Synthesis & Characterization Of Silver Nano Particles Composites

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Abstract: Silver nanoparticles easily interact with other particles and increases their antibacterial efficiency moreover has received considerable attention due to their attractive chemical, physical and optical properties. The optical properties of silver nanoparticles are highly dependant on the nanoparticle diameter and refractive index near the nanoparticle surface. Silver nanoparticle are extraordinally efficient at absorbing and scattering light due to their optical properties. These particles were synthesized by chemical reduction method of AgNO3 using NaBH4. The borohydride anions were adsorbed onto silver nanoparticles and addition of PVP prevented the aggregation of silver nanoparticles. A yellow colour was given by the silver nanoparticle solution.

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Introduction

Silver nanoparticles are of great scientific interest as they are effectively a bridge between bulk materials and atomic or molecular structures. Abulk material should have constant physical properties regardless of its size, but at nanoscale, size dependent properties are often observed. Thus the properties of the material s changes as their size approaches the nanoscale and the percentage of atoms at the surface of the material become significant. For bulk materials larger than one micrometer the percentage of atoms at the surface is insignificant as compared to the number of atoms in yhe bulk of the material. Silver is currently used to control bacterial growth in a variety of applications, including dental work and burn wounds. Also Ag ions and Ag based compounds are highly toxic to the envoironment and aquatic life. Reducing the particle size of the materials is an efficient and reliable tool for improving their biocompatibility. The extremely small size of nanoparticles exhibit different properties when compared with bulk material. As a result nanoparticle with large surface area relative to their volume have become possible. These particles easily interact with other particles and incresase their anti bacterial efficiency.

Due to vast application of nanotechnology in the area of bioscience, synthesis of silver nanoparticles was possible. Reagents such as sodium borohydride are used as reducing agent. The formation of silver nanoparticles can be observed by a change in colour since they form yellow colour on synthesis. Silver nanoparticles have been of interest since the IV century AD owing to their dichroic character when integrated into glass. For over centuries, silver based compounds have been used as nontoxic, inorganic, and antibacterial agents owing to their biocidal properties in many applications such as wood preservatives or for water purification in hospitals. Nanomaterials demonstrate unique and significantly modified physical and chemical properties, compared to their macroscaled counterparts, which make them of particular interest. For this reason, silver nanoparticles have become of major interest for their antibacterial properties and are already integrated into applications such as wound treatment, sterilization, food sanitation, antibacterial textiles, and more recently drug delivery. In fact, silver nanoparticles exhibit a broad spectrum of antibactericidal and antifungicidal activities making them extremely popular in a diverse range of consumer products, including plastics, soaps, pastes, food, and textiles, thus increasing their market value. In the present context, they have attracted increasing interest due to their unique physical, chemical, and biological properties compared to theirmacroscaled counterparts. Silver nanoparticles are also studied by material scientists who investigate their integration into other materials in order to obtain enhanced properties, as, for example, in solar cells where silver nanoparticles are used as plasmonic light traps. These properties make them valuable in applications such as inks, microelectronics, medical imaging, and waste management. Traditionally, metal nanoparticles are produced by physical methods like ion sputtering or pulsed laser ablation and chemical methods like solvothermal synthesis and sol-gel methods. More recently, however, environmentally friendly synthesis methods have been developed, called "green syntheses." Depending on the chosen method, silver nanoparticles with different morphologies, sizes, and shapes can be obtained. Nevertheless, one of the critical criteria remains the size distribution that should be as narrow as possible to target specific applications. The following special issue focuses on works that emphasize silver nanoparticles in today's technologically advancing society. The contribution from K.-S. Chou and C.-H. Lee "Fabrication of Silver Interdigitated Electrode by a Stamp Method" proposes the fabrication of interdigitated electrodes via a stamp containing the imprint of the required electrode and employing silver ink. The stamping force required appears to be crucial in the reproducible printability of these electrodes. Further improvements in the printing can be obtained by changing the consistency of the silver ink, keeping in mind an ultimate automated method for such electrode fabrication. The method is attractive due to its cost-effectiveness and possible applications as sensors. On a different note, K.-H. Tseng et al. in their study entitled "A Study of Antibioactivity of Nanosilver Colloid and Silver Ion Solution" prepare the mood for a biomedical application of silver nanoparticles. Synthesis of the nanoparticles by nontoxic methods, such as electrical spark discharge without

