IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Optical and Catalytic Properties of Silver and Gold Nanoparticles Using Biomedical plant, *Rotula aquatica* through Microwave Irradiation

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Abstract: **Synthesis of silver and gold nanoparticles from the biomedical plant, *Rotula aquatica*, using microwave irradiation is reported here. Confirmations of nanoparticles formation were executed using UV-vis. spectroscopy, identification of the functional groups in the plant chemicals responsible for reduction and capping of the nanoparticles were done by FTIR spectroscopy. Confirmation of crystalline character of the synthesized nanoparticles was conducted by XRD analysis. Investigation of catalytic activity of the synthesized nanoparticles on the degradation of the congo red dye. The antibacterial activities of the plant extract, silver and gold nanoparticles were performed in reference to a standard antibiotic by well diffusion pathway**

***Index Terms* - *Rotula aquatic*, catalytic activity, natural antibiotic, Congo red, multifunctional.**

I. INTRODUCTION

Biodegradable multifunctional nanomaterials are of immense attraction in the new age scientific fraternity because of green chemistry metrics. Metal nanoparticles prepared in the context of green chemistry has several advantages less waste production, increased use of solvent waste, high-yield of production and generation of single-sized metal nanoparticles etc [1]. Metal nanoparticles have are found their applications in medical equipments like wound healing ribbons, self curing antibiotic fabrics, food packing polymer coating. Use of food preservatives to inhibit the microbial growth is a common strategy in the modern junk food culture even though serious health issues are embedded in it. By employing the metal nanoparticles in food packaging is a major concern and promising method for the manufacture of food packing containers[2]. Metal nanoparticle-coated textiles containing silver, gold, or palladium exhibit properties commercial bandages[3]. Hybrid systems composed of noble metal nanoparticles loaded on smart polymer microgels gained much attraction and can be studied by simple UV-vis. spectral studies[4]. Organic coupling reactions for development of carbon–carbon and carbon–heteroatom bond can be catalyzed by metal nanoparticles supported on grapheme supported polymers[5]. Metal organic frameworks have excellent hetero catalytic capacities in the oxidation, reduction reactions. CO_2 reduction, water splitting, and organic reactions can be effected by MoFs in presence of light[6].

Synthesis of noble metal nanoparticles silver and gold using the biomedical plant, *Rotula aquatica*, by microwave irradiation is reported here for the first time. UV-vis., FT-IR, XRD, TEM and photoluminescence analysis were conducted to characterize the particles. Catalytic activities and biomedical applications of the synthesized nanoparticles were performed.

II. EXPERIMENTAL METHODS

2.1.Preparation of Rotula aquatica leaf extract

Fig. 1 Photograph of *Rotula aquatic* plant

Rotula aquatica is an important plant in traditional medicine. Important phytochemicals contained in *Rotula aquatica* that produce definite physiological action on human body are alkaloids, flavonoids, phenolic compounds, amino acids, and proteins. *Rotula aquatica* is used as remedy for many aliments such as kidney and bladder stones, coughs, fevers, heart diseases, blood disorders, ulcers, diabetes, and urinary disorders. The roots and leaves of plant *Rotula aquatica* (kallurvanchi) is an important medicine for increase kidney and heart functions.

20 g of *Rotula aquatica* is refluxed with 100 ml of distilled water in an R B flask fitted with a condenser for 30 minutes. Filtered through a Whatmann No.1 filter paper and kept at 4^0C for further use.

2.2.Preparation of silver and gold nanoparticles

Aqueous extract of *Rotula aquatica* and solution of $AgNO_3/HAuCl_4$ were mixed, stirred well and placed in a domestic microwave oven (Sharp R-219T (W)) operating at a power of 800 W and frequency 2450 MHz for microwave nurturing. The colours of the reaction mixtures are noted.

2.3.Characterization Techniques

Formation of nanoparticles was confirmed by recording UV-vis. spectra of the reaction mixture. In this present work Perkin Elmer FT-IR spectrometer is used with a frequency range of 400-4000 $cm^{-1.}$ The powered samples were used for analysis. X-ray diffraction studies of the synthesized silver and gold nano particles were carried out for the better understanding of the crystal planes of the nanoparticles. The XRD studies were conducted on a PANalytic X'PERT-PRO X-ray spectrometer with a scan rate of 1.2^0 per min and 2Ө is measured from 20^0 to 90^0. The radiation used is Cu K_α (1.5418 A^0) with a Ni filter. X-ray diffraction (XRD) relies on the dual wave/particle nature of X-rays to obtain information about the structure of crystalline materials.

