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Silver Nanoparticles synthesis by green method and their characterization

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ABSTRACT
Nanoparticles is a very extensively studied area and for good reasons. They exhibit good photocatalytic activity and enhanced micro bacterial properties in comparison to their Macroscopic counterparts. Here in our effort, we have tried to synthesize nanoparticles with the help of natural elements (Clove) via green synthesis. Then synthesized nanoparticles were analyzed with XRD, SEM, TEM, UV and FTIR. Chemicals such as flavonoids, triterpenes etc. in these spices are responsible for the reduction. We also propose their utility for the purpose of building inexpensive and ecofriendly photovoltaic cells. This auxiliary property of nanoparticles can be ascribed to the Surface Plasmon Resonance property exhibited by them
Key Word: Green synthesis, Metal nanoparticles, SEM, Solar cells, Surface Plasmon Resonance, TEM

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INTRODUCTION

The nanotechnology falls into all the domains of science. Nanoparticles are tiny particles that have the size in the range of 10^{-9} m. Special thing about nanoparticles is that they have large surface to area ratio. Along with that they have large surface energy, surface plasmon resonance and reduced imperfections in comparison to the larger particles. Biological process of production of nanoparticles presents a much safer and economic approach. There is still room for a safe and better bio-synthesization [1], an approach which is immune to the harmful microorganism and antibiotics. We have tried to present an approach to provide just that in our work. Development of nano-devices using biological materials and their use in wide array of applications on living organisms has recently attracted the attention of biologists towards nanobiotechnology.[2] Few applications of this technology are given below which would help in understanding the use of diverse living organisms in nanodevices production and also the use of these nanoproducts in various applications. Nanotechnology could be useful to make nanoscale confining environments channels or post arrays for long polymers such as DNA. Gene expression could also be increased by enhancing the delivery of intact DNA to nuclei of the cell by producing hybrid polymer-protein conjugate nanoparticles.[3] They (nanoparticles) could be used in building automated nano-chip sensors and diagnostic devices,[4] where DNA itself would be a target, or where DNA might be used as a 'conveyor-belt' for attached molecules.

The sensitivity and performance of biosensors have been improved by using nanomaterials. Many new signal transduction technologies have been introduced in biosensors, bioprobes and other biosystems using nanomaterials produced through living organisms. There are different properties like the effect of different organic optoelectronics[5] and optical sensing. Further, the effect of different organic solvent vapors like methanol, benzene and acetone on the conductivity of the extract we get from the herbs like tamarind leaf or clove, this opens up possibilty of application of gold nanoparticles (gold nanotriangles to future chemical sensors). Bioremediation of radioactive wastes, (resulted from nuclear power plant such as of Uranium) have been achieved by using nanoparticles. Uranium, as we know is a long-lived radionuclide which is hazardous for both flora and fauna. Cells and S-layer proteins of bacteria like Bacillus sphaericus have special capabilities of cleaning Uranium contaminated waters [6].

Furthermore, the Surface Plasmon Resonance (SPR) of silver nanoparticles plays an important role in the storage of incident light energy to enhance photogeneration of excitons. Excitation of surface plasmons by light at specific wavelength at which resonance occurs, results in strong light-scattering with the appearance of intense surface plasmon band enhancing local electromagnetic fields [7]. SPR effect can be maximized by controlling the distance between metal NPs and active layer of the junction. When this distance between metal NPs and active layer is little then there is a non-radiative transition and the interaction between excitons and surface plasmons decreases as the distance between active layer and nanoparticles is increased [8]. The introduction of nanoparticles mainly affects properties of semiconductor such as structure of the potential energy where transfer of generated carriers is carried out. It also affects the reaction rate of the semiconductor surface and the ability of the semiconductor to absorb or scatter the light [9].

MATERIAL AND METHODS

Preparation technique: To prepare $AgNO_3$ solution we add 0.173 gm (because molar mass of $AgNO_3$ is 169.872 g·mol^{-1}) of $AgNO_3$ into the 10ml distilled water and stirred for 15 min with the help of magnetic stirrer. Then extract was prepared from clove (a spice easily found in Indian household) [10 - 14] The preparation of extract is done by heating the precursor material - clove (added with water) on a burner for 10-15 min at a temperature range of 40° C to 70° C depending on the material used for the extraction. After the heating process is done the extract is obtained by filtering the heated solution with the help of Whatmann filter paper no.1 and the filterate is mixed with the silver nitrate solution at different ratios [15]. Then the solutions are put in a clean dark chamber for an hour which helps in turning the color of the solution to brown, this turning of color of solution signifies the formation of silver nanoparticles [16]. The chemicals involved in the augmentation of this process are flavanoids, steroids, terpenoids etc [17]. After the preparation of the nanoparticles, the solution placed in flasks, nanoparticles are centrifuged at 8000 rpm for 10min. Clear supernatant was obtained and filtered further and preserved for future analyses.

