GREEN SYNTHESIS OF SILVER NANOPARTICLES USING GARLIC EXTRACT

Submitted in partial fulfillment of the requirement for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

BIOTECHNOLOGY

UNDER THE SUPERVISON OF

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<u>CERTIFICATE</u>

This is to certify that the work entitled **"Green synthesis of siver nanoparticles using garlic extract"** done by Janhvi chauhan (151846) in a partial fulfillment for the degree of Bachelor of Technology in Biotechnology from Jaypee University of Information Technology, Waknaghat has been carried out under my supervision. This part of work has not been submitted in part to some other University or Institute for any degree or appreciation.

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We would also like to thanks the ph.D. , and the laboratory workforce of the Department of Biotechnology and Bioinformatics for their well-timed help and support.

Janhvi chauhan (151846)

DECLARATION

I hereby confirm that the work proclaimed in the B-Tech thesis entitled **"Green synthesis of siver nanoparticles using garlic extract"** submitted at Jaypee University of Information Technology, Waknaghat, Solan is a credible record of my work carried out under the supervision of Dr, Abhishek Chaudhary. The results embodied in this thesis have not been submitted to any other university or institute for the award of any degree or diploma.

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LIST OF FIGURES

LIST OF ABBREVIATIONS

Symbol	Abbreviation
°C	Degree Celsius
%	Percentage
g	Gram
NP	nanoparticles
AgNP	Silver nanoparticles
ml	Milliliter
ul	microliters
4-PNP	Para- nitro phenol
dH_2O	Distilled Water
rpm	Rotation per minute
$AgNO_3$	Silver nitrate
$NaBH_4$	Sodium borohydride
SEM	Scanning Electron Microscopy
XRD	X-Ray Diffraction

ABSTRACT

Silver nanoparticles have been researched, studied and synthesized from a long time due to their unique properties. They have unique optical, chemical,physical properties. They have high surface area to volume ratios which is an important factor in the catalyst industry. They have various applications in biomedical, health care industry, food industry. The green approach for the synthesis of nanoparticles using plant extracts is widely used as it neglects the use of harsh chemicals and reducing agent and many toxic surfactant for the synthesis of the nanoparticles. The green approach is also very cost effective, requires less time, and in most of the cases is a one-step process. Therefore, with the green approach or the biological approach we can produce large quantity of contamination and harsh chemical free nanoparticles in lesser time and cost.

CHAPTER 1

INTRODUCTION

Nanobiotechnology is increasing with time for its ability to adjust metals into their nanosize, which effectively changes their chemical, physical, and optical properties. Appropriately, significant consideration is being given to the advancement of novel systems for the blend of various types of nanoparticles of explicit arrangement and size utilizing organic sources. The greater part is that other methods are costly, earth unsafe, and wasteful regarding materials and vitality use. A few factors, for example, the technique utilized for amalgamation, pH, temperature, weight, time, molecule measure, pore size, condition, and closeness incredibly impact the quality and amount of the integrated nanoparticles and their applications. Also, morphology of the incorporated nanoparticles is fundamental to their potential use in different medication conveyance and biomedical applications.[1][2]

Metallic nanoparticles have been widely researched because of their one of a kind size-subordinate properties which make them valuable in uses including optical/compound sensors, electronic gadgets, and impetuses[3]. Far reaching combination conventions utilized for nanoparticle creation regularly require the utilization of harsh solvents/surfactants and reducing agents (e.g., borohydride or hydrazine) , which commonly produce huge amounts of toxic waste. Subsequently, nanoparticle blend systems that take out the utilization of hazardous reagents and manage the cost of greener, more practical choices are winding up increasingly attractive as the quantity of nanoparticle applications increments. This is especially valid for biomedical research uses of metallic nanoparticles, which are increasing because of their potential as remedial and differentiating operators.[4][5]

Various endeavors are being made all through the world to grow ecofriendly advancements to deliver ecofriendly, nontoxic nanoparticles utilizing green nanotechnology and biotechnological instruments [5]. Nanoparticles combined utilizing organic strategies or green innovation have diverse natures, with more noteworthy stability and proper measurements since they are synthesized utilizing a one-step method. Different unfortunate handling conditions are in this manner disposed of by enabling the combination to continue at physiological temperatures, pH, weight, and, in the meantime, an irrelevant expense. Hence, specific characterization strategies might be utilized to describe the potential for utilization of nanoparticles for use in medication conveyance and biomedical fields.[6][7][8]

Nanoparticles have increased suface to volume ratios which is utilized in fields where high surface area to volume ratios are needed as an example in the catalyst industry.nanoparticles also have antibacterial properties. These essential properties have been observed in silver nanoparticles. For this reason AgNPs have been widely used.AgNPs have unique biological, chemical, optical properties and application in electronics, optics and medical field.[9]

Nanoparticles have unique properties because of their small size. Silver nanoparticles have high and extraordinary anti-microbial properties as compared to its bulk element due to their small size. In a very few quantity silver nanoparticlescan lead anti-microbial effect to hundreds of square meters of its host material.[10][11]

Nanoparticles have been used in theraputical tools against microbes, nanoparticles are studies and their effect on microbes have been studies, drugs against microbes have been made using nanoparticles. Among all the known nanoparticles, silver has gained great attention for its effect against microbes.[12]

1.1.Significance of using plant extract for synthesis of nanoparticles:

Use of plant extract for the synthesis of metalic nanoparticles is also known as the green approach for the synthesis of nanoparticles and it has been known for a long time. The use of plant extract for the synthesis of nanoparticles reduces the use of chemicals some toxic compounds and gives contamination free nanoparticles. If these NPs are used for biomedical applications such as drug delivery, used as skin care ointments then the important aspect is that they should be contamination free and should be composed of very less amount of chemicals which may prodce side affects.[13][14]

Using plant extract for the synthesis of NPs also reduces the cost for production as seen it is very high if certain chemicals are used. the green approach also requires less time than other physiological or chemical approaches. So, a lasrge quantity with a good quality of nanoparticles can be produced in lessser time using the green approach.[15][16]

1.2.Use of plant extract for nanoparticles synthesis:

In the synthesis of nanoparticles with plant extract , the extract is simply mixed with the metal salt solution at room temperature or in the sunlight for photochemical reaction. This is a simple approach and require very less time. The plant extract acts as both , stabilizing agent and reducing agent for the generation of nanoparticles.[13]

The synthesis of the nanoparticles is dependent on some factors:

- ph
- Concentration of extrat
- Time of contact
- Concentration of the metal ion
- Temperature

In this report of my project work I have used garlic (*Allium sativum*) extract for the synthesis of silver nanoparticles. The AgNPs were synthesized using photochemical reaction. It is a one-step process. The garlic extract acts as both stabalizing agent and the reducing agent in the reaction.[17]

Garlic is known well for its biomedical application. It contains componds with potent medicinal properties. It has antimicrobial properties, contains high nutritional value, can combat sickness, used to control blood pressure and many more applications.[17][18]

1.3.Biological applications of AgNPs:

Silver nanoparticles have unique properties and therefore they are used in house-hold utensils, food storeage, drug delivery, health care industry, many skin ointments. They have anti-mocrobial properties, anti-fungal properties, anti-inlamatory properties, anti-cancer properties. They have also been used for the targeted drug delivery system, for cancer treatments. They have also been used in the food industry for packaging, storage. They are also used in the pesticide and fertilizer industries.[19][20]

1.4. Charatcterization of nanoparticles

The various techniques used for nanoparticles characterization are; UV-visible spectroscopy, XRD, XPS, NMR, SEM, TEM, FTIR, liquid TEM, cyro TEM, TSEM, and many more which characterizes the nanoparticles on the basis of shape , size, optical properties, chemical structure, chemical composition of the element, crystal structure, surface charge, concentration.[20]

CHAPTER 2

REVIEW OF LITERATURE

2.1.Nanoparticles

Nanoparticles are a wide range of particles whose dimentions varry from 1-100nm. Due to their shape and size they are classified as 1D , 2D, 3D. their size influences the physochemical properties of any substance which is an important aspect of the nanoparticles. Various types of nanoparticles ave been used, eg; gold NPs, silver Nps, palladium NPs etc.

NPs are not simple molecules itself. They are madeup of three layes; 1. The surface layer:functionalized with small molecules or metal ions, surfactants and polymers. 2. The shell layer: it is chemically different layer from the core in all aspects. 3. The core or the nanoparticle itself which is essentially the central portion of the nanoparticle.[21][22]

2.2.Classification of nanoparticles:

Based on the morphology, chemical and physical properties nanoparticles are broadly divided into a variety of groups.

- **Carbon based nanoparticles:**

The two major types of carbon based NPs are fullerence and CNTs (carbon nano-tubes). These are widely used for many commercial applications. These are based on the different arangements of the carbon atomes and have unique properties and have applications such as fillers, efficient gas adsorbents, support medium for different catalysts.[23]

- **Metal nanoparticles:**

These are made up of metal precursurs. They have a broad absorption band in the visible region of the electromagnetic spectrum. Due to their high surface area to volume ratios they have unique optical and electrical properties. Some NPs madeup of cobalt, nickle, etc also possess magnetic properies. They have a wide range of applications like in day cutting-edge materials,. Gold NPs are used for sampling of SEM, to enhance the electroni8c stream, and many more applications.[23][24]

- **Ceramic nanoparticles:**

These are nonmetallic inorganic solid NPs, which are synthesized by heat and successinve cooling. They are available in a variety of shaes and sizes therefore , they are gaining attention in the research field nowdays. These are used as catalysts, photocatalysts, used for photodegredation of dyes, and imaging applications[25]

- **Semiconductor nanoparticles:**

Semiconductors lies properties between metals and nonmetals. They also possess wide bandgaps. So, semiconductor nanoparticles showed significant alteration in their properties with bandgap tuning. These have applications in photocatalysts, photo optics and electronic devices.

- **Polymeric nanoparticles:**

These are simple organic based nanoparticles. They are nanosphere and nanocapsular shaped. In these NPs the solid mass is encapsulated within the particle completely. These PNPs are readily functionalized and thus possess a wide variety of applications.

- **lipid based nanoparticles:**

these nanoparticles are usually made up of lipid moeties. They have applications mainly in biomedical. These are usually spherical in shape. Lipid nanoparticles have a solid core made up of lipid and amatrix containssoluble lipophilic molecules. They are used as drug carriers, used in drug delivery and release of RNA in the cancer therapy.[26]

2.3.Synthesis of nanoparticles:

A variety of methods are used for the synthesis of nanoparticles. Chemical biological and physical methods are all used for producing nanoparticles with different morphology, chemical and physical properties. These all methods are categorized under two broad approaches that are “bottom-up syntheses” and “top-down syntheses”.

