Synthesis and characterization of fruit mediated silver nanoparticles using tamarindus indica fruit extract

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Abstract:

The production of silver nanoparticles by chemical and physical methods is expensive and the reagents used are deleterious. Green syntheses of silver nanoparticles have more attention due to their eco-friendliness, least toxicity and cost effective. Tamarindus indica fruit was selected, because of its low cost, easily available and medicinal value. Silver nanoparticles are prepared using aqueous silver nitrate with tamarindus indica fruit extract as reducing and stabilizing agent. The formation of silver nanoparticles was monitored by UV- Vis spectrophotometry. The mean particle diameter of silver nanoparticles was calculated from the XRD pattern according to the line width of the plane and refraction peak using the Scherrer's equation. The FTIR spectrum analyses identify the biomolecule that are responsible for reduction and stabilization of silver nanoparticles.

Key Words: Greensynthesis, Tamarindus indica, Silver nanoparticles, UV-Vis, XRD, FT-IR

Introduction:

Nanotechnology is an emerging field in an area of interdisciplinary research, especially in biotechnology. In recent years, noble metal nanoparticles have attracted considerable attention because of their unique optical, electronic, mechanical, magnetic and chemical properties that are significantly different from those bulk materials [1]. Now a days, silver nanoparticles have been found to exhibit interesting antibacterial activities, burn treatments, coating stainless steel metals, and sun creams [2]-[5]. The noble metal nanoparticles have been fabricated by chemical reduction with stabilizing reagents ($NaBH_4$, citrate, or ascorbate) [6], thermal decomposition [7], photo reduction [8], and radiation chemical reduction [9].

Many of these approaches are expensive, consume a lot of energy, result in low yields, and the chemicals used in their production are toxic and hazardous [10]. Recently, silver nanoparticles have been formed by biological approaches, using microorganisms [11], enzymes [12], and fungus [13]. The disadvantages of these approaches are they need special culture preparation and isolation techniques for synthesis of the nanoparticles [14], [15]. Silver is a nontoxic, safe inorganic antibacterial agent that is capable of killing about 650 types of diseases causing microorganisms [16]. Silver nanoparticles have also been fabricated using plant extracts

as reducing and capping agents. The main advantages of using plant extracts are that the process is simple, cheap, scaling-up, eco-friendly and safe [17]-[20].

Nanoparticles were synthesized from all parts of the plant like fruit, seed, stem, flower leaf and skin of fuits. In this present work, tamarindus indica fruit extract was used for the reduction of silver nanoparticles. Tamarind fruit contains many volatile phytochemicals such as limonene, geraniol, safrole, cinnamic acid, methyl salicylate, pyrazine and alkylthiazoles. In addition, it is also rich in many vital vitamins, including thiamin, vitamin-A, folic acid, riboflavin, niacin, and vitamin-C [21]. Much of these vitamins play antioxidant as well as co-factor functions for enzyme metabolism inside the body. The health benefits of tamarind fruit is used in various lotions and extracts that are used in the treatment of jaundice and regulating the blood pressure.

Experimental:

Preparation of the peel extract:

Tamarindus indica fruit was selected because of its low cost, availability and medicinal value. Fresh fruits of tamarindus indica (tamarind) were collected locally and washed thoroughly using double distilled water to remove all the unwanted impurities and chopped into small pieces. 10g of thin finely cut tamarind fruit were weighed and transferred into a 500ml beaker containing 100ml double distilled water, mixed well and boiled for 20 minutes. The extract obtained was filtered through Whatmaan No.1 filter paper and the filtrate was collected and stored for further use.

Fig. 1. (a) Tamarind fruit (b) aqueous Silver nitrate solution

(c) colour change after 5 min (pale brown)

(d) colour change after 30min (chocolate brown)

Synthesis of Silver nanoparticles:

To synthesis silver nanoparticles, dissolve 1mM of silver nitrate in 100ml of distilled water. To reduce silver ions the fruit of extract was added drop wise to the solution of silver nitrate, so that the resulting mixture became diluted. The solution colour was changed from light brown to chocolate brownish colour.

Characterization:

Characterization of silver nanoparticles is done by using UV- Visible spectrometer, X-ray diffractometer and Fourier Transform infrared spectroscopy.