2.4.Degradation of Congo red dye using metal nanoparticles as catalysts

The degradation of Congo red dye by $NaBH_4$ is the model reaction used to study the catalytic activity of the synthesized Ag NPs. To study this reaction, 2 mL of Congo red (0. 1mM), 0.5 mL freshly prepared $NaBH_4$ solution (0.06 M), 0.5mL Ag NPs were taken in a quartz cuvette of 1 cm path length. A control experiment was also conducted without using Ag NPs.

2.5.Antibacterial activity

The antibacterial activities of the nanoparticles were tested using disc diffusion method. One gram positive and one gram negative human pathogenic bacterial strains, *Streptococcus sp and E. coli* were employed in this study. The agar medium solidified and the plates were uniformly spread by swabbing method. Wells of 5-6 mm is created on the grown microbes and filled with 50-70 µl each of samples and the plates were incubated at 37°C for 24 h. The zones of inhibition formed after the incubation period after their treatment with samples were noted. The zone of inhibition was measured in mm.

III. RESULT AND DISCUSSIONS

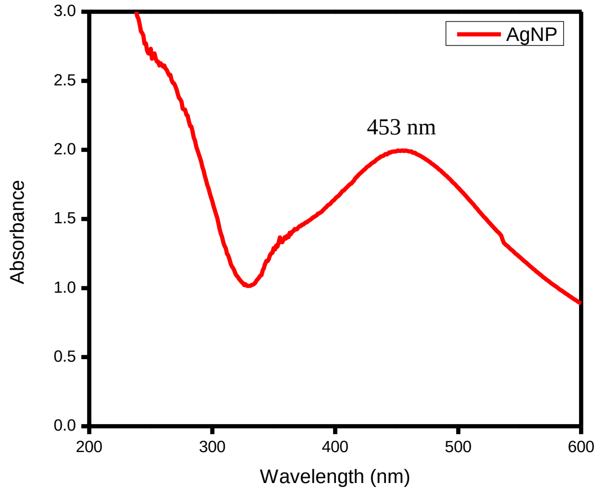
3.1.Visual observations

The formation of silver nanoparticles were identified by a sudden colour change from yellow to brown and that of gold nanoparticles is identified by the formation of wine red colour in the reaction mixture.

Fig.2 Images of plant extract (light colour), AgNPs (brown colour) and AuNPs (Pink colour)

3.2.UV-vis. spectroscopic analysis

The production of silver and gold nanoparticles by reduction of their ions was followed by UV–Vis spectroscopy. UV-Visible spectrophotometric analysis confirmed the formation of silver and gold nanoparticles by observing a peak at 453 nm 528 nm respectively due to the surface Plasmon resonance (SPR) of noble metal nanoparticles.



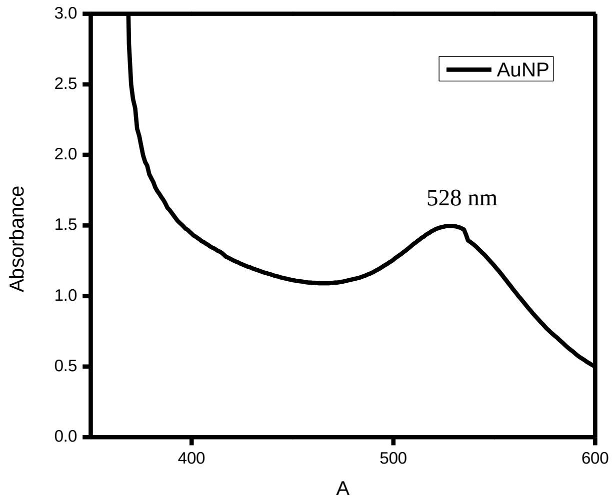


Fig.3.UV-vis.absorption spectrum of AgNPs and AuNPs

The peak is almost symmetrical and there are no peaks in the range of 450-700 nm indicating the absence of nanoparticle aggregation. The SPR band arises due to the collective oscillations of the conduction electrons of nanoparticles in presence of visible light which is highly influenced by shape and size of the nanoparticles. The UV-visible spectral studies propose that the nanoparticles are uniformly distributed and are more or less spherical in shape. The main attraction of microwave synthesis is that it yields small, uniform sized nanoparticles in much lesser reaction time. The speedy consumption of starting materials reduces the formation of agglomerates in microwave assisted methods and provides nanoparticles with narrow size distribution.

