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Silver Nanoparticle Synthesis using Ocimum Santum

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Abstract: ***Silver nanoparticles are synthesised using green nanotechnology and environmentally friendly chemistry, with Ocimum Santum (Krishna Tulasi) leaf extract serving as a reducing and capping agent. This technique enables us to eliminate the usage of harmful reducing reagents while maintaining eco-friendly, cost-effective, and capable large-scale production due to the plentiful supply of greener products. This would accelerate science and technology forward at an alarming rate in the production of agricultural and industrial products, superior and durable materials, novel therapies for chronic and hated diseases like cancer, and plenty of additional industrial applications. The stability of synthesised molecules is examined using several components, such as temperature, time, and aggregation. The characterization was further examined using UV-Visible Spectroscopy, Scanning Electron Microscopy, and Transmission Electron Microscopy.***

Key words: SPR, AuNP's, spectra, UV/Vis, SEM, TEM, nano

I. INTRODUCTION

Nanotechnology is the key to the technological growth of the twenty-first century, and its success will be reliant on ongoing creativity and the culmination of research efforts from engineering, the natural sciences [1, 2] [17][19], medicine, and associated fields. Nanotechnology and green nanotechnology have massive economic and societal influences. Green nanotechnology allows for the design and production of nanomaterials in an ecologically friendly manner.

Nanotechnology covers the design, fabrication and management of particle architectures with dimensions less than 100nm [1]. Nano technological revolution has major consequences for everyday life. Green nanotechnology is a fast-evolving, multifaceted knowledge base at the crossroads of physics, chemistry, engineering, and the biological sciences (plant and life sciences). Environmentally benign ("green") nanotechnological processes are being developed to facilitate the design of new products that are made from eco-friendlier materials, including plants, crops, and various photochemical and phytoconstructs, using processes that use less energy and generate less waste throughout the product life cycle.

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To minimise detrimental consequences in medical applications, there is a rising need to produce environmentally friendly metal nanoparticle manufacturing that does not employ hazardous chemicals. Currently, there is a growing need to develop environmentally benign metal nanoparticle syntheses that do not use toxic chemicals to avoid adverse effects in medical applications. A nanotechnology revolution is taking place, with implications and consequences seen in a wide range of industries, including telecommunications, consumer electronics, medicine, alternative energy sources, agricultural productivity, and environmental restoration.

Green nanotechnology [3–7] [21] produces tailored nanoparticles using agricultural products such as Soya, Tea, Cinnamon, Cumin, Turmeric, Tamarind leaf, and Azadirachta indica leaf [8]. This brilliant discovery uses the chemical properties of various phytochemicals found only in agricultural produce or herbs to chemically reduce metallic salts and convert them into nanoparticles, while the entire production process is free of toxic chemicals. Due to a strong coating of a cocktail of phytochemicals on nanoparticulate surfaces, certain phytochemicals from agricultural produce and plants play a dual function in nanoparticle formation and subsequent stabilisation. Establishing connectivity between engineering and green nanotechnology in the development of sophisticated electronic materials, medical sensors, imaging, and therapy products in automobiles, telecommunication industries, silver nanoparticle-based sensors, environmental restoration. In Fashion and design industry use of nano silver particle based clothes, and are very much changing future world textile industries. Green nanomaterial production reduces dangerous pollutants and promotes noxious-free configurations. Because of their chemical reductants and sterile surroundings, photocatalysis and antibacterial resistance are more promising disciplines. Researchers and scientists have lately shown considerable interest in the green synthesis of silver nanoparticles due to their convenience, non-toxicity, cheap cost, and capacity to operate as an antibacterial agent. Silver nanoparticles' optical and electrical characteristics can be altered by altering their size, shape, surface chemistry, or aggregation state. Silver is one of the metals found in nature in its purest form. These metal nanoparticles are widely used in the treatment of many diseases, such as cancer [4] [20], bacteria [3–8], drug delivery tools [7], tissue and tumour imaging [4–8], immunochromatography, photothermal therapy, identification of pathogens in clinical specimens [8], biolabeling [1–9], detection of various ailments, catalysis, biosensor devices for the detection of various bacteria and viruses, and treatment of several diseases using nanotattoos, and so on.

The use of plant extracts in the synthesis of silver nanoparticles has a significant advantage over manufactured compounds [8]. In comparison to other ways, the process of synthesising nanoparticles using plant extract is highly easy, time intensive, and cost-effective.