FIGURE I : PICTURE OF PREPARED EXTRACT, AGNO3 AND AGNPS

RESULT

UV visible spectroscopy

Silver nanoparticles prepared with the help of Clove extract and their UV-Vis (by model no. 2240) characterization confirms the synthesis of AgNPs because of the characteristic plasmon resonance exhibited by nanoparticles which depends highly on the size, shape and di-electric properties of nanoparticles as there is correlation between the colour of particles and its geometrical shape.

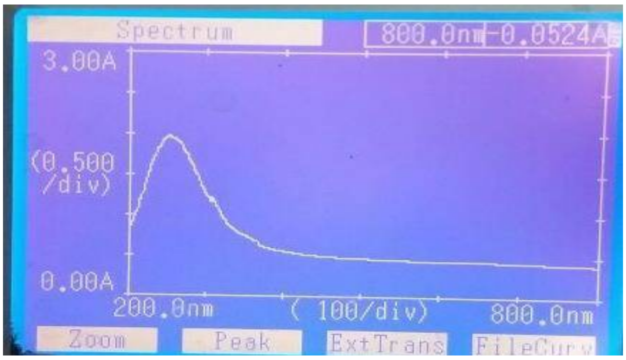


FIGURE II : UV CURVE IMMEDIATELY AFTER THE FORMATION OF NANOPARTICLES

FTIR

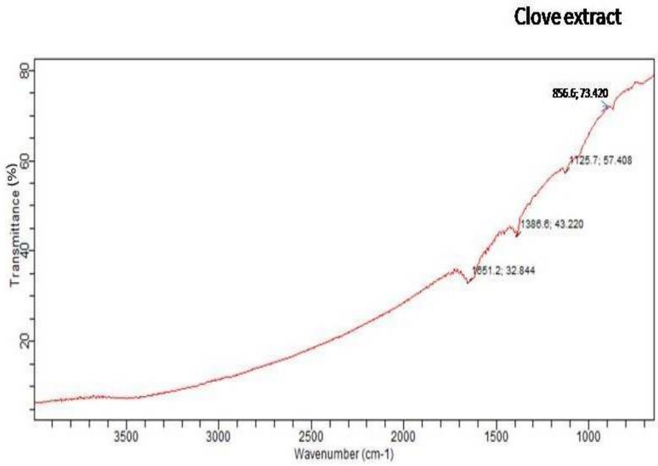


FIGURE III FTIR OF CLOVE MEDIATED AGNPS

The silver nanoparticles made of Cloves were sent through FTIR characterization and the following results were obtained. The FTIR spectrum of Clove extract shows peaks at 856, 1125, 1386, 1651 cm^{-1} which corresponds to different functional groups. The peak at 1386 cm^{-1} corresponds to the symmetric stretching vibrations of –COO– groups of amino acid residues. The peak observed at 1651 cm^{-1} attributes to the skeletal vibration of the –C–C– bond.

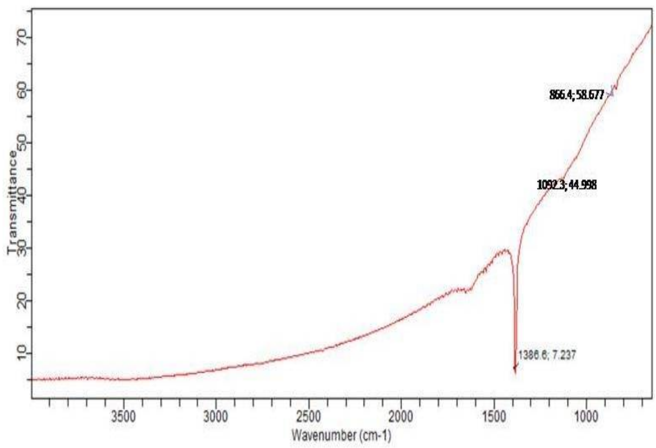


FIGURE IV FTIR OF CLOVE MEDIATED AGNPS

FTIR spectrum of AgNPs synthesized from clove shows the considerable peaks at 856, 1092, 1385 cm^{-1}, the peak at 1092 cm^{-1} can be attributed to –C-O-C- vibrations. The peak at 1385 cm^{-1} can be attested to the nitrate present in the residual solution. The peak at 856 cm^{-1} corresponds to the presence of arenes in the mixture. Hence this spectrum shows the functional groups responsible for the reduction of the AgNO3 into the Ag^{+} ions.