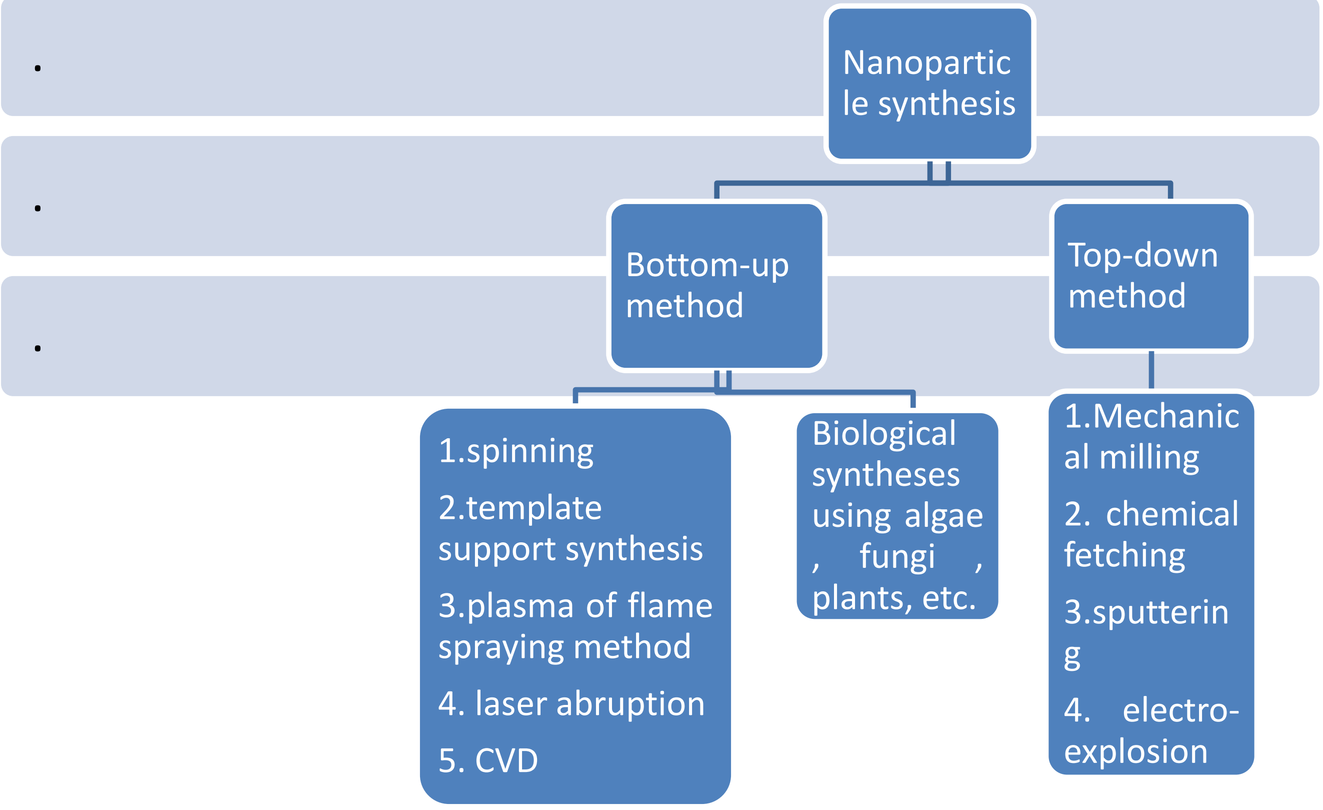


Fig1: synthesis method for nanoparticles ; (bottom-up) (top-down).[27]

2.4.Methodology for the synthesis of nanoparticles:

- **Chemical method:**

In the chemical method for the synthesis of nanoparticles a variety of chemicals are used as reducing agent and stabilizing aqgents (inorganic and organic both). Reducing agents such as sodium citrate, sodium borohydride, polyol process, tollens reagent are used.

- **Physical methods:**

Physical method for the synthesis of nanoparticles are mainly the top-down processes. Microwave irradiation, ultra-sonication, electrochemical methods, etc are used. evaporation condensation and laser ablation are some of the most important types of physical approach for the synthesis of metalic nanoparticles.

- **Biological methods:**

The biological methods or the bio-based methods for the synthesis of nanoparticles produces highly stable, contamination free, less toxic, and ecofriendly nanoparticles as compared to the nanoparticles produced by physical and chemical approaches. The biological methods usually includes the use of plant extracts, fungi and yeast, bacteria, algae, for the synthesis of nanoparticles.

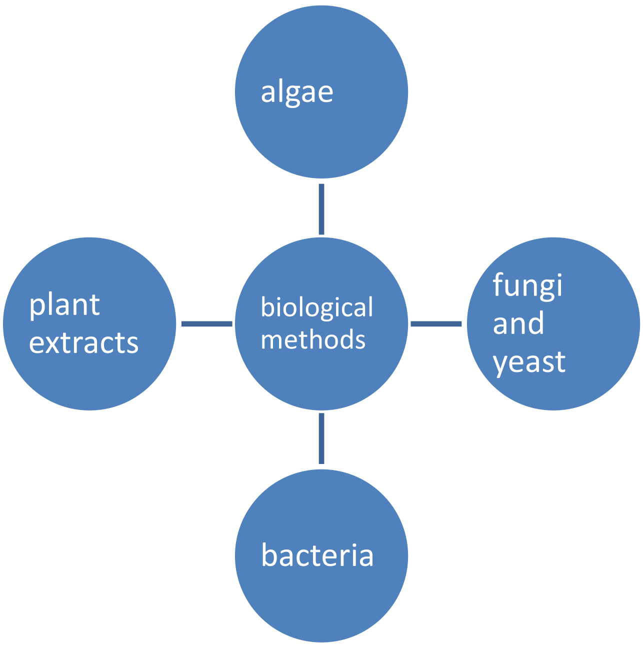


Fig2: components used for the biological synthesis of nanoparticles.[28]

2.5.Green approach for the synthesis of nanoparticles:

Traditional processes for the synthesis of nanoparticles have been used from a long time but many researches and experiments have proved that the green approach or the plant-mediated synthesis of nanoparticles has more advantages in the generation of nanoparticles with less faliure, less cost, less time required and ease of characterization.

