REVIEW

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SYNTHESIS OF DIFFERENT METAL NANOPARTICLES FROM PLANT EXTRACTS

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ABSTRACT

Objectives: To compile the various methods of synthesis of nanoparticles from plant extract.

Materials and Methods: The information was collected and compiled from scientific literature present in different databases.

Results: In this study we have reported the synthesis of various nanoparticles NPs from the different parts of the plants like leaf extracts, seed etc. And different types of methods like chemical synthesis, green synthesis used for the synthesis of nanoparticles were considered.

Conclusion: Therefore it is concluded that plants and their extractives are important in synthesis of nanoparticles as eco-friendly approach.

KEYWORDS: Silver Nanoparticles**,** Copper Nanoparticles, Zn Nanoparticles, Synthesis.

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INTRODUCTION

Nanoparticles exhibit novel properties which depend on their size, shape and morphology which enable them to interact with plants, animals and microbes. The Nobel metals like silver, gold, platinum, palladium, copper, zinc, and iron were used in synthesis of particles of nano size[1]. They are prepared from different perspectives, often to study their morphology or physical characteristics. Some authors have used chemical method and mistaken it with green synthesis, although they have done it inadvertently. Now a days, number of parts of plants such as flowers, leaves and fruits besides enzymes, have been used for the synthesis of gold and silvernanoparticles[2].

1. Silver nanoparticles of *P. guajava* leaves

Mixed 2 g of dried powder of *P. guajava* leaves with 100 mL deionized water and stirrer at room temperature for 24 h. filter the mixture through a Whatman No.1 filter paper and the filtrate was evaporated using rotary evaporator until the solvent was completely removed. PE obtained was kept in the refrigerator at 4ºC for further study.

Firstly prepared a solution containing 0.1 mg/mL of PE in deionized water and heated to 70ºC. 1 mL AgNO3 10 mM solution was added drop wise to the heated solution with continuous stirring at 100 rpm for 60 min. The obtained mixture was diluted with deionized water and subjected to centrifugation at 8,000 rpm for 15 min to remove any trace unutilized phytochemicals. This washing process was done in triplicate. The aqueous colloidal AgNPs were lyophilized using Freeze Dryer to obtained AgNPs powder[3].

2. Copper and Silver Nanoparticles of Green Alga *Botryococcus braunii*

2.1 Biogenic Synthesis of Copper Nanoparticles. Added 5ml algal extract dropwise into 50ml of 1mM aqueous copper acetate in a 100ml Erlenmeyer flask with vigorous stirring at 100°C for 24h. Simultaneously, maintained a positive control of copper acetate aqueous solution and algal extract and a negative control containing only copper acetate aqueous solution under the same conditions. Formation of copper nanoparticles are indicated by Colour change in positive control from light sky blue solution changed to dark brown. But in the negative control, the colour remains unchanged. The progress of the process was regularly monitored by observing colour change and recording UV-visible spectrum. After the completion, the above reaction mixture was centrifuged for 15min and the obtained material was subsequently re-dispersed and washed with deionised water. This process of separation and washing was carried out thrice and copper nanoparticles were dried in oven.

2.2 Biogenic Synthesis of Silver Nanoparticles. Mixed5ml algal extract with 45ml and 1mM silver nitrate aqueous solution in a 100ml Erlenmeyer flask and were put on magnetic stirrer at room temperature for 3h. Simultaneously, maintained a positive control of silver nitrate aqueous solution and algal extract and a negative control containing only silver nitrate aqueous solution under the same conditions. The progress of the process was regularly monitored by observing colour change and recording UV-visible spectrum. Completion of process was observed by change in colour of positive control from initial light pale yellow solution turned to reddish brown. After that reaction solution was centrifuged for 20min, and the obtained pellet was washed with deionised water to remove impurities. This process was repeated thrice to get a better separation of nanoparticles. The obtained silver nano particles were oven-dried at 55°C for 5 hr[4].