Visual observation study:

The present study deals with the biosynthesis of silver nanoparticles (AgNPS) using tamarind fruit extract. The reduction of silver ions (Ag+) into silver (Ag) nanoparticles in the presence of fruit extract is followed by colour change and the formation of AgNPS was visually observed. The colour change of synthesized silver nitrate solutions was observed for various time intervals. Fig 1(c) shows the colour change after 5 min and fig 1(d) shows the colour change after 30 min. It was observed that the colour of the mixture changed after mixing the extract with silver nitrate solution. This confirms that silver ions can be reduced by the extract of tamarind fruit to form stable AgNPS in water. The reason for the brown colour is due to the extraction of surface Plasmon vibrations in the silver metal nanoparticles [22], [23].

UV- Visible Spectrometer:

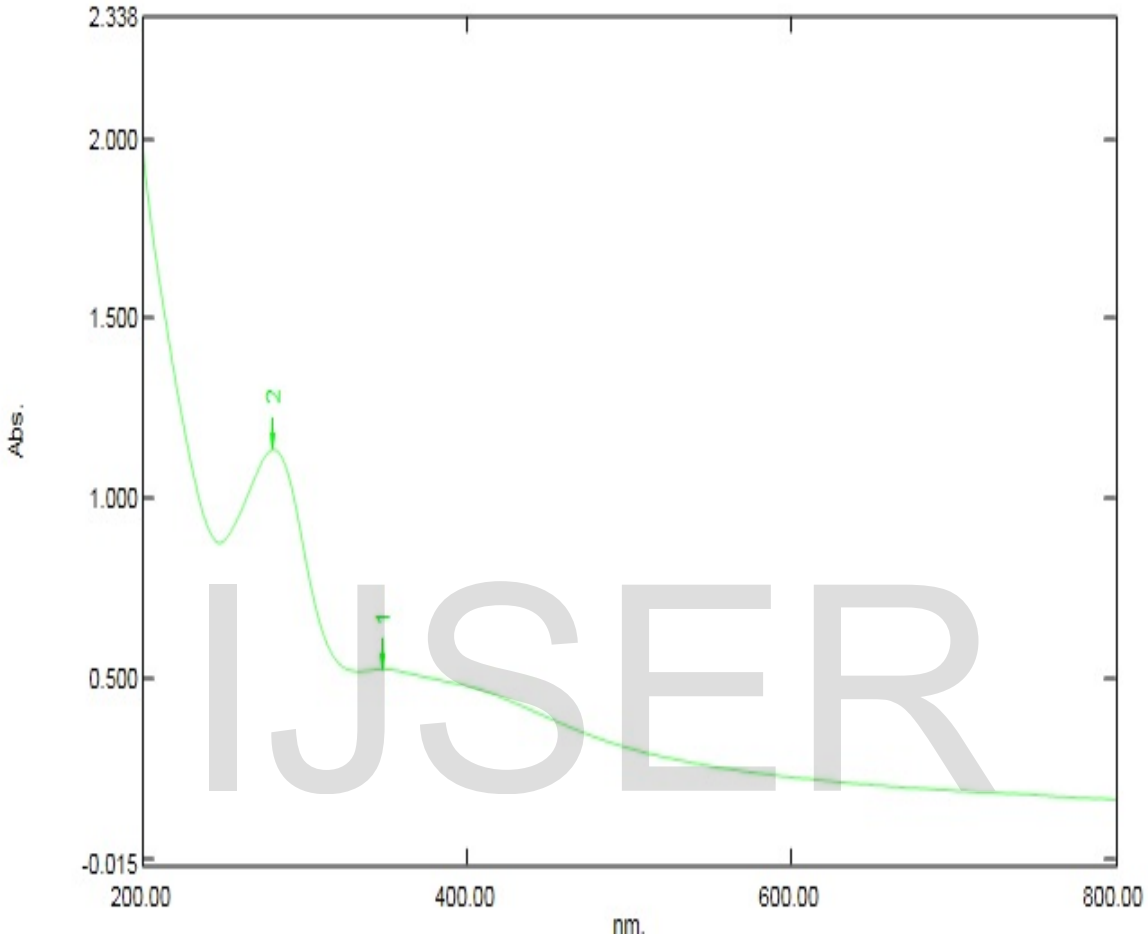

Fig. 2. UV- Visible spectra of AgNPS from 1mM of silver nitrate solution with tamarindus indica fruit extract.

