**Indian Journal of Science and Technology,** *Vol 11(22), DOI: 10.17485/ijst/2018/v11i22/121154, June 2018*
*ISSN (Print) : 0974-6846*
*ISSN (Online) : 0974-5645*

# Green Synthesis of Silver/Polystyrene Nano Composite (Ag/PS NCs) via Plant Extracts Beginning a New Era in Drug Delivery

**Abdullah Hasan Jabbar, Maytham Qabel Hamzah, Salim Oudah Mezan, Amira Saryati Binti Ameruddin and Mohd Arif Agam***

Department of Physics, Faculty of Applied Sciences and Technology, University Tun Hussein Onn Malaysia, 84600 Pagoh; physics1984@yahoo.com, maythamqh@gmail.com, ousalim80@gmail.com, amira@uthm.edu.my, arif@uthm.edu.my

## Abstract

**Objectives:** The development of polystyrene silver nanocomposite of multi-drug resistance through several microbial bacteria has been a cause of real auspices to the medical world, shorter option of antibiotics. Contemplating that it may take decades to synthesize new nanocomposite drugs that combat resistant pathogens the search for alternatives to conventional antimicrobial agents has begun. Development of Ag nanoparticles was growing in neoteric years and is for the time being considered for the user and medicalincomes. **Methods:** We review a novel phenomenon polystyrene silver nanocomposite (PS/AgNCs) for the combination of green leaf being and their physical, chemical, biological, mechanical and electrical attributes. The methods of action and potential use in medicine and research with special allusion to antimicrobial application shall be discussed. **Findings:** The current review scouts about the huge plant variety to be utilized towards rapid and single step protocol preparatory method with green principles over the conventional ones and describes the germicide motions of the (PS/Ag NCs). **Application:** Nanoparticles were positively estimated for their antimicrobial performances in the running study. Several properties, including powerful and stable materials, conductive devices, sensors and biomedical (drug delivery) were used as vehicles for drug delivery to enable the effective entry to the body.

**Keywords:** Biomedical Applications, Drug Delivery Systems, Green Synthesis, Nanotechnology, Silver, Polystyrene Nanocomposites

## 1. Introduction

Nanotechnology is an emerging technology including the development in new scale of range (1nm to 100 nm) at the atomic, molecular and bulk materials[1]. The macro levels in structures, devices, and systems that still prepare good or better achievement and functions related to their tiny size. Nanotechnology has now become world request and interest[2]. A lot of research and developments have been done in various fields including the solar cells devices. Contemporary developments in nanotechnology provide new exciting scope for further improvements in cell realization and cost lowering in the manufacturing procedure of the solar cell[3] nanotechnology synthesizes also the (NPs) size result of (1nm to 100 nm) (Figure 1). Moreover, there is a unique class of nanotechnology which is bio-nano. Those Mgmat essentials of biology with physical and chemical methods to create nano-sized particles with determined careers[4].

Bio-synthesis approach has more indemnification high anther traditional synthesis procedures due to the accessibility of more biological structure and environmentally friendly procedures. The opulent bio-variety and simple availability of plant structure have been more discovered for the nanomaterials synthesis[5]. Nanotechnology is foreseeable to have evolution influence on health.

*Author for correspondence

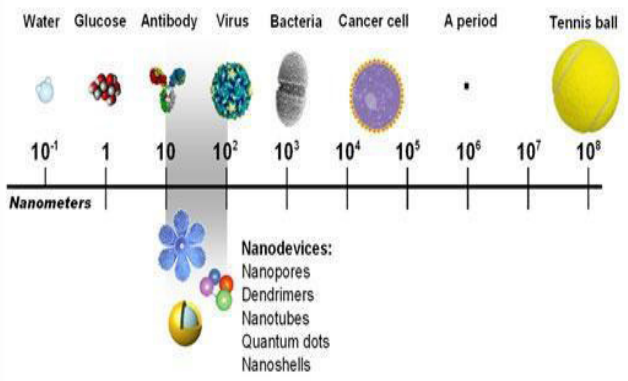


**Figure 1.** Scale of nano particles.

Nanoparticles can be the main base in medical and essentially in diagnosis and treatment of cancer cell, heart and blood vessels sickness and contaminated diseases. For more the application of nanoparticles in the drugstore, it is necessary that the systems are steady, the ability to being functionalized, biodiversity and directed to specific goal stall in the body after systemic management[6].

The idea of nanotechnology from the first suggested by Feynman in 1959. The term nanotechnology was the first original[7]. Where the term nano-medical was discovered[8]. The beginning evaluation in this scope was studied in the early 70s at the ETH Zurich when the first controlled progressive system was advanced along with other various drugs that showed the powerfully to cross the blood-brain barrier with more enhancement pharmacokinetics[9]. Despite, it was not until 2006 when the one international journal in nano-medicine was introduced named 'International Journal of Nano-medicine' to cater to the emerging needs of nanotechnology in medicine[10]. Normally, there are three generaltips involved in green preparation methods, i.e., response middle chosen, biological decrease agent cross, and chosen of Noncarcinogenic material for stabilization of nanomaterials.

