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Phyto-Assisted Synthesis of Silver Nanoparticles using *Solanum Nigrum* and Antibacterial Activity Against *Salmonella Typhi* and *Staphylococcus Aureus*

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ABSTRACT. This study aims to provide a simple and eco-friendly approach for the synthesis of Ag NPs using medicinal plant *Solanum nigrum* aqueous leaf extract. Fresh leaf extract mediated the reduction of silver from higher excited state to the ground extract when mixed with 1 mM silver nitrate solution. Reduction led the synthesis of silver nanoparticle with the size range of 20-40 nm was confirmed by TEM analysis. UV-Vis analysis demonstrates the synthesis of Ag NPs by its standard peak due to SPR (Surface Plasmon Resonance). XRD analysis confirmed the crystalline nature of Ag NPs. It was further characterized by FT-IR for the confirmation of functional groups responsible for Ag NPs synthesis and elements analyzed using EDX. Our study also showed the high antibacterial effect of nanoparticle against disease causing virulent bacterial strains (*Salmonella typhi* and *Staphylococcus aureus*).

Introduction. *Solanum nigrum* is one of the most important traditional medicinal plants belonging to the family of solanaceae. The parts of *S. nigrum* like leaves, stem and fruits are playing a vital role in Indian daily foods.

Synthesis of silver nanoparticles using plant extracts such as fresh bark of *Pongamia pinnata* [14], papaya fruit extract [15], *Boswellia ovalifoliolata* stem bark [16], leaves of *Alternanthera dentate*, *Boerhaavia diffusa*, *Ziziphora tenuior*, *Ficus carica*, *Cymbopogon citratus*, *Acalypha indica* and *Premna herbacea* [17-23], seed extracts of *Pistacia atlantica*, *Trachyspermum ammi*, *Argyrea nervosa* and *Psoralea corylifolia* [24 – 27], fruit extract of pomegranate and grape (*Vitis vinifera*) [28-29], With these points under consideration, the present study was carried out to investigate the synthesis of silver nanoparticles using medicinal plant *Solanum nigrum*, characterized the silver nanoparticles by using UV-visible spectrophotometer, analyse the morphology of silver nanoparticles by using transmission Electron Microscope (TEM) and the nature of the silver nanoparticles by using X-Ray Diffraction Assay (XRD pattern), analyze the phytochemicals by using Fourier transform infrared spectroscopy (FTIR) present in the medicinal plants responsible for the nanoparticles synthesis.

MATERIALS AND METHODS

Collection of plant. The plant leaves of *Solanum nigrum* were collected from Katpadi, Vellore district, Tamil nadu, India.

Preparation of plant extract. Fresh leaves were collected and dried under shade. The dried leaves were powdered by mixer grinder. 10 g of *Solanum nigrum* powdered was taken and added 100 ml of

distilled water in a beaker and boiled for 5 to 10 minutes and are filtered through filter paper whatmann no 1. The extracts were allowed to store and are used for experimental animals.

Table 1. Biomedical applications of *Solanum nigrum*.

S. No	Applications	References
1	antibacterial activity against gram+ and gram- bacteria	[1, 2, 3]
2	anticancer activity against HeLa cell line	[4]
3	Antifungal activity	[5]
4	Antiviral activity	[6]
5	Anti ulcerogenic effect	[7]
6	Hepatoprotective activity	[8, 3]
7	Anti-inflammatory activity	[9]
8	Anti-seizure activity	[10]
9	Hypoglycaemic activity	[11]
10	Free radical scavenging property	[12]
11	Cardioprotective activity	[13]
12	Anti-seizure activity	[10]

Synthesis of nano particles. The filtered extract was mixed with silver nitrate solution. (1mm of AgNO₃) and 90 ml of distilled water and 10ml of extracts and kept in shaker. Every 4 hour silver nitrate was detected by UV-Visible Spectrophotometer at the range of wave length of 370-510 nm.

Preparation of nanoparticles powder for characterization

The silver nanoparticles was prepared using centrifugation techniques, it was based on our previous studies [14]. The prepared particles were characterized using FT-IR, Transmission electron microscope and EDX.