Many plant extracts like aloe-vera extractr, garlic extract, ginger extract, onion extract, neem extract and many more have been used to generate metallic and non-metallic nanoparticles. These extracts are used for the production of gold nanoparticles, silver nano-particles, palladium nanoparticles and many more.

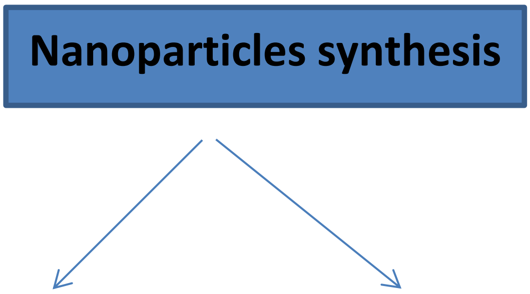
The nanoparticles produced by the green approach are very simple to synthesis, as it is usually a one-step method and requires very less time as less as a minute in many cases. The metallic solution is mixed with the plant extract and kept at room temperature or in sunlight for photochemical reaction and the nanoparticles are synthesized quickly. The plant extract acts as both stabalizer and as reducing agents so it compensates the use of harsh chemicals and surfactants which have been used as stabalizers and reducing agents in the chemical and physical methods.[29][30]

2.5.a. Advantages of green approach for the synthesis of nanoparticles:

Green approach has gained great importance in the material science. As it reduces the destructive effects of the chemicals used in the traditional processes for the synthesis of the nanoparticles. The plant extracts used in the green synthesis works as both stabalizers and reducing agents so, they neglects the use of harsh toxic chemicals and surfactants as used in other approaches.

Nanoparticles generation with green approach requires very less time as compared to the traditional processes. This method also works on a low cost as no chemicals are required and we can easily get the plant extract. This method also does not requires very high or specific equipmentation or energy or light source. The reaction can be performed at room temperature or in sunlight. Also characterization of nanoparticles synthesized with green approach is easy.

Nowdays nanoparticles are very much used in health care industries, food industries, pharmaceuticals, biomedical applications. These all areas requires contamination free and ecofriendly, less toxic compounds for use. Nanoparticles synthesized by green approach are contamination free, with no toxic chemicals and ecofriendly aslo so, the do not affects the surrounding and do nit cause any bigger side affects when used in pharmaceuticals or biomedical applications.[30][31]



Traditional methods	Green approach
Complex	Simple
Toxic byproducts	No toxic products
Expensive	Cost effective
High temperature	Low temperatures

Fig3: comparision between traditional methods and green approach for synthesis of nanoparticles.[31][32]

2.6. Silver nanoparticles: Silver nanoparticles are growing intrest in the research field due to their unique optical properties, anti-microbial properties, and catalytic properties. It also has applications in the biomedical field and food industries. Silver nanoparticles have extraordinary ability to absorb and scatter light like many other dyes and pigments. Their color depends upon the shape and size of the particles.

The optical, thermal and chemical properties of silver nanoparticles depends on their shape and size.because of their high anti-microbial activty, silver nanoparticles are widely used as sterilized nanomaterials for consuming and in biomedical fiels.[33]

Silver nanoparticles have various applications:

- Used in the textile industries
- Used for food packaging
- Pharmaceuticals
- Diagnostics
- Molecular sensing

- Nanocomposites
- Personal care products

2.6.a. Anti-microbial properties of silver nanoparticles:

Nanoparticles have unique properties because of their small size. Silver nanoparticles have high and extraordinary anti-microbial properties as compared to its bulk element due to their small size. In a very few quantity silver nanoparticlescan lead anti-microbial effect to hundreds of square meters of its host material.

Nanoparticles have been used in theraputical tools against microbes, nanoparticles are studies and their effect on microbes have been studies, drugs against microbes have been made using nanoparticles. Among all the known nanoparticles, silver has gained great attention for its effect against microbes.

Silver nanoparticles have been tested and are effective against both gram(+) and gram(-) bacteria. They have been used for drug delivery against microbes. Many microbes also develope resistance against antibiotics therefore, for an alternative silver nanoparticles can be used and studies and researches are already going on for this.

Silver when consumed in small amounts do not cause any harm to humans. And it has been proven that small amount of silver nanoparticles can cause anti-microbial effect to a large extent. Therefore, silver nanoparticles are widely used in biomedicines for their antimicrobial activity.[34][35]

2.6.b. Catalytic properties of silver nanoparticles:

Along with anti-microbial activities, silver nanoparticles alow exhibits catalytic properties for dyes, benzene, carbon monooxide, 4-nitro phenol, and many other compounds. Due to small size and high surface are to volume ratio nanoparticles has more catalytic activity because more catalytic reactions can be performed at the same time.[36][37]

2.7. Charatcterization of nanoparticles:

Nanoparticles ofent possess different properties from their bulk elements. Like different optical, chemical, physical, electrochemical properties. Their morphology also differs from their bulk elements. Nanoparticles chemical, optical and physical properties depends on their shape and size. Sice they are on nanoscale they cannot be characterized like other macromolecules or macro particles. There are various techniques and instruments for the charecterization of nanoparticles.