3.3.FTIR spectroscopy

FTIR analysis identifies the functional groups present in the extract of *Rotula aquatica* which causes the reduction of metal ions to zero valent nanoparticles.

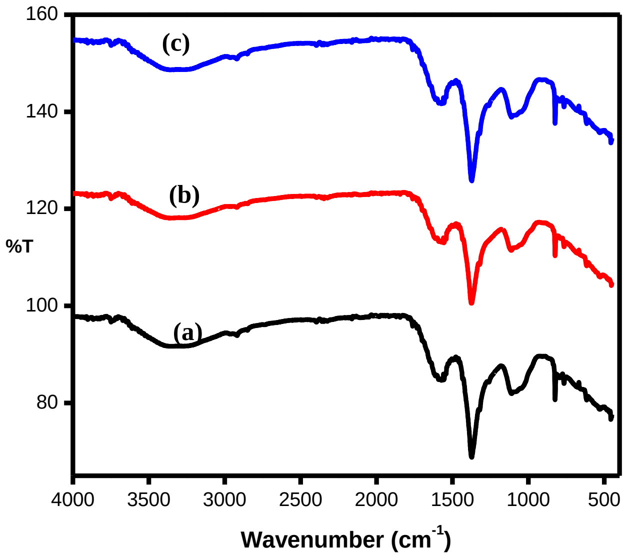


Fig.4. FTIR spectrum of (a) extract of *Rotula aquatica,* (b) AgNPs, and (c) AuNPs

The broad band appearing in the range of 3400 - 3300 cm^{-1} results from the stretching vibrations of the hydroxyls (-OH) group of various metabolites present in plant. A weak band observed at 2927 cm^{-1} is associated with aliphatic O-H stretching vibrations. The absorption peak at 1607 cm^{-1} is attributed to C=C stretching vibrations of aromatic ring. An intense band at 1386 cm^{-1} can be assigned to –C-O stretching vibrations in carboxylic group. The strong absorption band at 1030 cm^{-1} is characteristic of –C-O stretching vibrations of alcohols. The peak at 824 cm^{-1} is due to the presence of aromatic ring.

3.4.XRD analysis

X-ray diffraction study was performed to confirm the crystalline nature of AgNPs and AuNPs (Fig. 5).

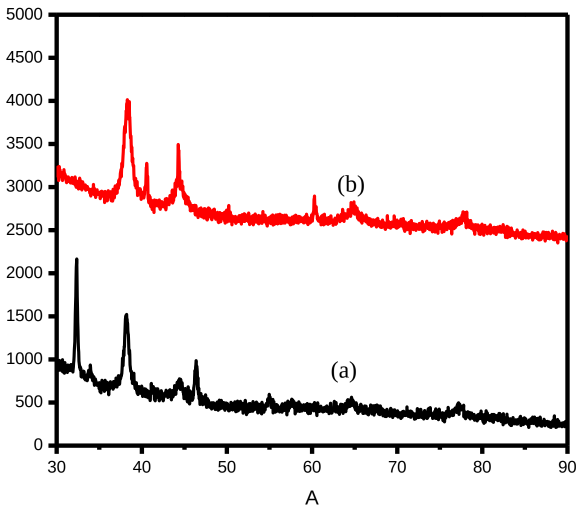


Fig.5 XRD pattern of (a) AgNPs (b) AuNPs

The major peaks observed for AgNPs at 2θ values are 38.17, 44.41, 64.23,78.02 and for AuNPs the peaks 38.35, 44.23°, 64.03, 78.56° respectively for of nanosilver and nanogold which corresponds to (111), (200), (220), and (311) planes of face centered cubic (fcc) structure. XRD paterns show some sharp peaks superimposed on broad peaks. The area under the sharp peaks is much smaller than the area under the broad peaks confirming the statement that the nano-crystalline phase is predominant. This indicates that the synthesized metal nanoparticles have the crystalline structure.