Antibacterial activity of AgNPs. Antibacterial activity was performed against typhoid causing bacteria (*Salmonella typhi*) and skin disease causing bacteria (*Staphylococcus aureus*) using disk diffusion method. Disks were impregnated with 3 different concentration of nanoparticle (25 mg/ml, 50 mg/ml, 75 mg/ml). The antibacterial effects of nanoparticles were measured against a positive control (cephalexin disk). The experiment was performed in triplicate.

RESULTS AND DISCUSSION

Phytosynthesis of silver nanoparticles using *S. nigrum*

FT-IR Analysis

Fourier transform infrared spectroscopy (FT-IR) is the best tool for identify the chemical groups of different biological extracts [28]. The chemical groups *Solanum nigrum* leaves and its based synthesis of silver nanoparticles was analysed using FT-IR shown in Fig. 1 and 2. In that the main peaks at 3282.13, 2918.33 and 1613.47 corresponds to the functional groups of C-H Stretch of alkynes, C≡C Stretch of alkynes and c-c=c symmetric stretch respectively. In the *Solanum nigrum* assisted synthesis of silver nanoparticles shows well developed peak at 3332.94 and 1634.30 indicates the chemical groups of Hydrogen bonded O-H Stretch and C-C=C Symmetric stretch respectively confirms the plant phytochemical are responsible for synthesis of nanoparticles [14, 28].

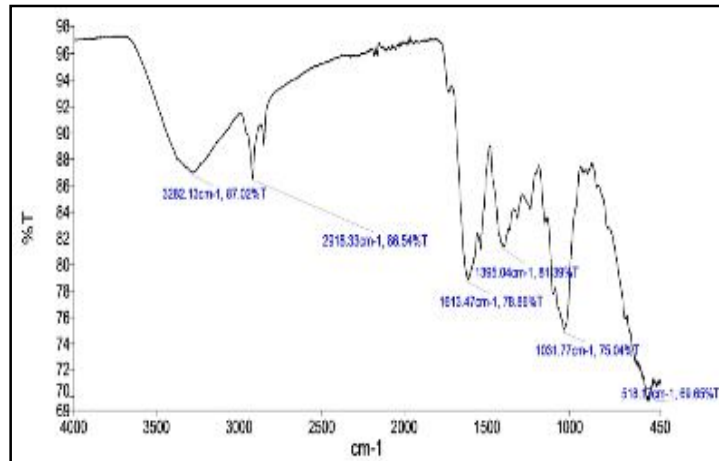


Fig. 1. *Solanum nigrum* plant leaves extract.

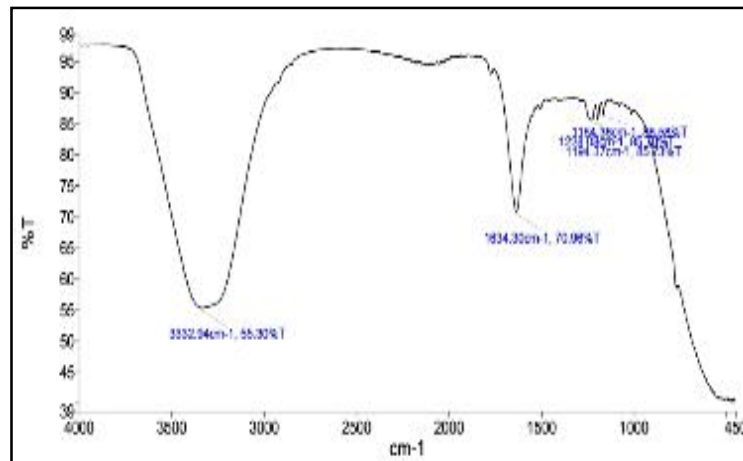


Fig.2. *Solanum nigrum* plant leaves extract mediated silver nanoparticles.

UV-vis spectroscopy analysis. The UV–visible absorption spectra result reveals a one step procedure for the preparation of the Ag NPs. The scale of wavelength was fixed between 380 and 480 nm, the surface Plasmon resonance (SPR) of the Ag NPs formed corresponded to 430 nm and there was an increase in intensity till 10 min 24 hr as a function of time without any shift in the peak wavelength (**Fig. 3**). It can be observed that the reduction of silver ions reaches saturation within 24 hr of reaction and after that, only slight variations can be noted in the intensity of SPR bands. This result indicates that the reaction is completed in 24 hrs [27, 30].