Due to their unique applications, the synthesis of silver nanoparticles has been considered an important area of research. Several studies have been published on the utilisation of natural resources such as plants, fungus, yeast, honey, and bacteria to synthesise silver nanoparticles. In addition, we hope to synthesise silver nanoparticles from the leaves of Ocimum Santum (Krishna Tulasi) [9]. Krishna Tulasi [9] (Figure 1)] to heal various disorders precedes the oldest known history of a traditional medicine system. This plant [8] has been known to have anti-bacterial activity, anti-anaphylactic activity, anti-histaminic activity, wound healing effect, radio-protective effect, anti-diabetic effect, anti-oxidant activity, anti-carcinogenic properties, immunologic effects, contraceptive effect, and larvicidal effect due to a wide variety of phytochemical compounds (Figure 2), including eugenol, euginal, urosolic acid.

Figure 1: Ocimum Sanctum (Krishna Tulasi) (family Lamiaceae) was used for the Synthesis of Silver Nanoparticles. Tulasi Leaves Were Collected from the Botanical Garden, Karnatak University, Dharwad

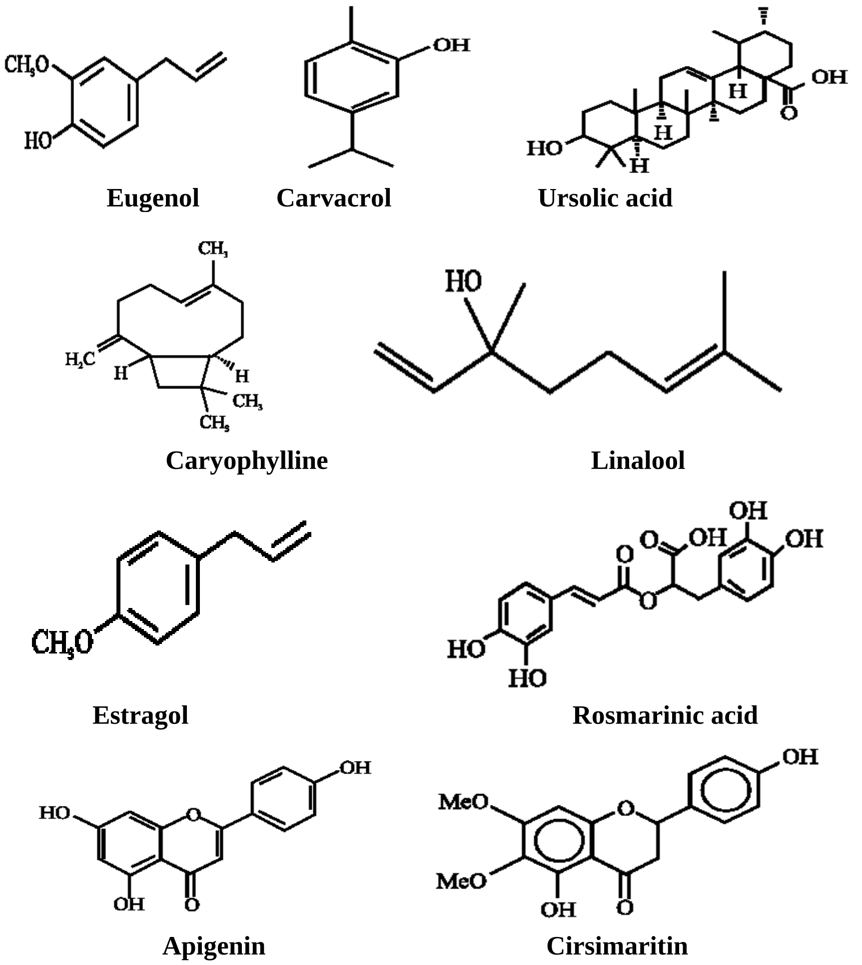

Figure 2: Phytochemical Composition of Ocimum Sanctum (Krishna Tulasi)

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II. ROLE OF GREEN TECHNOLOGY IN THE MODERN ERA

1. The synthesis of nanoparticles using green nanotechnology in chemistry is a thriving technology. This method allows us to eliminate the usage of harmful reduction reagents while also being eco-friendly, cost effective, and allowing for large-scale production due to the abundance of greener goods.
2. Green-synthesised nanoparticles have the same impact as chemically reduced nanoparticles in all applicative processes.
3. Green nanotechnology development would propel science and technology forward in the production of agricultural and industrial products, improved and durable materials, new drugs for chronic and dreaded diseases such as cancer, AIDS, and so on.
4. These technologies would also improve efficiency in harnessing solar and non-conventional energy sources, making the world less polluted and creating environmental safeguards for the future.
5. The use of this futuristic technology is inexpensive, environmentally benign, non-hazardous, and non-toxic.

