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International

ISSN:2320-3714
Volume 3 Issue 3
September 2022
Impact Factor:10.2
Subject Chemistry

Gold and Silver Nanoparticles Biosynthesis as Photocatalysts from Plant Extract in photochemical Reaction

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Abstract:

We describe biosynthesis of silver nanoparticles and gold nanoparticles using plant extract and investigate antibacterial activity and catalytic performance for pollutant degradation in order to extend the area of bio-nanotechnology's applications. The average diameter of spherical AgNPs is 20.5 nm, whereas the average size of multishaped AuNPs is 17.6 nm. The AgNPs effectively suppressed the activities of four bacterial strains.

Keywords: Gold Nanoparticles, Silver Nanoparticles, Biosynthesis, Photocatalysts, Plant Extract, photochemical reaction

Introduction:

Nanoscience & nanotechnology are the major applications small things that range from 1 to 100 nanometers (1nm=10-9 m) and could be used in scientific fields like chemistry, biology, physics, science of materials, engineering & technology. The word "nano" is originated from the greek term (Rai et al. 2008) meaning dwarf or incredibly tiny. The properties of nanometric materials vary materially from those of atoms & bulk materials. Bionanoscience & Bionanotechnology is an

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interdisciplinary research area that operates at the interface between chemistry, biology, science of materials, engineering, & medicine.

This assures advanced chemical reactivity thereby affecting their physical, chemical properties. Secondly, at nanoscale quantum effects goes on dominating which in turn affect the optical, electric and magnetic performance of nanomaterials. They consist of i) single or isolated particles, assemblies of particles, ii) one dimensional material (thin films and graphene sheets) iii) two-dimensional material (carbon nanotubes, biopolymers) iii) three dimensional dendrimers, fullerenes or Quantum dots. These nanomaterials were fabricated by two methods "top down" more often used by physicists and secondly "bottom up" used by chemists. Bottom-up approach is found to be superior as it changes the chemical character of distinct molecules to create orderly and useful conformational assembly. Such bottom-up approaches build the material (atom to atom, molecule to molecule) in parallel, cheaper manner with low defects, and with greater homogeneity.

Experimental

- **Methods**

Chloroauric acid (HAuCl4. X·H2O, 99.9% MERCK), Terepthalic acid (C6H4(COOH)2, MERCK), Sodium hydroxide, (NaOH, MERCK), 30% Hydrogen Peroxide (H2O2,MERCK), Ni(NO3)2.6H2O, (CH3COOH)2 Zn.2H2O, C4H6CdO4.2H2O, CuCl2.2H2O, CoCl2.6H2O, Pb(NO3)2, FeCl3, HgCl2, Silver nitrate (AgNO3, 99.9% MERCK), and Ammonia solution (NH3, RANKEM) were used without further purification. The Mili-Q water was utilized to organize all solutions. A stock solution of metal ions was prepared in Mili Q water & further diluted whenever necessary.

- **Plant Extract Preparation**

The leaves from C. latifolium are thinly crushed and dried in open air with the use of a 1 - 2 mm electric blender. With 100 mL distilled water the resulting powder (10 g), was refluxed for 1 hour.

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The mixture has been filtered and brown filters may be kept for future study at 4°C in the refrigerator.

- **Biosynthesis of Silver and Gold Nanoparticles**

In Ag+ or Au3 ion solutions the plant extract (C. latifolium leaf) had to be hung and stirred in the dark at 1200 rpm. Due to color variations, the growth of MNPs was easily apparent. UV-Vis measurements were utilized for optimizating reaction parameters, such as concentrated metal ions (0.5, 1.0, 1.5, and 2.0 mM), reaction temperatures (ranging between 30 and 120°C) and reaction durations from 200 to 800 nm (180 min). At maxima of 400 nm and 540 nm, respectively, the plant extract produced an increase in absorption by decreasing the Ag+ and Au3+ ions. In ideal conditions for future study AgNPs and AuNPs were biologically produced. 10 minutes of centrifugation produced solid MNPs at 10000 rpm, which were subsequently washed with water three times to remove metallic ions and impurities. After heating in an oven throughout the day at 90°C, MNPs were finally dried powdered.