surfactants, is the appeal of the paper. Antibioactivity effectiveness of these ionic nanoparticles on yeast and bacteria is compared. Clearly, the study is of fundamental importance in understanding the effect of silver ions on various bioactivities. In the same spirit, Y. Jeong et al. in "Assessment of Size-Dependent Antimicrobial and Cytotoxic Properties of Silver Nanoparticles" have studied not only antimicrobial activities of these silver nanoparticles but also their cytotoxicity.

The size controlled synthesis of these nanoparticles further helped in assessing their size-dependent properties. Their work brings in new information on such materials as their experiments suggest that even though smaller nanoparticles tend to be more efficient antimicrobial agents, they also tend to present higher cytotoxicity for humans. In their work, they have studied antibacterial effect of Ag on *Methylobacterium* spp. and cytotoxicity on human peripheral blood mononuclear cells. They suggest that not only silver ions but also the nanosize of silver could be a factor in determining the antimicrobial activity. The special issue also proposes review articles. The paper "Preparation of Silver Nanoparticles and Their Industrial and Biomedical Applications: A Comprehensive Review" by A.

Haider I.-K. Kang, and as suggested by the title, is one such review article. The paper discusses the role of silver nanoparticles in industrial and biomedical applications. It describes various synthesis routes, including chemical and biological methods. Size of the nanoparticles and its effect on their cytotoxicity have been given a closer look along with their applications in textiles and plastic coatings, among others. Environmental consequences of releasing them into nature are also considered here. Furthermore, due to their antimicrobial properties, silver nanoparticles have also been an ingredient in wound dressings as presented by P. Uttayarat et al. in their research paper, "Radiolytic Synthesis of Colloidal Silver Nanoparticles for Antibacterial Wound Dressings." In this paper, the nanoparticles were synthesized by radiolysis where the precipitation of the silver nanoparticles depended on the gamma radiation dose. For a certain dose, the silver nanoparticleswere efficient in inhibiting *Staphylococcus aureus* and *Pseudomonas aeruginosa*. They therefore prove to be good candidates as antiseptic agents in wound healing. Finally, a contribution from the guest editors entitled "A Review on the Green Synthesis of Silver Nanoparticles and Their Morphologies Studied via TEM" is part of this special issue. Since green synthesis is gaining importance and health and safety risks of other synthesis methods are continuously being assessed, the present review article by P. Rauwel et al. provides an overview of different green synthesis methods of silver nanoparticles using bacteria, fungi, yeast, and plant extracts. Furthermore, a review on the various particle sizes as a function of different plant extracts has been explored. In fact, even if organisms from bacteria to eukaryotes are used to produce silver nanoparticles, plant extracts possess the advantage of cost-effectiveness and abundance. In conclusion, all the articles in the present issue present original research efforts in the field of the synthesis of silver nanoparticles, the study of their properties, and their integration in applications. This issue presents new research results developed in the field of interdigitated electrodes and their roles as antibacterial and antifungal agents. This issue also demonstrates the broad field of applications of silver nanoparticles via the two review articles that present the recent advances in industrial and biomedical applications and the development of new environmentally friendly methods for the synthesis of silver nanoparticles. Finally, we hope that this issue is useful and a reference for scientists, researchers, and teachers in the field of materials science and nanotechnology. For over centuries, silver basedcompoundswere used as nontoxic inorganic antibacterial agents owing to their biocidal properties in many applications such as wood preservatives, water purification in hospitals, in wound or burn dressing, and so forth. In fact, silver ions and their related compounds have low toxicity toward animal cells but present a high toxicity to microorganisms like bacteria and fungi. The recent advances in the field of nanoparticle synthesis have a strong impact in many scientific areas and the synthesis of silver nanoparticles has also followed this tendency. These unique properties of nanomaterials have spurred numerous investigations and applications in electronics, nanomedicine, biomaterials, energy, and food. In fact, silver based compounds are much cheaper than gold based one; moreover, silver nanoparticles are now considered as an important class of nanomaterials. They are presently mainly used as catalyst [1] or antibacterial/antifungal agents [2]. Environmentally friendly synthesis methods are becoming more and more popular in chemistry and chemical technologies. This trend has several origins, including the need for greener methods counteracting the higher costs and higher energy requirements of physical and chemical processes. For this reason, scientists search for cheaper methods of synthesis. The other reason is that conventional methods for nanoparticle synthesis usually require harmful reductants such as sodium borohydride or hydrazine and many steps in the synthesis procedure including heat treatments, often producing hazardous by-products. In order to reduce the environmental impact of nanoparticle synthesis, greener routes have been investigated for over a decade. The principles of green chemistry were presented by Anastas and Warner who developed 12 principles that eloquently describe green chemistry [3]. Green chemistry should aim at thwarting waste, minimizing energy use, employing renewable materials, and applying methods that minimize risk.