III. EXPERIMENTAL

A. Materials:

Ocimum Sanctum (Krishna Tulasi) leaves were collected at the Botanical Garden, Karnatak University, Dharwad (Figure 1). $AgNO_3$ (silver nitrate) (analytical grade) is from Sigma Aldrich Chemicals. Distilled water is used for the synthesis, and all the washed glassware is dried in a hot air oven.

B. Preparation of Ocimum Sancturm Extract:

Leaves were gathered and rinsed many times with doubly deionized water for the manufacture of Ocimum Sanctum (Krishna Tulasi) extract. 20g of the dried leaves were chopped and combined with 200 ml of distilled water after drying at room temperature. For 60 minutes, the extraction was produced on a magnetic stirrer with a heater set to 1000 degrees Celsius. After cooling to room temperature, the solution was filtered (Whatman filter paper No. 1). And kept the extract at 40 degrees Celsius for further testing. This extract was obtained in order to create silver nanoparticles.

C. Synthesis of Silver Nanoparticles using Ocimum Sanctum (Krishna Tulasi) Leaf Extract:

When Krishna Tulasi leaf extract was applied to 20 ml of silver nitrate (AgNO3) solution at room temperature, the colour changed to yellow after 5–6 minutes. And then it was stirred with a magnetic stirrer. With 8 hours of reaction time, it slowly decreases Ag+ ions to Ag0 ions. The resultant dark-coloured solution proved the full reduction of silver. The creation of silver nanoparticles is indicated by the brown colour of the solution. The phytochemicals (Figure 2) eugenol, euginal, urosolic acid, carvacrol, linalool, limatrol, caryophyllene, methyl caricol, sitosterol, and anthocyans contained in Krishna Tulasi plant extract are responsible for reducing the silver salt into silver nanoparticles. Furthermore, UV-visible (UV-vis), transmission electron micrograph (TEM), and SEM instruments are used to characterise the synthesised silver nanoparticles.

D. UV/VIS Spectrophotometer:

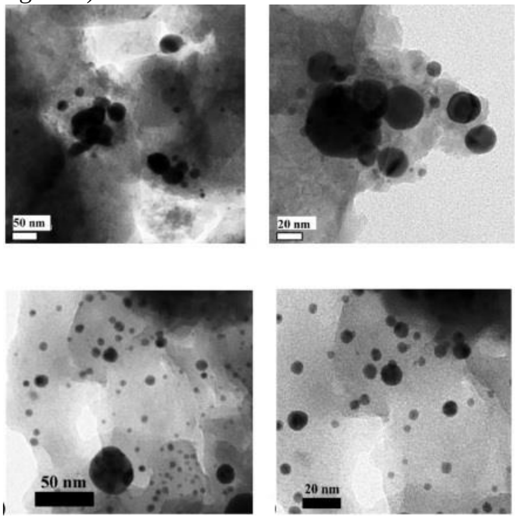
We employed a single beam Spectra Suite Ocean Optics Spectrophotometer (HR 400 high resolution model) to examine combined absorption and fluorescence studies [9].

E. SEM (Scanning Electron Microscopy) Measurements:

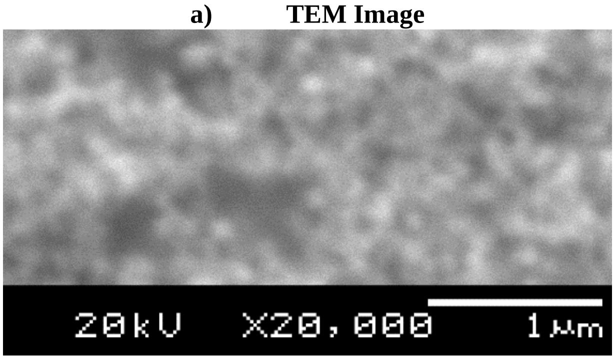
Scanning electron microscopy (SEM) (Model: JEOL JSM-6360) is a technique of electron microscopy that's capable of taking high-resolution photographs of a sample's surface.