3.5.Photoluminescence spectrum

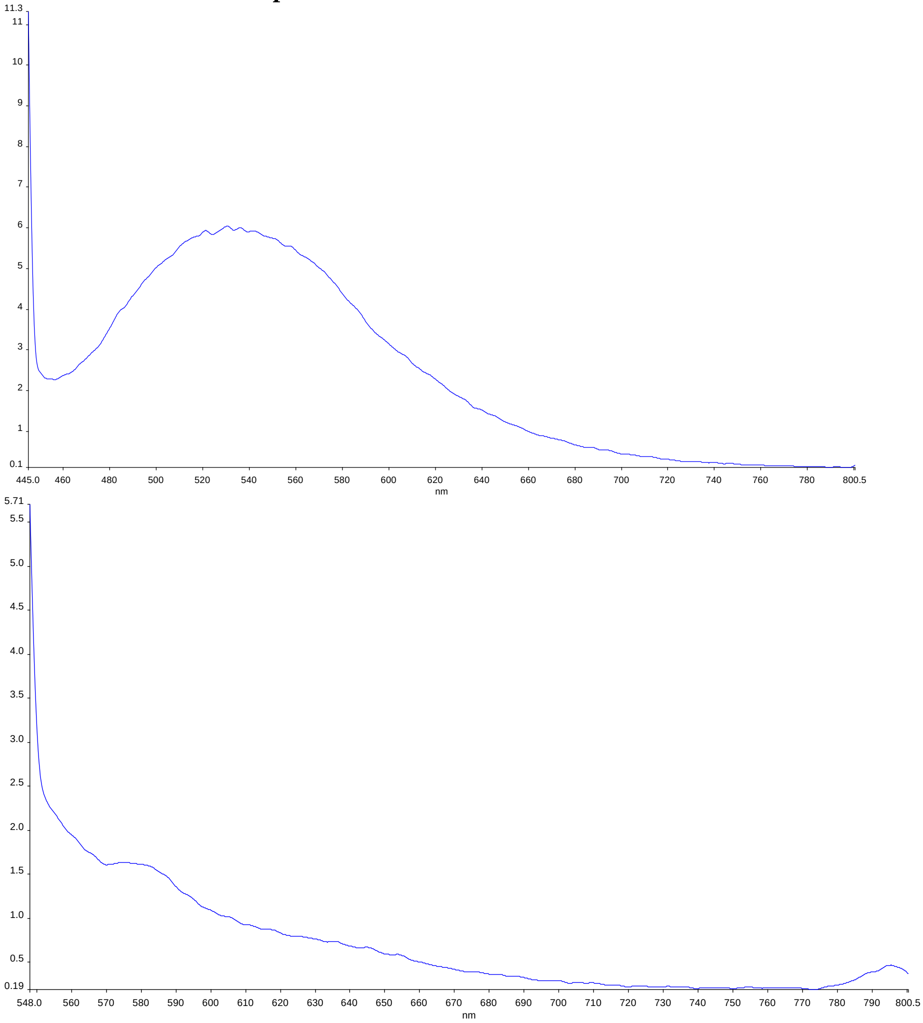
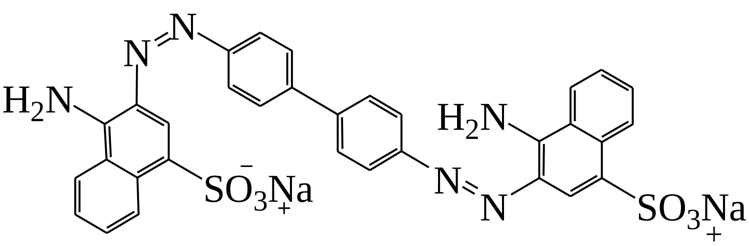


Fig.6 Photoluminescence spectrum of (a) AgNPs, and (b) AuNPs

3.6. Degradation of Congo red by using AgNPs/AuNPs as catalyst

Congo red is an organic compound, the sodium salt of 3,3′-bis. It is an azo dye. Congo red is water-soluble, yielding a red colloidal solution.



Congo red

Fig. 7 Structure of Congo red

The catalytic competence of AgNPs was studied by selecting the degradation of Congo red by $NaBH_4$. The UV-visible absorption spectrum of Congo red has maximum absorption at 498 nm. The intensity of the peak at 498 nm remained almost unchanged even after hours suggesting that $NaBH_4$ alone is unable to effectively reduce congo red. Degradation of Congo red by the addition of $NaBH_4$ only is shown below

