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Green Synthesis of Nanoparticles Using Plants as a Bioreactor

Varsha. S. Nandeshwar[1], Surekha. A. Kalkar[2], Pratibha. S. Agrawal[3]
[1]Reseach Scholar, Department of Botany, Institute of Science, RTMNU, Nagpur, , Maharashtra, India
[2]Professor, Department of Botany, Institute of Science, RTMNU, Nagpur, , Maharashtra, India
[3]Professor, Department of Applied Chemistry, LIT, RTMNU, Nagpur, Maharashtra, India

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ABSTRACT

Metal nanoparticles synthesis by green route represents most important part of biotechnology that is reliable, simple, cost-effective and eco-friendly as compared to physical and chemical methods. In present study Silver nanoparticles was synthesized using aqueous leaf extract of Lowsonia inermis (Henna). This nanoparticles was used as stabilizing and reducing agent in bioreactors and was observed to be effective than chemicals and physical synthesis for its application in different type of dye degradation. Characterization of synthesized silver nanoparticles was by UV-Visible, Fourier transform infra-red-spectroscopy (FTIR), Scanning electron microscope (SEM), and X-ray diffraction (XRD) techniques. This paper emphases on naturally obtained nanoparticles for the further commercial use for dye degradation and so on.

Keywords: Green synthesis, Silver NPs, Bioreactor, Leaf extracts, Henna

I. INTRODUCTION

Nanotechnology is essentially related with the synthesis of nanoparticles of varying size and shapes. The synthesis of nanoparticles a diverse group of biological agents have been emerged within the search of environment- friendly protocols. Lead to green synthesis of nanoparticles these biological agents are safe and eco-friendly. Nanotechnology is the branch of technology, with the help of this technology producing the unalike kinds of metal nanoparticles [1]–[3]. Nanoparticles means their dimension is very small within 1-100 nm with enhanced unique catalytic activity, thermal conductivity, non-linear optical performance and chemical, magnetic, electrical properties to covering its large surface area per unit volume of an object. Current advance in technologies demands smaller/miniature products which require less energy to run, less material to build and incorporate the potential for recycling[4]–[6]. Among all the nanoparticles present, gained much importance by metal nanoparticles. Overall, nanotechnology encompass a diversity of subunits such as nanotubes, nanosensors and nanomaterials, each of them has many used into numerous industrial, health, food, feed, space, chemical, cosmetics, drug delivery, disease diagnostic and others industry of regulars which calls for a green and environ-friendly approach to their synthesis [7]–[11]. The most important and most usable nanomaterialsare are also include subunits that is one of them metal nanoparticles. Silver nanoparticles (NPs) are one of the best extensively used nanoparticles among metal nanoparticles and it finds more applications in the Nano world every day. Silver (NPs) have been the topic of investigators because of their appropriate conductivity, chemical stability, catalytic, photonic and optoelectronic attributable to their superior physical and chemical effects.[12]–[14] This nanotechnology field proves that it is one of the majority active research areas in modern material science. Near about last two decades scientists have been involved in the advance of novel synthetic routes enabling the precise control of the microstructure and proportions of the nanoparticles[15]–[20].

While nanoparticles can be prepared using a number of physiochemical methods [21]–[27] their production using non-hazardous and biologically benign biological methods is attractive especially if they are deliberate for invasive applications in medicine. [28], [29] told that NPs have in progress being well-thought-out as nano antibiotics for their antimicrobial activities [30]–[32]. As per Singh et.al.2018 ZnO NPs have large surface area to volume ratio that outcomes in a important increase in the fruitfulness in blocking UV radiation as related to the majority material[33]. Over the traditional chemical and physical methods modern biological approach to the synthesis of NPs has more an advantages [34]–[37]. Antimicrobial coatings, medical imaging and drug delivery to catalytic water treatment and environmental sensors are the applications of manufacture metallic NPs scope from a number of biomedical functions [35]. This green route chemistry reduces pollution threat at source level where the concept focus is on the options of bio-components which are ecofriendly as well as bio resource based green route synthesis of metal and also metal oxide NPs has been reported [38]–[43]. The increase profitable and marketable use and wide-ranging fabrication of engineered NPs may consequence in unintended disclosure to flora and fauna of the environment(44–47).