Properties

Due to the unique optical properties of silver nanoparticles, information about the physical state of the nanoparticles can be obtained by analysing the spectral properties of silver nanoparticles in solution. Silver nanoparticles are extraordinary efficient at absorbing and scattering light due to its optical properties. Their strong interaction with light occurs because the conduction electrons on the metal surface undergo a collective oscillation when they are excited by light at specific wavelenghts. this oscillation is known surface plasmon resonance (SPR). Noble metal nanoparticles display unique optical properties that differentiate them from their bulk counterparts. Metal nanoparticles often exhibit strong extinction bands in the visible Spectrum, which are not present in the spectrum of the bulk metal. Metal nanoparticles also scatter light with high efficiency and their extinction spectra are really a combination of both absorption and scattering. The interaction of the oscillating electromagnetic field of the light with metal nanoparticles, results in the collective coherent oscillation of the metal conduction electrons with respect to the nanoparticle positive lattice. At a particular frequency of the light this process is resonant, receiving the name of Localized Surface Plasmon Resonance, LSPR (Figure 2), and is the responsible of the strong extinction band exhibited by the nanoparticle. Additionally to the extremely high molar extinction coefficients and resonant Rayleigh scattering, LSPR also results in enhanced local electromagnetic fields near the surface of the nanoparticle.

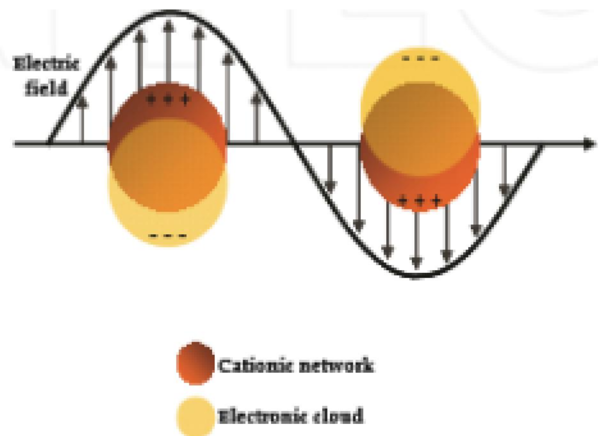


Figure: 1 Schematic representation of surface plasmon (electronic cloud) oscillation under the effect of an electromagnetic field [40]

The first theoretical approach for modelling the optical properties of nanoparticles proposed by Mie. According to the Mie theory, the resonance condition is achieved when the real part of the dielectric function of the metal equals the dielectric function of the surrounding medium (Mie, 1908). Therefore, the LSPR frequency depends both on the nanoparticle itself and on the medium where it is dispersed. Two important consequences arise from this dependency, on the one hand, the LSPR is tunable, i.e., its frequency can be modified through changes in the nanoparticle composition, size and shape (Kelly et al., 2003). On the other hand, metal nanoparticles are sensitive to their local environment, i.e., changes in the dielectric properties of their surroundings results in LSPR shifts that can be measured. Both tunability and sensitivity of LSPR convert metal nanoparticles in materials of choice for optical sensing and imaging applications. The most suitable metals are silver since the localized plasmon resonance condition mentioned above is satisfied at visible light frequencies. Additional advantages of these metal nanoparticles include simple preparation methods for a wide range of sizes and shapes.