3. Silver and Copper Nanoparticles of *Cassia occidentalis*

3.1 Green Synthesis of Silver Nanoparticles. Fresh leaves of *C. occidentalis* were washed with distilled water and air-dried at room temperature. Added 10gm of leaves in a beaker containing 100ml de-ionized water and boiled for 30 min. The extract was cooled and filtered with Whatman filter paper no.1and extract was stored in a refrigerator at 4ºC. To obtain silver nanoparticles treated the freshly prepared 1mM silver nitrate and stored under dark conditions with aqueous extract of the plant. The reaction mixture was prepared in a ratio of 9:1 (V/V) comprised of freshly prepared silver nitrate solution and plant extract, respectively. Stored the solution at room temperature for 24 hours for the complete settlement of nanoparticles. After that the reaction mixture was centrifuged at 5000rpmfor15minutesandpelletswerecollectedfollowed by washing with de-ionized water and dried at room temperature.

3.2 Green Synthesis of Copper Nanoparticles.Boiled10gm of leaves with 100ml de-ionized water for 30min. Cooled and filtered the

extract with Whatman filter paper no. 1 and stored in a refrigerator at 4∘C. To prepare the CuNPs added 10ml of aqueous extract of plant material to 50ml of 1mM aqueous solution of cupric nitrate. Irradiated the mixture in microwave oven for 4 hours and allowed to cool at room temperature. And finally, the reaction mixture was centrifuged at 5000 rpm for 15minutes and residue was dried at room temperature[5].

4. Silver and Iron Oxide Nanoparticles of Fenugreek Seed Extract

4.1. Synthesis of Nano particles Using Fenugreek Seed Extract

5 ml of fenugreek seed extract was added (3.28 mg/ml) drop wise into 50ml of 1mM silver nitrate solution in a conical flask under continuous stirring at room temperatureat500rpmfor1h.Covered the flask with aluminium foil to avoid photo-degradation. The same procedure was followed for ultrasound assisted synthesis. During the ultrasound assisted synthesis, sonication was applied for 15 min followed by stirring at 400 rpm for 15 min. As the reaction proceeded, the colour changed from colourless to pale yellow to brown, suggested the formation of silver nanoparticles. The obtained silver nanoparticles were centrifuged at 15000rpm for 20 min followed by lyophilisation.

4.2. Ultrasound Assisted Synthesis of Iron Oxide Nanoparticles.

Initially added 50 ml of fenugreek seed extract to100ml of 1MFeCl2 and 2MFeCl3, followed by stirring at room temperature for 2 h at 400 rpm. After that, 10 ml of 25% ammonia solution was added to the suspension under continuous stirring for 1 h. The nanoparticles were separated by magnet and dried in hot air oven at 60∘C

For the ultrasound assisted synthesis, add 10ml of28%aqueous ammonia solution drop wise into the suspension under ultra-sonication with a probe sonicator for 15 min followed by stirring at 400 rpm for 15 min.

4.3 Chemical Synthesis of Silver and Iron Nanoparticles.

For the preparation of Silver nanoparticlesby chemical reduction method sodium borohydride were used as reducing agent.Keep 50 ml of 1 mM silver nitrate solution in aluminium foiled cover conical flask and5mlof0.1Msodiumborohydride was added drop wise. Mixed the solution vigorously at 400 rpm for 1 hr at room temperature.

Iron oxide nanoparticles were obtained by chemical method at room temperature using ammonia solution without fenugreek seed extract. Initially, 100ml of 1MFeCl2 and 2M FeCl3 was mixed together. 10 ml of 28% aqueous ammonia solution was added drop wise followed by stringent room temperature for 2hrs [6].

5. Zinc Sulphate Nanoparticlesof Physalis Peruvianaby Green Synthesis

In the synthesis of ZnO nanoparticles, Physalis Peruviana extract is used as the reducing and stabilizing agent. Firstly leaves are washed three-four time with double distilled water to remove the dust particles. Then take 15g washed leaves into the mortar and gets crushed well. The crushed leaves are put into the beaker containing 200ml distilled water. After that the extract is filtered using Whatman filter paper.

5.1 Preparation of Zinc Sulphate (Zns) Nanoparticles

Take100 ml *Physalis peruviana* leaves extracted solution and stir using magnetic stirrer to this added (0.1g) of Zinc Sulphate continuously. After that Sodium hydroxide pellet is dissolved in 10ml of water and mixed along with the solution. After further stirring keep the solution in the hot air oven for 4 hours at 75^0C until the solution is completely dried. Then the dried powdered was grained using mortar[7].

