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Bio-inspired synthesis of silver nanoparticles from Cotoneaster acuminatus leaf extract and their characterization

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ABSTRACT

In this research work, bio-inspired approach was applied for the synthesis of silver nanoparticles. In this approach, silver nanoparticles were synthesized by interacting aqueous solution of 1mM silver nitrate and leaf extract of Cotoneaster acuminatus. Formation of silver nanoparticles was monitored by observing color changes and surface plasmon resonance absorption bands shown in UV-Visible spectroscopic study. Synthesized silver nanoparticles were characterized by using XRD, TEM and FTIR techniques. Results showed that the spherical, size within 06-10 nm range and stabilized by phytochemicals present in the leaf extract, silver nanoparticles were formed.

Keywords: Aqueous, Spherical, Phytochemicals.

I. INTRODUCTION

Bio-inspired methods in metallic nano-material synthesis has received significant attention in last few decades. Use of plant extracts for the synthesis of metallic nanoparticles could be beneficial over other ecofriendly benign biological processes because plants are easily available, non toxic and their extracts contain wide range of phytochemicals. The phytochemicals posses various biological activities that can be useful for the mankind. Thus, synthetic method by plant extracts exemplifies the promising application of green synthesis of metallic nanoparticles because plant extracts can potentially eliminate the problem of toxicity by making them biocompatible with wide range of applications.

An important area of research in nanotechnology is the synthesis of nano silver particles. Using plant for nanoparticles synthesis can be advantageous over other biological processes[1] and can also be suitably scaled up for large-scale synthesis. Bio-inspired synthesis of silver nanoparticles had been reported from various plant extracts like *Chenopodium album*[2], *Salacia chinensis*[3], *Ocimum tenuiflorum*[4], *Jatropha curcas*[5], *Murraya koenigii*[6], *Capsicum annuum* L.[7], *Argemone mexicana*[8] etc. In the present work, bio-inspired approach was attempted to synthesize silver nanoparticles from aqueous leaf extract of *Cotoneaster acuminatus. C. acuminatus* (Rosaceae) is a deciduous shrub having height upto 4m. Its bark is smooth with short and tubercled branches. Leaves are ovate-lanceolated, base rounded, tip acuminated with flat margins. Flowers are pinkish-white and fruits are oblong containing one seeded with 2-5 hard nuts. Flowering occurs between May and June. Fruiting happens between August and September. It is common in upper reaches of montane zones of

Himalaya; from Himachal Pradesh to Sikkim, Nepal and China. Flowers are useful in apiculture[9]and in another study, two new phenolic glycoside were isolated from the alcoholic root extract of this plant[10].

Fig. 1. *Cotoneaster acuminatus*

II. MATERIALS AND METHODS

All the chemicals were provided by Department of Chemistry, HNB Garhwal University, Campus Pauri-Uttarakhand (India). Deionized-distilled water was used for all experiments.

2.1 Preparation of plant extract and silver nanoparticles

Healthy leaves of *C. acuminatus* (**GUH20758**) were collected and washed several times with deionized-distilled water to remove any of the adhering dust particles and subsequently incised into very small pieces, placed in a hot air oven at 40^0C and then mashed to the powder form using mortar-pestle. 05 gm of dried finely cut *C. acuminatus* leaves were taken in a 250 ml Erlenmeyer conical flask containing 100 ml deionized distilled water and heated for 20-25 min at 70^0C. Then, the leaf extract was filtered in a separate conical flask and stored for further research work.

