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Biosynthesis of Silver Nanoparticles from Plant (Fenugreek Seeds) Reducing Method and their Optical Properties

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Abstract

In this paper, we synthesied the spherical silver nanoparticles (AgNPs) of 50-90 nm size, using $AgNO_3$ solution and the aqueous extract of Fenugreek plant seeds, which can act as a reducing, stablising and capping agent, at ambient condition. The formation of silver nanoparticles was confirmed by the XRD pattern and first excitonic peak of UV Vis. spectra that was supported by the change in colour of the solution (from colourless to dark pink). As synthesised Ag nanoparticles were characterized with the help of UV-Vis absorption spectroscopy analysis, Fourier Transform Infrared (FTIR) analysis, X-ray diffraction analysis (XRD), Scanning Electron Microscopy (SEM) analysis.

Keywords, Fenugreek seed, bioreduction, AgNPs.

Introduction

In recent research, nanotechnology plays a vital role our day to day life becuase it can not only engineer shape and size of metal but the basic properties (chemical, physical, mechanical, optical and catalytic, etc) may also be changed in the useful manner[1]. Nanotechnology has achieve the importance in different fields such as health care, food and feed, cosmetics, energy science, electronics, mechanics, space industries, environmental health, biomedical science, chemical industries, drug and gene delivery[2]. It also have expansively been achieved for the treatments of cancer[3], diabetes[4], allergy[5], infection[6] and inflammation[7]. Green chemistry is an enhancement and development in such a fields, design, implementation of chemical products and processes to reduce the use and generation of substances that are harmful to human health and environment[8]. There are many ways to synthesize nanoparticles such as solid reaction, co-precipitation, chemical reaction, and sol gel method etc. In recent years green synthesis of NPs has a number of advantages over chemical synthesis, such as cost effectiveness and simplicity,. Moreover it is compatible for food applications and biomedical, and this method eliminates the use of toxic chemicals, temperature, energy and high pressure[9,10]. The growing need of environment friendly nanoparticles has attracted lots of researchers to use green synthesis methods of a variety of metal nanoparticles[11] due to their interesting, motivating, attractive and remarkable properties with a variety of applications over their bulk material[12]. Considering the chemical reduction methods, photochemical reduction, electrochemical reduction and heat evaporation etc., the biological method is more beneficial and advantageous[13]. In this biosynthesis method, the plant extract has been used as reducing agent and capping agent for the synthesis of nanoparticles[14] due to their reducing properties[15]. Some properties such as size, morphology and distribution of the particles are clearly obtained from the nanoparticles[16].

The synthesis of silver nanoparticles has been synthesized using green methods which are less usage of chemicals, non-toxic and low cost and Environmental friendly. Plants used for green Synthesis of silver nanoparticles like using plant extracts have been reported in *Argemone maxicana*[17],*Ocimum*[18],*Cleome Viscosa*[19], *Trigonella foenum-graecum*[20], *Cycas*[21], *Eucalyptus hybrida*[22], *Iresine herbstii*[23], *Avena sativa*[24], *Lantana camara*[25], *Citrus limon*[26], *Calotropis gigantean*[27] *Achillea wilhemsii*[28], *Tagetes erecta*[29] Trachyspermum ammi[30]. Zea mays[31], Azadirachta indica (Neem)[32], Medicago sativa (Alfa alfa)[33,34], Aloevera[35], Emblica officinalis (Amla)[36], Capsicum annuum[37], Geranium sp.[38,39], Diopyros kaki[40], Magnolia kobus[41] and Coriandrum sp.[42], etc.,. All the parts of the plant like leaf, stem, flower, seed and skin of the fruits were used earlier for the synthesis of AgNPs. Plants have been used for the synthesis of nanoparticles were coated by the plant extract which has medical benefits and can be used as drug and cosmetic applications[43]. The various nanoparticles like Ag[44], Au[45], Fe[46], Pd[47], ZnO/Au and ZnO/Ag[48] nanoparticles as well as quantum dots CdS[49], among these, Silver nanoparticles places a major role because it has a number of important properties such as optical, electronic, chemical, photo electro chemical, catalytic, magnetic, antibacterial, and biological labelling, antimicrobial, catalytic. Silver nanoparticle acts as antimicrobial agent which finds applications in medical field such as AgNPs coated blood collecting vessels, coated capsules, band aids etc[50]. The silver is non-toxic to animal cells and highly toxic to bacteria, and other microorganisms (E-coli, Pseudomonas aeruginosa, Staphylococcus aureus). Due to these phenomena it is considered to be safe and effective bactericidal metal[51-53].