The tamarindus indica fruit extract was used for the biosynthesis of silver nanoparticles. After adding the solution fruit extract to the silver nitrate solution, the reaction mixture colour was gradually changed from pale brown to chocolate brown colour, indicating the formation of silver nanoparticles. The maximum absorption peaks for tamarindus indica and silver nanoparticles were 280nm and 348 nm from fig 2.

XRD (X-Ray Diffraction):

The biosynthesized silver nanoparticles using tamarindus indica fruit extract was further

demonstrated and confirmed by the characteristic peaks observed in the XRD image (fig.3) .The

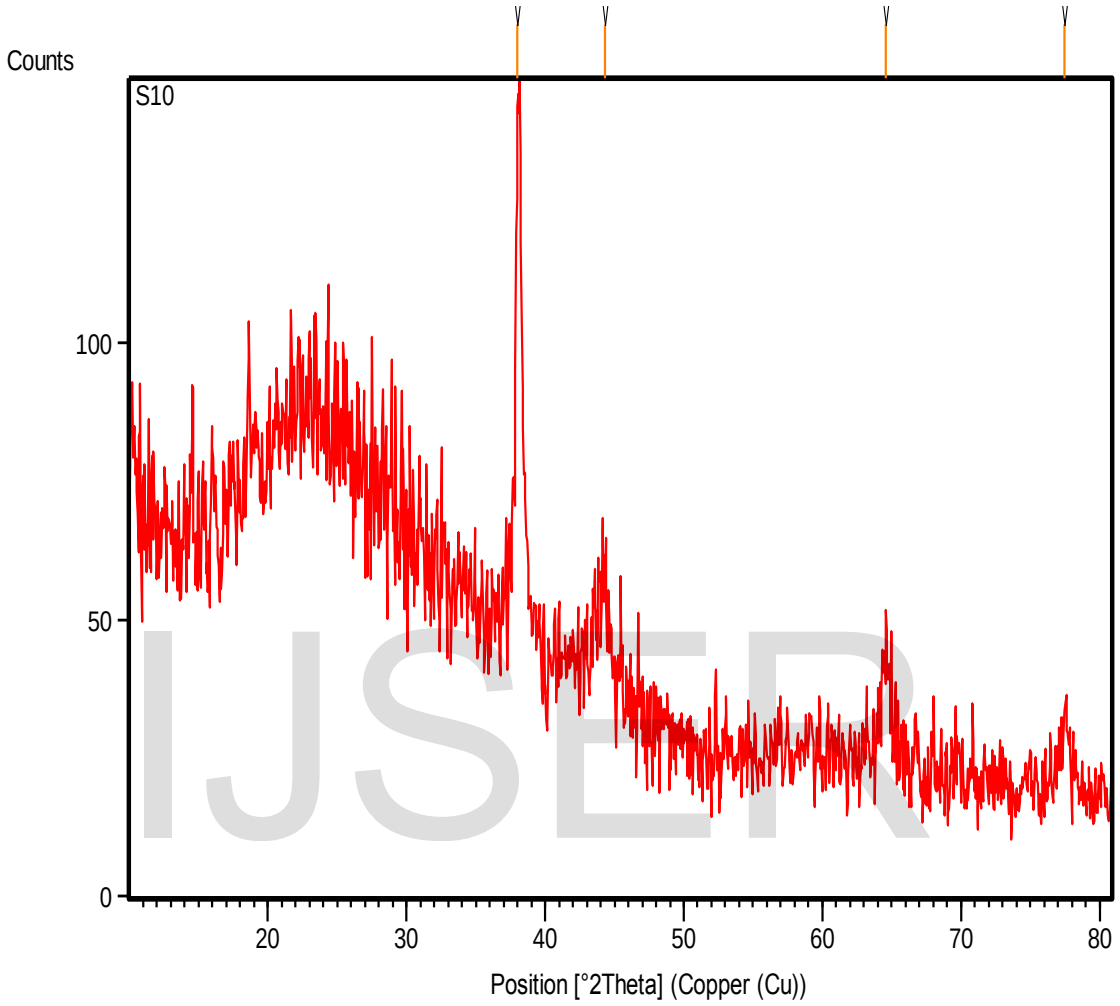

Fig. 3. XRD patterns of AgNPS

XRD pattern shows the intense peaks in the whole spectrum of 2θ value ranging from 10 to 80. The crystalline size of the particles was measured as 9nm to 25nm with an average size of silver nanoparticles are 17nm. The typical XRD pattern revealed that the sample contains a mixed phase of cubic and hexagonal structures of silver nanoparticle. As the width of the peak increases the particle size decreases which resembles that present material in nano range. The average crystallite size was measured by Debye Scherrer's equation as mentioned $D = K\lambda / (\beta \cos \theta)$. Where D is the average crystallite size of the particles, K is Debye Scherrer'sconstant (0.94), λ is the wavelength of the cu k-α radiation (0.154nm), β is the full width half maximum (FWHM) of the peak, θ is the Bragg's angle.