SEM Study

The SEM imaging of AgNPS was done and it shows the surface morphology of nanoparticles. The obtained images show that AgNPS are agglomerated in a cluster and we can clearly see that the order of size of these particles is in nanometers.

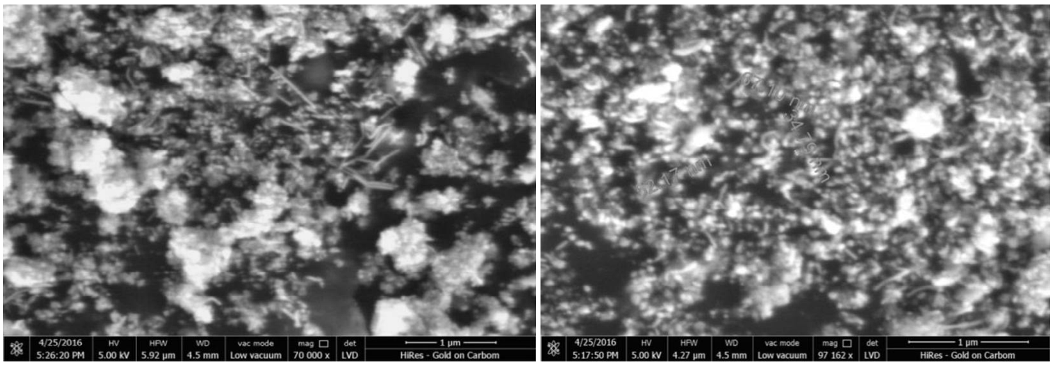


FIGURE V : SEM IMAGE FOR THE AGNPS SYNTHESIZED FROM CLOVE EXTRACT

TEM Study

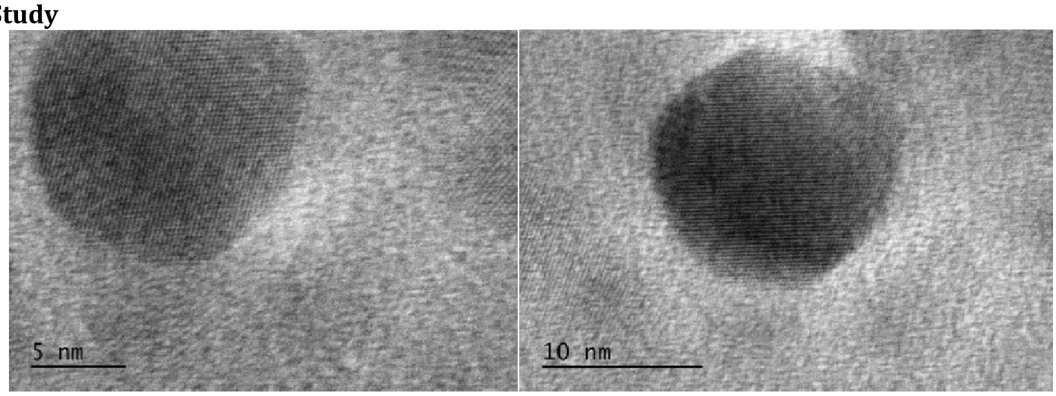


FIGURE VI : IMAGES FOR THE CLOVE MEDIATED AGNPS

TEM Images for the AgNPs show that the size of the nanoparticles is in the range of the 20- 50 nm and their shape is pretty much oval or a little deformed circle. We can also see that nanoparticles are evenly distributed over the grid. SAED pattern shows the four characteristic rings corresponding to the (111), (220), (200) and (311). Similarly synthesized nanoparticles from other precursors also show similar patterns. Crystalline structure of AgNPs was also confirmed by the SAED pattern.