Several types of sensors have been developed on the basis of the plasmonic properties of noble metal nanoparticles like extremely high molar extinction coefficients and resonant Rayleigh scattering and enhanced local electromagnetic fields near the surface of the nanoparticle. Sensors are classified in two main groups depending on the type of interaction involved between the metal nanoparticle and the analyte molecule. The first group sensors involving LSPR frequency shift, due to the interaction between nanoparticle and target molecule. This group is further classified in two different sensors depending on the origin of LSPR changes as aggregation sensors and refractive index sensors. In aggregation sensors the LSPR shift is due to the plasmon coupling of nanoparticles in close proximity, in refractive index sensors the LSPR shift is due to changes in the local refractive index of the medium. The second main group of sensors is based on the electromagnetic field enhancement in the vicinity of noble metal nanoparticles, which results in the surface enhanced spectroscopy, such as Surface Enhanced Raman Spectroscopy (SERS).

Experimental:

Synthesis of AgNPs

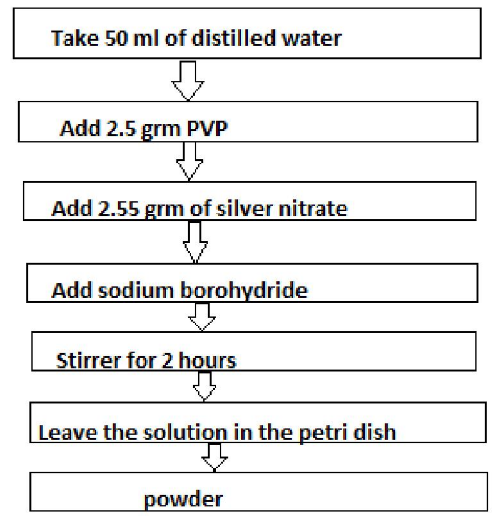
Chemical synthesis of AgNPs:

The rapid growth of nanotechnology is directly related to the ability to design novel materials at the nanoscale level alongside recent innovations in analytical and imaging technologies for measuring and manipulating nanomaterials. The rapid development of commercial applications involve the use of a wide variety of manufactured NPs. Nanotechnologies hold great promise for reducing the production of wastes, reducing industrial contamination and improving the efficiency energy production and use. However, the production, use and disposal of manufactured NPs will inevitably lead to discharges to air, soils and aquatic systems. Silver nitrate is corrosive, causing burns in contact with the skin and eyes. Sodium borohydride is flammable and toxic.

Chemicals used:

The chemicals used in the process was silver nitrate, sodium borohydride, poly vinyl pyrodiline.

Prepration of silver nanoparticle using sodium borohydride as reducing agent required following process:



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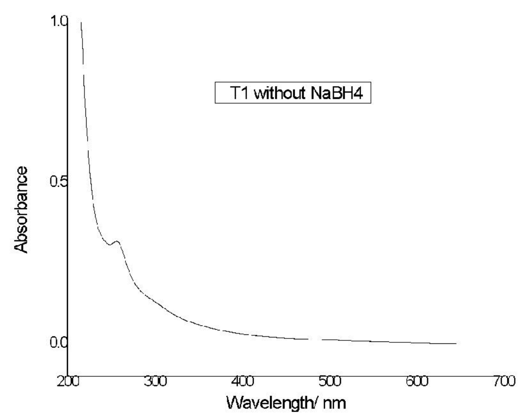

