



Research articles

Nano phytoremediation for textile dye degradation using abutilon indicum silver nanoparticles: photo catalytic activities

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ABSTRACT

Synthetic dyes are colouring agents mainly used in textile industries which generate a huge amount of wastewater in the process of dyeing. Different dyes used in textile industry usually have a synthetic origin and complex aromatic molecular structures which make them more stable and more difficult to be biodegraded and thus polluting the environment. To overcome the deleterious effects of such dyes, it is necessary to decolorize them. In the present study, fabric azo dyes were decolorized by silver nano particle isolated from plant *Abutilon indicum*. Production and characterization of silver nanoparticles synthesized from *Abutilon indicum* was analysed by UV-visible spectroscopy and Fourier transform infra-red spectroscopy. Photo catalytic degradation using *Abutilon indicum* synthesized silver nanoparticles showed significant dye degrading efficiency against azo dye. At the end of 24 hours, nanoparticles of *Abutilon indicum* showed 17.41% of degradation, followed by increased degradation of about 72% at the end of 7th day of incubation. Results confirmed the complex, toxic azo dyes were degraded into simple, non-toxic compounds. In conclusion, *Abutilon indicum* synthesized silver nanoparticles can exhibit excellent photo catalytic activity against dye molecules and can be used in water purification systems and dye effluent treatment.

Keywords: *Abutilon indicum*, azo dye, photo catalytic degradation, phytochemicals, silver nanoparticles,

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INTRODUCTION

Dyes are versatile chemicals which are consumed by a number of chemical industries like textile, printing, paper, food and cosmetics industries.^[1] This azo dye comprise of one or more azo groups (-N=N) with benzene, naphthalene, and aromatic heterocyclic and aliphatic rings.^[2] Anthraquinone dyes and phthalocyanine dyes are similar to azo dye on the basis of containing chromophoric groups. Cationic, anionic and non-anionic dyes are classified based on their solubility in aqueous solution. Disperse dye and reactive dye are based on their application method and used for polyester and cotton respectively.^[3] This synthetic dyes produced can have detrimental impacts when it is discharged into the environment without any treatment.^[4] Almost 700,000 tons of different synthetic dyes are said to be produced annually and they are non-biodegradable with resistant to degradation by heat, light, or water.^[5] Effects of such dyes when contaminated the water bodies causes an increase in BOD and COD levels, threaten aquatic biota ^[6], generation of new xenobiotic compounds^[7], toxicity, mutagenicity and

carcinogenicity^[8].

The treatment of such industrial effluents should be necessary prior to their discharged into the environment. The conventional chemical processes are effective but produces toxic intermediate products^[9] and the physical processes are less efficient with high operational cost.^[10] Biological processes have received more interest by today because of their cost effectiveness, lower sludge production and environmentally friendly. Microbial systems (bacterial and fungal species either as pure or mixed cultures) with efficient decolorization or degradation of colorants were well documented.^[11] Plants can uptake contaminants persisting in environment and such phytoremediation is used for effective elimination of wastes including azo dyes and colorants. The use of plant extracts for the synthesis of nanoparticles known as green synthesis of nanoparticles and this emerging research contributes for Nano phytoremediation. Even plants not aid in remediation may remediate various contaminants by altering their physiology and biochemistry with the

exogenous application of nano-chemicals.^[12] *Abutilon indicum*, is a native plant of South Asia, belongs to Malvaceae family. This woody and shrubby plant has several biologically active Phyto macromolecules with anti-bacterial and anti-inflammatory actions.^[13] In the present research, the decolourization and degradation potential of nanoparticles isolated from *Abutilon indicum* were investigated.

MATERIAL AND METHOD

Collection of Plant Material

Fresh *Abutilon indicum* leaves were collected from Herbal Garden, St. Joseph College Tiruchirappalli, Tamilnadu. The plant was washed with sterile distilled water, dried for about two to three weeks under shade. These leaves were then grinded to form a powder, stored in an airtight container and used for extraction.