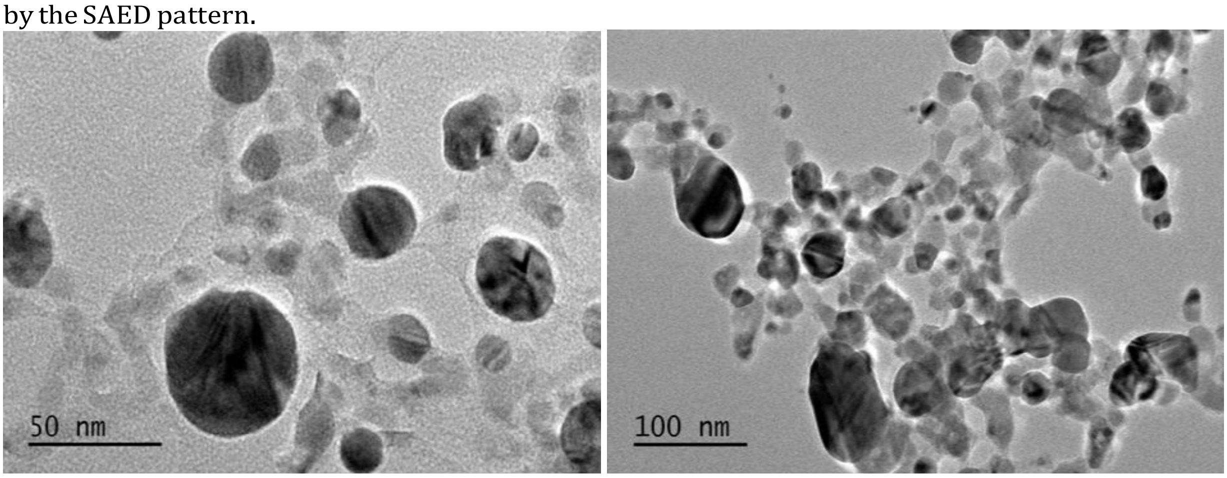


FIGURE VI*A TEM IMAGES OF NANOPARTICLES CONGLOMERATE

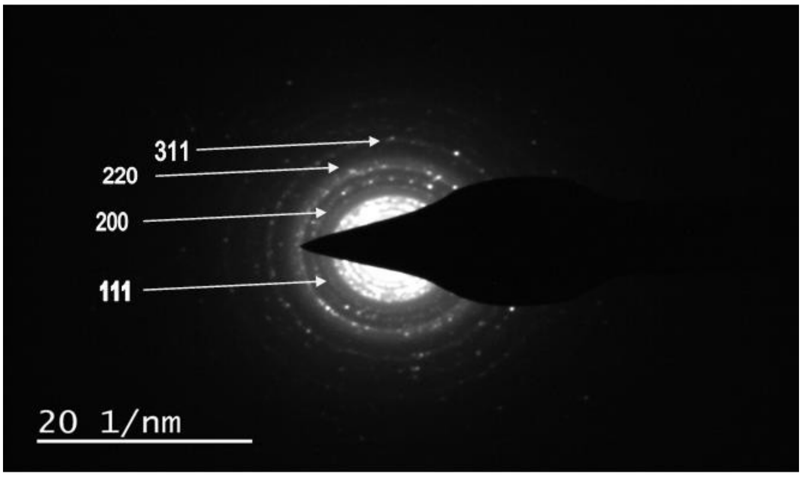
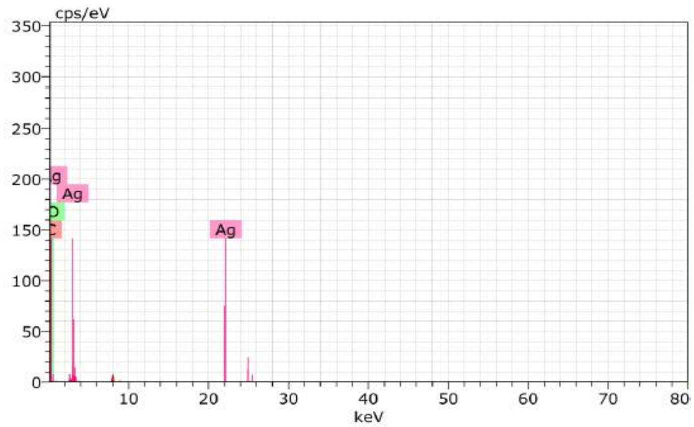


FIGURE VII SAED PATTERN OF SILVER NANOPARTICLES

The EDX pattern shows strong peaks at 6-7 keV and 22 keV indicating the presence of elemental Silver. There were also strong peaks for Oxygen showing aqueous nature of the Silver nanoparticles solution.
Content of the elements present in our nanoparticles can be seen in the picture below. It shows the presence of elemental silver along with the organic carbon and oxygen present in the capping with clove content of silver nanoparticles.



Spectrum: Acquisition 150

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
C	6	K-series	82.38	82.38	96.87	2.53
Ag	47	K-series	16.52	16.52	2.16	0.57
O	8	K-series	1.10	1.10	0.97	0.06
		Total:	100.00	100.00	100.00	

FIGURE VIII CHEMICAL COMPOSITION OF PREPARED SILVER NANOPARTICLES

CONCLUSION

We prepared Clove mediated silver nanoparticles via eco-friendly green synthesis. The size and shape of the nanoparticles depended on the concentration of the precursors in the AgNPs solution. Nanoparticles were measured at 20 nm to 40 nm range. The shape of the nanoparticles was primarily oval. Hence in our humble effort we have successfully synthesized Silver nanoparticles without the use of any toxic chemical and tried to present an economical and very easy way of nanoparticles synthesis which can be used for studies like their photocatalytic activity, their utility to assemble economical and bio-friendly solar cells and their role as an important ingredient to reduce the ailments in many potential bio-fuels.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

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