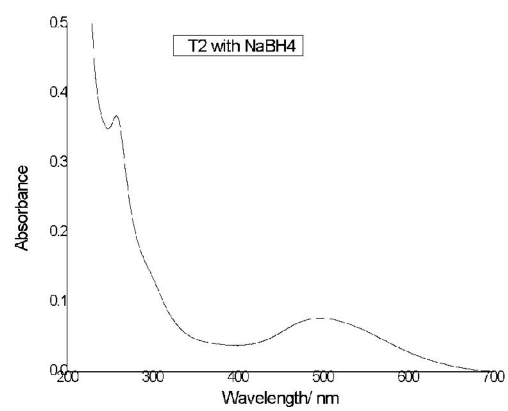

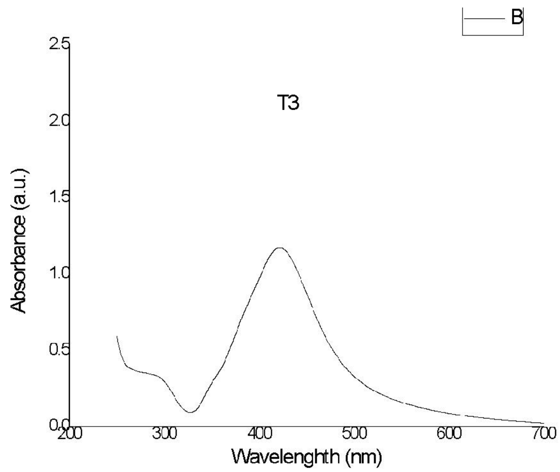

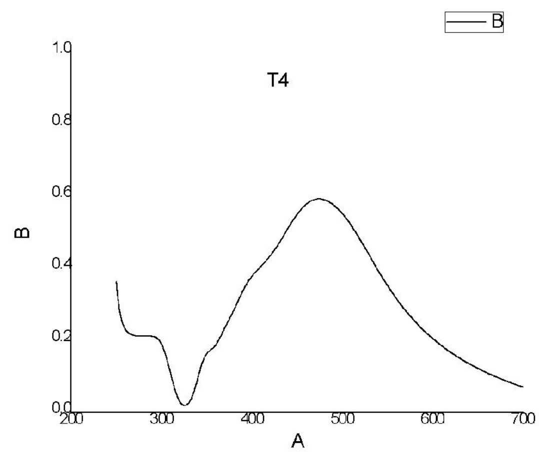

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396 nm, associated with the presence of smallspherical silver nanoparticles. If the particles would not be spherical (or equiaxial), the absorption band would appear at longer wavelengths and would gradually shift to shorter wavelengths as the particles become more spherical Absorption bands are smooth with a single pronounced plasmonresonance that appear around 400 nm. have reported that the electronic transitions involving the Ag+ ion give rise to absorption bands located between 200 and 230 nm, whereas the electronic transitions of metallic Ag0 appear in the 250-330 nm spectral range. The UV-VIS spectra of all samples analyzed in this study did not show distinct absorption signals around 230 nm due to the electronic transitions involving Ag+ ions. The presence of silver ions in the synthesized nanoparticle