In this report, Fenugreek is a self pollinating annual leguminous bean which belongs to Fabaceae family[54] commonly known as Indian methi, It is one of the most ancient medicinal herbs[55]. Fenugreek seeds are the most important and useful part of

fenugreek plant. The fenugreek, plant mainly shows the presence of saponin and alkaloids are anti-nutritional factors[56]. The current investigation focuses on the aqueous seeds extract of Fenugreek used to synthesize AgNPs using different experimental conditions and thereby enhancing the importance of plant sources and implementing green chemistry for the future research.

Material and Methods

Preparation of Dried Biomass, The seeds of Fenugreek Seeds were collected from herbal garden of University of Rajasthan Campus, Rajasthan, India. The seeds were thoroughly washed with deionised distilled water and crushed. The powder was further used for preparation of 10 g/L aqueous seeds extract. This extract was filtered and stored at 4^{o}C until further use for present investigation.

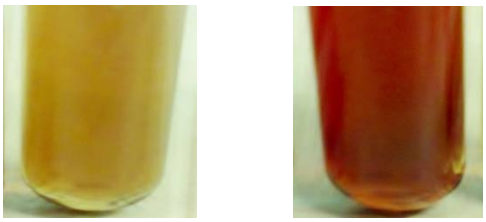
Chemicals: Silver nitrate ($AgNO_3$) was purchased from Sigma-Aldrich. Deionised distilled water was used throughout the experiment. All other chemicals were of analytical grade.

Synthesis of nanoparticles: For biosynthesis of nanoparticles, 2.0 ml plant seeds extract was mixed with 25 ml of freshly prepared silver nitrate 10^{-3} M $AgNO_3$ solution was prepared in 250 mL of deionised water in a sterile conical flask and kept in dark condition at room temperature. The reaction mixture was incubated for 30 min or till colour change to dark pink was observed. The nanoparticles were then synthesized by drying at 90^{o}C.

Characterization of nanoparticles: The syntheised nanoparticles were characterized using UV-Vis Spectroscopy (LABINDIA UV- Visible 3000^{+}) over a range of 200-800 nm. The topography of the nanoparticles was studied by SEM (Scanning Electron Microscope) analysis. FTIR (Fourier Transform Infrared Spectroscopy) was performed to obtain wide spectrum of nanoparticles over a narrow range. This method gives us information about plant peptides that have covered the particles during synthesis procedure. The XRD (X-Ray Diffraction Analysis) was performed to note the size of the obtained nanoparticle.

Results and Discussion

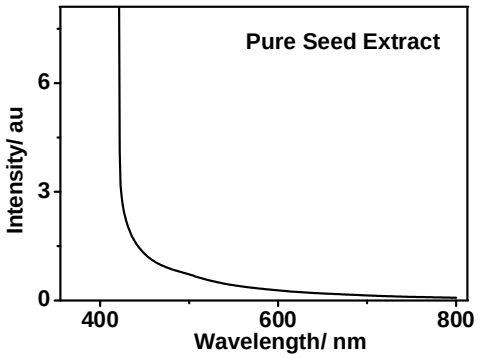
Synthesis and characterization of silver nanoparticles, Aqueous seed extract of Fenugreek acts as a reducing agent[57] which reduces metallic silver to nanosilver and hence the colour change was obtained figure-1. It is well known that silver nanoparticles exhibit reddish pink colour in aqueous solution due to excitation of surface plasmon vibrations in silver nanoparticles. Ag^{2+} ions of silver nitrate are found to be reduced to Ag atoms. It is generally recognized that UV-Vis spectroscopy could be used to examine size and shape controlled nanoparticles in aqueous suspensions. Figure 1 show the UV-Vis spectrum recorded from the reaction medium after 24 hours and gives rise to an absorption band at 420 nm.



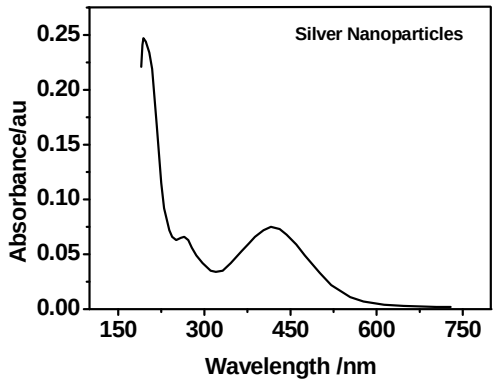
(A) (B)

Figure-1
(A) Aqueous seed extract (B) Aqueous extract and silver nitrate after incubation

The synthesized nanoparticles were characterized using FTIR, SEM, XRD and UV Vis spectroscopy analysis. The reduction of silver ions to nano silver was monitored and confirmed using UV spectra. After the colour change was obtained a small aliquot of sample was diluted with distilled water and subjected to UV analysis. The characteristic peak value for silver nanoparticles is between 400-580nm. Figure-2.