The various techniques used for nanoparticles characterization are; UV-visible spectroscopy, XRD, XPS, NMR, SEM, TEM, FTIR, liquid TEM, cyro TEM, TSEM, and many more which characterizes the nanoparticles on the basis of shape , size, optical properties, chemical structure, chemical composition of the element, crystal structure, surface charge, concentration.[38][39]

2.8. Synthesis of silver nanoparticles using garlic (***ALLIUM*** **.** ***sativum***) extract:

Garlic has lots of health and medicinal properties. Garlic also possess anti-microbial properties. It has been used in the health care industries, personal care products, pharmaceuticals. Synthesis of silver nanoparticles with garlic is a green approach. Garlic extract acts as the stabalizer and reducing agent. So, no chemicals or surfactants are required in the synthesis of the nanoparticles. Garlic is easily available, the procedure is not expensive, it is a simpke process, not much time is required.

Silver nanoparticles are widely used in the biomedical field for thei anti-microbial properties and also for drug delivery as they do not harm humans when taken in small amount. Use of garlic enhances its affects as garlis also has anti-microbial properties and are also used in biomedicines.[40][41]

CHAPTER 3

MATERIAL

AND

METHODS

3.1.a. Equipments used:

- Pipette
- Pipette tips
- Petri dish
- Falcon tubes
- Micro vials
- Test tubes
- Flask
- Beaker
- Eppendorf tubes
- UV-Visible spectrometer
- Digital weighing balance
- Cuvette
- Filter paper
- 96-well plate

3.1.b. Chemicals used:

- Silver nitrate ($AgNO_3$)
- 4-nitro phenol
- Sodium borohydride ($NaBH_4$)
- Garlic extract
- Liquid nitrogen
- Nutrient agar
- Luria broth

3.2. Methodology:

3.2.a. Preparation of garlic extract:

Peeled and weighed 25 grams of garlic

⇩

Crushing was done using liquid nitrogen (mortar pestle was kept at -80 half an hour before crushing process).

⇩

Boiled the garlic extract with 200ml dis. H2O.

⇩

Filtered the extract using filter paper.

⇩

Stored at -4˚C.

3.2.b Photochemical synthesis of silver nanoparticles using garlic extract and silver nitrate and optimisation at different parameters:

- **varrying the concentration of garlic extract**

Falcon tubes were taken

↓

In each falcon tube 1ml of $AgNO_3$ was taken.

↓

Varrying concentration of garlic extract (0.5ml, 1ml, 1.5ml, 2ml, 2.5ml) were mixed with $AgNO_3$.

↓

Tubes were kept in sunlight for photochemical reaction.

↓

400ul of sample from each test tube was taken in interval of 15 mins for 1 hour.

↓

OD was taken using UV-VIS spectroscopy at different dilutions of the sample (10 times, 50 times, 100 times)

- **varrying the concentration of silver nitrate:**

5 falcon tubes were taken

⇩

Extract concentration was kept constant (1ml).

⇩

Varrying concentration od $AgNO_3$ were mixed with the extract (0.5ml, 1ml, 1.25ml, 1.5ml, 2ml).

⇩

Falcon tubes were kept at sunlight for 1 hour for photochemical reaction.

⇩

Sample was taken after 1 hour and OD of the sample was taken at different dilutions

- **Varrying time:**

AgNO3 and garlic extract were taken in 1:1 ratio in a beaker

Beaker kept in sunlight for photochemical reaction for 1hour 15 minutes

Sample were taken in falcon tubes in every 15 mins

OD was taken of every sample

3.3. To check anti microbial activity of silver nanoparticles using E.coli DH5α:

3.3.a. Quantification of microbial colonies on agar plate:

Preparation of nutrient agar(7.4g LB agar in 200ml water) plates and luria broth (0.5g luria broth in 25ml of water)

⇩

Primary growth of E.coli DH5α culture

⇩

Incubation for 24 hours at 37˚C

⇩

Secondary growth of E.coli DH5α culture

⇩

Incubation for 24 hours at 37˚C

⇩

Streaking of the culture on nutrient agar plate

⇩

Incubation for 24 hours at 37˚C

3.3.b. ANTI-MICROBIAL ASSAY OF SILVER NANO PARTICLES USING WELL PLATE METHOD:

OD of the E.coli culture was taken using UV-VIS spectroscopy(0.825)

Spreading of the E.coli DH5α strain on the nutrient agar plate

Wells were punctured in the agar plates and marked

Garlic extract , $AgNO_3$, silver nano particles samples were inserted in the respective wells

The agar plates were kept for incubation for 24 hours at 37˚C and results were observed

Fig4: well puncturing on agar plates

3.4 Catalytic reduction of para nitro phenol using silver nanoparticles:

0.0370mg of sodium borohydride was taken in 10ml of water

⇓

7mg of para nitro phenol was taken in 50ml of water and dilution was prepared.

⇓

Peak of para nitro phenol and sodium borohydride was observesd at 300-400nm.

⇓

Both sodium borohydride and para nitro phenol were taken in equal concentrations in cuvette and silver nanoparticles were mixed in the solution with varrying concentrations.

⇓

Spectrum was taken using UV-Visible spectrometer and absorbance was recorded.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1. Photochemical reaction for synthesis of silver nanoparticles by varrying time.