Until now plenty-mediated Prepare of the nanomaterial can be useful on another bio-based structure because the execution from look after, Cell cultures ability be to edit and it is too durable extensive output under nonaseptic milieu[3,11]. Nanomaterial, mostly silvery and gold nanomaterial, using implant excerpt as nano-manufactory is a substantial topic for researchers in the area of nanomaterial. Silver nanomaterial has higher hesitancy Plasmon reverberation than gold nanomaterial.

The review focusing on the green extract preparation of nanoparticles is cheap, separated step and fast method. The leaves are used clearly in the synthesis of various green nanoparticles such as copper, silver, gold and zinc oxide. Siver nanoparticles are scope for many treatments for different diseases such as paludism, cancer, human immunodeficiency virus, hepatitis and other critical diseases. The novel research (PS/Ag NCs) in this review construction on the fast and easy biological synthesize cooperation (PS/GA) to study drug delivery technologies, modify drug liberate profile, absorbance, disturbance and elimination for the benefit of improving production activity and safeness, as well as patient status suitability and compliance with the drug delivery system.

## 2. Syntheses of (Ag NPs) Byleaf Extracts

Silver nanoparticles are entirely famed antimicrobial operatives in surgically planted catheters in status to minify the contagions occasioned during surgery[12] and offered to hold antifungal anti inflammatory anti-angiogenic and anti permeability motions. Argentums is so one of the major motifs in different kinds of medicament gashes[13]. However, Ag nanoparticles are presently being pressed as introduced antibacterial tool replacing Ag ions. Both Ag ions and Ag nanoparticles have restrained and grave effects on bacterial types like Escherichia coli, *Staphylococcus aureus*, and even leaven. But, the formation of complexes for Ag ions is restricted and the influence of the Ag ions somehow residues only for a low period[14]. Yet, this hurdle has been determined by the application of the right Ag nanoparticles which have major antibacterial properties by promoting the synthesis of interacting oxygen types like hydrogen peroxide[15]. In additionthe antibacterial efficiency of the Ag nanoparticles, a perfect disturbance of the bacterial membrane of coli cell was spotted after few minutes in connect with Ag nanoparticles beneath TEM analysis[16]. The high competence of Ag nanoparticles is fundamentally due to the availability of bigger roof area to the size proportion for interactions, sedative the breakthrough and disturbance of nanoparticles in the cells of bacterial, as a contrast to micro-sized Ag ions[17,3].

The employ of plants as the output assembly of Ag nanoparticles has pulled interesting, because of its fast, simple, convenient[18], eco-friendly, non-pathogenic, economical protocol and providing a single step technique for the biosynthetic processes. The lessening and firmness of Ag ions by a group of biomolecules like proteins,

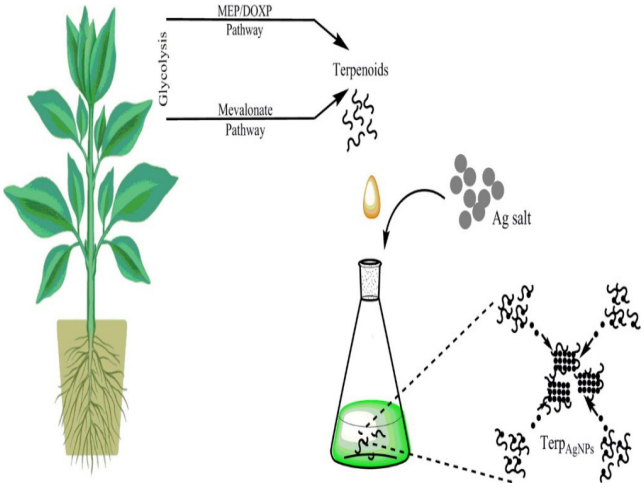


**Figure 2.** Preparation of Ag nano particles plants method.

amino acids, enzymes, polysaccharides, alkaloids, tannins, phenolics, saponins, terpenoids and vitamins which are formerly confirmed in the plant excerptions having medicinal worth's and are environmental decent, yet chemically gleaner structures[19]. A large numeral of plants is reported to ease Ag nanoparticles synthesis are mentioned (Figure 2)[20].

## 3. Nanoparticles in Drug Delivery

Nanoparticles drug delivery regulation isnon-metric transporter utilized to carry drugs or molecule-bio. Definitely, nanotechnology founded unique method incorporate metal particles with a polymer template have accomplished unique physical and mechanical properties that were not potential with the supplement of micronized particles. These metal nanoparticles (NPs) established in plenty polymer matrix have become the concentrate of rising attention because of their application in many domains contain optical fibers, subwavelength waveguides, non-linear optical transitions[21], super-lenses[22], magneto-optical data store, directional connector, electronics as nano-wires[23] for bio-medical materials. Moreover, these polymers are catchy materials for applications in bio-sensors because of the significant suppleness in their chemical structure and those redox properties[24]. The scope of variations of the properties relies on the rule polymer size, disturbance, and scuttle action of the NPs and adhesion at the filler-matrix surface[25]. When the NPs are embedded or encapsulation in a polymer, the polymer work as a flatness cover agent[26,11].

