International Journal of Interdisciplinary Innovative Research &Development (IJIIRD)
ISSN: 2456-236X
Vol. **08** Special Issue **01 | 2023**

The current trends in the green syntheses of Gold nanoparticles and their applications

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I. Abstract:

Nanotechnology is a rising star on the scientific horizon with a wide range of promising uses. It encompasses the creation and application of materials with nanostructures. Green science pathways are cost effective and do not use toxic chemicals, high pressure and temperatures .Gold nanoparticles Gold nanoparticles, among other metal oxides, have mostly been used for photocatalytic, antibacterial, and antifungal, antiviral purposes. The precursor metal salt is reduced into the appropriate nanoparticles using a variety of biological entities. The bio-reduction and capping processes involve the secondary metabolites found in leaf extract. An overview of the green synthesis of Gold will be given in this article.

Keywords: Gold Nanoparticles, *Azadirecta indica*, Biological method, Chemical method

II. Introduction:

Nanoparticles have novel or superior properties depending on their size, shape and distribution (Song and Kim 2009). The synthesis of nanomaterial can be broadly categorized into two approaches: top-down and bottom-up. Top-down approaches involve crushing or cutting of the bulk materials into fine particles at the nanoscale (Banerjee *et al*., 2014). There are reports on antimicrobial activity of nanoparticles such as Au which are effective against different drug resistant bacterial, viral and fungal strains (Rai and Bai *et al*., 2011).

Gold nanoparticles has been studied due to its various applications of sensors, photoelectrodes, optoelectronic devices, photocatalysis, photovoltaic, ultracapacitors & also photovoktaic because of their excellent photoelectrochemical & photocatalytic properties that is possesses (Khan *et al*.,2015). Nanoparticles have attracted great interest due to their unique physical and chemical properties, which are different from those of either the bulk material or single atoms. Nanoparticles show completely improved properties based on specific characteristics such as size, distribution and morphology. The field of nanotechnology is one of the most active areas of the research in modern material sciences. Green science pathways are cost effective and do not use toxic chemicals, high pressure and temperatures (Aromal *et al*., 2012).

Due to their unique properties, the precious metal nanoparticles and the semiconductor quantum dot nanoparticles have been increasingly used in the field of biological, biotechnological and biomedical research. In particular, the metal nanoparticles are applied to the visualization of cells, sub cellular structures, and the processes in living organism, the delivery of genes, drug and other targeted to proper destinations, the hypothermia treatment of tumors etc. (Mohanpuria *et al*., 2008). Gold nanoparticle shows size dependent properties. The most common stabilizing agents reported are sodium citrate, transferrian and cetyltrimethyl ammonium bromide, while common species used for functionalization include various amines, oligonucleotides, peptides, antibodies and lipids. The interest in GNPs is largely due to the relative case of their synthesis, with good control of their sizes and shapes, their optical characteristics and their good biocompatibility. The accumulation of Gold nanoparticles in the body following repeated administrations can reach toxic levels (Wang *et al*., 2012).

To improve the biocompatibility of GNPs it is preferable to use nontoxic reagents. All GNP-preparation methods are based on the reduction of gold ions, mostly as solutions of $HAucl_4$. Various reducing agents have been reported in the literature, the most common being sodium borohydride and sodium citrate.(Ghosh *et al*.,2008) . Green reduction and protection are widely used in Nanosciences recent years. Simple, green and novel method of nanoparticle synthesis is now a great area of interest (Shukla *et al*., 2012).The characterization of these gold nanoparticles begins with a visual color change which works on the principle of surface plasmon resonance (SPR). The color change occurs when the size of the particles increases, in the case of gold it is from deep red to purple. The varying color changes are due to LSPR that they exhibit, and it lies in the visible region of the electromagnetic spectrum, which means that particular portion of the wavelength in the visible region is absorbed while another portion gets reflected and the emitted wavelength is reflect its own color. The absorbance of these color changes is measured using UV-Visible spectroscopy (Zhang *et al*., 2016 and Kumar Das *et al*., 2010)

A novel use of the ethanolic leaf extract of Centella asiatica to produce gold nanoparticles by reduction of Aucl4- ions. The gold nanoparticles obtained were characterized by UV-visible spectra, transmission electron microscopy (TEM) and X-ray diffraction (XRD). TEM studies showed the particles to be of various shapes and sizes. Selected-area electron diffraction (SAED) pattern and high-resolution TEM image confirmed phase and high crystallinity of the particles. The XRD patterns showed a (111) preferential orientation of the gold nanoparticles. Fourier transform infra-red spectroscopy (FTIR) measurements showed the GNPs having a coating of phenolic compunds indicating a possible role of biomolecules responsible for capping and efficient stabilization of the gold nanoparticles. As no synthetic reagents were used in this method, the synthesized gold nanoparticles have potential for application in biomolecular imaging and therapy (Song *et al*., 2009).