FTIR analysis:

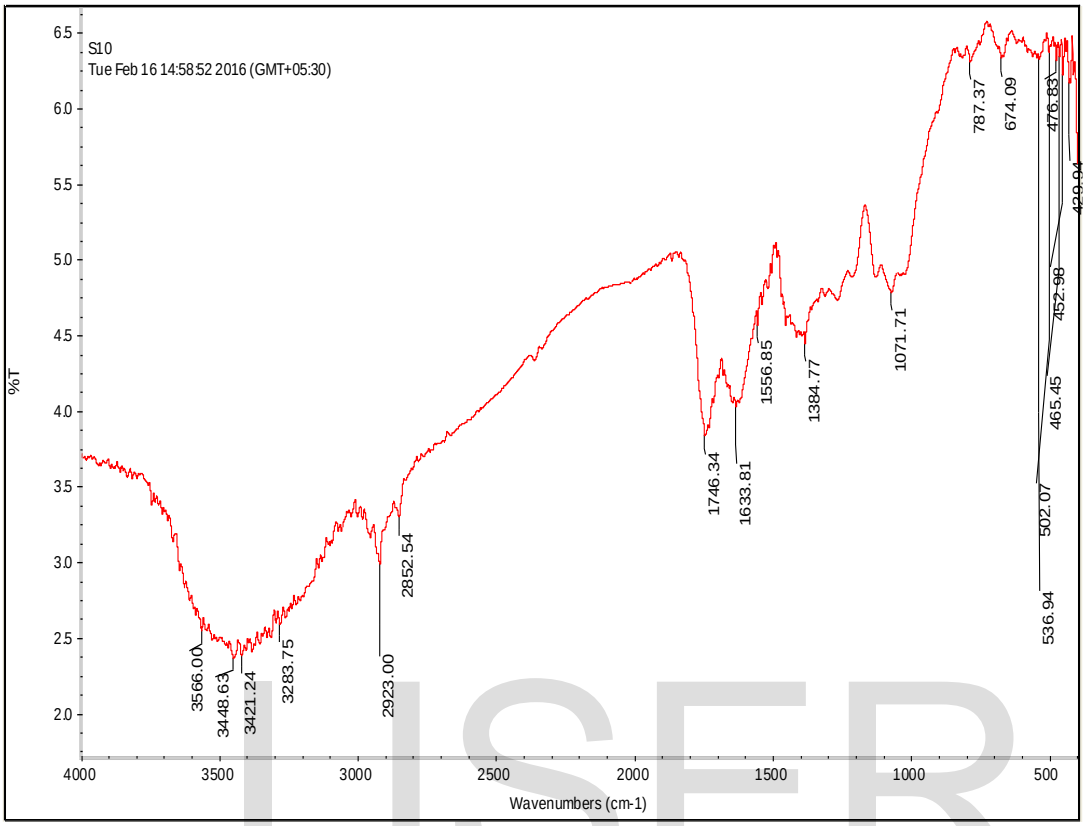

Fig.3. FTIR spectra of AgNPS.

FTIR spectrum is used to identify the biomolecules that are responsible for the capping and reducing agent of synthesized silver nanoparticles. The FTIR showed the presence of bands at 3448.63,3421, 3283,2923,2882,1746,1633,1566,1384,674 cm^{-1} respectively. The band at 3421.24 cm^{-1} and 3448.63 cm^{-1} exhibits N-H stretching vibrations. The peak at 1384 cm^{-1} is due to the presence of nitrate ions after its reduction. The peaks like 3283.75 cm-1, 2923 cm^{-1}, 2852.54 cm^{-1} OH stretching vibrations of carboxylic group and 1071 cm^{-1} gives rise to C-N stretching of amine group. The methylene group exhibits two bands at 2923 cm^{-1} and 2852.54 cm^{-1}. The band at 1633cm^{-1} indicates C=O stretching vibrations of carbonyl group. These results suggest that the carboxyl group (-C=O), hydroxyl (-OH) and amine (-NH) group of fruit extracts are responsible for the reduction of silver ions due to their capping and stabilizing ability [24]. The formed silver nanoparticles are surrounded by proteins, terpenoids and secondary metabolite indicates the minor peaks.