In addition, the casting of the film be easily, and the particle dimension is planned completely within the required regime. Silver and gold are favorite NP coating materials because of their well-known properties of shown optical reduction (absorption) in the scene area. Silver has been exceedingly prepared because it is much reactive than gold. Polymers are generally elastic, lightweight, and capable to supply wanted immobilization of the nanoparticles, avoiding their coherence or separation, thus saving the narration size dependent characteristic of the Nanomaterials is sub-micrometer magnitude particles (PNPs)[27]. In addendum, polystyrene (PS) show many wonderful properties such as biocompatibility, nontoxicity, height surface district, powerful adsorption capability, and chemical Idlein addition to[28,29]. Polystyrene spheres have been most applied[30]. The copolymer of methyl methacrylate and styrene (PSMMA) is a task polymeric substance that has a lot of usage in medicine[31].

## 4. Polymeric Nanoparticles

Polymeric NPs can be specified as sub-micronic (extend< 1μm) colloidal transfer. Contrasted to other colloidal carrier polymeric NPs contract important promise for the programs of therapy sickness and troubles. They have catching physicochemical property like as size, roof effect, and hydrophilic-hydrophobic equilibrium and for this reason; they have been famous as scope drug carrier for bio-active ingredients such as anti-cancer drugs, virus, oligonucleotides and peptides. Their diffuse use for oral delivery also goals to enhancing the bio-availability of drugs with small absorption special, decreasing GI mucosa excitement caused by drugs and confirm the stability of drugs in the GI field. Consequently, all these and more like feature of NPs reserve them as a hopeful nominee in drug-delivery technology. Though different bio-degradable NPs (Figure 3) of physical polymers like starch, chitosan and liposomes, are generally in use as drug transport in controlled Drug delivery technology[32]. Many FDA-approved bio-degradable and bio-compatible polymers have been used in NPs synthesis. These content polylactide-polyglycolide copolymers, polyacrylates and polycaprolactones[33]. Recently the synthesis of NCs of polystyrene (PS) and (PS/AGNPS) can be synthetic to scope the target venue by a morality of their size and face adjustment with a specific confession ligand. Their sur-

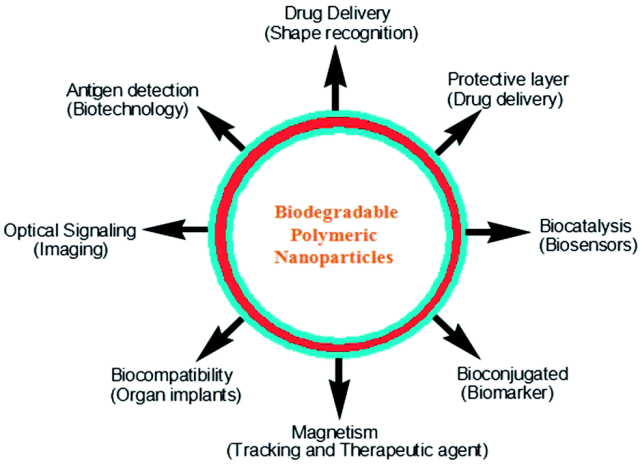


**Figure 3.** Bio-degradable polymeric nano particles applications.

face able to be easily modified and functionalized. From the polymer chemistry point of view, the future an object scope to make a new polymer suitable hydrophilic and lipophilic property of upcoming drugs for smart formularization.

## 5. Metallic Nanoparticles

Presently these nanoparticles are emerging as better drug delivery and bio-sensor. For the property of metallic NPs diverse metals have been discovered though Ag and Au's nanoparticle is of first significance for biomedicine. Polymer molding has been extremely utilized as particle stabilizers in preparing of metal colloids over this stopping cluster of the particles. During the old contract, mixture Ag nanoparticle into a polystyrene PS is more enjoyable because of the result (NCs) shown the applications in catalysis, drug delivery, injury plaster, antimicrobial activity and optical pieces of information store[34,35]. It is intractable to disperse (Ag NPs) homogeneously into a polystyrene (PS) matrix by different methods because of easy agglomeration of nanoparticle[36]. For the time it is likely to getting nanomaterial of various forms and size in a nano construct a polymeric climate where diverse polymeric order and various diversity can be applied, many processes used sublime and potentially serious reactants. Rising environmental worry have performed in a try to take eco-friendly mode[37].