III. Applications:

Novel uses of nanoparticles have recently or globally been developed. By encasing the medication, attaching therapeutic drugs, and delivering them to the desired tissue, nanotechnology allows for the development of nanomedicines.

A. Drug delivery: As the cell is functionalized with binding agents, a nanoparticle's center contains the medicinal ingredient. The targeted nanoparticles recognized the target cell through the binding agents, which causes the nanoparticles to dissolve and release the medicinal drugs (Tripathi *et al*.,2015)

B. Focusing on a particular cell: In active targeting, drug delivery systems are coupled with moieties, like as antibodies and peptides, to bind them to receptor structures expressed at target sites. In passive targeting, a prepared medication combination is transported to the target side by the bloodstream (Saha *et al*.,2012).

The receptor on cell membrane is the primary target in the body. Antiretroviral therapy (ART) has improved lifespan and quality of life of patients infected with the HIV-1. However, ART has several potential limitations, including the development of drug resistance and suboptimal penetration to selected anatomic compartments. Improving the delivery of antiretroviral molecules could overcome several of the limitations of current ART(Garrido *et al*.,2015). Gold nanoparticles of 2 – 10 nm diameter as well as gold nanoparticles coated with Polyethylene Glycol were tested for their cytotoxicity and anti-viral activity. AuNP and AuNP+ PEG were found to be effective as virus neutralizing candidate when allowed to interact with HIV- infected CD4+ T cells (Kesarkar *et al*.,2012). Antiviral activity of gold nanoparticles could be used to treat and control the infection of Measles virus (MeV). The number of cases of measles has increased due to a lack of vaccination coverage. AuNPs-As inhibited MeV replication in Vero cells with a 50% effective concentration (EC50) of 8.829 µg/mL, and the selectivity index (SI) obtained was 16.05(Melendez *et al*.,2019).

VI. Materials and methods-

Chemicals required for the chemical and biological synthesis of Gold nanoparticles were Chloroauric acid (HAuCl4), Tri Sodium Citrate (TSC), Sodium hydroxide (NaOH), Leaves of *Azadirecta Indica*. All chemicals used in this study were analytical reagent grade and deionized water was used throughout the work. All the glassware were washed with dilute nitric acid (HNO3) and distilled water then dried in oven.

A. Chemical Method

The protocol was follow for the synthesis of Gold nanoparticles with slight modification from (Fren *et al*.,) with slight modification. An appropriate volume of 1% aqueous stock solution of $HAuCl_4$ and TSC was prepared. 99ml of Milli-Q water and 1ml of 1% HAuCl4 was added in 500ml conical flask, the final concentration of $HAuCl_4$ was 0.01%. The solution was mixed thoroughly and refluxed with constant stirring. Within 2-5 min, the initial pale yellow colored solution turned colorless and changed to bluish- gray. In anather 5min the solution turned to reddish-purple indicating the formation of AuNPs. The solution was stirred for another 10 min and cooled to room temperature. (Borse *et al*., 2020).

Synthesis of Gold nanoparticles by chemical method

B. Biological method

The plant selected for the synthesis of gold nanoparticles was *Azadirecta indica* which belongs to Meliaceae family, the plant was been used in Ayurveda, folk medicine, cosmetics, in organic farming application.

C. Preparation of plant extract

Collected part like leaves of *Azadirecta indica plant* washed with DDwater to remove the associated dust particles, shade dried in laboratory then grinded it to form fine powder. Five grams of powder of *Azadirecta indica* leaves was boiled in 100 ml distilled water for 8-12 min. The extract were cooled and filtered through a Whatman filter paper. The filtrate was stored at $40^{o}C$ and used for further synthesis.