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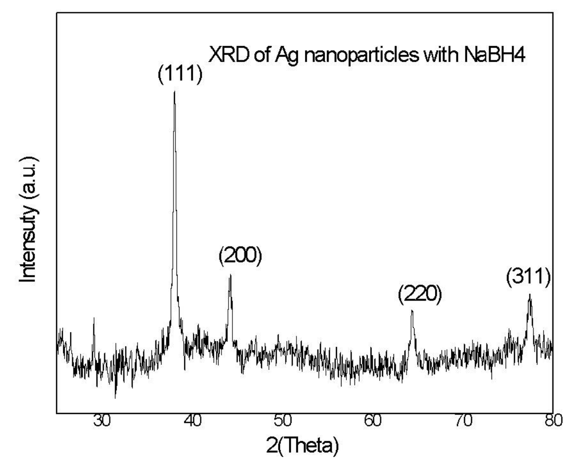
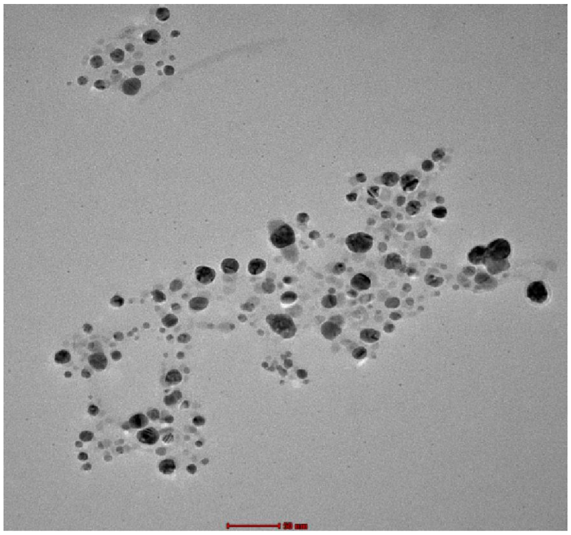
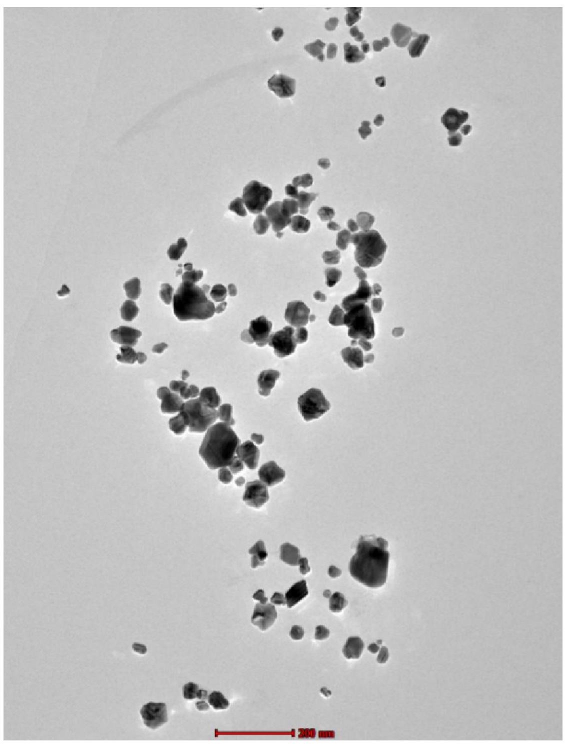


A number of Bragg reflections in the (111), (200), (220) and (311) set of lattice planes were observed. The high intensity for fcc materials is generally (111) reflection, which is observed in the samples. This confirmed the lattice structure to be fcc (face centered cubic).

To sum up, in the X-ray diffraction pattern of silver nanoparticles four peaks at 2θ values of 38.3°, 44.5°, 64.6° and 77.1° corresponding respectively to (111), (200), (220) and (311) planes of silver were observed. The results indicate that the resultant particles are fcc silver nanoparticles with a predicted size of ~ 10nm.





A TEM image of the prepared silver nano particles is shown in the fig. The Ag nano particles are spherical in shape with a smooth surface morphology. The diameter of the nano particles is found to be approximately 16 nm. TEM image also shows that the produced nano particles are more or less uniform in size and shape.

Conclusion

Nanotechnology has helped in overcoming the limitations of size and can change the outlook of the world regarding science.

Synthesis of silver nanoparticle has become possible using $NaBH_4$ as a reducing agent and using $AgNO_3$ as a reluctant. These gave dark yellowish colour when synthesized by a protective layer of borohydride ions. The Ag solution became yellowish in colour because of absorption of wavelength at 386nm. As silver nanoparticles are very delicated to the absorption of light, they interact with light due to very high dielectric constant that makes the light response occur in the visible region. Thus silver nanoparticles absorption and scattering properties can be tuned by controlling the particle size shape, and the local refractive index near the particle surface. Silver nanoparticles are harmful to the environment, due to which mesocosms are created to protect it.