Conclusion:

The tamarindus indica (Tamarind) fruit extract used for the synthesis of AgNPs is a simple, low cost, eco-friendly and large scale production. The UV- Vis spectrum shows the characteristics absorption peak for silver nanoparticles at 348nm. The crystalline structure of synthesized silver nanoparticles was investigated by XRD method. The particle size of AgNps ranged from 9 to 25nm, with an average size of 17nm. FTIR study showed absorption bands corresponding to the main functional groups present in the natural fruit extracts. The significant reduction in reaction time with fruit extract is an important result of biosynthesis method compare to other routes for the formation of nanoparticles, which are currently much more rapid and reproducible.

References:

1. Chen J., Wiley B J., Xia Y., Langmuir, Vol.23, No.8, PP. 4120-4129, (2007).
2. Song J.Y. and Kim B.S. Bioprocess and Biosystems Engineering, 32, 79-84, (2009).
3. Rai M., Yadav A. and Gade A.,Biotechnology Advances, 27, 76-83, (2009).
4. Kumar A., et al., Nature Materials, 7, 236-241 (2008).
5. Furno F., et al.,Journal of Antimicrobial Chemotherapy, 54, 1019-1024(2004).
6. Liz-Marzán L.M. and Lado-Tourino I. Langmuir, 12, 3585-3589 (1996).
7. Esumi K., et al., Chemistry of Materials, 2, 564-567(1990).
8. Sun Y., Atorngitjawat P. and Meziani M.J. Langmuir, 17, 5707-5710(2001).
9. Henglein A. The Journal of Physical Chemistry, 97, 5457-5471 (1993).
10. Ponarulselvam S., Panneerselvam C., Murugan K., Aarthi N., Kalimuthu K. and Thangamani S. Asian Pacific Journal of Tropical Biomedicine, 2, 574-580,(2012).
11. Konishi Y., Ohno K., Saitoh N., Nomura T., Nagamine S., Hishida H., et al., Journal of Biotechnology, 128, 648-653,(2007).
12. Willner I., Baron R. and Willner B. Advanced Materials, 18, 1109- 1120, (2006).
13. Zhang X.R., He X.X., Wang K.M. and Yang X.H. Journal of Biomedical Nanotechnology,7, 245-254, (2011).
14. Saxena A., Tripathi R. and Singh R. Digest Journal of Nanomaterials and Biostructures, 5, 427-432,(2010).

15. Jain D., Daima H.K., Kachhwala S. and Kothari S.L. Digest Journal of Nanomaterials and Biostructures, 4, 557-563, (2009).
16. Jeong S.H., Yeo S.Y., & Yi S.C. Journals of Materials Science, 40, 5407e5411 (2005).
17. Azar A.R.J. and Mohebbi S. Micro &Nano Letters, 8, 813-815 (2013).
18. Moulton M.C., Braydich-Stolle L.K., Nadagouda M.N., Kunzelman S., Hussain S.M. and Varma, R.S. Nanoscale, 2, 763-770, (2010).
19. Dubey M., Bhadauria S. and Kushwah B. Digest Journal of Nanomaterials and Biostructures, 4, 537-543, (2009).
20. Parashar V., Parashar R., Sharma B. and Pandey A.C. Digest Journal of Nanomaterials and Biostructures, 4, 45-50, (2009).
21. Fabiana Rossi Hamacek., Priscila Rossini Gomes Santos., Leandro de Morais Cardoso., Helena Maria Pinheiro-Sant' Ana. EDP sciences, vol.68, P.381-395(2013).
22. Alzarani E. and Welham K.. International Journal of basic and applied Sciences, 3,392-400, (2004).
23. Xu H. and Kall M. Physical Review Letters, 89(2002).
24. Manisha R Donda., Karnakar Rao Kudle., Jahnavi Alwala., Anila Miryala., B Sreedhar and Pratap Rudra. INT J CURR SCI 2013,7: E 1-8,(2013).