## 6. Technical Analysis of PS/AGNCS

Characterization of nanoparticles is very important to realize and understand nanocomposite cooperation (PS/GA) and implementation of the drug delivery techniques. Characterizationis perfect to use the different types of techniques such as Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), X-Ray Diffractometry (XRD), Fourier Transform Infrared Spectroscopy (FTIR) and UV–Vis spectroscopy[38]. These techniques can be applied to characters of varioustypes of vectors such as particle size, shape, crystal, fractal dimension, small size and surfaces scope[39]. Moreover, nanocomposite could be specific by these techniques, the morphology and particle size could be determined by TEM, SEM, and AFM. The morphology of polystyrene/silver (PS/Ag) nanocomposite specific by scanning electron microscope SEM and TEM. The AFM measures three-dimensional status. Moreover, X-ray diffraction is using for the determination of crystallinity. The UV-vis absorption and dynamic light scattering methods have been used to characterize thecolloid system.

## 7. Applications of Silver Nanoparticles

Ag nanoparticles are of particular attention in the new research of nanotechnology due to its unparalleled property, which able to be not integrated into a domain area of width application Optical resonators[40] agents in the medical industry, cosmetics, food packaging, bio-engineering,

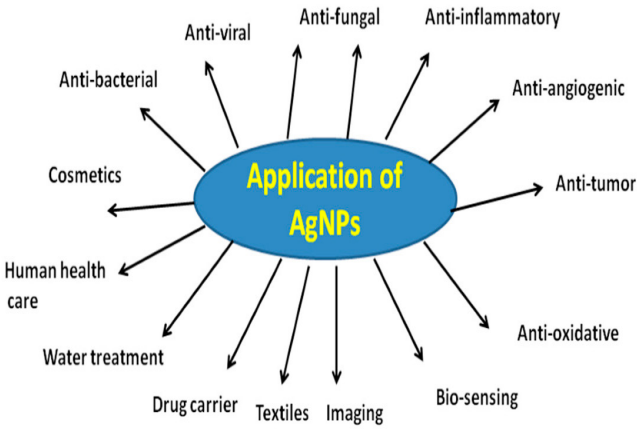


**Figure 4.** Different types of applications Silver nano particles.

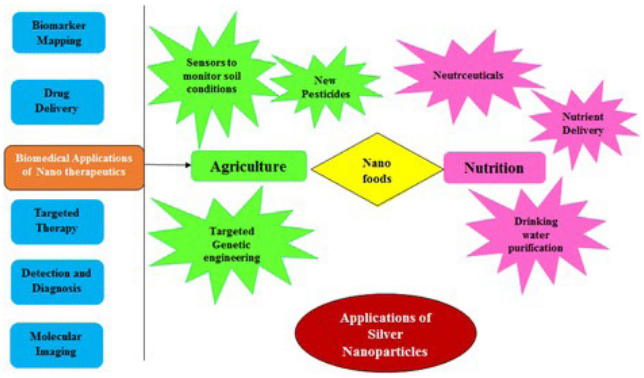


**Figure 5.** Different applications of synthesized silver nano particles.

electrochemistry, catalysis, and circumferential using (Figure 4). As featured in their size materials, unique nanoparticles showed various catalytic actions, and thus nano-catalysis lately has obtained more active in this a path of using NPs as catalysts in a different kind of method[41]. Prepare of silver nanoparticles (AGNPS) is of frequently service to the scientific because of their vast domain of purposes. This (AGNPS) are subsistence successfully applied in the cancer diagnosis and therapy[42].

Silver nanoparticles (AGNPS) has been used more closely in the health manufacture, food storage, woof coatings and a number of environmental applications (Figure 5). The antimicrobial property of silver nanoparticles has also been hard-done-by together in the medicament and at home. Silver sulfadiazine creams use sometimes to stop the infection at the burning position and at least one devices company has united argentine into their lotion instrument. Presently, Argentine is utilized in the extending area of nanotechnology. It is a well-known truth that silver nanoparticles and their composites offer major catalytic work on the section of dye decrease and their elimination[43].

## 8. Drug Delivery

Pharmaceutical manufacturers are continuously meeting demands and expectations of different technologies and possibilities for expansion of drug design due to medical and healthcare item research. The exploitation of recipients in medicinal manufacture develop from their imitative subsidiary occupation in the formula like ease flow ability and matchmaking of the production along with their biological part in the enhancement of drug rendering in particular firmness, emission, and bio-availability. For now, bio-based materials are beheld as key ingredients for the pattern drug delivery regulation because of their stabilization, availability, renewability and low toxicity[44]. Appropriate chemical alterations of bio-materials much necessary with single properties of they use in drug delivery system actually than their customary biodegradability and bio-compatibility. Drug delivery is a multidisciplinary area which comprises realization from the domain of chemistry, pharmaceutical sciences, drug, biological analyses[45] and engineering. It mostly depends on the chemical formulation of medicine, form and administration route.

Drug delivery method ameliorates the problems of imitative section by reinforcing drug solubility, extend period time, decrease part belongings and detained drug bioactivity. Drug delivery method has increased bioavailability better the uptake preserves drug focuses by control the average of drug, liberation and minimizes part wares by emission the drugs at aim cells[42,46].