IV. RESULTS AND DISCUSSION

UV/Vis spectroscopy has been successfully used to examine the development and stability of metal nanoparticles in aqueous solutions. Silver colloida's absorption band is 400–410 nm, with a high peak at 408nm attributed to the SPR, which is generated by an interacting electromagnetic field [10–14] [18]. The silver nanoparticles are spherical, according to SPR (Figure 4). Further, characterization of silver nanoparticles is done through SEM and TEM images (Figure 3).



a) TEM Image



b. SEM Image

Figure 3: a) Ocimum Sanctum Reduced AgNP's. TEM Image (b) SEM Image

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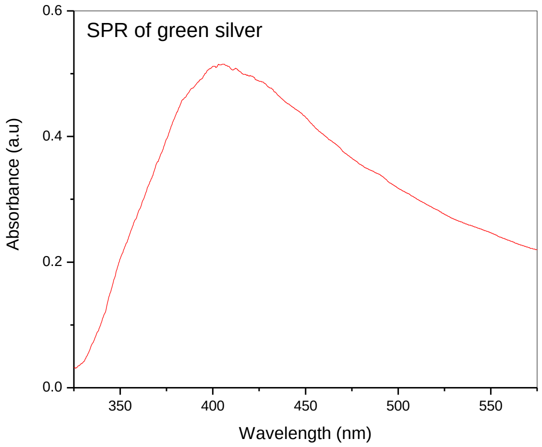

Figure 4: Surface Plasmon Resonance (SPR) of Silver Nanoparticles Synthesized by Ocimum Sanctum (Krishna Tulasi)

Phytochemicals found in Ocimum Sanctum (Krishna Tulasi) leaves include ursolic acid, rosmarinic acid, oleonic acid, pegenin, orientin, apigenin, luteolin, moludistin, carvacol, eugenol, and caryophyllene. Zn, Mn, and Na can also be present as trace elements. The extract's water-soluble components are responsible for metal ion reduction and nanoparticle stability.

A. Role of Phytochemicals as a Reducing and Stabilizing Agent:

It is critical to note that numerous herbs, spices, and plant sources contain powerful antioxidants that function as phytochemical elements in their seeds, stems, fruits, and leaves. These naturally occurring antioxidants are already present in the human food chain and have been shown for thousands of years to be non-toxic to living individuals and the environment. The use of plant-based phytochemicals in the overall synthesis and building of nanoparticles, as well as numerous nanoparticle-enhanced products, is particularly appealing since it represents an essential symbiotic relationship between natural and plant sciences and nanotechnology. This link between plant sciences and nanotechnology enables a naturally green approach to nanotechnology known as green nanotechnology. Professor Kattesh Katti, the father of green nanotechnology, has revealed the use of phytochemicals found in Soya and Tea as dual reducing and stabilising agents in the production of gold nanoparticles with Cumin [2–8]. We present here the use of phytochemicals found in Krishna Tulasi (Ocimum Santum) as reducing agents for the conversion of silver salts to silver nanoparticles. Krishna Tulasi phytochemical elements include eugenol, euginal, urosolic acid, carvacrol, linalool, limatrol, caryophyllene, methyl caricol, sitosterol, and anthocyans. The phytochemicals in both of these plants comprise volatile oils, lipids, a variety of alcohols, and aldehydes. Aroma rings are found in almost all phytochemicals. The chemical role of various phytochemicals in Krishna Tulasi responsible for AgNP synthesis is yet unknown, however, we believe that water-soluble elements in Krishna Tulasi may play an integral part in the complete reduction process of $AgNO_3$.

B. Effect of Temperature on SPR of Green AgNP's:

The influence of temperature on the SPR of silver nanoparticles synthesised by Ocimum Sanctum extract was investigated. The absorption spectra of silver nanoparticles were measured at four distinct temperatures (300, 400, 500, and 600 degrees Celsius). Figure 5 depicts the SPR spectra of silver nanoparticles. As the temperature rises, the SPR peak shifts slightly to the higher wavelength side, resulting in a redshift. The absorption peak may also be widening. The explanation underlying the redshift is that as the particle's temperature rises, the volume of the nanoparticle expands and the density of free electrons falls. The reduced electron density results in a lower plasma frequency of the electrons and, as a result, a red shift of the SPR. The absorbance of silver nanoparticles decreases as the temperature rises [1].

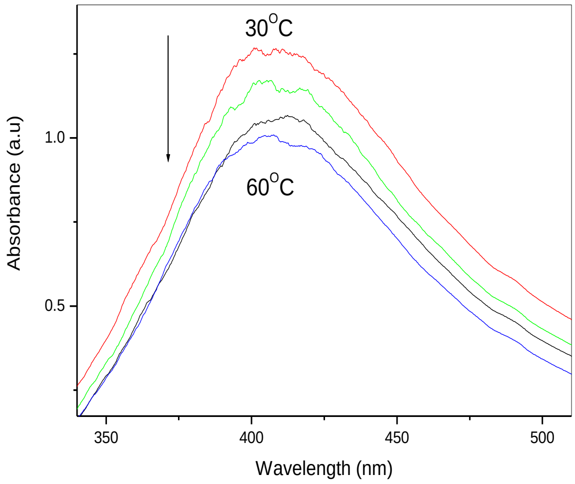

Figure 5: Absorption Spectrum (SPR) of Silver Nanoparticles Synthesized by Ocimum Sanctum (Krishna Tulasi) Leaves Extract at Various Temperatures

