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WATER HYACINTH MEDIATES THE CREATION OF SILVER NANOPARTICLES AND THEIR USAGE FOR PHOTOCATALYTIC DYE DEGRADATION STUDIES

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Abstract

This investigation employed water hyacinth leaf extract. The creation of silver nanoparticles was identified by a color shift from pale yellow to brown, followed by a peak in the UV spectrum. Functional groups are identified by FTIR analysis. The peaks ranged between 400 and 3251 cm^{-1}. The greatest peak consists of C-N and C-C stretching. The band was formed by the stretching of O-H groups in water, alcohol, and phenols. The silver particles were utilized to break down the methylene blue (MB) dye, which is harmful to both aquatic and human life. The MB dye was totally destroyed after 48 hours (2 days). The photocatalytic destruction of methylene blue with nanoparticles demonstrated the feasibility of utilizing nanoparticles for water purification.

Keyword: Water Hyacinth, silver nanoparticles, dye degradation, FTIR, UV-Visible.

Introduction:

Water hyacinth is a kind of plant. It may grow at a pace of up to 220 kg per hectare per day, making it one of the most common aquatic weeds worldwide [1]. Depending on the locale, the population might double every 15 days [2]. The plant is renowned for its capacity to easily and quickly extract nutrients from water, as well as its rapid reproduction rate [3]. Nutrient runoff from agricultural areas, as well as excessive fertilisation, stimulate the fast development of this aquatic weed and contribute to the premature demise of aquatic ecosystems [4]. India is a prime illustration of this problem, with high-yielding crops that rely significantly on artificial fertilizer. Aside from serious ecological degradation and biodiversity loss, the spread of water hyacinth (WH) in bodies of water poses substantial economical and public health problems. Rapid development of WH mats depletes dissolved oxygen and increases water loss via evapotranspiration [5], leading in the depletion of aquatic resources and the destruction of fishery habitats [6]. The species also acts as a considerable barrier to water movement and promotes to the spread of mosquito-borne illnesses by providing enough breeding grounds for vectors (e.g., mosquitos).

Infectious illnesses are induced by providing large breeding grounds for vectors (e.g., mosquitos). Blockage of irrigation canals and quick siltation caused by WH make flood control inefficient and decrease water quality for bathing and other useful purposes. In India, the extensive presence of WH has an impact on the local aquaculture business by lowering water oxygen content, increasing silt accumulation rate, and reducing water body capacity, resulting in fish mortality and low fish yields. These issues have resulted in the establishment of many WH control strategies that depend on costly chemical, physical, or biological methods with little long-term success [7]. Controlling this plant hence relies heavily on the implementation of such other possible applications.

WH is a non-wood, lignocellulosic substance made up of 32% cellulose, 22% hemicellulose, 6.7% lignin, and 1.2% silica. The plant is good for pulp and paper manufacture because it contains more cellulose, hemicelluloses, and less lignin than other woody and non-woody plants [8]. The plant also has a high concentration of growth hormones, including gibberellins, which encourage plant development. Because of its availability and good chemical composition, various studies have been conducted to investigate potential uses for WH [9]. It's possible applications include oil spill adsorption, biochar, bio-fertilizer, animal feed, biogas, waste water treatment and adsorbent, biohydrogen fuel, crafts, composites, kraft pulp, and new materials [10].

When the active principle is administered as a crude extract, its bioavailability is greatly reduced. The synthesis of NPs has received the most attention in recent years [11], owing to their widespread use in domains such as catalysis, optics, and electronics [12-13], as well as their antibacterial and antimicrobial properties [14-16]. Metallic nanoparticles have physical and chemical characteristics that differ greatly from their bulk form, making them effective antibacterial agents [17]. Plants and plant components can be utilized to decrease metal and form metal nanoparticles [18,19].

Silver nanoparticles (AgNPs) are one type of metallic nanoparticle that has several uses in medical and biological materials [20]. AgNPs may be generated using both chemical and physical methods. Physicochemical techniques, on the other hand, include downsides such as high operational costs, the use of toxic chemicals, and increased energy consumption. Physical operations are sophisticated techniques that fail to regulate particle sizes at the nanoscale. The main drawbacks are that they produce particles of different sizes and have high manufacturing costs [21]. Chemically synthesized NPs are costly and ecologically harmful due to the high energy requirements [22]. This occurs when biological approaches using less costly sources are utilized as AgNP precursors. The green production of nanoparticles has received a lot of attention since it employs nontoxic.

