ISSN 2321 3361 © 2018 IJESC

Research Article Volume 8 Issue No.11

A Review to Silver, Carbon and Silver-Carbon Nanoparticle Composites and their Application

Cristobal, Raymond D [1], Bernardo, Freymar Dave M[2], Manalo Rowell R[3], Dizon, Rogelio.[4], Cambiador, Christian Jay B.[5]
BS Chemistry Student[1, 2, 3], Physicist and Professor[4], Chemist and Professor[5]
San Roque, Navotas City Metro Manila, 1485 Philppines[1]
Tondo, Manila City, Philippines[2], Rodriguez, Rizal City Philippines[3]
Bocaue, Bulacan City Philippines[4], Tanay, Rizal City, Philippines[5]

Abstract:
The increasing interest to carbon and silver nanotechnology and its various applications nowadays caught the attention of many researchers. The common size known for nanoparticles were from 1 nm to 100nm.Due to its high demand of application, many methods were established to produce a large amount of it at the same time not sacrificing the qualities, but some negative feed backs were drawn along the way of synthesis. This challenge boosts the interest of researchers to promote a more ecofriendly (Green Chemistry Route) way of synthesis of nanoparticles compared to the present ones that can also potentially used in various fields of its application. In this review the reviewer`s evaluate each method and found out that green chemistry and biological route synthesis gets the initiative of being eco-friendly, costly effective and industrially applicable and at the same time holding the core quality of synthesized CNP`s, AgNp`s and Ag-CNP`s composite. Furthermore, the resulting difference of the methods leads to the new potentials, uses and application of carbon, silver and silver-carbon nanoparticle composites. In this text review, the focus is about the mechanism, synthesis, application including their advantages and disadvantages of carbon, silver and silver carbon nanoparticles composite. Furthermore, the reviewers included their own method of synthesis and its application.

Keywords: Ag-CNp`s Composite, CNP`s, AgNP`s, Green Chemistry Route, Silver-Carbon Nanoparticles composite

I. Introduction

The increasing needs of solution to various problems in the society such as; renewable energy, water pollution, air pollution and medicine call out the Nanotechnology [42]. Nanoparticles as one of the materials used in nanotechnology caught up the attention of the researchers because of its various and unique properties that exceeds physical limitations of bulk materials [22]. Silver and carbon as one of the nanoparticles studied for the past years, discovered to have wide application including electronics, medicine [7], water disinfectant, air pollution, chemical sensors [18], [42] and as antibacterial agent [5]. However, the physical limitation of carbon and silver nanoparticles is still present such as; the oxidation of carbon nanoparticles with oxygen which degrades it structure and hence produce inefficiency to its application, the optical property of silver and carbon nanoparticle, the chemical sensitivity of both silver and carbon, antibacterial property of silver, bioimaging property of carbon quantum dots and many others [44]; to combat these problem scientists developed composites of it called silver-carbon nanoparticles. In line with these, various methods were developed such as; adsorption [14], adsorption: ultrasonication [35], adsorption: coating [41], spray pyrolysis [8], nucleation-adhesion [42] and many others. Today, most of the methods design was pro-environment for the reason that the previous existing methods produce harmful effects to the environment.
The objective of this journal review is to clearly navigate the synthesis, mechanism and application to various fields of silver, carbon and silver-carbon nanoparticles composite which can also help the reviewer`s study. In line with the objectives, the next section of the paper is designed to easily understand the vast knowledge of silver-carbon nanoparticles.

I.1 Nanotechnology and Nanoparticles

Nanotechnology deals with the maximize development of the structural features of the molecule that produce different properties compare to bulk materials [22]. This technology concerned with the molecular size of 1 to 100nm [1]. The nanotechnology breakthrough the physical limitations of bulk materials because of the superior control to molecular and atomic scale [2]. In the 21st century, the age of nanotechnology was renowned and caught the attention of many researchers around the world because of its unique feature combing different disciplines such as; chemistry, physics, materials, engineering and biology [3]. Together with information technology and biotechnology, nanotechnology continuously grow and far beyond developed to build up a materials or devices that is more efficient comparing to existing ones. With regards to nanotechnology, the word nanoparticles are always associated. Nanoparticles is the material used in nanotechnology, these materials show different properties that is well specific, this material are divided into two common characterization; nanoparticles, nanocrystal or nanolayer level. For the thousand years have passed, nanotechnology is never realized existed and synthesized, for example a long time known synthesized carbon black is a nanoparticle [2]. In addition, Roman masterpiece that is existed for four centuries, which known as the Lycurgus Cup, exhibit eerie dichroism. The cup appearing to be green during light reflection and red at light transmission. The phenomena are said to happen because of the nanoparticles suspended in it [3]. Since then, the gradual progresses of nanotechnology persist and until today the nanotechnology make itself to the mainstream of science and technology.

I.1.1 Carbon Nanoparticles

Carbon nanoparticles existed for the past thousand years that did not notice by our early ancestors. The material is said to be present in the smoke and soot that is traces of their campfires which are commonly known as fullerenes and carbon nanotubes [13]. The materials contained with nanoparticles was used in art and found in different bodies of rock. The carbon nanoparticles were later characterized based on different sizes such as carbon nanoparticles "CNP`s" (100nm) [22]., carbon nanotubes "CNT`s" (1-10nm) [14] and carbon nanodots "CND`s (10-30nm) [44] which are later developed to produce various derivative of the characters of carbon nanoparticles, along with these derivatives including multi-walled carbon nanotubes "MWCNT`s" and carbon quantum dots "CQD`s". Carbon nanoparticles associated to vast applications; electronics, biomedicine, sensors, water disinfectant and many others [44]. With these, arising methods of synthesis are developed such as, laser ablation, adsorption, green chemistry route, pyrolysis and many others. The various potentials of carbon nanoparticles push it to new studies to develop new applications of it.

I.1.2 Silver Nanoparticles and its Composite

The discovery of nanotechnology is first termed by Mr. R. