the wavelength of 740 nm by using Agilent 8453 UV-VIS spectrophotometer. The obtained result is expressed as milligrams of Gallic acid equivalent (GAE) per gram of dry weight.

D. 1, 1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenger spectrophotometric assay

The DPPH assay is a technique in which we can evaluate the free radical removal capacity of plan extract, accordingly described by Shyu *et. al.* [17]. For this assay, 5µl of 0.5% Maqui extract was mixed with DPPH reagent and the decreased absorbance was monitored continuously at the wavelength of 517 nm using Agilent 8453 UV-VIS spectrophotometer. The result is expressed as % consumed DPPH.

E. FRAP Assay (Ferric reducing antioxidant power)

This assay was described by Benzie *et. al.* [18] that measure the ability of a specific sample to reduce Fe (III) to Fe (II) through the formation of blue complex, tripyridyltriazine (TPTZ). This produced complex gives maximum absorbance at 593 nm. In that purpose, 20µl of 0.5% Maqui extract was mixed with180 µl of FRAP reagent (the ratio of 10:1:1of acetate buffer, TPTZ and $FeCl_3$) and the absorbance of test sample was measured at 593 nm by using Agilent 8453 UV-VIS spectrophotometer.

F. Characterization

1. UV-Vis spectroscopic study of biosynthesized CdS nanoparticles

For the UV-Vis spectroscopic study, 1ml of biosynthesized CdS nanoparticles suspension and only plant extract were taken in cuvette and data was recorded by scanning in the range between 300-650nm.

2. Dynamic Light scattering (DLS) Study of biosynthesized CdS nanoparticles

The bio-synthesized nanoparticle suspension was used for DLS measurement study by using Malvern Zetasizer nano series compact scattering spectrometer.

3. Zeta-potential Study biosynthesized CdS nanoparticles

The zeta-potential of biosynthesized CdS nanoparticles was measured using zetameter. The applied electric volt is 300V (4X scale) for the measurement of zeta-potential of bio synthesized CdS nanoparticles. The pH of the biosynthesized CdS nanoparticle was adjusted either by using 0.1M NaOH or by 0.1M HNO_3 and 0.001M $NaNO_3$ is used as an electrolyte.

III. RESULTS AND DISCUSSIONS

A. Visual appearance of synthesized CdS nanoparticles

After addition of cadmium nitrate containing into the plant extract, the light yellow coloured extract is started to change into pale yellow colour. After 20 hours of continuous stirring, the reaction mixture converted to transparent pale yellow colour. The colour change is the first indication for the synthesis of nanoparticles (Figure 1A, B).

B. UV-VIS Spectroscopic study

According to the UV-Vis spectra of Maqui plant extract (Figure 1C) we can observe there is absorption peak in the range of 330-400 nm. This peak indicated the presence of phenolic compound and their derivatives such as flavones, flavonols, phenylpropenes and quinones [19]. But after synthesis of CdS nanoparticle, the Maqui plant extract with CdS nanoparticles shows absorption shoulder at around of 400- 450 nm (Figure 1D).

C. Dynamic Light scattering (DLS) Study of biosynthesized CdS nanoparticles

The average hydrodynamic size is measured by applying DLS. Figure 2A represents the average size of the synthesized CdS nanoparticle is 95.6 nm in diameter with 0.133 PDI value. The obtained single peak indicates that the quality of the synthesized CdS nanoparticle is good and polydispersive in nature.

D. Zeta potential study of biosynthesized CdS nanoparticles

A minimum of ±30 mV zeta potential values is mandatory for indication of stable nano suspension [20]. Plant extract mediated synthesized CdS nanoparticles shows different ZP value at different pH (Figure 2B). In acidic pH 5.42, it shows lowest ZP value is -17.90mV. On the other hand when the pH range increased, the ZP value also increased. The nanoparticles show highest ZP value at pH 9.19 (-45.60mV) and it has indicated that there is a negative–negative repulsion [21] i.e. result clearly indicated that the particles are honestly stable due to the electrostatic repulsion.

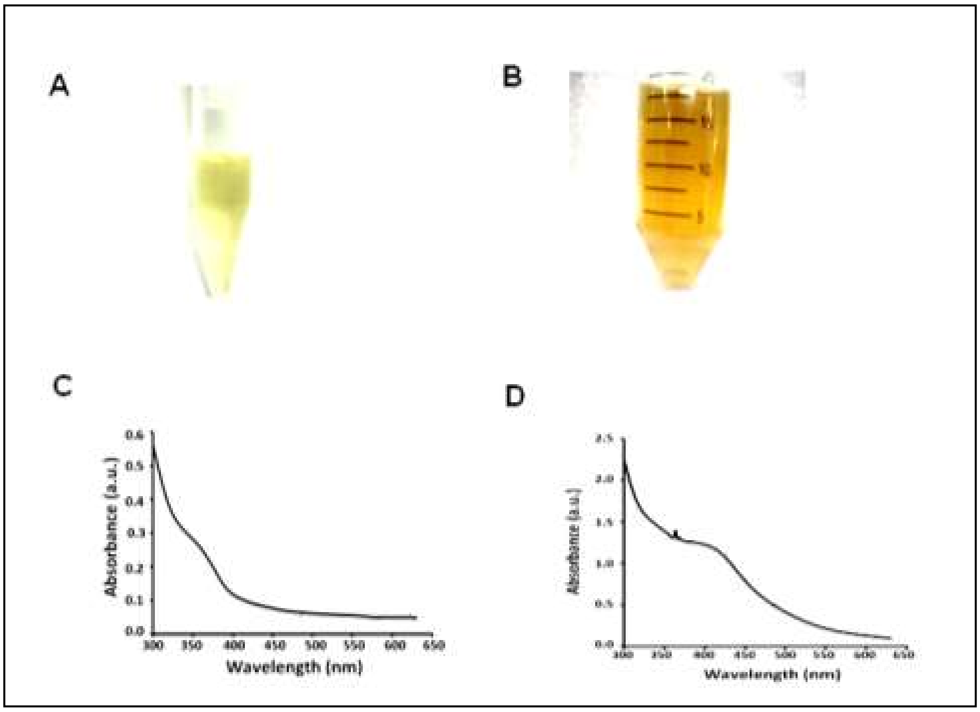
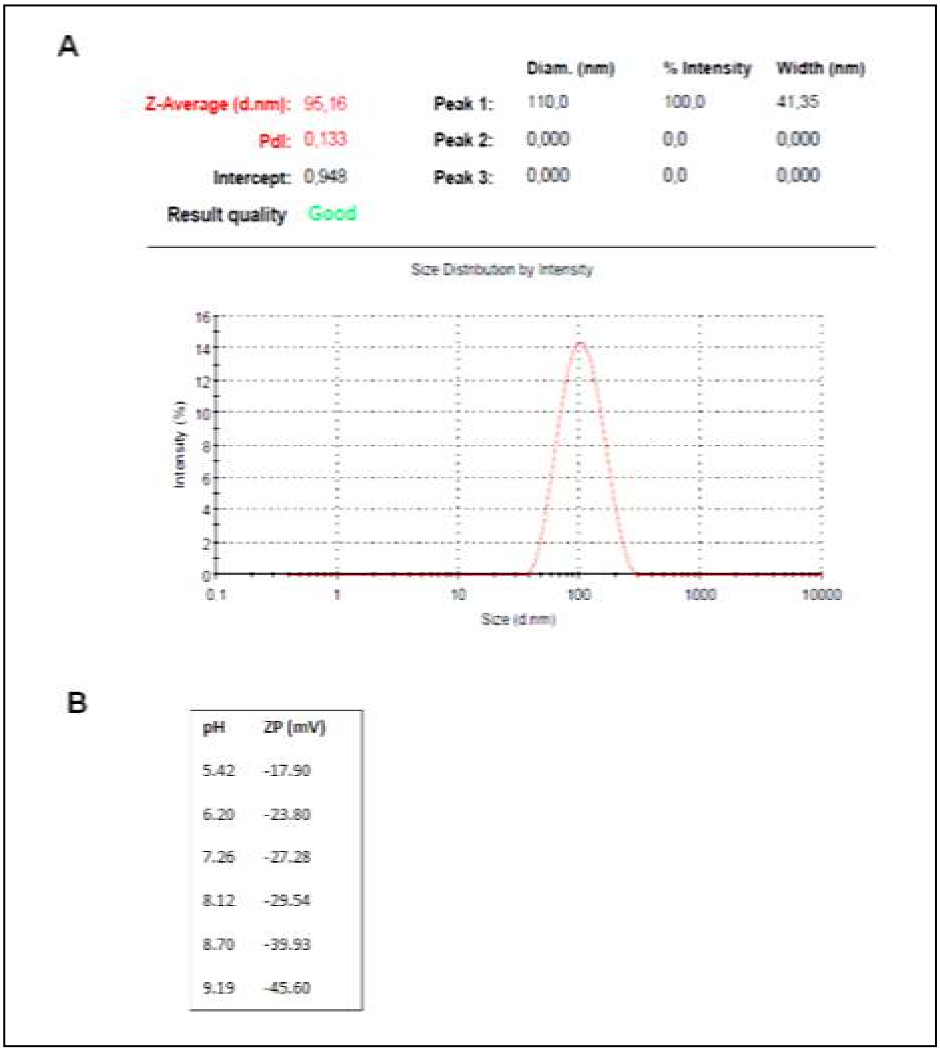


Figure 1. Primary characterization of biosynthesized CdS nanoparticles: Visual appearance of synthesized CdS nanoparticles (A) Maqui plant extract, (B) Maqui plant extract with CdS nanoparticles. UV-VIS Spectroscopic study (C) Maqui plant extract, (D) Maqui plant extract with CdS nanoparticles.



pH	ZP (mV)
5.42	-17.90
6.20	-23.80
7.26	-27.28
8.12	-29.54
8.70	-39.93
9.19	-45.60

Figure 2. Dynamic Light scattering (DLS) Study of biosynthesized CdS nanoparticles (A) DLS study, (B) Zeta-Potential value at different pH.

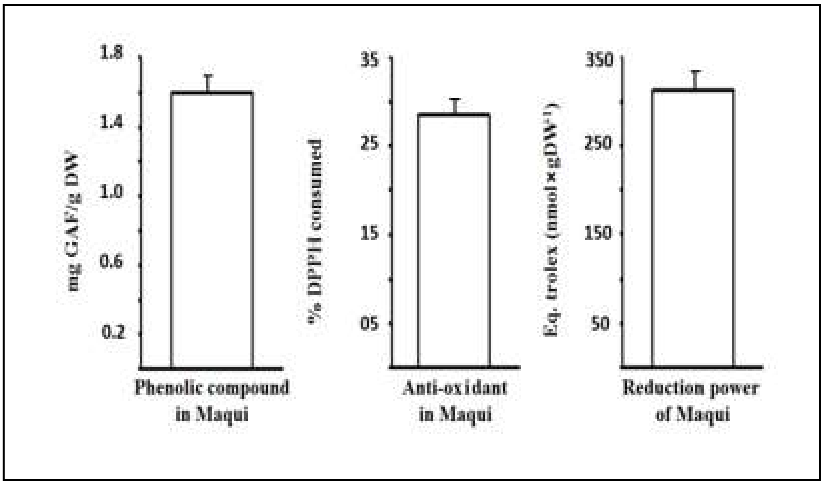


Figure 3. Biochemical Assay (phenolic compound assay, DPPH assay and FRAP assay).

E. Biochemical Assay (phenolic compound assay, DPPH assay and FRAP assay)

The total phenolic content for 5µl of 0.5% Maqui plant extract is shown in Figure 3. It shows the total phenolic content is (1.6mg /g DW). The antioxidant capacity and reduction power of. 0.5% Maqui extract is shown in the Figure 3. Plant extract contains phenolic compounds, antioxidants that are responsible for the synthesis of nanoparticles and stabilization [22].

IV. CONCLUSION

In summary primarily we are reporting that Maqui plant leaf extract can synthesize CdS nanoparticles with considerable size and stability. The phenolic compounds of the extract may be responsible for such stability of CdS nanoparticles. But advanced tools, like Atomic Force Microscopy (AFM), Scanning and Transmission Electron Microscope (SEM and TEM), X-ray Diffraction studies (XRD) are to be considered for better and accurate establishment of the synthesized particle size and morphology. Furthermore, instead of role of a group of phenolic compounds, a specific compound should be identified for the explanation of particle stability. Therefore large scale production of nanoparticles becomes easier and cost effective.

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