Fig. 1: Image of Lawsonia inermis (Henna)

Henna (Lawsonia inermis of family Lythraceae) contains an active dye (red-orange pigment), lawsone (2-hydroxy1,4-naphthoquinone), which can be used to color hair and skin. Traditionally, it is used as a medicine to remedy several ailments. Medical properties for the treatment of renal lithiases, menstrual cycle, uterus problem, jaundice, wound healing, prevent skin inflammation[48]. The leaves, bark and fruit also is traditionally used in treatment of jaundice and enlargement of the spleen, renal calculas, leprosy and obstinate skin disease. Henna has several biological activities Natural henna is commonly harmless and well-tolerated in humans, until such time as today, the scientific figures about the actual reasons that led to this widespread scale harming and death cases remain unidentified. Henna (Lawsonia inermis) leaf has recently been establish to be a potent antioxidant due to high concentrations of Lawson (2 hdroxy-1, 4-naphthoquinone)[48]–[50]. It contains p-benzoquinone unit, benzene unit, lawson and phenolic group that may be answerable for the reduction and stabilization of metal ions Phytochemicals, which are complexes existing in plants, have different biological activities and can be used for the production of metal oxide nanoparticles. They show most important characters in both stabilization and reduction of the nanoparticles. The focus of the present work was to synthesis silver nanoparticles (AgNPs) using the extract from the leaf powder of Lawsonia inermis (which be appropriate to the Lythraceae family) as a stand-alone capping agent and reducing agent. In this respect, nanotechnology suggestions efficient, environment-friendly and cost-effective solutions to rectify the problem of environmental pollution. Phytochemicals, which are composites present in plants, have different biological activities and can be used for the production of metal oxide nanoparticles. Nanoparticles have novel possessions due to their distinct morphology, size, ionic state and distribution. Due to their small size, nanoparticles have a high surface area-to-volume ratio, and also exhibit excellent electrical, catalytic, optical and magnetic properties. The use of metal oxide nanoparticles for ecological clean-up is a novel area of investigation in which only partial progress has been achieved thus far.

II. MATERIAL AND METHODS

A. Preparation of l. Inermis (henna) aqueous extract:
The fresh and healthy leaves were collected from our campus of Institute of Science College, Nagpur (Maharashtra) and washed with distilled water 3 times and was used for capping agent and reducing agent. After that cut the leaves in small pieces with sterile knife. These chopped leaves 173.33 gm were boiled in 1300 ml of double-distilled water on behalf of 1 hour at 600c to 700 c temperature. And after some time filtered with Whatman no. 1 paper. Lawsonia inermis plant material used for the production of metal AgNPs represented as a natural biosynthetic material. The active biomolecules of Lawsonia inermis played a twofold role of reducing agent and capping agent in the fabrication of highly stable AgNPs. On addition of aqueous extract of Lawsonia inermis to the solution of AgNO3, a rapid change in color from reddish brown dark blackish green at room temperature was observed on agitation for 10 to 15 min. The color developed more concentrated with the development of reaction with time. The experimental difference in color of the solution can be recognized to the SPR vibrations of the metal oxide AgNPs. A brief reaction technique depicting the biochemical response between AgNO3 and aqueous plant extract, resulting in the formation of AgNPs is shown in Fig. 2.

B. Synthesis of silver nanoparticles:

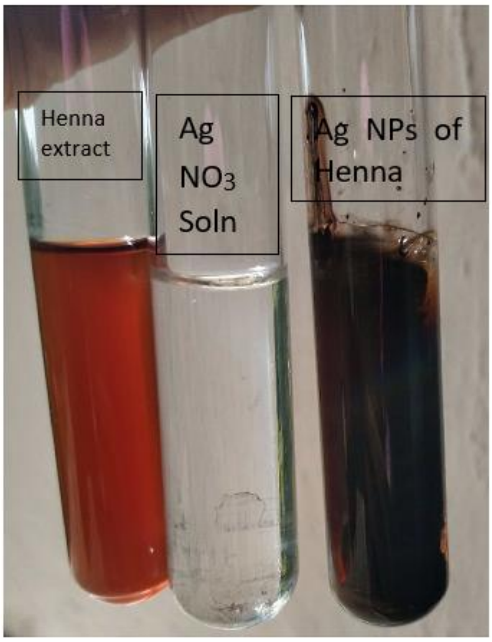

Fig. 2 : AgNPs of Lawsonia inermis (Henna)