Plant Extract Preparation and phytochemical analysis

The plant material was subjected to successive extraction using a Soxhlet apparatus. Accordingly, the substance, which is soluble in a water solvent with a particular range of polarity was extracted in that solvent and remaining material further extracted with the next solvent with different polarity. The extraction was carried out for 18 h with the selected solvents with a ratio 1:4 w/v, based on their polarity viz., aqueous. The aqueous extracts obtained by successive solvent extraction were also subjected to various phytochemical analysis.^[14]

Synthesis of nanoparticles

The resultant extract was filtered and then concentrated under vacuum in a rotary flash evaporator. The concentrated extract was then dried to get the crude plant extract.^[15] Synthesis of silver nanoparticles using plant extract were carried out following the procedure reported by Singh et al. ^[16], with slight modifications. To 750 ml of milli molar concentration of silver nitrate, 7.5 ml of the leaf extract homogenate was added and were exposed to the sunlight. Colour of the mixture turns from green to brown when exposed to sunlight and once it turns to colourless, the particles were settled at the bottom of the flasks. The particles were then centrifuged at 2000 rpm. After removing the supernatant, about 1ml acetone was added to the particles at the bottom of the centrifuge tubes, for the removal of any moisture content present in the nanoparticles. They were transferred to a watch glass, air dried, collected, weighed and stored in a sterile container. The nanoparticles prepared were then analysed for their characterization.

UV-VIS spectra analysis

The bio reduction of Ag⁺ ions in solution was measured using the UV-VIS spectrum of the reaction medium. The UV-VIS spectral analysis in the present study was done by using U-3200 Hitachi spectrophotometer at room temperature operated at a resolution of 1 nm between 200 and 800 nm ranges.^[17]

FTIR and SEM analysis

Fourier transform infrared (FTIR) analysis of the synthesized nanoparticles was used to determine the types of biological molecules of plant's leaves extract. The Ag nanoparticles solution was allowed to centrifuge at 10,000rpm for about 30 min. The pellet was then treated and washed with de-ionized water to remove any free biomolecules that are not capping the silver nanoparticles. The samples were dried and grinded with KBr pellets and analysed. Morphological determination of the synthesized NAPs was carried out using a scanning electron microscope (SEM).

Photo catalytic degradation

About 10 mg of biosynthesized silver nanoparticles was added to 100 ml of Azo dye solution and kept in the dark for 30 min. To obtain adsorption-desorption stage, the nanoparticle suspension with dye solution was exposed at different time intervals. During such time intervals, the solution was centrifuged, filtered and that filtrate solution was used to evaluate the photo catalytic degradation of dye in aliquots. The absorbance spectrum of the supernatant was subsequently measured using UV-Vis spectrophotometer at the different wavelength. Concentration of dye was calculated by the absorbance value at 660 nm and the percentage of dye degradation was estimated using the formula:

$$\text{Decolourization \%} = [(C_0 - C_1)/C_0] \times 100$$

Where C₀ is the initial concentration of dye solution and C₁ is the final concentration of dye solution

after photo catalytic degradation. FTIR analysis was also carried out.

RESULT AND DISCUSSION

Phytochemical analysis

The preliminary phytochemical analysis was carried out in the leaf extracts of *Abutilon indicum*. Qualitative analysis revealed the presence of alkaloid, flavonoid, tannin, terpenoid, saponine, phenols and coumarin. The glycosides, steroids and quinine were completely absent in aqueous extract. A number of previous studies have shown that the phytochemicals have a specificity to reduce the silver ions into silver NPs and further stabilized them by preventing from agglomeration through chelating with the metal atom. Phytochemicals may have acted as reducing and stabilizing agent so there was no need of any external surfactants.^[18]

Synthesis of Silver Nano Particles

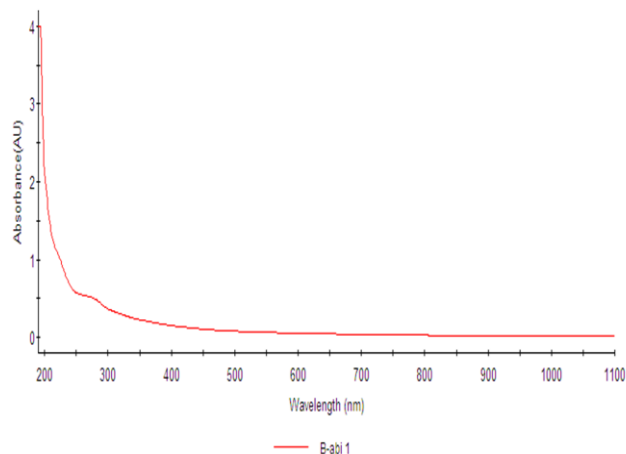
The formation of silver nanoparticles using *Abutilon indicum* extract was clearly represented visually and determination of colour change indicated the formation of nanoparticles, where yellowish brown colour was developed by addition of silver nitrate rapidly within 15 minutes of incubation period.