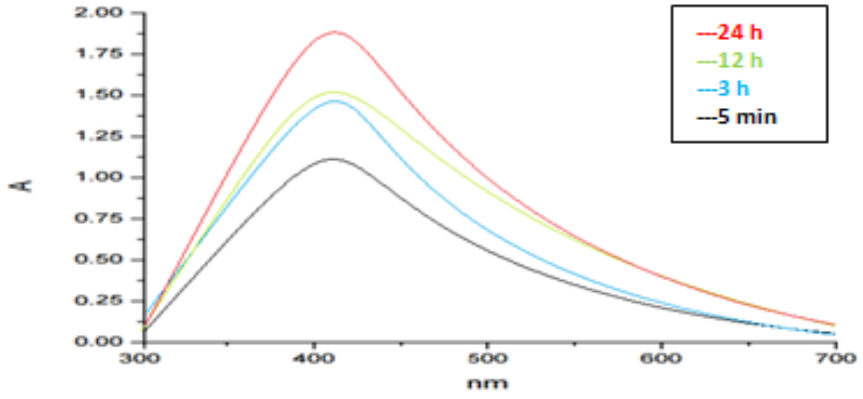
At room temperature, 1:9 mixture of *C. acuminatus* leaf extract and 1 mM silver nitrate solution was prepared. The mixed solution was kept for 24h in the dark place. In the beginning, red color of solution appeared but after 12 and 24 h, it was observed that the color of the solution changed to dark red and reddish black, respectively; which indicated that silver nanoparticles were completely formed. Silver nanoparticles were collected by centrifuging for 10 minutes at 5000 rpm; then with water and ethanol so as to remove unreacted/uncoordinated material. Finally, centrifuged nano-material was dried in the oven at 65^0C and greyish black nano-material of silver nanoparticles was collected; but, to get finer and uniform nature of nanoparticles for characterization, nano-material was mashed by using mortar-pestle.

Fig. 2. (a) *C. acuminatus* leaf extract, (b) 1:9 Mixture, (c) 12 h and (d) 24 h

III. RESULTS AND DISCUSSION

Fig. 3(a) is displaying the UV-Vis spectrum of aqueous solution of leaf extract and silver nanoparticles as a function of time variation. Silver nanoparticles have free electrons, which gives surface plasmon resonance absorption band due to joint vibrations of electrons of silver nanoparticles in resonance with light waves. Leaf extract solution was kept as blank and sharp absorption bands of silver nanoparticles at 410 nm were observed at different intervals of time. Intensity of absorption band was increased with the passage of time and after 24 h, no such increase was observed which means silver nanoparticles were completely synthesized. The band gap of silver nanoparticles was 3.02 eV and it was calculated by following, the equation i.e. Eg =1240/410. Cubic phase orientation and crystalline nature of silver nanoparticles were further confirmed by XRD analysis [Fig. 3(b)]. XRD pattern of silver nanoparticles displayed the three distinct 2θ (degree) peaks at 37.01, 43.14 and 63.38 that can be indexed to (111), (200) and (220) hkl values of cubic face centred orientation, respectively.

TEM micro-image [Fig. 3(c)] confirmed that the silver nanoparticles were spherical in shape and size of synthesized silver nanoparticles was within 06-10 nm range. Fig. 3(d) is showing the FTIR spectrum of Ag Nps synthesized by using *C. acuminatus* leaf extract. Peaks at 3585.62 and 3562.15 cm^{-1} may be due to -NH_2 stretching vibrations; sharp peak at 3385.61 cm^{-1} corresponds to hydroxyl groups without hydrogen bonding but C=C unsaturated bonds are represented by peak at 1620.20 cm^{-1}. Peaks below 650 cm^{-1} region are due to Ag nanoparticles. It can be assumed that amines, polyols, flavonoids, etc are the biomolecules that may be present in the leaf extract of *C. acuminatus*, involved in the formation and stabilization of the silver nanoparticles.



(a)