Stock solution was prepared by dissolving 1mM silver nitrate and volume make up to 250 ml with distilled water. 5 ml of Lawsonia inermis leaf extract was added to 100ml of 1mM AgN03 solution and allowed to react and stirred at 200 rpm for 1 day at room temperature. A change in the colour of the reaction medium indicated the establishment of metal oxide AgNPs (Silver nanoparticles). The solution was cooled and the product was detached by centrifugation (10,000 rpm) for 25 minutes. The invention was dehydrated at 60°C for 4 hours and the dehydrated powder of henna leaves was the silver nanoparticle.

C. CHARACTERISATION OF THE SILVER NANOPARTICLES:

1.1 UV-VISIBLE SPECTROSCOPY:

The development of silver nanoparticle was confirmed by UV-visible spectroscopy using spectrophotometer. Size of the silver metal oxide nanoparticle was analysed with UV-Spectrometer in the range between 410- 460nm. The manufactured silver metal oxide nanoparticles by reducing silver metal ion solution with Lawsonia inermis leaf extract were primarily characterized by UV visible absorption spectroscopy. In a spectrophotometer containing double beam in identical compartments the tasters were taken in a 1cm quartz cuvette and measured each for reference and test solution from 300 nm to 900 nm. Effect of reaction time (40, 50, 60, 70, 80 & 90 min), concentration of leaf extract (100, 200, 300 & 400 µl) and pH (2, 4, 6, 8 & 10) on the surface plasmon resonance of silver metal oxide nanoparticles has been observed using UV visible absorption spectroscopy. In this research work, ultraviolet-visible spectrophotometer (UV-Vis) was used to discover the optimal conditions for silver nanoparticles synthesis by using Lawsonia inermis extract. Affecting restrictions such as pH, extract volume, concentration of salt solution, reaction temperature and time have been improved for biosynthesis of silver nanoparticle by fascinating UV-Vis spectra. The extreme absorbance wavelength of silver nanoparticles was observed at 425 nm.

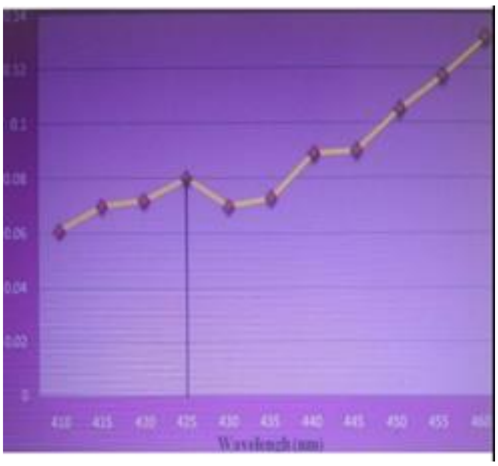

Fig. 3 : UV-Spectroscopy of AgNPs of Lawsonia Inermis.

1.2 FTIR SPECTROSCOPY :

Perkin Elmer FTIR spectrometer was taken for using FTIR spectroscopy. Atomic Force Microscopy picture was taken using Park system AFM XE 100. The aqueous silver metal oxide nanoparticles were set down onto a freshly cleaved mica substrate. The trial aliquot was left for 1 min and then wash away with double distilled water and leftward to dry for 15 min. The picture were found by scanning the mica in air in non – contact mode. Fourier Transform Infrared Spectroscopy (FTIR) Spectroscopy was used to investigate the interactions between different species and changes in chemical compositions of the mixtures. The FTIR spectra of silver oxide nanoparticle using Lawsonia inermis leaf powder were recorded in Perkin Elmer spectrum 1 in diffuse reflection mode operating at a resolution of 4cm-1, recorded between 4000 and 400cm-1