UV-VIS spectra analysis

The reduction process of aqueous silver ions into AgNPs using *Abutilon indicum* extract was examined through UV-Vis spectrophotometer. This analysis showed an absorbance peak at 280

nm which was specific for Ag nanoparticles as shown in Figure. 1.

Figure. 1. UV-Vis analysis of *Abutilon indicum* leaves extract



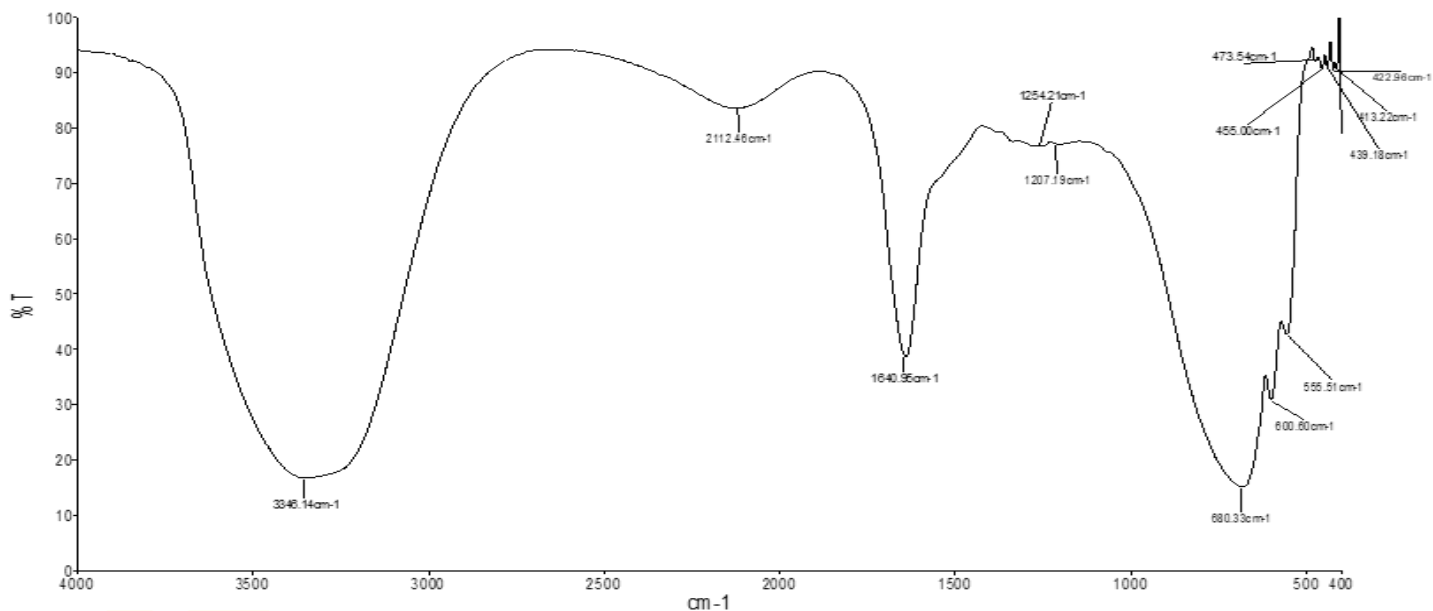
It was well known that leaf extract with a rich source of polyphenols and flavonoids surely absorb UV light due to the presence of hydroxyl (OH) moieties.^[13]

FTIR analysis of *Abutilon indicum* leaves extract

FTIR measurement was carried out and it showed many absorption bands which indicates the presence of active functional groups as shown in Figure. 2.

The intensity peaks were increased at 3346, 2112, 1640 cm^{-1} were decreased at few peaks such as 1207 and 680 cm^{-1} . The band at 3346 correspond to amines and amides. The peak at 2112 related to nitrites with C=N whereas peak at 1640 represents primary amines. The decreased peak at 1207 and 680 represents aliphatic amines and alkyl halides.

Figure 2: FT-IR spectrum of *Abutilon indicum* leaves extract.