Drug evolution and formulation experiment have much low prosperity averages with a salutation to drugs that get in the mart. These shortfalls are due to the agent such as poison of the curative complexes, needy solubility major to minimized bio-availability and decreased capacity. These challenges are even much significant in poverty-related sickness (PRS) essentially paludism, due to the top diffusion of impedance and patient noncompliance to obtainable drugs applied in malaria chemotherapy[47-48].

Nanoparticles are applied to the site-specific to drug delivery (Figure 6). In this technique, the wanted drug dosage is applied and side effects are decreased safely as the actual factor is deposited in the pathological area only. This much elective path can minimize costs and clinical practice of diagnostics[49]. Thus a vari-

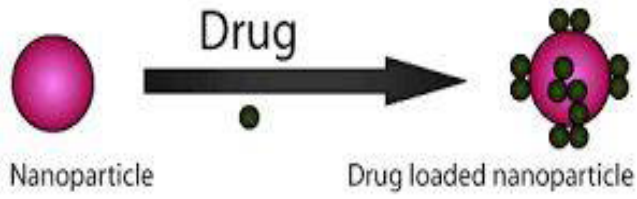


**Figure 6.** Drug delivery in nano particles.

ety of nanoparticles such as dendrites, and nanoporous materials find the applications. Micelles acquired from block copolymers are applied for drug encapsulation. They carry little drug molecules to the desired position. Similarly, nano-electromechanical systems are used for the active emission of drugs. Iron (Fe) nanoparticles or gold (Au) shells are found important applications in the cancer therapy. A targeted drug decreases the drug consumption and treatment cost, working the therapy of patients cost efficient[50].

## 9. Drug Delivery Silver Nanocomposite

Nanotechnology is presently utilized as the devices to exploration the dusty avenues of the health science invarious methods like imaging[51], sensors[52], target drug delivery[53] and gene delivery[54] and synthetic plants[55]. Hence, nano-sized (organic and inorganic) particle are find rising interesting in health applications[56]. The amenability to biologically function increase effectiveness, the novel era drugs are nanoparticles of polymer, metal or ceramic, which able conflict condition such as cancer[57]. Ag has been recognized to have a purifying impact and has found application in conventional medicine and culinary sections. Different salt of Ag and their derivative are commercially utilized as anti-microbial agent[58]. Consequently, nanoparticles of silver have ability been inspected for their antibacterial properties[59-60]. The commendable effort has been synthetic to look these properties employ electron microscopy, which has detected the size-dependent interaction of silver nanoparticle with bacteria[61] (Figure 7). (AGNPS) have thus been prepared as a middle for

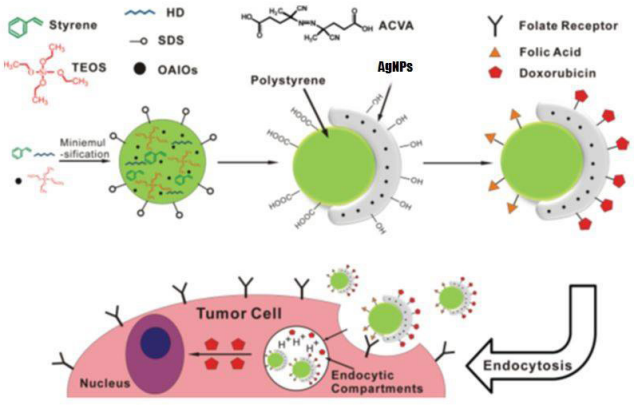


**Figure 7.** Drug delivery in polystyrene/ silver nano composites (PS/Ag NCs).

antibiotic delivery. And synthesize composite for employ as sterilize filter and coating materials[62].

## 10. Aim of the Present Paper

In this paper concentrate on the features and bio-medical application of polystyrene/silver nanocomposites (PS/AG NPS). An extended study is transported out based the new signs of progress reported in the literature label category of powerful and settled materials, conductive tools, sensors and bio-medical production. Furthermore, the several development applications are specified for the future challenges in science and manufacturing community.

## 11. Conclusion

Green synthesis of silver/polystyrene nanocomposite using plant extract it is most studies in the last. The leaves extracts produce the fabrication of silver/polystyrene cooperate in the fast and novelcooperate for the biological work (drug delivery). The biosynthesis of nanoparticles using plant wet extract and pure is novel cooperation PS/AG for the great scale product. The plant extract nanoparticles have the possibility to apply in the different areas such as pharmaceuticals, human immunodeficiency virus, hepatitis, critical diseases and other Drug delivery technologies. The plant material/polymer nanoparticles have plan effect on diagnosis and treatment of many diseases with stripy side effects. In future, The plant extract to prepare silver nanoparticles and incorporate with polystyrene PS/AGNCS need a more details study on more issues such as taking the possibility of a different kind of activities of the PS/AGNCS at the cellular and molecular scales.