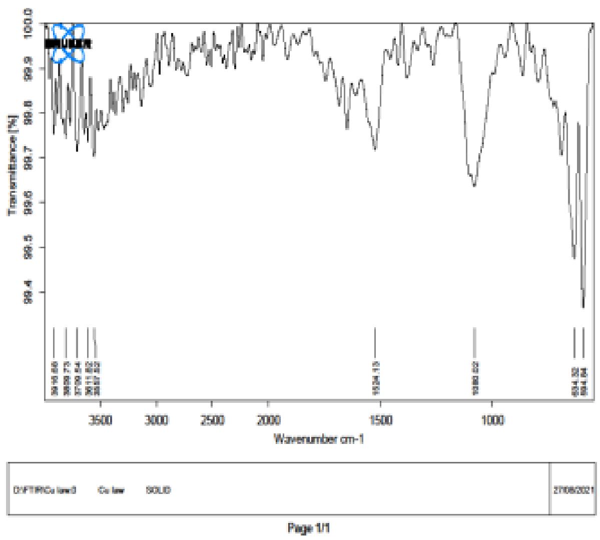

Fig 4: FTIR spectra of AgNPs of Lawsonia inermis.

1.3 SCANNING ELECTRON MICROSCOPE (SEM) :

Scanning electron microscopy (SEM) operated at an accelerating voltage of (200) kV. The samples were done using (Zeiss instrument). Figure 3 shows the size and shape of the silver nanoparticles. The result indicates that the silver nanoparticles were just about spherical in shape, and through an average width of 15 ± 46 nm.

Microscopic techniques such as scanning electron microscopy (SEM) is mainly used for morphological studies of nanoparticles. In figure 5, SEM image undoubtedly confirmed the presence of silver metal oxide nanoparticle with a size of 6nm - 50 nm. The results obtained from SEM analysis were very similar to the findings of other researchers.

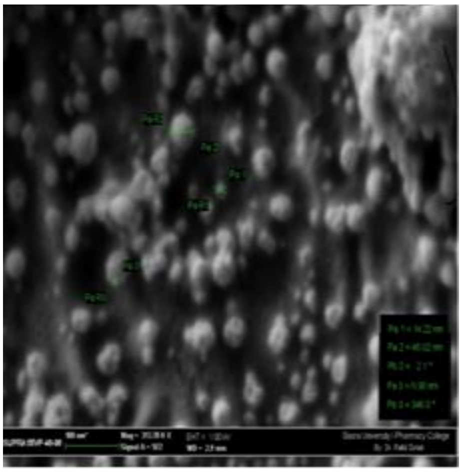

Fig 5 : SEM images of AgNPs of Lawsonia inermis.

1.4 X-RAY DIFFRACTION (XRD):

X-ray diffraction (XRD) analyses were passed out with a GNR MPD 3000 made Italy diffractometer via a Cu anode (λ = 1.54056 Ǻ).

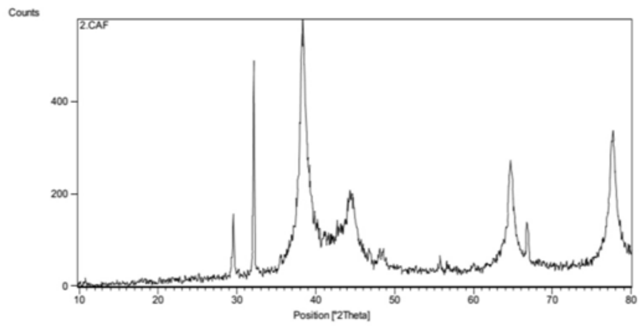

Fig. 6: X-Ray diffractogram of AgNPs of Lawsonia iner

The diffractograms were recorded at 2θ in the range 10° - 80°, counting time is 0.5 secound and with step size of 0.02°. In the above figure , the XRD pattern clearly shows cubic structure matches the values (38.4) , (44.52), (64.7), (77.73) correspond to the hkl planes (1 1 1), (2 0 0), (2 2 0), (3 1 1), respectively, with an average size ~ 20. All the peaks match well with the standard JCPDS file 87-0717.

III. RESULT AND DISCUSSION

The results of this study showed that Biological production by using Lawsonia inermis (Heena) abstract is a very low cost method without the need for energy. Reducing mechanism and FTIR analysis FTIR spectra of aqueous abstract of fresh Henna leaves and silver nanoparticles respectively were shown in Fig. 4. Owing to the interface of silver nanoparticles with the abstract, the sensations are lesser in Ag – Henna extract FTIR spectrum when associated to Henna extract FTIR spectrum. It displayed the presence of clusters/bonds due to free O-H stretching (around 3412, 3495cm-1), (polyols) C≡N stretching sensations, (around 2076cm-1), C=O stretching sensations (around 1630cm-1), aromatic stretching sensations (670cm-1). Their occurrence is symptomatic of terpenoid group of compounds existing in the aqueous Henna extract which might be accountable for the reduction of silver nitrate into silver nanoparticles.