D. Preparation of stock solution of Chloroauric acid

The stock solution was prepared using chloroauric acid which served as the precursor for synthesis of gold nanoparticles. Chloroaurate was dissolved in double distilled water and the pH of the solution was adjusted to alkaline (pH-8). This was stored as stock solution and used for further synthesis. (Kamala *et al*., 2014)

E. Synthesis of Gold nanoparticles

The plant extract was added to chloroauric acid solution at room temperature. The plant extract serve as a reducing and stabilizing agent aided in the synthesis of nanomaterial. The initial confirmation of formation of nanoparticles was based on the distinctive change in color of chloroauric acid from pale yellow to deep wine red, as a result indicating synthesis of gold nanoparticles.

Azadirecta indica | **Powered form** | **Color change indicated formation of AuNPs** | **Au NPs**

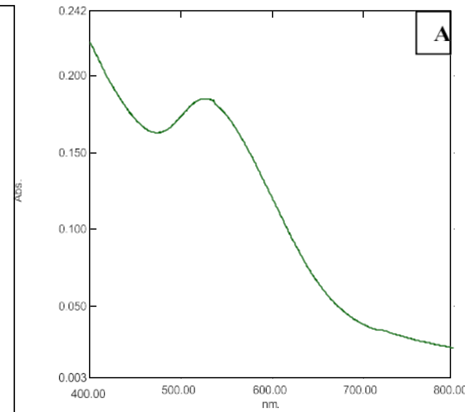
Synthesis of Gold nanoparticles by biological method

V. Characteristics of Gold nanoparticles-

A. Visual Observation – Ruby red color formation indicates the formation of Gold NPs.

Some spectrophotometric analysis also performed for characterization of Gold nanoparticles.

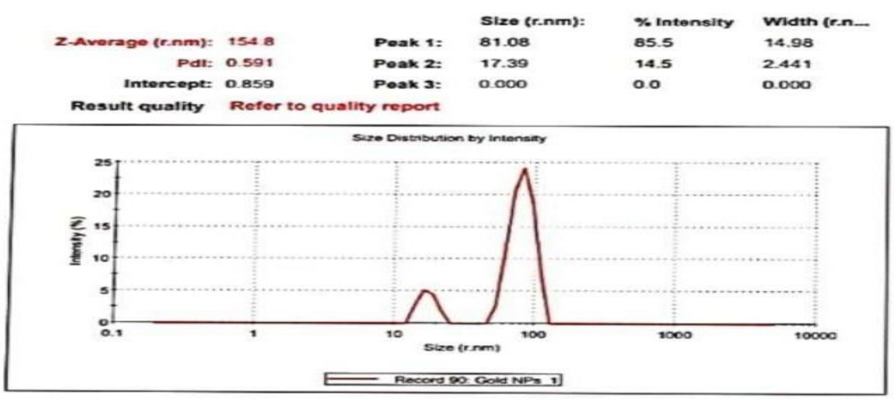
B. UV-Visible spectrophotometer- The peak between 500-600nm indicates the formation of Gold nanoparticles. The UV-Vis spectra of green synthesized gold nanoparticle in which the SPR band was located at 529 nm confirm the formation of gold nanoparticle in solution. This clearly demonstrate that the leaf extract can perform as an excellent reducing and stabilizing agent for Gold nanoparticle synthesis.



Graph of UV-visible absorbance spectrum of AuNPs synthesized with **leaves extract** (λ_{max} -529 nm). The peak between 500-600 nm **confirms the formation of AuNPs.**

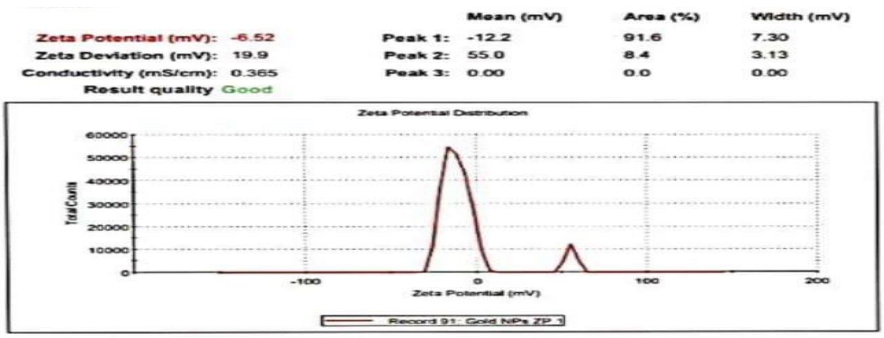
C. Zeta analyzer:

The common practice is to determine the electric potential of a particle at a location away from the particle surface, somewhere in the diffuse layer. This location, related to particle movement in liquid, is called the slipping or shear plane. The potential measured at this plane is called zeta potential which is a very important parameter for colloids or nanoparticles in suspension. Its value is closely related to suspension stability and particle surface morphology. Therefore it is widely used in product stability studies and surface adsorption research (Delgado *et al*., 2007). The Zeta sizer Nano range of instruments provides the ability to measure three characteristic of particles or molecules in a liquid medium. These three fundamental parameters are Particle size, Zeta potential and Molecular weight. It also used to measure size of nanoparticles. **Zeta Size** – Average size of Gold Nanoparticles was found to be 154.8nm.



Graph of Size by Zetasizer for Au Nanoparticles

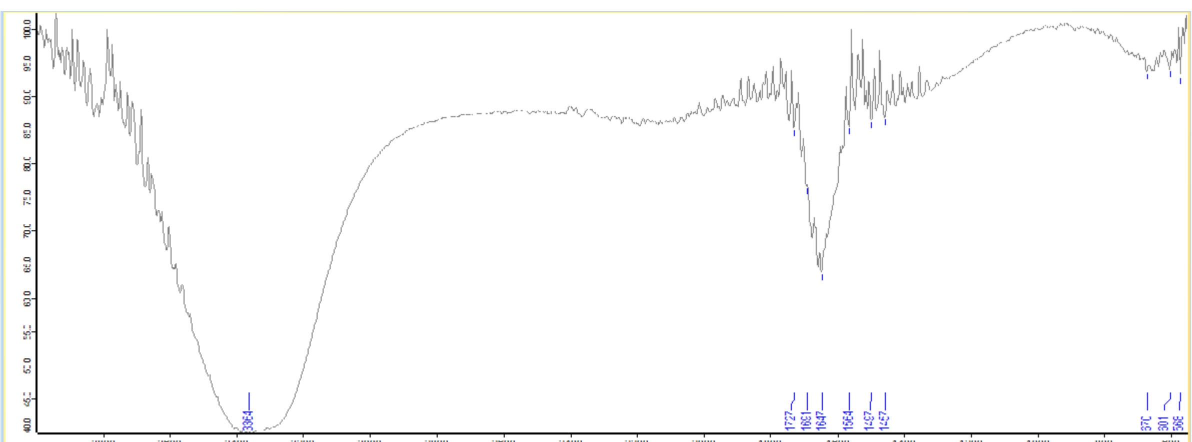
Zeta Potential- The value of zeta potential for Gold nanoparticle was found to be -6.52



Graph of Size by Zetaspotential for Au Nanoparticles

D. FTIR-

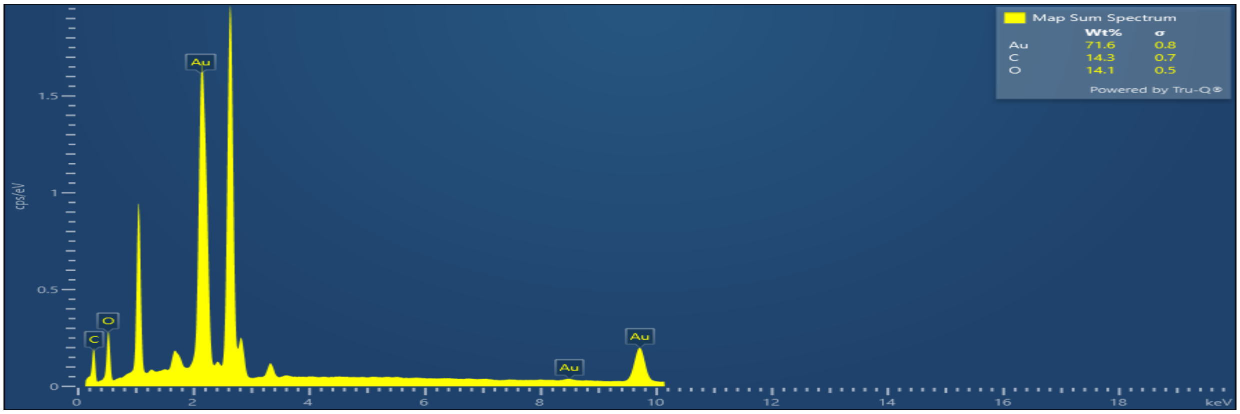
The FTIR analysis was used for characterized extract and synthesized nanoparticles. The FTIR spectra of *Azadirecta indica* leaf extract before and after bioreduction did not show any significant changes. The FTIR spectrum of leaf extract show major bands at 3364 $cm^{-1}$and 1647 cm^{-1}. The intense band absorbance at 3364 cm^{-1} is the characteristic of the hydroxyl functional group in alcohol and phenolic compounds. The band at 1647 cm^{-1} can be assigned to the amide 1 band of the protein released by *Azadirecta indica* leaves or to C=C group/ aromatic rings.