The intensity peaks are slightly increased for the silver nanoparticle synthesis and the highest peaks found were at 3440, 2839, 2075, 1395 cm^{-1} and few low intensity peaks were at 1631, 2092, and 1362 cm^{-1} respectively. Band at 3440 for hydroxyl group stretching vibrations of silver, amide, alcohol and H-bonded to phenols. The peak at 2839 for alkanes, 2075 for aldehyde groups. Other bands at 1395 for carboxylic acids and 1016 and 676 corresponds to primary amines and alkyl halides. The FTIR analysis of plant leaf extract has showed the presence of many biological Phyto molecules with different molecular functionalities such as O-H, C-H, CHO, C≡, N-H. Such possible bonds characterized by FTIR was well documented in previous studies.^[19]

Photo catalytic degradation

In the current investigation, fabric azo dyes were collected from Tirupur, Tamilnadu, South India, and decolourized by silver nano particle isolated from *Abutilon indicum* extract under solar light. Colour change in the dye after degradation was initially identified,

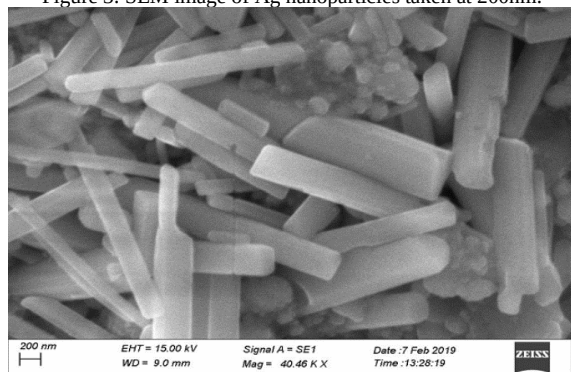
where the colour of dye from deep pink colour was changed into light pink after the 1h of incubation with silver nanoparticles while exposed to solar light. The degradation was analysed using FTIR. At every 24 hours interval, sample was derived and analysed where there was 17.41% degradation. As the days of incubation increases from 1 day to 7 days, the degradation efficiency was increasing 72%. Synthesized Ag nanoparticles can function as photo-catalyst and such function was observed in the current study when the azo dye was degraded by the nanoparticles. This disintegrative property of green synthesized Ag nanoparticles is due to their physical nature. Studies shown that the higher the crystalline nature, then greater will be the disintegrative ability and the disintegration rate.^[15]

SEM analysis

Figure. 3. represent the SEM image of the green synthesized AgNPs. Image with high intensity further confirmed the development of silver nanostructures. SEM was used for providing morphology and size details of the silver nanoparticles. SEM analysis

showed about 200nm particle size and crystal structure of the nanoparticles.

Figure 3: SEM image of Ag nanoparticles taken at 200nm.



FTIR analysis

FTIR analysis was also carried out to differentiate the possible functional groups of phytochemicals present in the silver nanoparticle leaves extract responsible for the bio-reduction. Figure

4 and 5 showed the FTIR spectrum of control and samples obtained after decolourization, respectively. Appearance of some new peaks and absence of important peaks were observed in the FTIR analysis of the metabolites produced after decolorization. A new peak formed at 1384 cm^{-1} was -N=N- stretching vibration. The C-H deformation showed at 1112 cm^{-1} . The peak at 1384 cm^{-1} showed N-H stretching vibration when compared to control. The significant change in the FTIR spectrum of metabolites compared to control spectrum suggest the biotransformation of complex dyes present in the mixture into simple form. The FTIR spectrum of control Dye have peak at 3449 cm^{-1} for intramolecular hydrogen bonding and O-H stretching with symmetric stretching at 1384 cm^{-1} and asymmetric stretching at 1114 cm^{-1} for C-N. In degraded extracted metabolites, a new peak at 435 cm^{-1} represented C-H deformation of alicyclic CH_2 whereas a peak at 685 cm^{-1} was observed for substituted anilines.

