Green Synthesis of Silver Nanoparticles Mediated using Lagerstroemia Speciosa and Photocatalytic Activity Against Azo Dye

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ABSTRACT. The present paper reports that the method is simple in the biosynthesis of silver nanoparticles using the aqueous leaves of L. speciosa. The functional groups for the plant extract and silver ions were explained by FTIR. The biosynthesized silver nanoparticles were characterized by UV- VIS spectroscopy, X- Ray Diffraction -XRD, High Resolution- Transmission Electron Microscopy, Zeta potential and particle size analysis. The maximum absorbance peak was found at 427 nm. The average silver nanoparticles were found to be 12 nm by XRD and it was spherical in shape. The nanoparticles were subjected to dye degradation process for methyl orange. Hence the biosynthesis silver nanoparticles possess photocatalytic. This evident helps to analysis the silver nanoparticles for various applications in future.

Introduction. Human activities such as pollution are causing major challenge to the environment [1]. The organic dye pollutant from textile, paper etc is now considered to be major threat to the biodiversity. Several methods were being proposed to remove dyes from the textiles viz. physical, chemical and biological methods. [2]. Recent literature states that a metal nanoparticle degrades the dyes as an effective photocatalyst at ambient temperature with visible light illumination. [3] Using micro-organisms, plants, enzymes were being suggested to be eco-friendly compared to the chemical methods [4]. Lagerstroemia Speciosa contains a wide range of biologically active compounds such as being rich in alkaloids, glycosides, flavonoids, tannins, terpenoids, phenols, saponins, alkaloids and vitamins. [5]. This paper explains about the green synthesis of silver nanoparticles mediated using leaf extract of Lagerstroemia speciosa, characterization and photocatalytic activity against azo dye.

Materials and Methods

Silver Nitrate (99.99%), Methyl Orange, Methylene blue reagents were procured from Merck Inc. (Mumbai, India) of Analytical grade. The leaves of Lagerstroemia speciosa (Fig. 1) was collected during March- Aug, from VIT University, garden, Vellore, INDIA. The plant leaves were authenticated by Dr. P. Jayaraman, Plant Anatomy Research Centre, Chennai, India.

Preparation of Phyto-reducing agent

About 10 g of air dried leaves were taken into the clean beaker and it was boiled with 100 mL double distilled water for half an hour at 60°C for decoction extract. The extract turns the colour from colourless to yellow brown colour indicates the extraction is complete. It was subjected to preliminary screening for phytoconstituents by J.B. Harbone [6].
Biosynthesis of Silver Nanoparticles

Approximately 20 gm of dry leaves were cut into pieces and about 0.10 g of silver nitrate was added to the extract slowly and continuous stirring for 1 h at 75°C. The reduction of Ag⁺ to Ag⁰ was monitored by visual color change from yellow to dark blackish brown in color. It was centrifuged at 2000 rpm for 20 min for thrice. It was characterized using UV-Vis spectrophotometer (UV-2450 Shimadzu). Infrared (IR) spectra, powder X-ray diffraction in (X-per pr- D8 Advanced, buker, Germany) X-ray diffractometer. The morphology was studied by Scanning Electron Microscope (SEM, Model JSM 6390 LV, JOEL, USA), Transmission Electron Microscopy. (Model JSM 6390 LV, JOEL, USA). The electrophoretic mobility was analysed by zetasizer Nano ZS (Malvern Instruments, Ltd. UK) and zeta potential was measured by henry equation.

Phytoremediation activity against dyes

The phytoremediation studies were carried for methyl orange (C_{14}H_{14}N_{3}NaO_{3}S) using sunlight as the source during the month of Aug- Sep 2016 between 11 am to 3 pm. The light flux was measured during the reaction, at the begin of the analysis it was 1250 W/m² and increased to 1300 W/m² following 290 minutes. About 0.1 mg of Ag NPs was weighed and mixed to 10 ml dye solution and the mixture was sonicated for 20 min in dark room. Similarly control was prepared and maintained in same condition. Dye degradation was finalized visually by the colour change. For methyl orange (MO) the solution changes from deep orange to yellow colour. Optical absorption spectra were resolved after varying light exposure durations utilizing an UV/Vis spectrophotometer (JASCO- V-730) to screen the rate of degradation methyl orange at the maximum wavelength (λ_{max} = 460 – MO). The degradation efficiency (PE) was ascertained as in condition1:

\[ DE = \frac{I_0 - I}{I_0} \times 100 = \frac{C_0 - C}{C_0} \times 100 \]

where \( I_0 \) is the initial absorption intensity of methyl orange solution at \( \lambda_{max} = 460 \) nm (MO) and \( I \) is the absorption intensity after photo-degradation. \( C_0 \) is the first concentration of methyl orange solution and \( C \) is the concentration after photo-degradation. [7]

3. Results & Discussion

It was observed during the qualitative analysis; that the phyto-constituents like tannins, phytosterols, carbohydrates, alkaloids, terpenoids, flavonoids, glycosides, proteins were found to be predominant, while gums and mucilage were found to be absent. The leaf extract of \( L. \) speciosa when incubated with silver nitrate under stirring in dark condition, the brown colour of the extract changed to blackish brown colour. The formation of metal silver nanoparticle in aqueous solution was presented by UV-VIS spectroscopy. From the Fig. 1 (a, b) The absorption spectra of prepared Ag NPs from leaves of \( L. \) speciosa showed the absorbance at 427 nm. [8] There is a peak at 361 nm indicates the active compounds which is interacting with silver ions into the solution and helps for possible reduction of metal ions present in the solution.
Fig. 1. UV spectra of (a) plant extract of L. speciosa (b) Ag NP.

The XRD pattern of the biosynthesized Ag NPs is shown in Fig. 5. The diffraction pattern were observed from 20° to 80°. The four bragg’s reflection was observed at 38.45°, 46.35°, 64.75° and 78.05° corresponds the planes of (1 1 1), (2 0 0), (2 2 0) and (3 1 1) respectively (JCPDS card no. 89-3722). All diffraction peaks of the sample represents to the characteristic face centered cubic crystal structure of silver nanoparticles (a, b, c = 4.085 Å). [9]. The average particle size of ZnO-NPs can be estimated using the Debye-Scherer equation which gives a relationship between peak broadening in XRD and particle size is explained with the following equation:

$$D = \frac{K\lambda}{\beta \cos\theta} \text{Å}$$

Using the Scherer equation the average crystalline size of Ag NPs is found to be 12.4 nm. Diffraction pattern doesn’t have any impurity peak hence the prepared Ag NP is highly pure.

Fig. 2. XRD spectra of prepared silver nanoparticle from L. speciosa leaf extract.

The HRTEM of the biosynthesized Ag NPs from the leaf extract of L. speciosa extract are shown in Fig. 6a & 6b. The Ag NPs predominantly showed spherical in shape morphology showing the average particle size of 14 nm [10]. This attribute the secondary metabolic present in the plant act as reducing agents.
The particle size and zeta potential of synthesized Ag NPs were determined by DLS (Fig. 4a and b). The higher the zeta potential value the higher the electric charge on the surface of the particles. Here, using water as dispersant the zeta potential is found to be $-37 \text{ mV}$ for Ag NPs (Fig. 7b). [11].

The photocatalytic degradation was carried for methyl orange using silver nanoparticle prepared from leaves of *L. speciosa*. The procedure was carried out, using sun as the main source of light. [12] The time dependent UV-Vis spectra of the MO are explained in Fig. 5. The maximum absorption of MO was found at 460 nm was degraded to 10% after irradiating with sunlight for 310 min [13].
Summary. To conclude this paper, a convenient method for preparation of efficient visible photocatalytic nanoparticles, using the plant leaf extract of L. speciosa. The green synthesize was confirmed by the visual colour change and by UV-VIS spectroscopy at 427nm. The prepared Ag NPs had cubic and spherical shape in XRD and TEM respectively with average particles size as 12.4 nm. The biosynthesized was environmental friendly nanomaterials, by degrading the various dyes like methyl orange. But further investigations are required to scale up the Ag NPs for wider medical applications in future.

Reference

Cite the paper