Application of silver nanoparticles synthesized from *Raphanus sativus* for catalytic degradation of organic dyes

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Abstract. Biosynthesis of metal nanoparticles is gaining more importance owing to its simplicity, economical, sustainable route of synthesis of nanoparticles and ecofriendliness. Based on the search to improve and protect the environment by decreasing the use of toxic chemicals and eliminating biological risks in biomedical applications, the present article reports an environment friendly and unexploited methods for biofabrication of silver nanoparticles (AgNPs) using *Raphanus sativus* leaf extract. The synthesized AgNPs were characterized by UV-vis spectroscopy and transmission electron microscopy (TEM). The absorption spectrum of the dark brown color silver colloids showed a single and prominent peak at 431nm, indicating the presence of AgNPs. Further, catalytic degradation of methylene blue (organic dye) by using AgNPs was measured spectrophotometrically. The results revealed that biosynthesized AgNPs was found to be impressive in degrading methylene blue and can be used in water purification systems.

1 Introduction

At present, there is a greater need to develop non toxic, reliable, clean and eco-friendly methods for the preparation of nanoparticles to expand their biomedical applications [1]. Over past few years, researchers in the field of nanotechnology present opportunities to exploit the array of biological resources in nature for nanoparticles synthesis. Nature has been invaluable source of medicinal plants since the time man realized the preventive and curative properties of plants [2]. Medicinal importance of plants is derived from the fact that approximately 25% of all prescription drugs are being derived from trees, shrubs or herbal compounds. The use of medicinal plants for the fabrication of nanoparticles offers numerous benefits of ecofriendliness, low cost, energy efficient, compatibility with pharmaceuticals and other biomedical applications as they do not use toxic chemicals for synthesis protocols. The methods using plant extracts involve phytochemicals such as terpenoids, flavonoids, phenol derivatives, plant enzymes (hydrogenases, reductases, quinones) and their derivatives, dihydric phenols and so on act as reductants in the presence of metal salt for nanoparticles synthesis [3-7].

The roots and leaves of radish plant (*Raphanus sativus*) are used as vegetables in numerous parts of the world and well reported in literature to possess a wide range of pharmacological activities [8-10]. Furthermore, the juice of *Raphanus sativus* root and its ash has been reported to possess antiulcer and anticancer activities respectively [11, 12]. In the present research work, we discuss the green-synthesis of AgNPs using the commercially economic and abundantly available *Raphanus sativus* and its application for catalytic degradation of organic dyes.

2 Materials and methods

2.1 Materials

Silver nitrate ($AgNO_3$) and methylene blue (MB) purchased from Sigma-Aldrich chemicals for this study. All glassware's were washed with distilled water and kept in the autoclave at 15 psi pressure, 120^{o}C for 15 min.

2.2 Preparation of leaf extract

Fresh leaves of *Raphanus sativus* were collected from institute surroundings and washed with deionized water and air dried before it is extracted. A 20g of this plant leaves were finely cut and were boiled in a Erlenmeyer flask with 150 ml of deionized water at 60^{o}C for 20 min and were finally filtered through Whatman No.1 filter paper to get the leaf extract. The filtrate stored in refrigerator at -10^{o}C and used as reducing and stabilizing agent

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2.3 Synthesis and characterization of silver nanoparticles (AgNPs)

For all experiments, the source of silver was $AgNO_3$ in distilled water. Aqueous solution (1 mM) of $AgNO_3$ was prepared and used for the synthesis of AgNPs. In a typical synthesis of AgNPs the leaf extract (2.5ml) was added to 47.5 ml of 1mM $AgNO_3$ aqueous solution in a 100 ml Erlenmeyer flask and heated on water bath at 80^{o}C for 60 min. Reduction of silver nitrate to silver ions was confirmed by the color change from colorless to dark brown. The synthesized AgNPs were characterized by UV-vis spectroscopy (Hitachi U-1800) and transmission electron microscopy on Tecnai G2 20S-TWIN instrument.

2.4 Catalytic activity of AgNPs

The catalytic activity of AgNPs was evaluated by investigating the degradation of MB dye. For all catalytic experiments the source of MB was the aqueous solution of 10mg MB in 1000 ml of double distilled water. First 0.5ml of MB was mixed with 2.5ml of de-ionized water and measured for absorbance using Hitachi U-1800 spectrophotometer after 30 min. Further, 0.5ml of MB was mixed with 2.5ml of AgNPs extract and measured for absorbance at different time intervals viz., 30 min, 60 min, 90 min, 120 min, 5 h, 12 h, 24 h, 48h and 72 h.

3 Results and discussion

3.1 Characterization of AgNPs

The synthesized AgNPs were primarily visually observed for color change and characterized by UV-visible spectroscopy. During the visual observation, AgNO3 incubated with leaf extract showed a color change from colorless to light brown within 1 h, as a result of the surface plasmon resonance (SPR) phenomenon, whereas no color change could be observed in $AgNO_3$ without leaf extract (Fig. 1).