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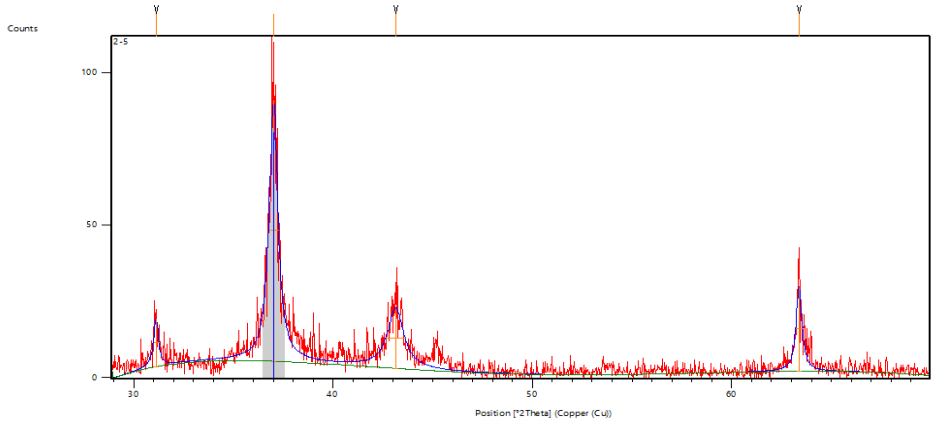
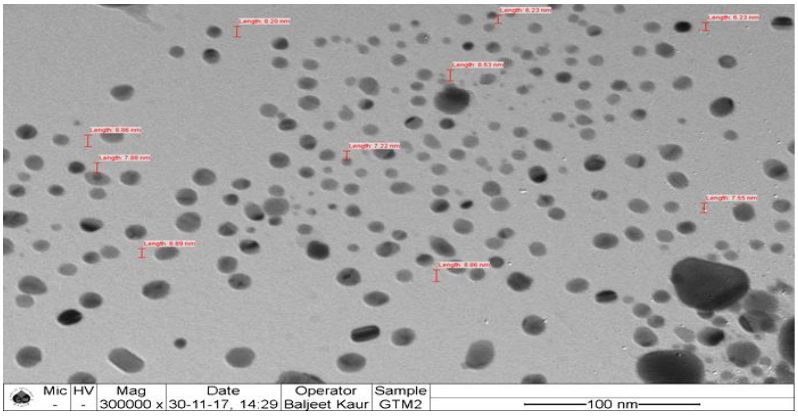
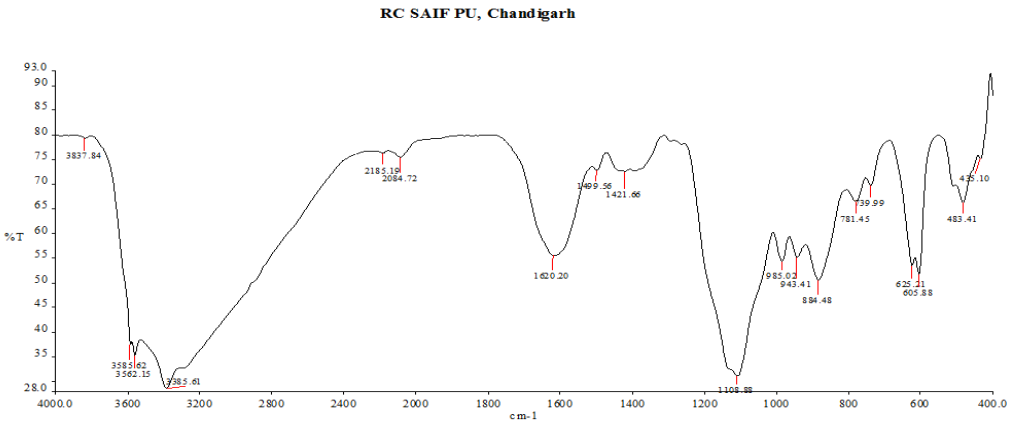


(b)



(c)



(d)

Fig 3(a)-UV-Vis spectrum, (b)-XRD pattern, (c)-TEM micro-image and (d)-FTIR spectrum of Ag nanoparticles.

IV. CONCLUSION

In conclusion, the study reveals that the formation silver nanoparticles was exhibited by using aqueous leaf extract of *C. acuminatus*. Spherical, size within 06-10 nm range, band gap 3.02 eV and stabilized by phytochemicals present in the leaf extract, silver nanoparticles were formed. It is a low temperature and pressure, non toxic, low cost and eco-friendly process for the production of silver nanoparticles.

V. ACKNOWLEDGEMENT

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