6. Gold Nanoparticles of Leaf Extract of *Ziziphus zizyphus*

The plant extract for the reduction of Au3+ ions to Au0 was prepared by combining thoroughly washed Ennab leaves in a 200 mL Erlenmeyer flask with sterile DD water (100 mL). Boil the mixture for 5 min. Add, 5 mL of the plant extract to 1 mM aqueous HAuCl4 solution (45 mL). Reduction of AuCl4− was monitored by recording the UV-vis absorption spectrum as a function of time[8].

7. Silver nanoparticles of *Nigella sativa*

Preparation of extract from seeds by homogenization: Wash the seeds of *Nigella sativa* several times with de-ionized water. The extract was prepared by taking 20 g of thoroughly washed *Nigella sativa* seeds with 100 mL of distilled water boiled for 3 min. The suspension was homogenized and the suspension was centrifuged and the supernatant was collected. The extract obtained was filtered through Whatman No 1 filter paper and stored at 4^0C for further use. The colour change

was observed after adding silver nitrate solution to the homogenized extract[9].

8. Silver nanoparticles of *Catharanthus roseus*

For the preparation of plant leaf extract mix 10 g of dried powder with 100 mL de-ionized water in 500 mL of Erlenmeyer flask and boiled for 10 min. Then For the reduction of Ag+ ions, 10 mL of leaf extract was mixed to 90 mL of 1 mM aqueous of AgNO3 and then, heated at 80^{o}C for 15 min A change from brown to reddish colour was observed[10].

9. Silver Nanoparticles of the Aqueous Extract of Leaves of *Ocimum sanctum*

Preparation of Plant Extract. Wash thoroughly20gm of fresh leaves of Tulsi with double-distilled water and were then cut into small pieces. And then mixed with 100mL doubled-distilled water, and this mixture was kept for boiling for a period of 5 minutes. Cool and filter through Whatman Filter paper no.1.

Synthesis of AgNPs: Add 10mL of aqueous extract of Tulsi leaves into 90mL of silver nitrate solution so as to make its final concentration to 10^{-3}M. And allowed to react at room temperature. Monitor the formation of AgNPs after 30 minutes[11].

10. Silver nanoparticles of Lonicera japonica

For the preparation of plant leaf broth solution take 10 g of washed and finely cut leaves in a 250 mL Erlenmeyer flask with 100 mL of de-ionized water and then boil the mixture at 60 ^{0}C for 5 minutes. After boiling, decant the solution and 12 mL of this broth was added to 88mL of 1 mM aqueous AgNO3 solution and the solution was heated at 60 _C for 5 minutes. The resulting solution became brown in colour. Filter this extract through a nylon mesh, followed by a Millipore hydrophilic filter (0.22 mm) [12].

11. Silver nanoparticles of Salvia spinosa

Powdered the dried plants in mortar and pestle. Poured 10 ml of distilled water to 0.2 g of plant powder. And allow to boil for 5 min and then was cooled, filtered with Whatman No. 1 filter paper.

Biosynthesis of Silver nanoparticles

Prepare aqueous solution of silver nitrate (1 mM) and mixed with fresh plant extract of *S. spinosa* at a ratio of 9:1. Place this solution on a shaker with constant rotation in the room temperature at 27 ± 2°C for 6 h[13].

12. Silver nanoparticles of Moringa oleifera leaf extracts

Leaf material was, washed with distilled water and air dried to remove residual debris. A portion of the leaf material was placed in a freeze dryer for 72 h until all moisture was removed. Thereafter, it was stored at −16 °C for further use. For the preparation of extract take 10g of FD leaf material and the equivalent amount of F leaf tissue (in terms of dry weight), in replicates of four. Each replicate was homogenised thoroughly in 50 ml Millipore water and the final volume was adjusted to 100 ml. and transfer the resulting homogenates to 250 ml Erlenmeyer flasks. Flasks were covered with foil and placed on a mechanical shaker at 115 rpm, for 24 h at room temperature. To obtain aqueous extracts, homogenates were subjected to vacuum filtration using Whatman no.1 filter paper

Synthesis of AgNPs

5 ml of aqueous plant extract were added to 50 ml of 1 mM aqueous AgNO3. To drive nanoparticle formation the expose the reaction mixtures to direct sunlight. Colour change of the reaction mixtures were monitored to determine nano-particle formation which is indicated by a dark brown colour. Once colour intensities of the solutions reached a maximum, the vessels were removed from sunlight and stored in darkness at room temperature to prevent agglomeration of the nanoparticles [14].