- **Characterization techniques**

UV-Visible spectroscopy

Ultraviolet technique is an effective way of qualitative analysis of organic & inorganic samples. while a molecule absorbs a photon of light it gets excited to depending on its electronic structure and band gap of material. In metal nanoparticles absorption of radiation takes place due the surface plasmon resonance property. Thus this technique gives an idea of SPR band of nanoparticles. Further it also defines optical properties of nanoparticles varying with their sizes and results in peak shifting and its broadening

FTIR

This is improved form of IR technique which is able to analyse all possible chemical bonds which is not possible in a dispersive IR spectrometer. In FTIR technique all frequencies are analyzed simultaneously with far better resolution and signal to noise ratio than other conventional

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techniques. This is used in the quantitative analysis of solid, liquids and gases from an unknown mixture. This is fully based on the atomic vibrations within the molecule.

X-ray diffraction spectroscopy

It is a versatile, routine technique used by solid state chemists to determine structure of crystalline material. In crystalline solids atoms ions or molecules are prearranged in an ordered manner. When X-Rays interact with them particular diffraction pattern is obtained depending on its structure.

Result and Discussion

- **Findings of Biosynthesis study**

The *C. latifolium* contain a high concentration of active compounds, including phenolic antioxidants, which are responsible for MNP decrease. As a result, the aqueous extract of C. latifolium leaves, which is anticipated to be a bioactive source, may be utilized to make MNPs in an ecologically benign manner. The leaves were dried in an oven and then refluxed with water for 2 hours, as shown in Figure 1. Following the completion of the filtering procedure, a brown solution was produced. Changes in reaction parameters such as metallic ion concentration, reaction temperature, and reaction duration may be used to optimize stable MNP production. Colored changes in the solution and UV-Vis measurements indicated the production of the nanoparticles. MNPs were then cleaned by washing them in water and collecting them using centrifugation. Finally, physicochemical analytical methods were used to characterize the biosynthesized nanoparticles, which were then tested for antibacterial and catalytic activity.

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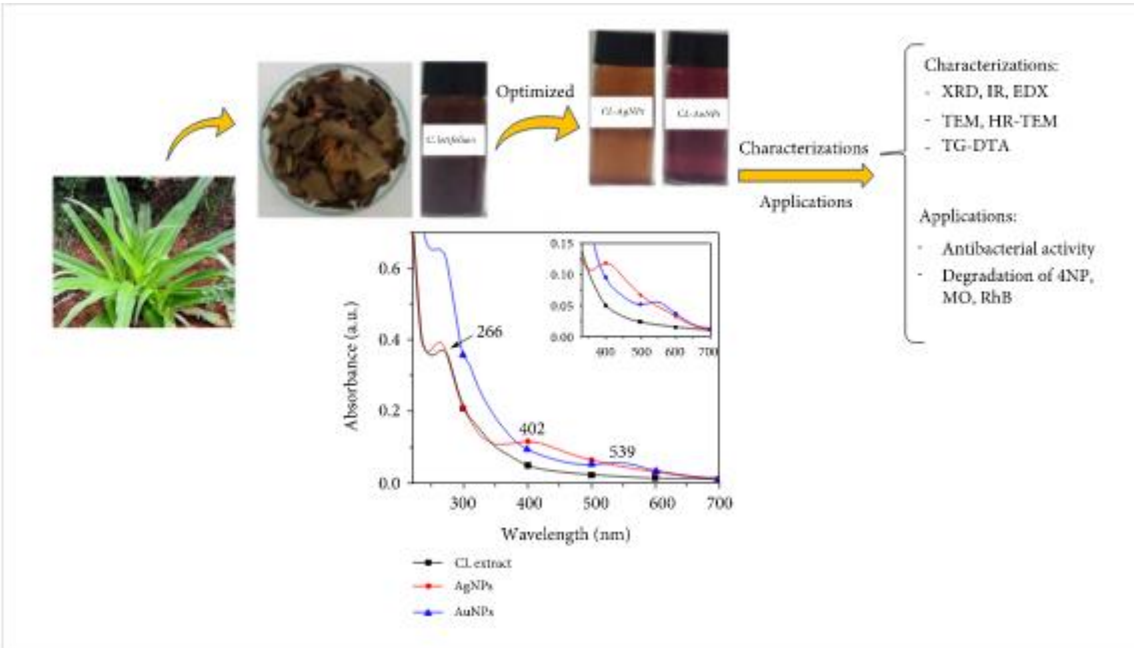

Figure 1: Schematic illustration of biosynthesis of AgNPs and AuNPs from aqueous extract

- **Physicochemical Characterizations**

Since all of the samples displayed the same absorption bands, MNPs may be stabilized by phytoconstituents in CL extract. The reduction of metallic ions and the stability of MNPs were revealed to be caused by the phytoconstituents present in the aqueous extract of C. latifolium leaf.