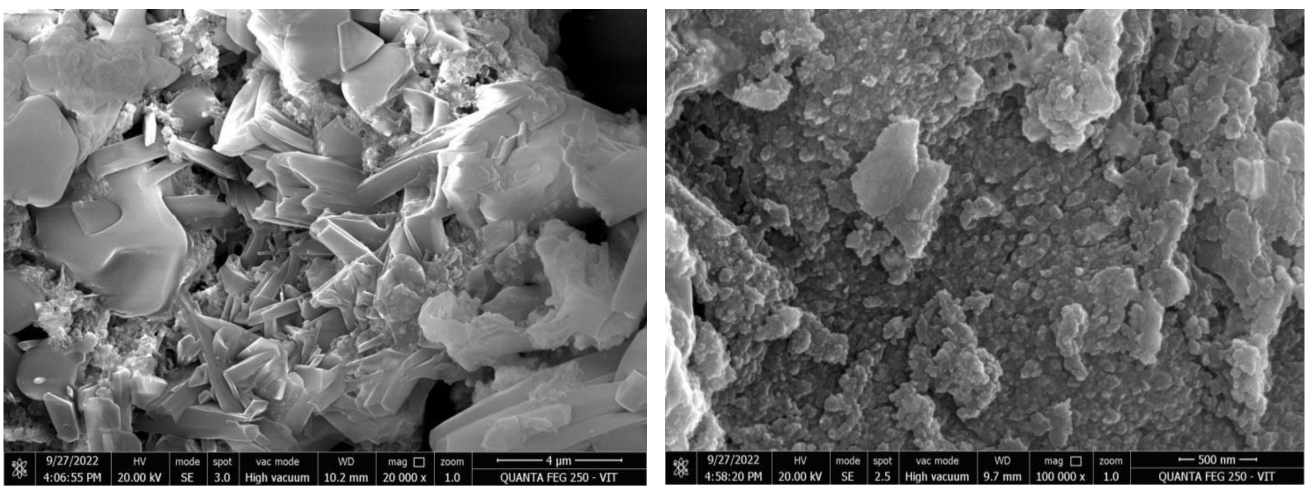
Graph of Flourier Transform Infrared Microscopy (FTIR) for Au Nonoparticels

F. EDAX-

This graph (Fig-9) mentioned the composition of synthesized Nanoparticles that is (Au- 71.6 Wt %, C-14.3Wt %, O- 14.1Wt %). C, O these were phytoconstituents of leaf extract associated with Gold nanoparticles.



Graph EDX analysis showing elemental composition of Au nanoparticles



Images of Au NPs with different Magnification range

VI. Conclusion:

We give the viewer an insight of both traditional and novel synthesis methods for gold nanoparticles in this paper. The biological-based synthesis methodology is acknowledged as the finest choice among the existing synthesis approaches due to its unparalleled benefits.The significant potential of AuNPs-based systems directed by nanotechnology makes it a desirable study area for the scientific community today, including biomedical research. Gold nanoparticles have a remarkable potential for a variety of biomedical-related applications, including targeted and controlled drug delivery platforms, bio detection and biomedical imaging platforms, (photo) hyperthermia, and gene therapy. This is due to the physicochemical characteristics of AuNPs and their versatility (in terms of morphological and dimensional aspects, as well as physical, chemical, biological, and immunological behaviors). It is essential to create uniformly sized and shaped AuNPs for each of the systematic scientific lines, as well as stable, benign AuNPs with high permittivity. This makes them the best possible prospects for the nanotechnology-based creation of individualized healthcare practices.

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