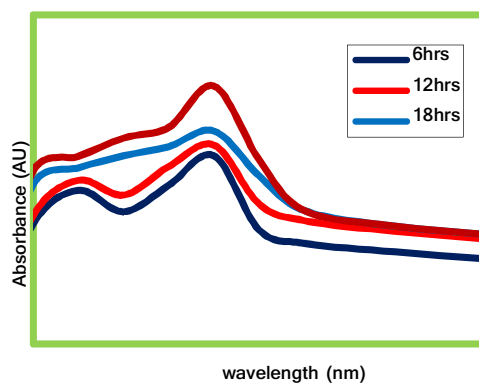


Fig. 3. UV-vis spectrum of silver nanoparticles by *Solanum nigrum*.

TEM and EDX analysis

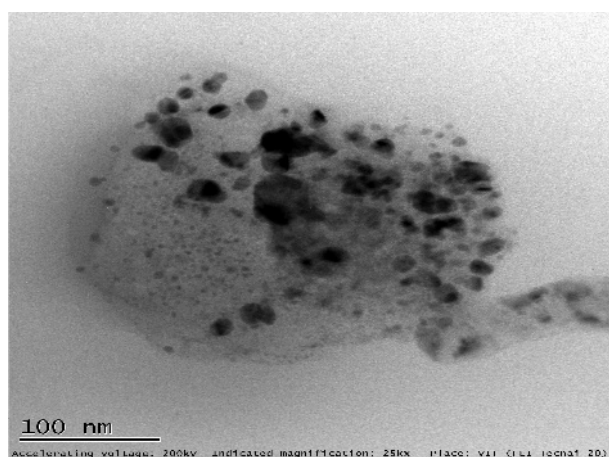


Fig. 4. Tem image and EDX spectrum of silver nanoparticles synthesized by *S. nigrum*.

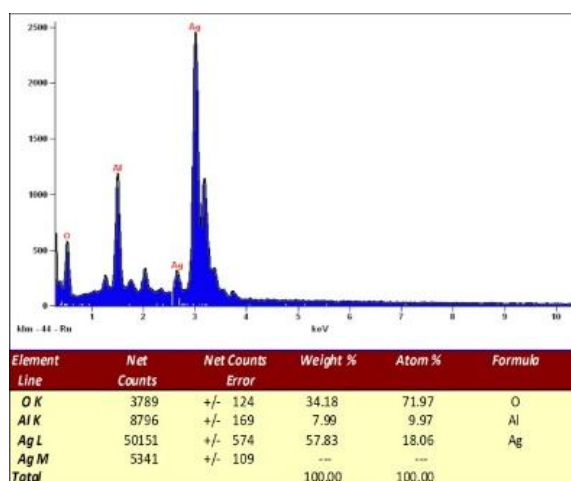


Fig. 5. Tem image and EDX spectrum of silver nanoparticles synthesized by *S. nigrum*.

The morphology of phytochemical mediated silver nanoparticles was viewed by TEM. Fig. 4 shows a well-dispersed AgNPs has identified in the sizes range 20–40 nm. The particles are clearly identified by their spherical, pseudospherical and some of undefined shapes because the nanoparticles are

associated with phytochemicals present in the *Solanum nigrum* leaves extract. The phytochemicals of plant extracts have been bind with the nanoparticles and some time it shows undefined shape in the background of the images and EDX analysis [24, 25, 30]. The results of elemental analysis also confirmed that the silver nanoparticles are bind with the biochemicals present in the plant extract (Fig. 5).

Antimicrobial activity of silver nanoparticles. The synthesized AgNPs were used for the antibacterial actvtiy against disease causing pathogens such as *Salmonelltyphi* and *Staphylococcus aureus*. Silver nanoparticles are the very major antimicrobial agents having good antimicrobial capability against different type of gram positive and gram negative microorganisms [14, 30, 31]. The Fig. 6 and 7 shows the antibacterial actvtiy of AgNPs and its zone of inhibition against *S. typhi* and *S. aureus*.