Silver nanoparticles were synthesized from water hyacinth leaf extract and examined for phytochemical characteristics [25]. Syzygiumcumini [26] and Eugenia caryophyllata [27] have previously written about the production of AgNPs and their biological uses. Silver nanoparticles were created from Eugenia uniflora leaf extract and investigated for antibacterial and antidiabetic properties [28].

Several plant extracts have previously been shown to produce silver nanoparticles, including Azadirachta indica (Neem), Aloe vera, Emblica Officinalis (Amla), and Cinnamomum camphora [19,33-36]. However, little information is known on how the water hyacinth plant produces silver nanoparticles or their biological uses. As a result, in this work, silver nanoparticles were synthesized from leaf extract and examined for color removal capability.

2. Experiment

2.1 Plant extract preparation:

Fresh (disease-free) and fully formed water hyacinth leaves were collected from a small pond in Raipur. The plant was taxonomically recognized and certified by Kalinga University's Botany Department in Raipur (C.G.). The experiment used fresh leaves and distilled water three times. After washing, the methanolic extract was prepared by coarsely crushing 25 g of leaves with liquid nitrogen in a mill and pestle before adding 50 mL of methanol. The debris from the leaf extract was separated with filter paper (Whatman No. 1). The filtrate was collected and stored at -20 °C.

2.2 AgNPs with Water hyacinth leaf extract preparation:

A one-molar stock solution of silver nitrate ($AgNO_3$) was prepared. To make AgNPs, a 0.1M $AgNO_3$ solution was combined with the leaf extract in a 3:1 ratio and incubated in a shaker incubator at 300 rpm and 37 °C for 48 hours. The deep green solution eventually became yellowish-brown, suggesting that Ag^+ had been transformed to Ag^0. The effect of silver nanoparticle generation was investigated using a UV-VIS spectrophotometer. Spectrophotometric readings were acquired at various time intervals.

2.3 AgNPs characterization:

Several analytical methods were used to characterize green silver nanoparticles synthesized from water hyacinth leaf extract. The Ag^+ ion reduction process was continuously monitored using a twin beam UV-Vis spectrophotometer (Simadzu 1900i) to detect the OD (optical density) between 200 and 700 nm. Further characterization of AgNPs was carried out utilizing a fourier transform infrared spectrophotometer (FTIR) at 400-4000 cm^{-1}.

2.4 Removal of dye

The use of synthetic water hyacinth-silver nanoparticles in the elimination of methylene blue dye. Methylene blue was employed as a model pollutant to evaluate the removal of the methylene blue dye degradation process, with the greatest absorbance detected at 490 nm. The overall degradation was examined using UV-visible spectroscopy. Initially, the reaction was carried out by quickly adding silver nanoparticles to a beaker containing methylene blue ($1x10^{-4}$M) at ambient temperature and pH 6, preserving the optimal concentration throughout the whole reaction mixture. Complete degrading processes were carried out from 11 a.m. to 3 p.m. in the presence of sunlight (March-April), with continual stirring.

After a certain period of time, the reaction mixture was centrifuged and put in a spectrophotometer for further examination. The degradation percentage of methylene blue is calculated as follows:

$$\% R = C_0 - C_t / 100 \quad (1)$$

C_0 represents the initial concentration of MB, while C_t represents the concentration of methylene blue after time t.

3. **Results**

3.1 Characterization by UV–Vis spectrophotometer.

The initial investigation of silver nanoparticle production was carried out using UV-Vis spectrophotometers. A color change was observed in the combination of plant extract and AgNPs. During the firming process, the mixture's color gradually changes from green to yellowish brown. The creation of water hyacinth AgNPs. The solution's absorbance was monitored for a week. The spectral analysis indicated that the AgNPs peak appeared at 402 nm, which was the highest peak (Fig. 1), and it stayed stable for a few days since the absorption did not rise. The UV spectra of synthesized AgNPs are at around 402 nm.

In this study, after combining extract and silver nitrate solutions, a color change in the extract was observed over time, which might be ascribed to the reduction of silver ions, resulting in the stimulation of Surface Plasmon Resonance (SPR) of AgNPs. To validate this, UV spectra analysis found a peak at 402 nm, demonstrating a consistent range for nanoparticle formation.