13. Silver nanoparticles of Azadirachtaindica

Fresh leaves were collected and surface cleaned with running tap water to remove debris and other contaminated organic contents, followed by double distilled water and air dried at room temperature. Kept About 20 gm of finely cut leaves in a beaker containing 200 mL double distilled water and boiled for 30 min. The extract was cooled down and filtered with Whatman filter paper no.1 and stored at 4 ^{0}C for further use.

Green synthesis of silver nanoparticles

100 mL, 1 mM solution of silver nitrate was prepared in an Erlenmeyer flask. Then added 1, 2, 3, 4 and 5 mL of plant extract to 10 mL of silver nitrate solution keeping its concentration at 1 mM. Silver nanoparticles were also synthesized by varying concentration of AgNO3 (1 mM to 5 mM) keeping extract concentration constant (1 mL). This setup was incubated in a dark chamber to minimize photo-activation of silver nitrate at room temperature. Formation of AgNPs was confirmed

by the colour change of solution from colourless to brown[15].

14. Copper nanoparticle of *Magnolia Kobus* leaf

Magnolia Kobus leaves were collected and dried for 2 days at room temperature. For the plant leaf broth solution take 25 g of thoroughly washed and finely cut leaves in a 1 L beaker with500 mL of sterile distilled water and then boiling the mixture for5min before finally decanting it and stored at 4 ^{0}C and used within a week. Typically, 30mL of leaf broth was added to 170 mLof 1 mmol L−1aqueous CuSO4·5H2O solution for the reduction of copper ions. The effects of temperature on synthesis rate and particle size of the prepared copper nanoparticles were studied by carrying out the reaction in a water bath at 25–95 ◦C with reflux. The leaf broth concentrations were also varied between 5 and 20% by volume. The copper nanoparticle solution thus obtained was purified by repeated centrifugation at 15000 rpm for 20 min followed by redispersion of the pellet in deionized water. The purified copper particles were freeze-dried[16].

15. Manganese nanoparticles of *Ctenolepis garcini* (Burm. f.) C.B Clarke

Take 2g air dried *Ctenolepis garcinii* (Burm. f.) C.B. Clarke powder in a 100ml Erlenmeyer flask with 30ml of sterile distilled water and then boiled the mixture for 2 minutes and filtered in the Whatmann No.1 filter paper. Prepare 1mM solution of potassium permanganate. 5ml of plant extract was mixed with 25ml of 1mM potassium permanganate solution. The formation of red colour was observed and λ max at different time intervals were taken for 8h using a UV-Visible spectroscopy. The solution is stored in room temperature for 24h for the complete settlement of nanoparticles. After 24h centrifuge the reaction mixture, discard the supernatant. Add 1ml of distilled water to the pellet and wash by using centrifugation. Collect the pellet by using acetone/ethyl acetate/alcohol. Dry in the watch glass and store the nanoparticles[17].

16. Silver nanoparticles of leaves of S*yzygium samarangense*

Preparation of plant extract :Washed thoroughly the collected leaves of *S. samarangense* 2-3 times in running tap water followed by sterile distilled water and were dried in hot air oven at 60 ºC overnight. The dried leaves were grounded well with the help of mortar and pestle and 5g of the powder was mixed with 100 ml of double distilled water (50 mg/ml). Boil this solution in a water bath at 60 ºC to 80 ºC for one hour. The cooled solution was filtered through Whatmann filter paper no.1 and the filtrate was stored at 4 ºC. Synthesis of herbal silver nanoparticles Synthesis of silver nanoparticles was carried out in 250 ml Erlenmeyer flask containing 90 ml of 1 mM silver nitrate and 10 ml of leaf extract. The solution was kept at dark room at 37 ºC with continuous agitation at 100 rpm for 24-48 hrs for the reduction of Ag+ions. The colour change of the solution from pale yellow to dark brown indicates the synthesis of AgNPs[18].

CONCLUSIONS

The objective of review was to report on synthesis of different metal nanoparticle by using different methods from plant parts. These metal nanoparticles were applied for disease treatment and antimicrobial activities. Therefore it is concluded that plants and their extractives are important in synthesis of nanoparticles as eco-friendly approach.

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