Phytosynthesis of AuNPs and AgNPs

Biological resources are gaining importance in the synthesis and applications of the nanomaterials. Plants are able to reduce the metal ions faster than fungi or bacteria. Furthermore, plant extract found to be an easy and safe green method in scale up and industrial production of well dispersed metal nanoparticles as compared to plant biomass or living plants. Future research on plant mediated biological synthesis of nanoparticles with unique optoelectronics and physicochemical properties are of great importance for applications in chemistry, electronics, medicine and agriculture. The study presents extracellular and intracellular synthesis of AuNPs and AgNPs from leaf extracts of Cassia auriculata, Cassia fistula, Cassia occidentalis, Cassia sophera and Cassia tora belonging to Family: Ceasalpiniaceae. The present study demonstrated the extracellular synthesis of AuNPs and AgNPs from leaf extract of Cassia auriculata L. by varying concentrations of leaf extract and HAuCl₄ and AgNO₃ resulted in spherical and polydispersed nanoparticles. Increase in concentration of leaf extract was found to decrease the size of AgNPs and increase in particle size of AuNPs.

Rapid Synthesis of AuNPs and AgNPs

The study demonstrated the rapid extracellular synthesis of AuNPs and AgNPs nanoparticles from leaf extract of Cassia auriculata. It provides efficient, simple and good control over the particle. While very high temperatures were required to carry out the reduction, the same was possible within seconds under microwave irradiation. Compared to other methods investigated the microwave irradiation is considered as better
for reduction to gold nanoparticles. Biosynthesis of AuNPs and AgNPs was also carried out in sunlight (Photo irradiated) by direct sunlight.

**Characterization of AuNPs and AgNPs**

The biologically synthesized nanoparticles were confirmed by UV-Vis spectra which showed characteristic peaks of AuNPs and AgNPs. XRD pattern reveals that Gold and Silver nanoparticles are crystalline in nature. FTIR analysis reveals the peaks in the region between 3292 cm\(^{-1}\) to 1599 cm\(^{-1}\) and 1066 cm\(^{-1}\) were assigned to stretching of N-H, O-H and C=O of primary and secondary amides, carbonyl group from amino acid residue and protein stabilized the colloidal medium. TEM image has shown AuNPs and AgNPs are spherical and polydispersed.

**Identification and Purification of biomolecules associated with Gold and Silver Nanoparticles**

The presence of polar phytochemicals and essential amino acids in *Cassia auriculata* has dual function which facilitates the synthesis and stabilization of nanoparticles in the aqueous medium. Two associated polar water soluble proteins (42kD and 15kD) were characterized by SDS PAGE. The adsorbed proteins on nanoparticles have significant role in living system and also make the nanoparticles biocompatible. Therefore compared to bacteria and fungi, plants are better candidates for the synthesis of nanoparticles. The enduring efforts to understand the mechanism of protein nanoparticle growth may aid in protein biochemistry. Future research to concentrate on using plant mediated synthesized nanoparticles on optoelectronics and physicochemical properties are of great importance for applications in chemistry, electronics, medicine and agriculture.
Immobilization of AuNPs and AgNPs

We have demonstrated a simple green methodology for preparing noble metal nanocomposites by gel casting method. The gold and silver nanoparticles immobilized on alginate films were characterized by UV-Vis spectroscopy, Fourier transform infrared (FTIR) spectroscopy, Transmission electron microscopy (TEM) and Thermal gravimetric analysis (TGA). Swelling and Degradation studies, Moisture content of the films were determined. The new type of bio-nanocomposite would improve assembly and performance developed by the effective combination of Ca-Alg and metal nanoparticles reduced and immobilized by biological method. The anchored ions reduced size and shape controlled AuNPs and AgNPs inside the hydrogel networks within few minutes and offers an ecological and economic alternative to the procedures currently used. Gold and Silver nanocomposites showed antibacterial activity against *E. coli* and *B. subtilis*. Bio-nanocomposites exhibited antibacterial activity which makes it an ideal candidate for wound dressing. Au-BNC and Ag-BNC could be utilized in biomedical, optical, catalytic and electronic applications. By considering the above mentioned properties, we may expect these bio-nanocomposite can be further used in biological, medical and electronic field. In addition, this biological method can be industrialize into a general coating technology for the preparation of other types of thin films.
Applications studies of Biosynthesized AuNPs and AgNPs

Antimicrobial Study

The AgNPs showed considerable antimicrobial activity. The antimicrobial activity of synthesized nanoparticles was evaluated against *Escherichia coli*, *Bacillus subtilis*, *Aspergillus niger* and *Aspergillus flavus*. Fungi were most susceptible to silver nanoparticles followed by bacteria. It can be concluded that the silver nanoparticles constitute an effective antimicrobial agent against common pathogenic microorganisms.

Impact of AuNPs and AgNPs on *Pennisetum glaucum*

Nanoscience is leading to the development of low-cost applications for enhanced plant growth. Plant mediated synthesis of metal nanoparticles is benign and can be used for large scale production. Germination rate and root elongation, as a rapid phytotoxicity test method possess several advantages, such as sensitivity, simplicity, low cost and suitability for unstable chemicals or samples. Different concentration of nanoparticles were used to investigate their effect on seed germination and seedling growth, the tested concentrations had no significant effect on seed germination, but increased the rate of germination compared to control. The biologically synthesized gold nanoparticles have potential to increase the germination and plant growth whereas silver nanoparticles effected the shoot and root length. Hence NPs can be used as test materials to reveal their nontoxicity mechanisms in plants. However, there is a need for further research at physiological, biochemical and genetic levels for reaching any conclusions.
The cytotoxicity and genotoxicity of AuNPs and AgNPs on Cancer Cell Lines

*Cassia auriculata* mediated gold and silver nanoparticles were used to analyze their effect on cytotoxicity and genotoxicity against cancer cell lines. Anticancer activity of synthesized AuNPs and AgNPs were carried out against A549, LNCap-FGC, MDA-MB human carcinoma cells lines by MTT (3-[4,5-dimethylthiazol-2-yl]-2,5-diphenyltetrazolium bromide) assay, even the lowest concentration of AgNPs were more toxic and AuNPs reveals dose dependent response. The hypothesis of this study, that cell killing could be the possible mechanism induced by the cytotoxic effect of biosynthesized gold and silver nanoparticle was proved, as the growth of the cells was observed to be inhibited. However, further study is needed to understand the exact mechanism of anticancer activity of these nanoparticles. Based on MTT assay, AgNPs less than 10µg/ml revealed 100 % cell lysis whereas IC50 of AuNPs was 10µg/ml in all tested cell lines. Genotoxicity of the AuNPs and AgNPs was examined on cancer cell lines by DNA fragmentation. The gel after electrophoresis clearly revealed that the intensity of all treated DNA samples has diminished, possibly because of the cleavage of the DNA. Therefore, it can be concluded that biologically synthesized AgNPs and AuNPs has promising anticancer effect. AgNPs are more toxic than AuNPs and can be further manipulated for potential biomedical applications. However, the exact mechanism behind the anticancer effects of these nanoparticles needs to be studied in detail.