The ultra-fast catalytic reduction of dye pollutants using biosynthesized AgNPs can be discussed based on surface adsorption behavior of dyes. Generally, the biological molecules or surfactants are used for capping of nanoparticles in chemical reduction methods, which makes an insulating layer around the nanoparticles and affect the diffusion of dye molecules to adsorb efficiently on surface of metal particles. However, the biomolecules can easily be separated by simple washings with water and thus does not restrict the adsorption of dye molecules on metal surfaces, which makes them efficient catalysts. AgNPs catalyzed reduction of pollutants can also be explained by electrochemical means, in which the AgNPs behave as an electron relay for oxidant and reductant

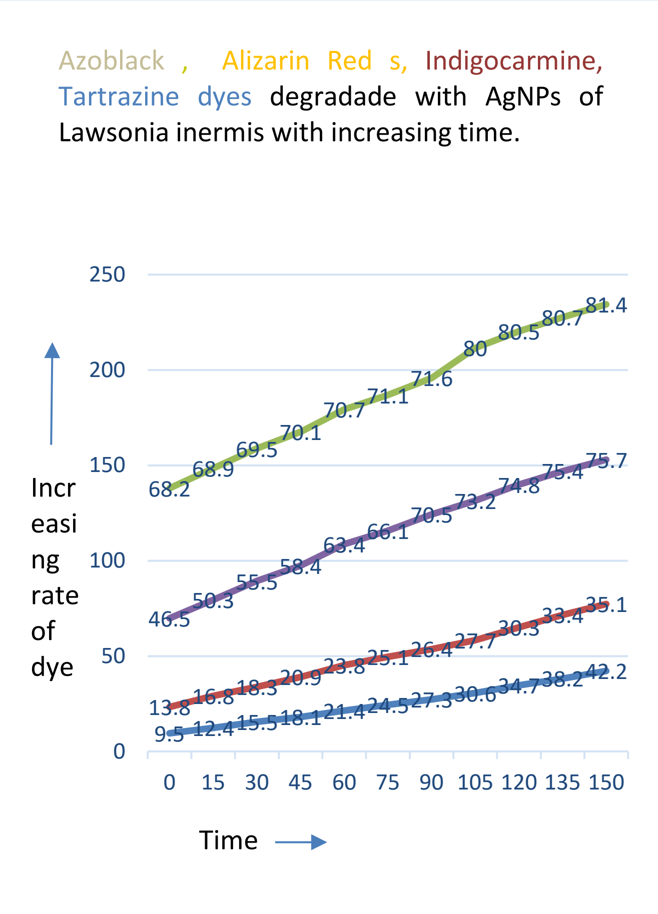

Fig. 7 : Degradation of Azoblack, Alizarine, Indigocarmine and Tartrazine dyes with AgNPs of Lawsonia inermis (Henna) plant with increasing time with photo catalytic activity.

IV. CONCLUSION

Based upon the investigations, it has been concluded that the biosynthesis of AgNPs using Lawsonia inermis is a facile, cost effective and portable detection method has been developed an efficient and rapid process, completing in 2 to 4 h. The phytoconstituents present in Lawsonia inermis clearly play the role of reducing and stabilizing agent. The interaction between the freshly formed AgNPs and phytoconstituents was confirmed from FTIR study. Further, the crystalline nature of NPs and their morphology with mean particle size of 46±5 nm was verified from XRD and SEM analysis, respectively. The synthesized AgNPs have been proven to be extremely efficient catalysts for rapid degradation of various dye. The facile preparation and extraordinary stability of biogenic AgNPs permit this protocol to be easy and simple to apply. The complete 90% degradation of Azoblack, Alizarine, Indigocarmine and Tartrazine dyes . This extraordinary efficient dye degradation efficiency of biogenic AgNPs may open new doors for their further applications of industrial waste water samples and environmental importance.

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