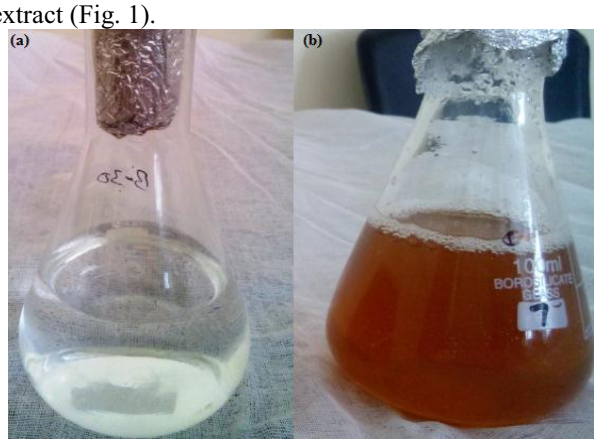

Figure 1. (a) Color of $AgNO_3$ solution, (b) Color changes after the addition of leaf extract with $AgNO_3$.

The appearance of light brown color in leaf extract treated flask is clear indication for the formation of AgNPs. The absorption spectrum of the colored silver colloids showed a single and prominent peak at 431nm, indicating the presence of AgNPs (Fig. 2). TEM results showed that the synthesized AgNPs were nearly spherical in shape with an average size of ~50nm (Fig. 3).

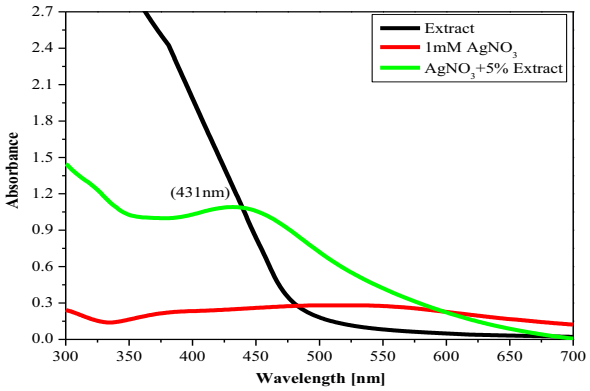

Figure 2. UV-vis spectrum of synthesized AgNPs.

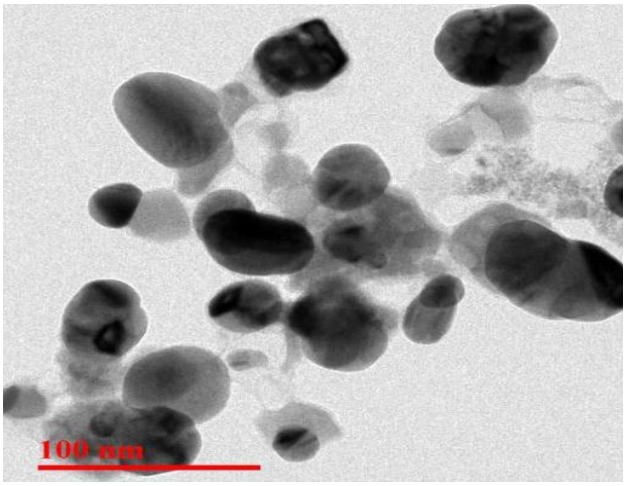

Figure 3. TEM image of synthesized AgNPs.

3.2 Catalytic activity of AgNPs on reduction of methylene blue

Many researchers reported that AgNPs are highly capable, good and stable photocatalysts under ambient temperature with visible region for degrading organic compounds and dyes [13-15]. The catalytic activity of synthesized AgNPs on degradation of dye is demonstrated by using the MB dye by carrying the degradation process in the visible region. The absorption spectrum of aqueous solution of MB dye in the presence of AgNPs is shown in Fig. 3. Pure MB has a main absorption peak of 664nm with a tail around 615nm. This main absorption peak at 664nm decreased abruptly and the tail at 615nm almost diminished with the exposure of dye to AgNPs in visible light for 72h, indicating the photocatalytic degradation of MB. The percentage of degradation of silver nanoparticles was calculated as 46% at 12h, 60% at 24h, 71% at 48h and 86% at 72h and observed to increase as increasing the exposure time.

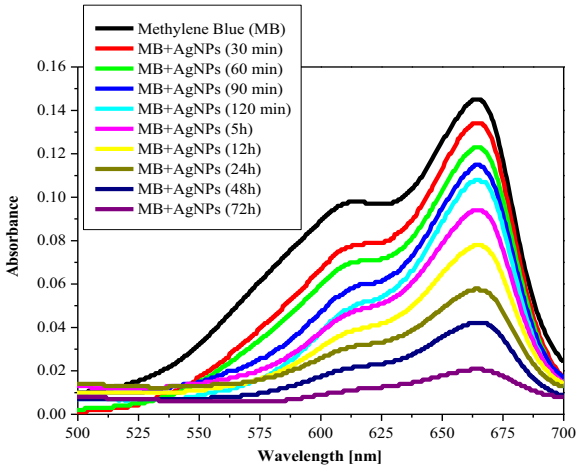

Figure 4. The absorption spectra of aqueous solution of methylene blue tested in the presence of AgNPs.

4 Conclusions

Silver nanoparticles were synthesized by using plant leaf extract of Raphanus sativus. The synthesized silver nanoparticles were characterized by UV-visible spectroscopy and transmission electron microscopy. The main absorption peak at 664nm for methylene blue dye decreased drastically after 72h time indicating the photocatalytic degradation of methylene blue dye. The maximum degradation percentage of methylene blue dye with silver nanoparticles was calculated as 86% at 72h. In the present study, it is found that the biosynthesis of silver nanoparticles exhibits magnificent photocatalytic activity against dye molecules and might be utilized in water purification systems.

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