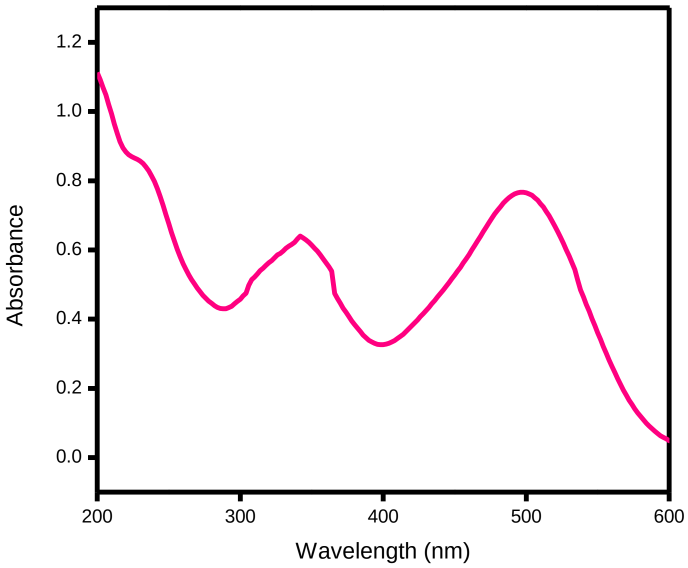


Fig.8 Degradation of Congo red by the addition of $NaBH_4$ only after 30 min of reaction

The intensity of the peak at 498 nm remained almost unchanged even after hours suggesting that $NaBH_4$ alone is unable to effectively reduce Congo red. But the reduction reaction started immediately after the addition of a small amount of AgNPs/ AuNPs catalyst.. The UV-visible absorption spectra for the $NaHB_4$ reduction of Congo red catalyzed by AgNPs and AuNPS are shown in Fig 9 and Fig 10. To pursue the progress of the reaction, the spectrum was recorded at regular intervals after the addition of the catalyst to the reaction medium.

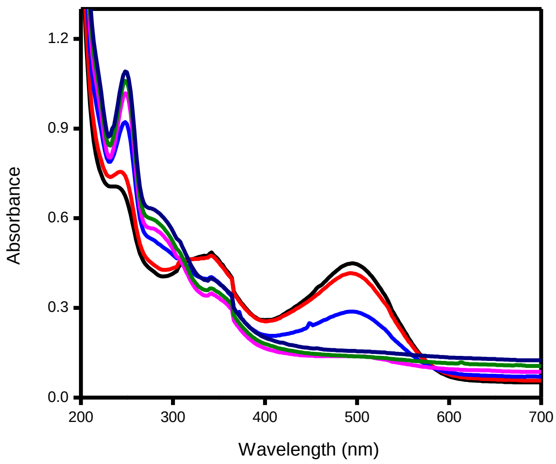


Fig.9. (a) The UV-visible absorption spectrum for the reduction of Congo red by $NaHB_4$ in presence of 0.02 mg/ml of AgNPs.

Upon addition of the catalyst, the borohydride ions which are the electron donors and Congo red which accepts the electrons gets adsorbed on the surface of the nanoparticle catalyst.

3.7.Bactericidal activity

The antimicrobial properties of silver and gold have been known for thousands of years. It has been used to treat a wide variety of infections. Due to the small size and large surface area, they can undergo more efficient binding with the bacteria. The antibacterial activity of the synthesized AgNPs and AuNPs were clear from the photographs of the developed plates. The zone of inhibition formed by AgNPs against *Streptococcus sp* and *E.coli* are 1.8 mm and 1.6 mm respectively. It is seen that AuNPs is not show any significant antibacterial activity since no observable zone is formed around the well.

Fig. 10 Bacterial plates in the agar well diffusion method. AD= plant extract (70µl, 0.02mg/ml), BD= AgNPs (70µl, 0.02mg/ml), CD= AuNPs (70µl, 0.02mg/ml), and Streptomycin (positive standard)

IV. **CONCLUSIONS**

A critical need in the field of nanotechnology is the development of a reliable and eco- friendly method for the synthesis of metallic nanoparticles. Nanoparticles are being viewed as a fundamental building block of the 'nanoculture' of present era. Silver and gold nanoparticles play a profound role in many fields due to their excellent physiochemical properties. We have demonstrated a green, low cost biological reducing agent *Rotula aquatica* -plant extract which can produce Silver nanoparticles. Plant extracts may provide better alternatives to toxic reducing agents for the synthesis silver nanoparticles. The route is simple, efficient and low cost and generally leads to the formation of crystalline nanoparticles with variety of shapes and sizes. We adopted microwave irradiation method for the preparation of nanoparticles which holds many advantages over the traditional process as it follows rapid initial heating, homogeneous reaction medium, the increased reaction kinetics, clear reaction products with higher yields.

V. DISCLOSURE OF INTEREST

The authors have no conflict of interest regarding the content and write up of the paper.

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