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References

1. Chauhan J, et al. Synthesis and Characterization of Ni and Cu Doped ZnO. Nanomed Nanotechnol. 2017; 8(2).
2. S Deepti Pateria, Jyostna Chauhan *American Journal of Nanomaterials*. 2016, 4(3), 52-57
3. A. Mehto, V. Mehto, J. Chauhan, I. Singh, R. Pandey, Preparation and characterization of polyaniline/ZnO composite sensor. J. Nanomed. Res. 5, 00104 (2017).
4. Journal of Physics: Conference Series 365 (2012) 012012 Comparative X-Ray crystallographic studies of systemic fungicides hexaconazole and tricyclazole J Chauhan, A K Sharma and G Bhattacharya.
5. CHARACTERIZATION OF NANOSTRUCTURE LEAD SELENIDE (PBSE) THIN FILMS vol 8, issue 4 page 89-93 2018, IOSR JEN JOURNAL Jyotsna Chauhan1, Varsha R. Mehto and Roopal soni.
6. Synthesis and characterization of Mn doped ZnO nanomaterial, REPORT AND OPINION JOURNAL volume 9 issue 1 page 40-46 2017 Dr jyostna chauhan[1] Deepti Pateria[2†], Adil Aziz Khan.

7. Synthesis and characterization of size tunned CdS Quantum dots. Journal of Nanoscience Nanoengineering and Applications volume 8 isuue 1 2018 Jyostna Chauhan[*1], Varsha R Mehto[2] and DEEPIKA SONI.
8. Synthesis and Characterization of Pure and Co doped Zinc oxide, Global journal of Nanomedicine volume 1 issue 2 2017 Dr jyostna chauhan[1] Varsha R Mehto Shailendra Singh.
9. Synthesis and characterization and comparative studies of Ni, Cu, Mn, Co, Fe doped ZnO IN *Rep Opinion* 2017;9(11):14-29]. Jyostna Chauhan[*1], Varsha R Mehto[2] and Shikha gangwar.
10. Synthesis of ZnO Nanoparticles Using Different pH Values in Nano Trends: A Journal of Nanotechnology and Its Applications Volume 20, Issue 1, 2018 Jyostna Chauhan[*1], Varsha R Mehto[2] and Neeraj Malviya.
11. Jyotsna Chauhan, Abhishek Kumar Tiwari Synthesis and characterization of cadmium doped nickel oxide nanoparticles Report. Opin., 10 (3) (2018), pp. 82-91.
12. SYNTHESIS AND CHARACTERIZATION OF NEODYMIUM DOPED NICKEL OXIDE NANOPARTICLE, IOSR JEN JOURNAL vol 8, issue 4 2018 page 88 -93.
13. Study of Implementation of LED using CdS Based Quantum Dot"published in *IOSR Journal Of Pharmacy, Volume 8, Issue 4 Version. II (April 2018), PP. 85-94.*
14. Synthesis and Characterization of BFO Doped with Nickel NANOPARTICLE in International Journal of Nanomaterials and Nanostructures Vol. 4: Issue 1 2018 page 19-29 *Jyotsna Chauhan*, Poonam Patel.*
15. Synthesis and characterization of CdS Nanoparticle for LED Application" published IN International Journal of Applied Nanotechnology Vol. 4: Issue 1 2018 PAGE 12-18 *Jyotsna Chauhan*, Varsha R. Mehto, Dharmendra Kumar.*
16. Theoretical studies of single wall carbon nanotubes for synthesis and growth mechanism is published in STM Journal of Nanoscience Nanoengineering and Applications in volume 8 issue 1 2018 Mr. Pradeep Kumar Khiriya [1], Dr jyotsna Chauhan.
17. Chauhan J, et al. Synthesis and Characterization of Carbon Quantum Dot for Device Fabrication. Report and Opinion 2018;10(6).