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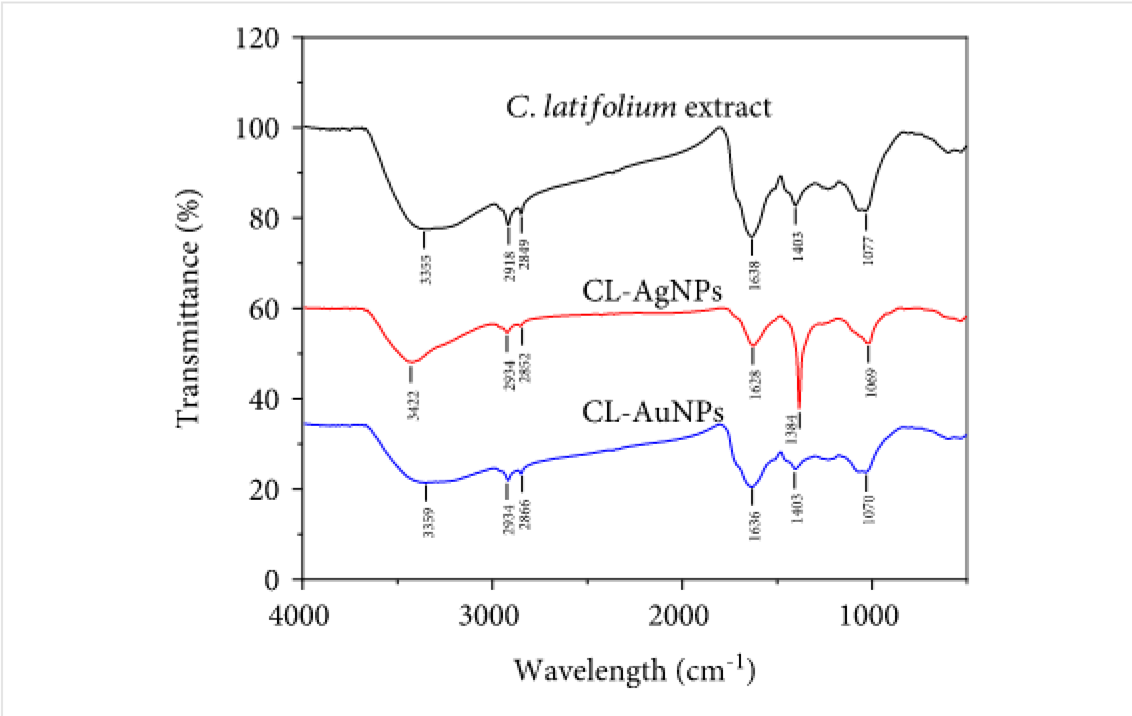

Figure 2: FTIR spectra of *C. latifolium* extract, AgNPs, and AuNPs.

The highest signal of crystalline silver and gold nanoparticles revealed a crystallographic preference for the (111) plane, according to XRD analysis.

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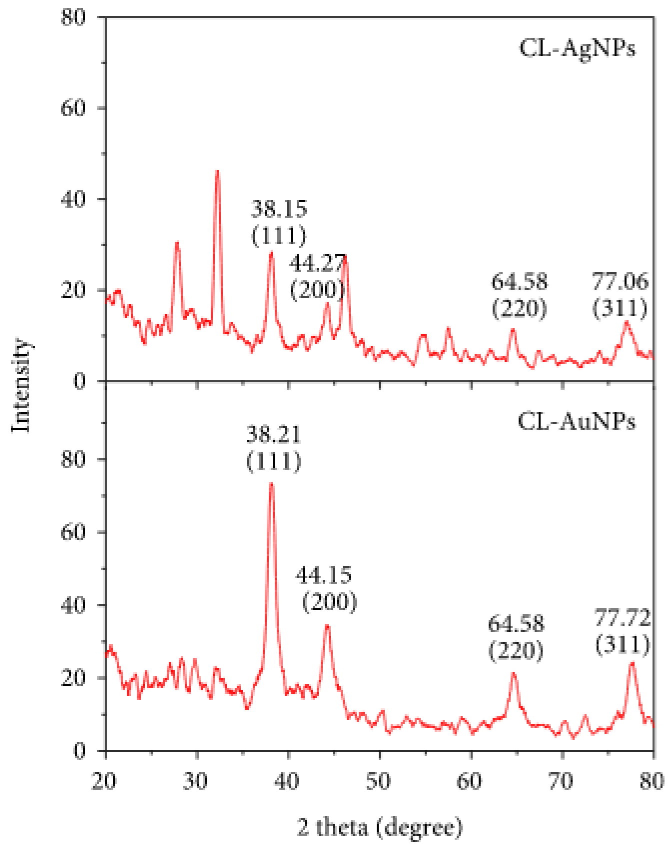