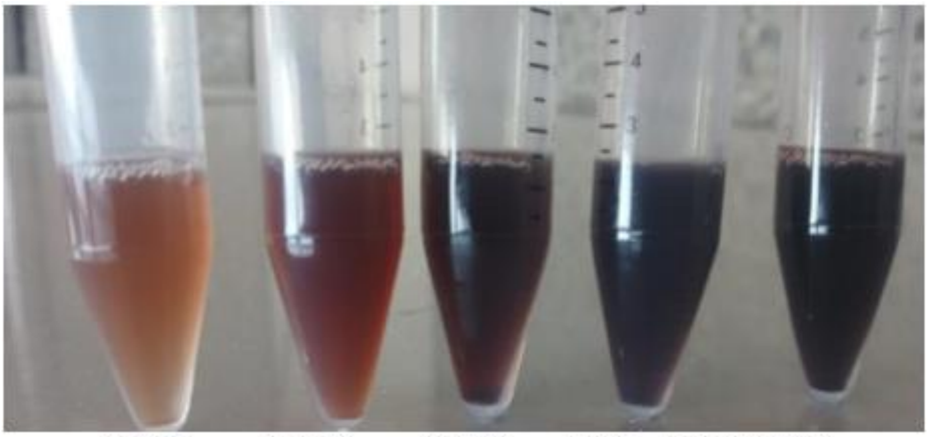
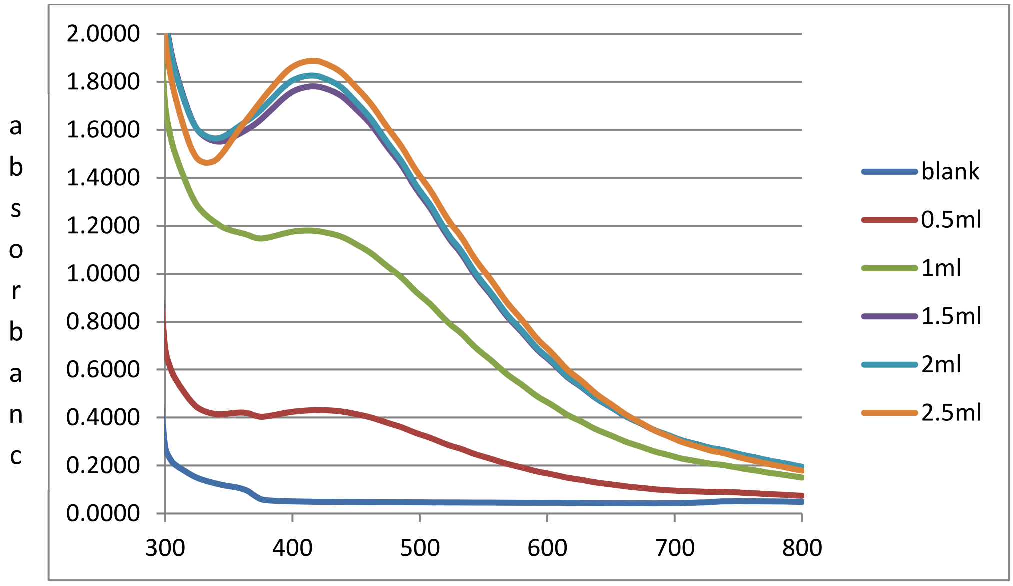


Fig 5: color change from orange to dark brown observed in the solution of silver nanoparticles during the synthesis process.

Discussion :

The color of nanoparticles changed from orange to dark brown on carrying out photochemical reaction and taking the sample after every 15 minutes. The optical properties of the silver nanoparticles changes and the particles start to aggregate and the conduction electrons becomes delocalized and their color changes. This phenomenon is also termed as surface plasmon resonance and is exhibited by nanoparticles. The color change also depends on the shape and size of the particles.

4.2 Absorbance vs wavelength graph of silver nanoparticles with varrying concentration of silver nitrate



Wavelength(nm)

Fig 6: absorance vs wavelength graph of silver nanoparticles with varrying concentration of silver nitrate and constant concentration of garlic extract using UV-Visibles spectroscopy.

Discussion :

In the above graph each peak determines the absorbance of the nanoparticles with different concentration of silver nitrate and constant concentration of garlic extract.

Silver nanoparticles have extraordinary efficiency to absorb and scatter light. This occurs due to surface plasmon resonance which is exhibitted by the nanoparticles and not by the bulk particles. Silver nanoparticles absorbance and scattering properties also depends on the shape and size of the nanoparticles. The small particles have narrow peaks and the big particles have broad peaks.

In this grapgh highest absorbance peak is observed at 2.5ml concentration of silver nitrate which means maximum amount of nanoparticles were formed at this concentration of garlic extract.