## 12. Recommendations and Future Work

To funding and organizational searching for a large amount of data for this cooperation polystyrene silver nanocomposite its not toxicity to use in drug delivery (cancer cell) and other medical and antibiological properties, that should be collected to conduct the review would be of greater help rather than individual data searching and self-funding Studies need to progress at a fast pathway from being most useful in the biological work. In the future, many biological fields such as (pharmaceuticals, human immunodeficiency virus, hepatitis, criti-

cal diseases and other Drug delivery) can also use same green synthesis cooperation with polymer (polystyrene) nanocomposite to observe weakness and hardness clearly in this field.

## 13. References


1. Lakshmi SYS, Banu F and Gopalakrishnan VBS. Antimicrobial activity of Aegle marmelos (Correa) Linn. Silver nanoparticles. 2014; 3(1):294-7.
2. Yunus NAM, Halin IA, Sulaiman N, Ismail NF, Aman NHN. A Compilation of nanotechnology in the Film Solar Cell Devices. World Academy of Science, Engineering and Technology International Journal of Energy and Power Engineering. 2015; 9(8):724-8.
3. Hamzah MQ, Jabbar AH, Mezan SO, Hasan NN and Agam MA. "Energy Gap Investigation and Characterization of Kesterite Cu 2 Znsns 4 Thin Film for Solar Cell". International Journal of Technical Research and Applications. 2018; 6(1):3-6. e-ISSN 2320-8163.
4. Keat CL, Aziz L, Eid AM, Elmarzugi NA. Biosynthesis of nanoparticles and silver nano particles. Bio Resources and Bio Processings. 2015; 2(1):1-47.
5. Kuppusamy P, Yusoff MM, Maniam GP, Govindan N. Biosynthesis of metallic nanoparticles using plant derivatives and their new avenues in pharmacological applications - An updated report. Saudi Pharmaceutical Journal. 2016; 24(4):473-84. Crossref
6. Duggal D. IJDDR Role of Nanotechnology in New Drug Delivery Systems. International Journal of Drug Development & Research. 2011; 3(4):4-8.
7. Tibbals HF. Medical Nanotechnology and Nanomedicine. CRC Cyclic redundancy checks press. 2011; p. 1-528.
8. Najlah M, Freeman S, Attwood D, D' Emanuele A. In vitro evaluation of dendrimer prodrugs for oral drug delivery. International Journal of Pharmaceutics. 2007; 336:183-90. Crossref
9. Cevc G. Lipid vesicles and other colloids as drug carriers on the skin. Advanced Drug Delivery Reviews. 2004; 56:675-711. Crossref
10. Maroof K, Zafar F. Scope of Nanotechnology in Drug Delivery. Journal of Bioequivalence & Bioavailability. 2015; 8(1):1-5. Crossref
11. Hamzah MQ, Abdullah Hasan Jabbar, Salim Oudah Mezan. "Synthesis and Characterization of Cu2ZnSnS4 (CZTS) Thin Film by Chemical Bath Deposition (CBD) for Solar Cell Applications". International Journal of Scientific Engineering and Research (IJSER). 2017 December; 5(12):35-37Oei JD. Available from: http://www.ijser.in/archives/v5i12/v5i12.php. Antimicrobial acrylic materials with in situ generated silver nano particles. Journal of Biomedical Materials Research Part B. 2012; 100(2): 409-15.
12. Keat CL, Aziz A, Eid AM, Elmarzugi NA. Biosynthesis of nanoparticles and silver nano particles. Bioresources, Bioprocessing. 2015; 2(1):1-47.
13. Mendez-Vilas M, Chandrasekaran N. Science against microbial pathogens: communicating current research and technological advances. Microbiology Book Series. 2011; 1(3):245-51.
14. Mohammed AE. Green synthesis, antimicrobial and cytotoxic effects of silver nanoparticles mediated by Eucalyptus camaldulensis leaf extract. Asian Pacific Journal of Tropical Biomedicine. 2015; 5(5):382-6. Crossref
15. Jasuja ND, Gupta DK, Reza M, Joshi SC. Green synthesis of AgNPs stabilized with biowaste and their antimicrobial activities. Brazilian Journal of Microbiology. 2014; 45(4):1325-32. Crossref PMid:25763037
16. Ra M, Gade A, Gaikwad S, Marcato PD, Duran N. Biomedical applications of nanobiosensors: The state-of-the-art. Journal of the Brazilian Chemical Society. 2012; 23(1):14-24. Crossref
17. Gopalakrishnan S, Kaupa P, Lakshmi SYS and Banu F. "Antimicrobial activity of synthesized silver nanoparticles and phytochemical screening of the aqueous extract of Antiaristoxicaria". 2015; 4(1):2-5.
18. Kulkarni N, Muddapur U. Biosynthesis of metal nanoparticles: a review. Journal of Nanotechnology. 2014; p. 1-8. Crossref
19. Ahmed S, Ahmad M, Swami BL, Ikram S. A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise. Journal of Advanced Research. 2016 Jan; 7(1):17-28. Crossref PMid:26843966 PMCid:PMC4703479
20. Kampf G, Dietze B, Große-Siestrup C, Wendt C, Martiny H. Microbicidal activity of a new silver-containing polymer, SPI-ARGENT II. Antimicrobial Agents and Chemotherapy. 1998; 42(9):2440-2. PMid:9736580 PMCid:PMC105850
21. Fang N, Lee H, Sun C, Zhang X. Sub-diffraction-limited optical imaging with a silver superlens. Science. 2005; 308:534-7. Crossref PMid:15845849
22. Sun Y, Gates B, Mayers B, Xia Y. Crystalline Silver Nanowires by Soft Solution Processing. Nano Letter. 2002; 2(2):165-8. Crossref
23. Pumera M. Graphene in bio sensing. Materials Today. 2011; 14(8):308-15. Crossref
24. Gubin SP. Metal containing nano-particles within polymeric matrices: Preparation, structure, and properties. Colloids Surface A. 2002; 202:155-63. Crossref
25. Alsharaeh EH. Polystyrene-poly(methyl methacrylate) silver nanocomposites: Significant modification of the