Figure 3: XRD pattern of synthesized AgNPs (a) and AuNPs (b)

- **Antibacterial Assay**

The size, shape, synthesis method, and composition of the capping agent have all been demonstrated to have a substantial impact on the antibacterial activity of MNPs [42, 43]. MNPs are examined for their bioactivity at weights ranging from 0.014 to 0.070 g. While AgNPs significantly inhibited each of the tested bacterial strains, AuNPs did not exhibit antibacterial action in the dose range examined. The bactericidal abilities of AgNPs are depicted in Figure 4. At a weight of 0.014 g, it had no effect on any of the tested strains, and the zones of bacterial inhibition widened as the AgNPs concentration rose. E. coli and A. tumefaciens, two Gram-negative bacteria, were the ones against which AgNPs were most active. Our research also showed

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that the activity of AgNPs produced through biosynthesis from aqueous extracts of the other plants was significantly higher. It was once more demonstrated that the bioactivity of biogenic AgNPs was significantly influenced by the compositions of the bioactive components from the plant extract.

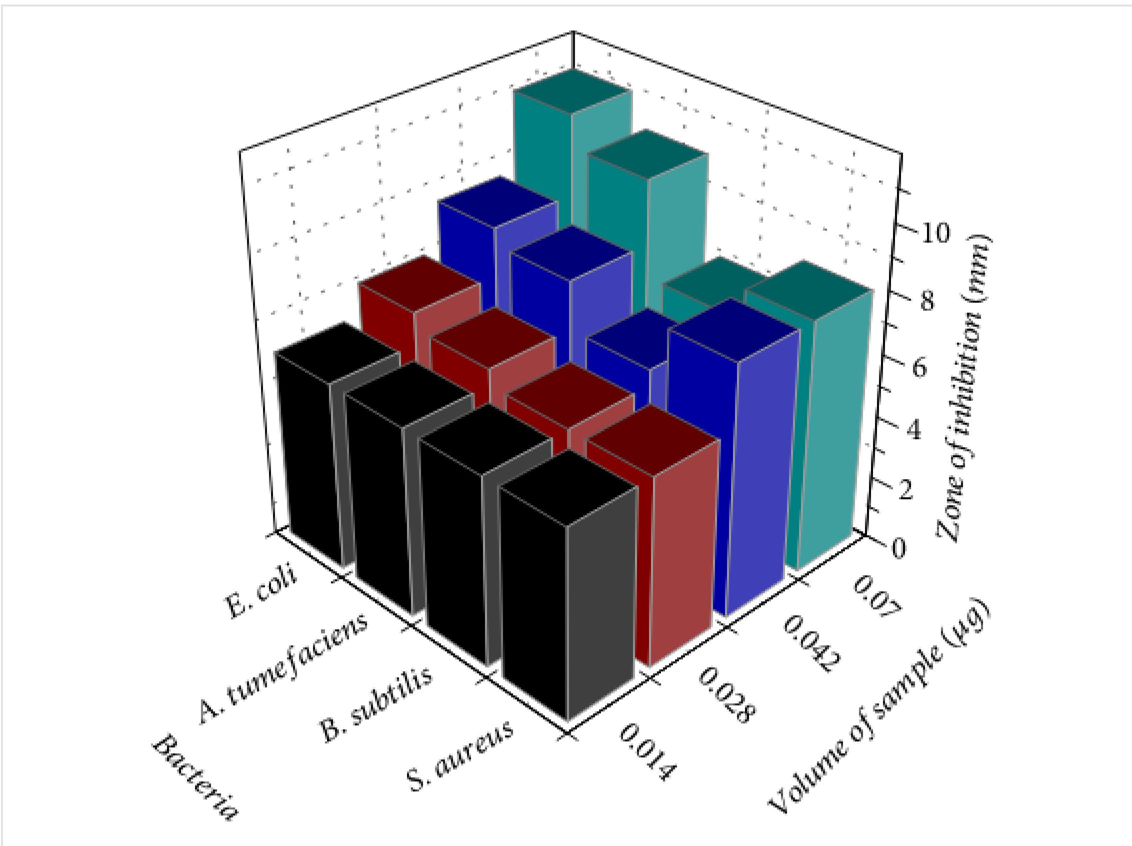

Figure 4: Plot of inhibition zone at the different concentrations of AgNPs for various bacteria.