C. Effect of Sodium Chloride on SPR of Green AgNP's:

To check whether nanoparticles of silver are formed or not, it can be done in the reverse manner, that is, by promoting silver nanoparticle aggregation. To promote the aggregation of silver nanoparticles and compare their activity, a NaCl chemical solution was created [8-14]. It was discovered that increasing the NaCl content of the added solution to the colloidal nanoparticle solution resulted in a decrease in absorption intensity at the surface plasmon resonance as well as an increase in the absorption band in the long wavelength region (red shift) [9–16]. This is an indication (Figure 6) of the formation of a fractal medium in which nanoparticles adhere to one another in enormous clusters. Many earlier research publications have been published to highlight the optical activity of fractal media, particularly their capacity to aggregate.

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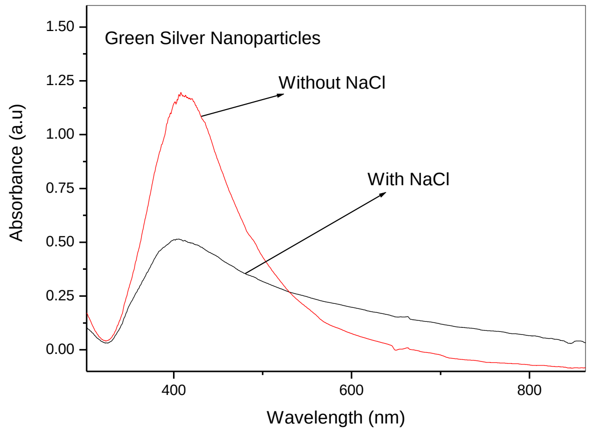

Figure 6: Absorption Spectrum (SPR) of Silver Nanoparticles Synthesized by Ocimum Sanctum (Krishna Tulasi) Leaves Extract. With (black) and Without (red) Addition of Sodium Chloride

D. Decay Effect on SPR of Green AgNP's:

The decay of synthesised green silver nanoparticles with the passage of time was investigated. SPR initially indicates a maximum [8–14], but as time passes, the intensity declines. In addition, a slight wavelength shift towards the red region was noticed (Figure 7) along with the intensity, due to a reduction in electron density as time passed and the volume of the nanoparticles increased. Because of the reduced electron density, the plasmon frequency is lower, resulting in a longer wavelength.

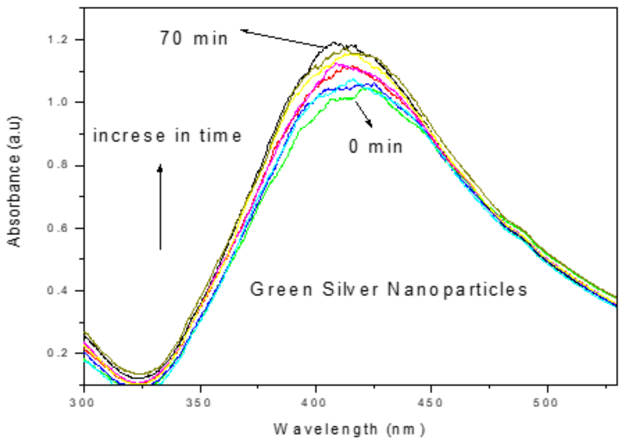

Figure 7: Absorption Spectrum of Silver Nanoparticles Synthesized by Ocimum Sanctum (Krishna Tulasi) Leaves Extract at Various Time i.e., Decay Effect

V. CONCLUSIONS

The green fabrication of silver nanoparticles has been carried out using Krishna Tulasi leaves. The analytical chemistry tool of absorption spectroscopy was used to assess the existence of silver nanoparticles. The absorption peaks for silver nanoparticles produced from Krishna Tulasi leaf extract are at 408nm. The temperature impact on silver nanoparticles was examined. The effectiveness of absorption of silver nanoparticles diminishes as the temperatures rise. The SPR peak shifts slightly to the higher wavelength side, causing a red shift. The absorption peak was also seen to widen.

The aqueous extract of Krishna Tulasi leaves has a significant potential for high-yield AgNP's production. The conversion of silver ions to AgNPs takes only one minute in these procedures. The procedure is environmentally friendly since no harmful reducing ingredient was utilised, and synthesised AgNPs can be used for therapeutic uses.

DECLARATION STATEMENT

Funding	No, I did not receive.
Conflicts of Interest	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal participation in this article.

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