thermal and electrical properties by microwave irradiation. Materials (Basel). 2016; 9(6):1-458. Crossref PMid:28773585 PMCid:PMC5456822

26. Calixto G, Bernegossi J, de Freitas L, Fontana C, Chorilli M. Nanotechnology-Based Drug Delivery Systems for Photodynamic Therapy of Cancer: A Review. Molecules. 2016; 21(3):1-342. Crossref PMid:26978341
27. Abdelsayed V, Alsharaeh E, El-Shall MS. Catalyzed radical polymerization of styrene vapor on nanoparticle surfaces and the incorporation of metal and metal oxide nanoparticles within polystyrene polymers. Journal of Physical Chemistry A. 2006; 110(39):19100-3. Crossref PMid:17004754
28. Alsharaeh EH, Othman AA, Aldosari MA. Microwave irradiation effect on the dispersion and thermal stability of RGO nanosheets within a polystyrene matrix. Materials (Basel). 2014; 7(7):5212-24. Crossref PMid:28788126 PMCid:PMC5455820
29. Agam MA and Guo Q. "Electron Beam Modification of Polymer Nanospheres". Journal of Nanoscience and Nanotechnology. 2007; 7(10):3615-9. Crossref PMid:18330181
30. Bajpai GK, Choubey J. Design of gelatin nanoparticles as swelling controlled delivery system for chloroquine phosphate. Journal of Materials Science: Materials in Medicine. 2006; 17:345-58. Crossref PMid:16617413
31. Ochubiojo M, Chinwude I, Ibanga E, Ifianyi S. Nanotechnology in Drug Delivery. Recent Advances in Novel Drug Carrier Systems. 2012. Crossref
32. Lee CC, Gillies ER, Fox ME, Guillaudeu SJ, Frechet JM, Dy EE, Szoka FC. A single dose of doxorubicin-functionalized bow-tie dendrimer cures mice bearing C-26 colon carcinomas. Proceedings of the National Academy of Sciences of the United States of America. 2006; 103:16649-54. Crossref PMid:17075050 PMCid:PMC1636509
33. Mahajan SD, Roy I, Xu G, Yong K-T, Ding H, Aalinkeel R. Enhancing the delivery of antiretroviral drug "Saquinavir" across the blood brain barrier using nano particles. Current HIV Research. 2010; 8(5):396-404. Crossref PMid: 20426757 PMCid:PMC2904057
34. Dutta T, Jain NK. Targeting potential and anti-HIV activity of lamivudine loaded mannosylated poly(propyleneimine) dendrimer. Biochimica et Biophysica Acta. 2007; 1770(4): 681-6. Crossref PMid:17276009
35. Pandey PP. Preparation and Characterization of Subsurface Silver Particulate Films on Polymer Blends of Polystyrene/ Poly(2-vinylpyridine)/Poly(vinylpyrollidone)/Poly (4-vinylpyridine). Soft Nanoscience Letter. 2015; 5 (1):3-11.
36. Khalil KA, Fouad H, Elsarnagawy T, Almajhdi FN. Preparation and characterization of electro spun PLGA/ silver composite nanofibers for biomedical applications. International Journal of Electrochemical Science. 2013; 8:3483-93.
37. Gubin SP. et al. "Molecular clusters as building blocks for nanoelectronics: The first demonstration of a cluster single-electron tunnelling transistor at room temperature". Nanotechnology. 2002; 13(2):185-94. Crossref
38. Abou El-Nour KMM, Eftaiha A, Al-Warthan A and Ammar RAA. "Synthesis and applications of silver nanoparticles". Arabian Journal of Chemistry. 2010; 3(3):135-40. Crossref
39. Drever RWP. et al. "Laser phase and frequency stabilization using an optical resonator". Applied Physics B. 1983; 31(2):97-105. Crossref
40. Korbekandi H, Iravani S. Silver nanoparticles, the delivery of nano particles. Hashim Abbass A. In Technical. 2012; p. 1-23. PMid:23181084 PMCid:PMC3501903
41. Gopi S, Amalraj A. Effective Drug Delivery System of Biopolymers Based On Nanomaterials and Hydrogels - A Review. Drug Designing: Open Access. 2016; 5(2):1-7. Crossref
42. Garcia-Gonzalez CA, Alnaief M, Smirnova I. Polysaccharide-based aerogels - Promising biodegradable carriers for drug delivery systems. Carbohydrate Polymers. 2011; 86(4):1425-38. Crossref
43. Zhang Y, Chan HF, Leong KW. Advanced materials and processing for drug delivery: the past and the future. Advanced Drug Delivery Reviews. 2013; 65:104-20. Crossref PMid:23088863 PMCid:PMC3565095
44. Yabagi JA, Kimpa MI, Muhammad MN, Nayan N, Embong Z and Agam MA. "Nanofabrication Process by Reactive Ion Etching of Polystyrene Nanosphere on Silicon Surface". 2017; 9(3):145-53.
45. Umeyor C, Kenechukwu F, Uronnachi E, Chime S, Reginald-Opara J, Attama A. Recent advances in particulate anti-malarial drug delivery systems: A review. International Journal Drug Delivery. 2013; 5(1):1-14.
46. Nikalje AP. Nanotechnology and its Applications in Medicine. Medicinal Chemistry (Los Angeles). 2015; 5(2):81-9. Crossref
47. Chan WCW, Nie S. Quantum Dot Bioconjugates for Ultrasensitive No isotopic Detection. American Association for the Advancement of Science Stable URL. 1998; 281(5385):2016-8. Crossref
48. Mustafa MK, Nabok A, Parkinson D, Tothill IE, Salam F and Tsargorodskaya A. "Detection of ??-amyloid peptide (1-16) and amyloid precursor protein (APP770) using spectroscopic ellipsometry and QCM techniques: A step forward towards Alzheimers disease diagnostics". Biosensors and Bioelectronics. 2010; 26(4):1332-6. Crossref PMid:20692146
49. Vaseashta A, Dimova-Malinovska D. Nanostructured and nanoscale devices, sensors and detectors. Science and