Figure 4: FTIR spectrum of control used in photo catalytic degradation

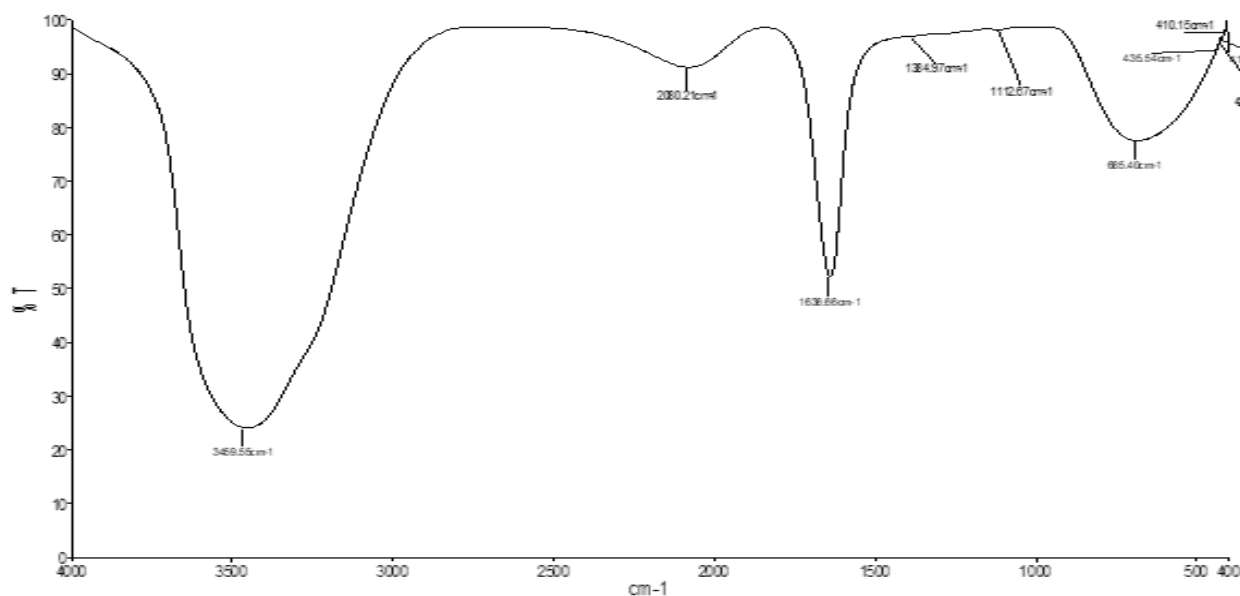
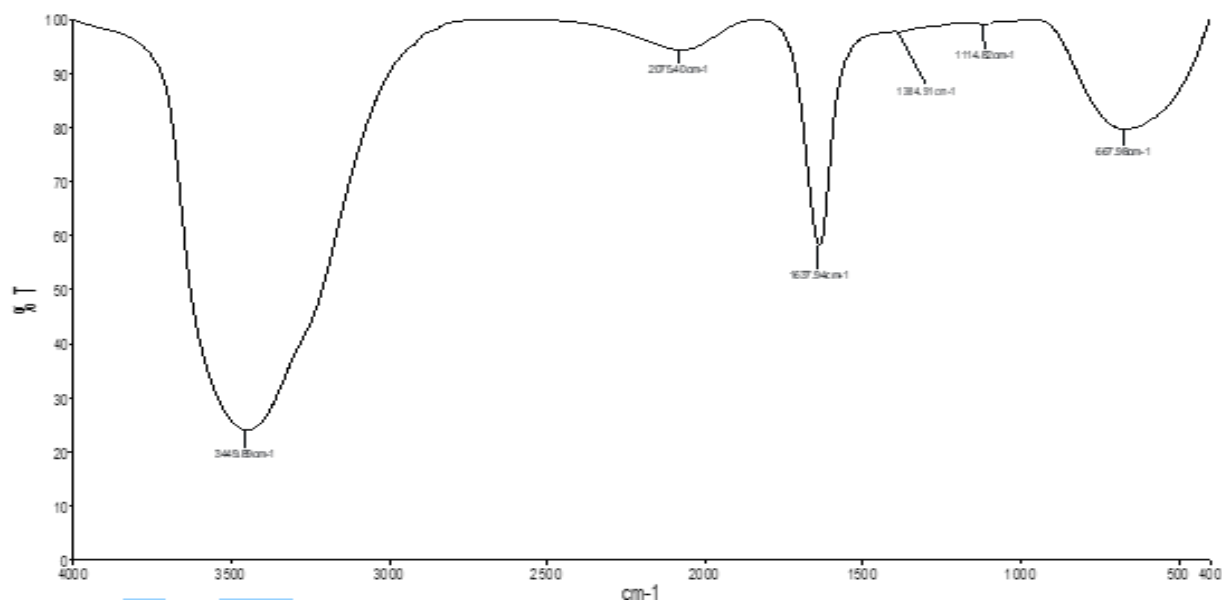


Figure. 4: FTIR spectrum of control used in photo catalytic degradation



Flavonoids present in the silver nanoparticles leaves extract contains variety of functional groups that is responsible for the bio reduction. The presence of alkyl amine groups also helps for bio reduction process.^[20]

CONCLUSION

It can be concluded that the process should be used as standard manufacturing process for further manufacturing of the Shiladhatri yoga and values of different parameters can be used as a reference value. Further preclinical and clinical studies should be carried out to validate and authentic the formulated compound.

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