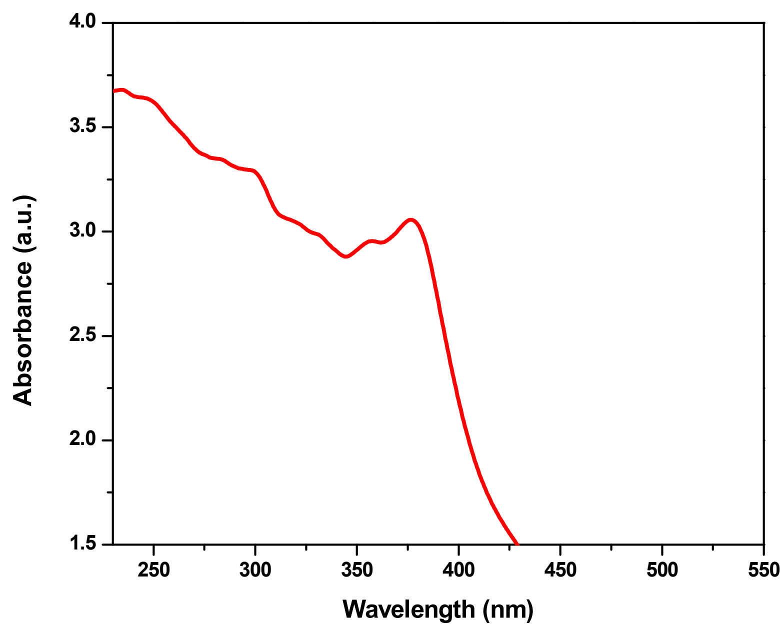


Figure 1. UV–Vis absorption spectra of synthesized AgNPs from Water hyacinth leaf extract.

3.2 Fourier Transform Spectroscopy (FTIR) study:

Figure 2 shows the FTIR spectrum of silver nanoparticles from water hyacinth. The peak of NH stretching was found at 3178.60 cm^{-1}. The peaks at 3082.25 and 2862.36 cm^{-1} correspond to symmetric CH_2 stretching. The peak at 2927.94 cm^{-1} results from CH_2 stretching. The peak at 2123.63 cm^{-1} indicates C≡C stretching, while the peak at 1948.10 cm^{-1} is related with allenes (C≡C).The carbonyl group's peak was detected at 1728.22 cm^{-1}. In the absence of chelating agents, the carbonyl groups indicated the existence of flavanones or terpenoids adsorbed on the surface of metal nano-sized particles via π-electrons.

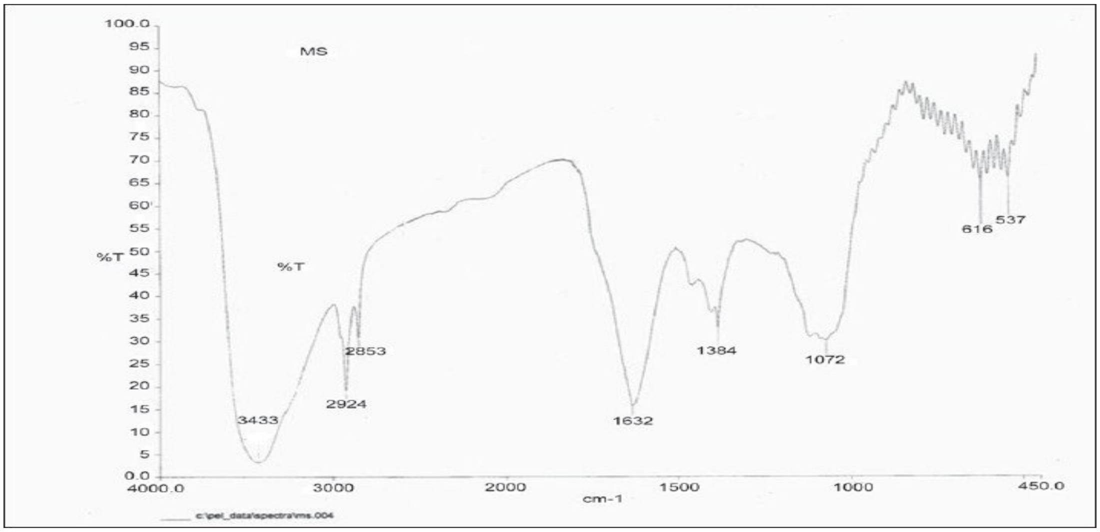


Fig. 2: FTIR spectrum of Water-Hyacinth mediated AgNPs

3.3 Degradation of methylene blue:

Prior to the dye degradation experiment, the solution was scanned between 400 nm and 700 nm to measure the absorbance maxima (λmax). The dye decolorization experiment (individually and concurrently) was carried out using methylene blue at time intervals ranging from 0 to 120 minutes. AgNPs decreased the blue color of the solution during a 10-minute interval (Fig 3). Methylene blue was scanned between 200 and 800 nm, with a maximum wavelength of 595 nm. In the presence of visible light, AgNPs generated pairs of e^- and h^+, which reacted with an aqueous solution of methylene blue to form OH*, H^+, and O_2^{*-} (reactive species).