18. Chauhan J, Bhattacharya G (2012) X-ray crystallographic and ir studies of systemic fungicide thiophanate methyl. International Journal of Pharma and Bio Sciences 3: 900-909. 21] V. Pillai, P. Kumar, M. J. Hou, P. Ayyub and D. O. Shah,, Adv. Colloid Interf. Science 55 (1995) 241-269.
19. W. Zhang, X. Qiao, J. Chen, Mat. Sci. Engin. B, 142 (2007) 1–15.
20. J. J. Mock, M. Barbic, D. R. Smith, D. A. Schultz, and S. Schultz, J. Chem. Phys. 116 (2002) 6755-6759.
21. M. Maillard, S. Giorgio, M.-P. Pileni, J. Phys. Chem. B 107 (2003) 2466 2470.
22. R. He, X. Qian, J. Yin, Z. Zh, J. Mater. Chem. 12 (2002) 3783–3786.
23. R. Jin, Y. W. Cao, C. A. Mirkin, K. L. Kelly, G. C. Schatz, J. G. Zheng, Science 294 (2001) 1901-1903. [27] I. Sondi., D. V. Goia, E. Matijevic., J. Colloid Interface Sci. 260 (2003) 75- 81.
24. I. Pastoriza-Santos, L. M. Liz-Marza´n, Langmuir 18 (2002) 2888-2894.
25. Catauro M, Raucci MG, De Gaetano FD, Marotto A. Antibacterial and bioactive silver-containing Na2O × CaO × 2SiO2. glass prepared by sol-gel method. J Mater Sci Mater Med 2004;15(7):831-7. [30] Crabtree JH, Burchette RJ, Siddiqi RA, Huen IT, Han dott LL, Fishman A. The efficacy of silver-ion implanted catheters in reducing peritoneal dialysisrelated infections. Perit Dial Int 2003;23(4):368-74.
26. Aldrich Prod. No. 730793, Aldrich Prod. No.730815, and 100 nm Aldrich Prod. No. 730777.
27. Creighton JA, Blatchford CG, Albrecht MG. Plasma resonance enhancement of Raman scattering by pyridine adsorbed on silver or gold sol particles of size comparable to the excitation wavelength. J Chem Soc Faraday Trans II 1979; 75:790-8.
28. Suh JS, DiLella DP, Moskovits M. Surface-enhanced Raman spectroscopy of colloidal metal systems: a two-dimensional phase equilibrium in paminobenzoic acid adsorbed on silver. J Phys Chem 1983;87:1540-4.
29. S. D. Solomon, M. Bahadory, A. V. Jeyarajasingam, S. A. Rutkowsky, C. Boritz, and L. Mulfinger. Synthesis and study of silver nanoparticles. Journ.
30. H. K. Hong and collegues, Dankook University.
31. Hongshui Wang, Xueliang Qiao, Jianguo Chena, Xiaojian Wang, Shiyuan Ding, Materials Chemistry and Physics 94 (2005) 449–453.
32. Li, W. R.; Xie, X. B.; Shi, Q. S.;, Zeng, H. Y.;, Ou-Yang, Y. S.; Chen, Y. B. Appl Microbiol Biotechnol. 2010, 85(4), 1115-22.
33. Lubick, N. Environ. Sci. Technol., 2008, 42 (23), p 8617.
34. Benjamin P. Colman, Christina L. Arnaout, Sarah Anciaux, Claudia K. Gunsch, Michael F. Hochella, Bojeong Kim, Gregory V. Lowry,

Bonnie M. McGill, Brian C. Reinsch, Curtis J. Richardson, Jason M. Unrine, Justin P. Wright, Liyan Yin, Emily S. Bernhardt. Low Concentrations of Silver Nanoparticles in Biosolids Cause Adverse Ecosystem Responses under Realistic 43 Field Scenario. PLoS ONE, 2013; 8 (2): e57189 DOI:10.1371/journal.pone.0057189.

35. Advances in Nanotechnology and Research and Applications 2011 edition. International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 3, March - 2013 ISSN: 2278-0181.

5/25/2019