4.3 Absorbance vs wavelength graph of silver nanoparticles with varrying concentration of garlic extract

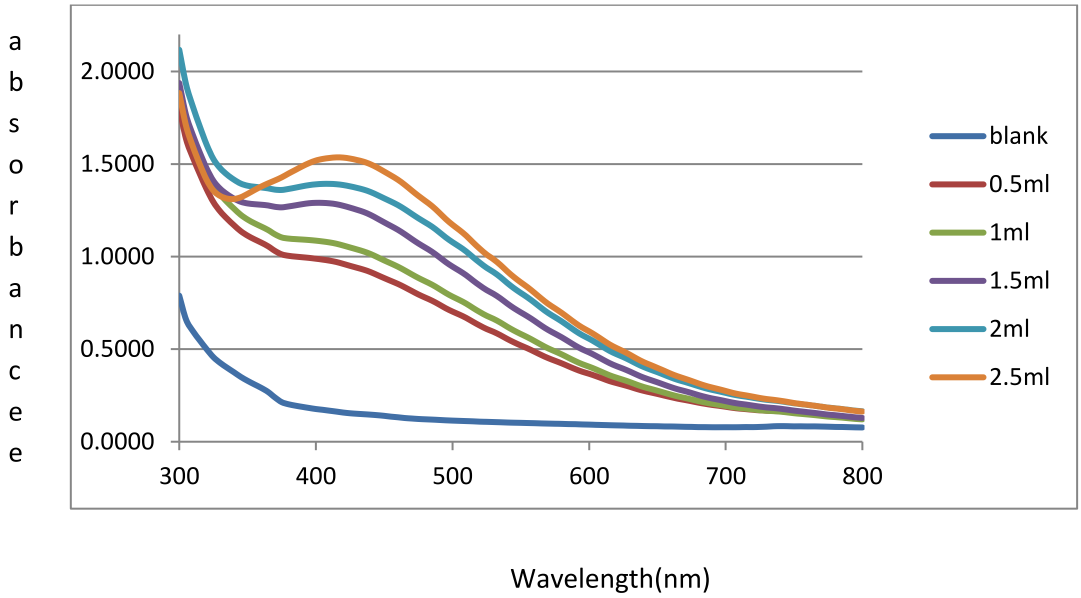


Fig 7: absorance vs wavelength graph of silver nanoparticles with varrying concentration of garlic extract and constant concentration of silver nitrate using UV-Visibles spectroscopy.

Discussion :

(0.5ml-2.5ml is the concentration of garlic extract)

In the above graph each peak determines the absorbance of the nanoparticles with different concentration of garlic extract and constant concentration of silver nitrate.

Silver nanoparticles have extraordinary efficiency to absorb and scatter light. This occurs due to surface plasmon resonance which is exhibitted by the nanoparticles and not by the bulk particles. Silver nanoparticles absorbance and scattering properties also depends on the shape and size of the nanoparticles. The small particles have narrow peaks and the big particles have broad peaks.

In this graph the highest peak is observed at 2.5ml concebtration of garlic extract which means at this concentration maximum amount of nanoparticles were formed.

4.4 Anti-microbial assay of silver nanoparticles suing E.coli DH5α strain {AgNo3 and Garlic extract in ratio 1.25:1)

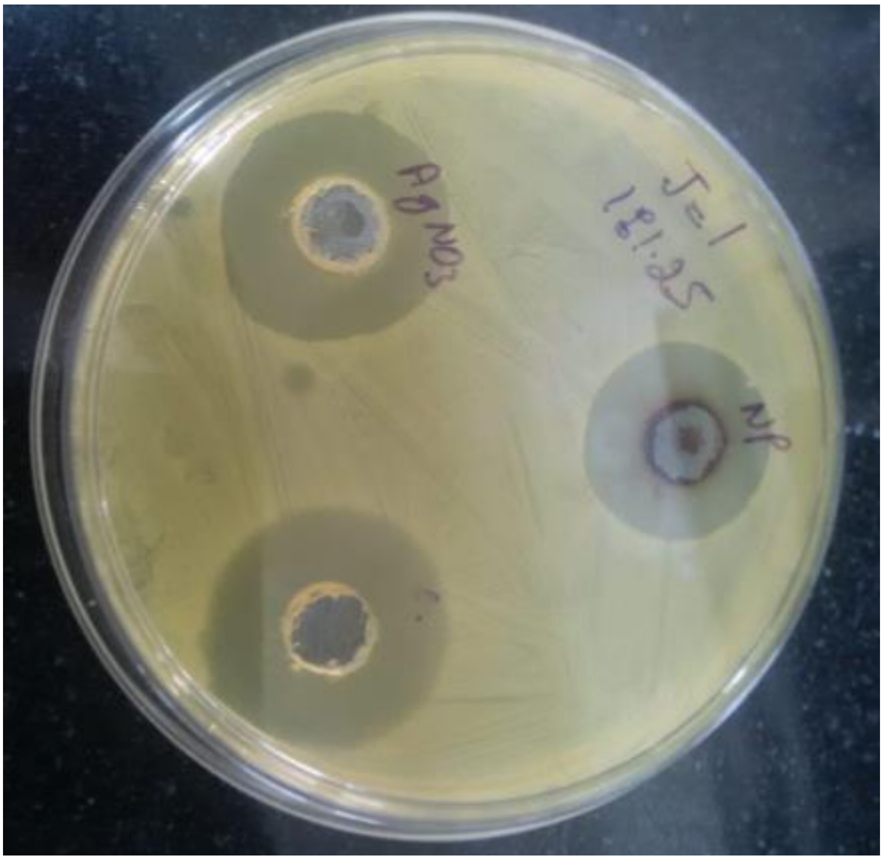


Fig 8: Zone of inhibition of garlic extract, AgNO3 and AgNPs for E.coli Culture

Discussion

1. The zone of inhibition of the nanoparticles(2ml) was 2.6mm, with the concentration of AgNo3 and Garlic extract in ratio 1.25:1