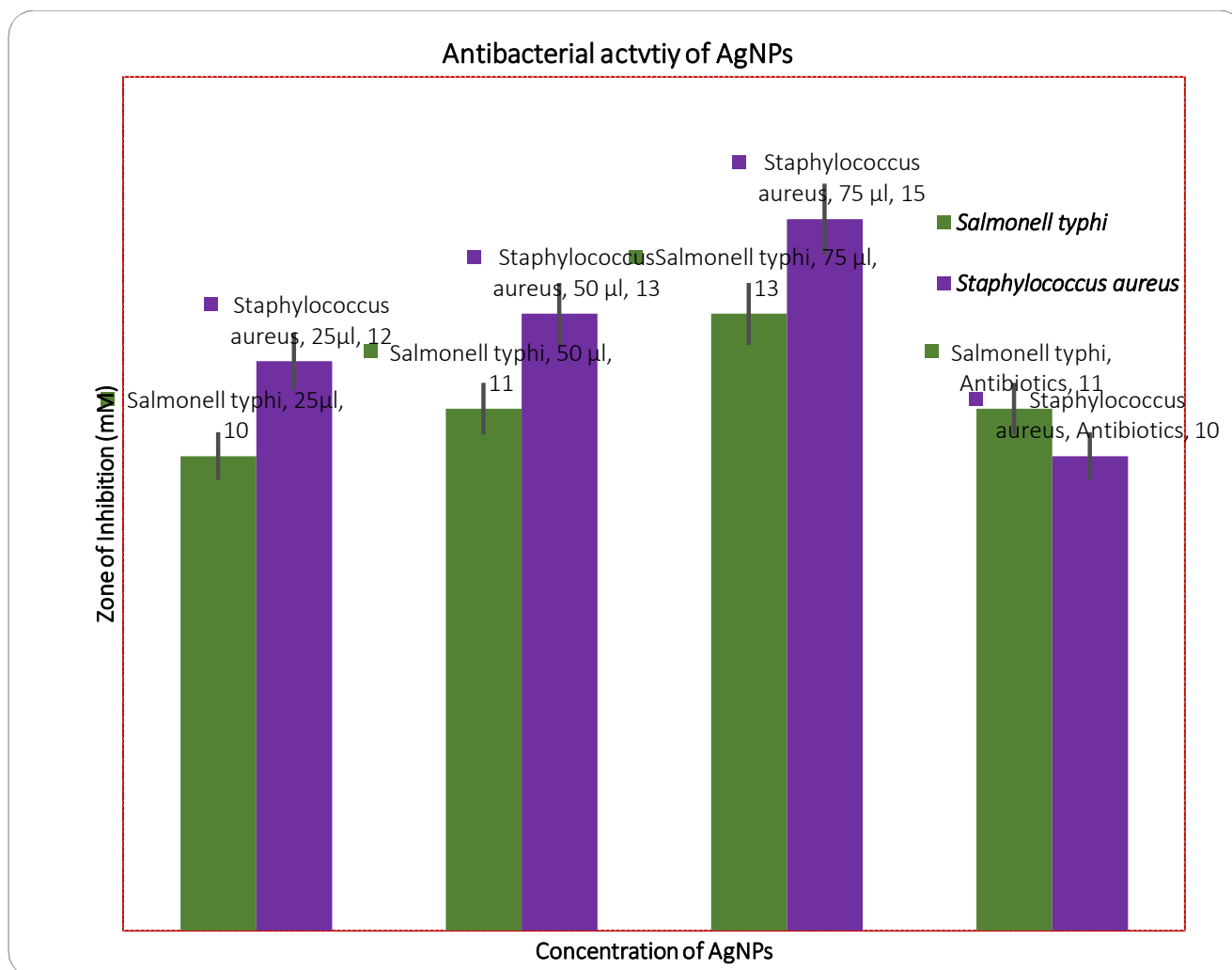


Fig. 6. Antibacterial analysis of AgNPs.



Fig. 7. Antibacterial analysis of AgNPs against *Salmonella typhi* and *Staphylococcus aureus*.

Summary. The present study confirms the synthesis of Ag nanoparticles by *Solanum nigrum* leaf extract. The extract acted as both reducing and capping agent and thus, stabilized the nanoparticles efficiently clearly demonstrated by the results. Uv-vis analysis confirmed the nanoparticle synthesis and EDX analysis depicts the presence of elemental silver. TEM analysis shows the synthesized nanoparticles with size range 20-40 nm. Nanoparticles show considerably high anti microbial effect against both the strains i.e. salmonella typhi and staphylococcus aureus when compared to standard antibiotic used. This suggests that it could be used as a potential drug against both the bacterial strain in future.

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