Technology of Advanced Materials. 2005; 6(3-4):312-8. Crossref

50. Roy K, Mao HQ, Huang SK, Leong KW. Oral gene delivery with chatoyant-DNA nanoparticles generates immunologic protection in a murine model of peanut allergy. Nature Medicine. 1999; 5(4):387-91. Crossref PMid:10202926
51. Crystals NCH, Sachlos E, Phil D, Gotora D, Czernuszka JANT. Collagen Scaffolds Reinforced with Bio mimetic Composite. Tissue Engineering. 2006; 12(9):2479-87.
52. Xu ZP, Zeng QH, Lu GQ, Yu AB. Inorganic nanoparticles as carriers for efficient cellular delivery. Chemical Engineering Science. 2006; 61(3):1027-40. Crossref
53. Farokhzad OC. Targeted nanoparticle-aptamer bioconjugates for cancer chemotherapy in vivo. Proceedings of the National Academy of Sciences of the United States of America. 2006; 103(16):6315-20. Crossref PMid:16606824 PMCid:PMC1458875
54. Abadi MFD, Mehrabian S, Asghari B, Namvar AE, Ezzatifar F, Lari AR. Silver nanoparticles as active ingredient used for alcohol-free mouthwash. GMS Hygiene and Infection Control. 2013; 8(1). PMid:23967391 PMCid: PMC3746608
55. Sondi I, Salopek-Sondi B. Silver nanoparticles as antimicrobial agent: A case study on E. coli as a model for Gram-negative bacteria. Journal Colloid Interface Science. 2004; 275(1):177-82. Crossref PMid:15158396
56. Baker C, Pradhan A, Pakstis L, Pochan D, Shah SI. Synthesis and Antibacterial Properties of Silver Nano particles. Journal Nanoscience Nanotechnology. 2005; 5(2):244-9. Crossref PMid:15853142
57. Ma A. Evaluation of antibacterial activity of silver nanoparticles against MSSA and MRSA on isolates from skin infections. Research Artic Biological Medical. 2011; 3(2): 141-6.
58. Ruden S, Hilpert K, Berditsch M, Wadhwani P, Ulrich AS. Synergistic interaction between silver nanoparticles and membrane-permeabilizing antimicrobial peptides. Antimicrobial Agents and Chemotherapy. 2009; 53(8):3538-40. Crossref PMid:19528287 PMCid:PMC2715642
59. Jain P, Pradeep T. Potential of silver nanoparticle-coated polyurethane foam as an antibacterial water filter. Biotechnology Bioengineering. 2005; 90(1):59-63. Crossref PMid:15723325
60. Li Y, Leung P, Yao L, Song QW, Newton E. Antimicrobial effect of surgical masks coated with nano particles. Journal of Hospital Infection. 2006; 62(1):58-63. Crossref PMid:16099072
61. Shrivastava S, Bera T, Roy A, Singh G, Ramachandrarao P, Dash D. Characterization of enhanced antibacterial effects of novel silver nano particles. Nanotechnology. 2007; 18(22):1-10. Crossref