- **Catalytic Performance of Nanoparticles**

The removal of dye pollution has grown in importance for wastewater treatment in the industrial sector during the last few years. In this investigation, aqueous NaBH4 was used as a model reaction to examine the degradation of the dyes 4-NP, MO, and RhB. Although this process is commonly acknowledged to be thermodynamically beneficial, the kinetic barrier made this degradation less likely since source and acceptor molecules have a large disparity in their oxidation-reduction

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potential. In fact, earlier research has demonstrated that reaction rates are extremely slow in the absence of the catalyst. In order to accelerate reactions and get beyond this kinetic barrier, noble metal nanoparticles are frequently used.

The color faded and the absorbance at 400 nm reduced quickly after the CL-AgNP and CL-AuNP catalysts were added to the solution, but a new peak emerged at 298 nm, indicating the formation of 4-AP. According to the UV-Vis spectra, 4-NP was degraded in the presence of AgNPs and AuNPs for 14 and 10 minutes, respectively. The pseudo-first-order reaction occurs after the deterioration of 4-NP, as seen by the strong linear relationship between and time in Figure 5.

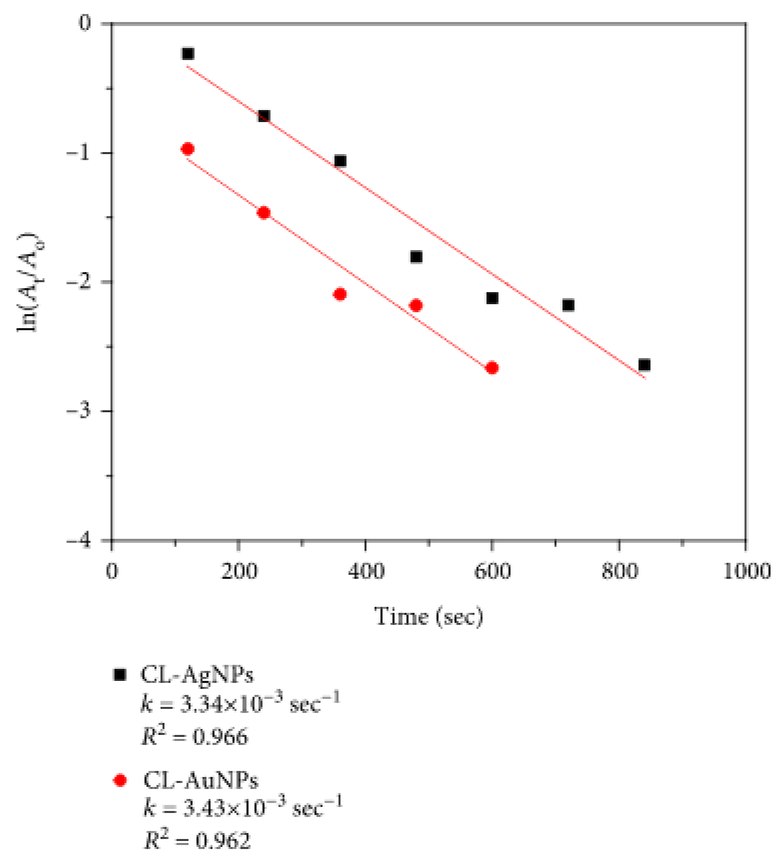

Figure 5: The degradation of 4-nitrophenol in AgNPs and AuNPs catalysts was studied using first-order kinetics

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Conclusions

In this study, Gold and silver Nanoparticles Biosynthesis as Photocatalysts from Plant Extract in photochemical reaction. The method developed enables the optimization and manufacturing of MNPs in a variety of shapes and sizes. MNPs' antibacterial activity was examined, and biosynthesized AgNPs were shown to be very effective in suppressing four distinct bacterial strains. In addition, catalytic studies using NaBH4 to reduce pollutants indicate that biosynthesized AuNPs exhibited greater catalytic activity than AgNPs in all tests. The present study demonstrates that C. elegans aqueous extract may be used to biosynthesize novel MNPs. latifolium leaf, which has potential as antibacterial agents and better catalysts for pollutant reduction in industrial effluents.

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