2. The zone of inhibition of the garlic extract(2ml) was 3.2mm

3. The zone of inhibition of AgNO3(2ml) was 2.9mm

4.5 Anti-microbial assay of silver nanoparticles suing E.coli DH5α strain {AgNo3 and Garlic extract in ratio 1:1)

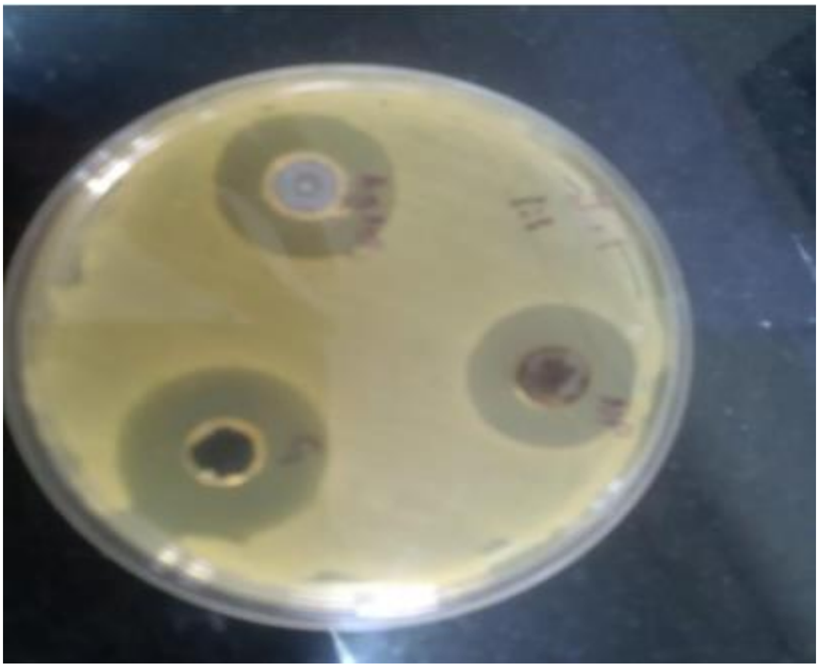


Fig 9: Zone of inhibition of garlic extract, AgNO3 and AgNPs for E.coli Culture

Discussion:

1. The zone of inhibition of nanoparticles was 2.5mm, with the concentration of garlic extract and AgNO3 (2ml)in ratio 1:1

2. The zone of inhibition of garlic extract(2ml) was 3.2mm

3. The zone of inhibition of AgNO3(2ml) was 2.7mm

4.6 . Graph ahowing catalytic reduction of 4-Nitrophenol by sodium borohydride catalyzed by silver nanoparticles

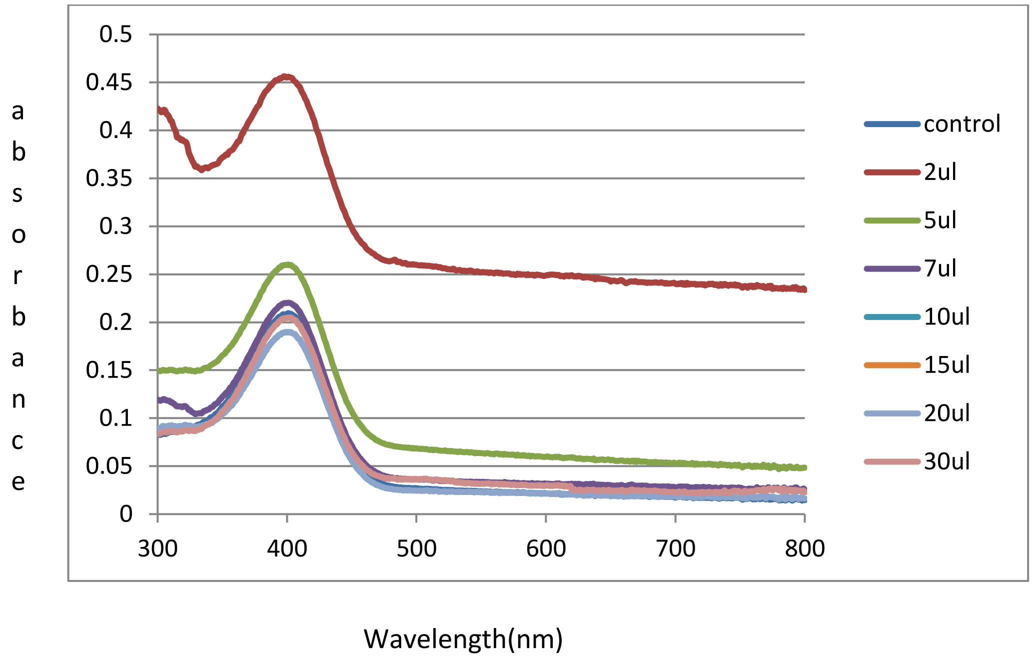


Fig 10: Graph showing catalytic reduction of 4-Nitrophenol by sodium borohydride catalyzed by silver nanoparticles.

Discussion :

(2ul-30ul is the concentration of silver nanoparticles)

The graph depicts the cactytic reduction of 4-nitrophenol by sodium borohydride to in the presence of silver nanoparticles. Here in this reaction silver nanoparticles acts as catalyst for the reaction to proceed. In this reaction 4-nitrophenol is reduced to 4-amino phenol. The absorbance peak when shifts from 400nm to 300 nm it indicated that 4-nitrophenol is been reduced to 4-aminophenol

Conclusion

Nanobiotechnology is increasing value these days for its ability to tune metals into nano size and then they exhibit unique properties. Nanoparticles have different optical properties, chemical properties and physical properties compared to their bulk materials.they also have high surface area to volume ratios. Due to these properties nanoparticles have a wide range of applications. Silver nanoparticles synthesized by green approach are contamination free from harsh chemicals and surfactants, they are ecofriendly. They have applications in biomedicines, food industries, health care industries textile industry, sued for drug delivery, pesticide industries and many more. There are various biological methods for synthesis of nanoparticles and a number of plant extracts can be used. green approach is a simple, time effective and cost effective process for synthesis of nanoparticles.

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