(A)



(B)

Figure-2
UV Vis spectra of (A) Pure Seed Extracts (B) Silver nanoparticles produced by extract of Fenugreek Seeds

The spectrum of the sample was obtained for wavelength range in-between 400nm to 580nm. The λ max of the nanoparticles was observed at 470nm. This is because of a phenomenon called Surface Plasmon Resonance (SPR) exhibited by silver nanoparticles. The silver nanoparticles oscillate when exposed to electromagnetic radiation and this oscillation gives a typical peak value[58]. The SEM (FESEM, JEOL JSM-6700F) image of the nanoparticles represents the topography of the particles is shown in image figure-3.

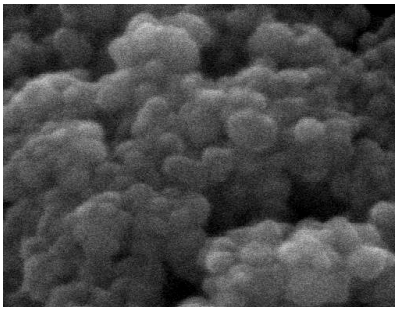


Figure-3
SEM image of silver nanoparticles produced by Fenugreek seeds extract

The SEM image suggests the presence of roughly spherical silver nanoparticles. The incidence of Xrays on the powdered nanoparticles gives a particular pattern which helps to characterize the nanoparticles as shown in the XRD graph figure-4.

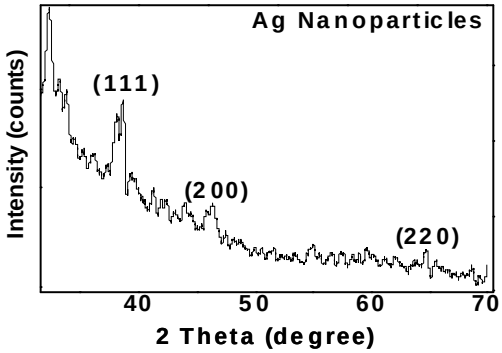


Figure-4
XRD pattern of the silver nanoparticles produced by extract of Fenugreek seeds

XRD (manual mode) was used to characterize the AgNp. The 2d angle is converted to the diameter using the Scherrer formula ($Dp = K\lambda / \beta 1/2 \cos\theta$). The size of silver nanoparticles synthesised by green synthesis was estimated to be around 20-50 nm. FTIR (Bruker -Tensor Model) analysis also gives a set of peak values unique for the sample along with information of the plant peptides that are present in the sample as the plant extract acts as a reducing agent figure-5. FTIR analysis is used to confirm the presence of plant peptides visible due to the bending produced by amide bonds[59].

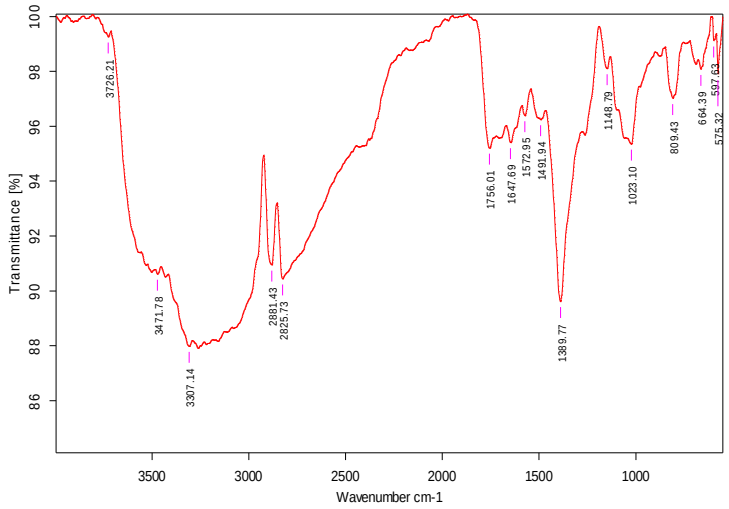


Figure-5
FTIR spectra of nanoparticles synthesized by extract of Fenugreek seeds

Biological synthesis of silver nanoparticles is an alternative to chemical synthesis and it used the reducing properties of biological products for synthesis of silver nitrate to nanosilver. Biological synthesis of nanoparticles has been previously reported using plant seed extracts. The phytochemical in the seed reduce the silver salts and not only produce silver nanoparticles but also stabilize it by capping the nanoparticles with the plant peptides. The antimicrobial activity of the nanoparticles is thus enhanced due to the presence of plant proteins and phytochemical.

Conclusion

In this present study the synthesis of silver nanoparticles was synthesized by biological method using Fenugreek seed extract which acts as a reducing agent to reduce silver metal to nanosize particles. The synthesized silver nanoparticles were subjected to analysis such as SEM, UV Vis Spectroscopy, XRD, and FTIR in order to characterize them. To the best of our knowledge this is the best information of the observations of the unique structures of fenugreek seeds extract mediated Ag nanoparticles. This opens a way to understand the synthesis mechanism of Ag nanoparticles formed from other plant seeds extracts.

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