The entire process was monitored by observing methylene blue degradation at 586 nm in aqueous solution as absorbance decreased (Fig. 3).

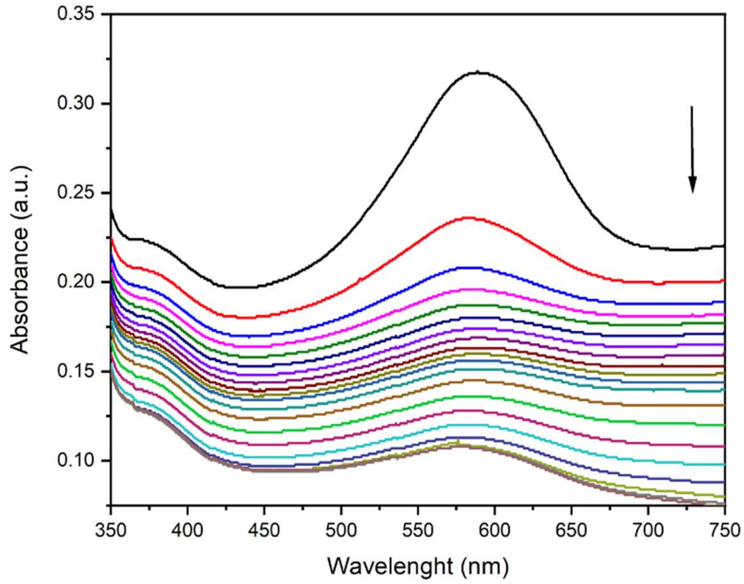
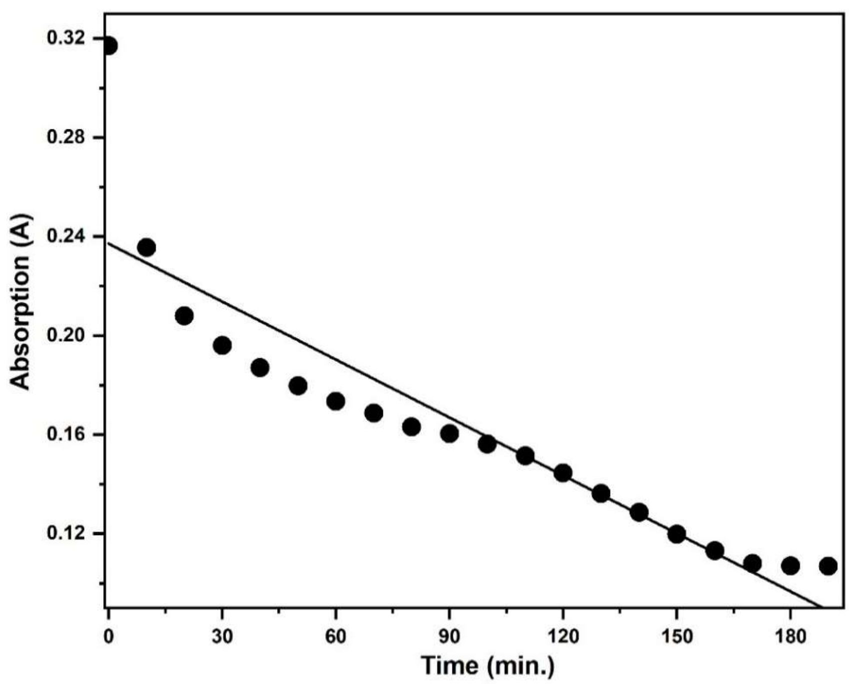


Fig 3. Demonstration of photocatalytic reaction of AgNPs(40.0 mg) via methylene blue (1.0 x 10^{-4} M) degradation in presence of light.

Fig 4. Decrease in absorbance of methylene blue at using AgNPs. In presence of light and



air, at 590 nm wavelength.

Because to the formation of reactive oxygen species (ROS) such as hydroxyl radical (OH*), superoxide radical anion ($O_2{}^{*-}$), and others, the blue hue of methylene blue aqueous solution fades with time (10 minutes).

Conclusion

The silver nanoparticles formed from water hyacinth leaf extract were discovered using UV-Vis Spectroscopy at 402 nm, and their functional groups were verified using FTIR analysis. AgNPs have been demonstrated to be particularly efficient in preventing methylene blue dye degradation. This study suggests a novel approach for synthesizing nanoparticles from water hyacinth leaves, which are plentiful in nature and contaminate water by blocking sunlight. Other nanoparticles, in addition to AgNPs, may be produced from leaf extract, and their medicinal properties and water treatment can be used to a wide range of applications. As a result, the current research might be seen as an attempt to exploit the active principle found in water hyacinth leaves to degrade contaminants.

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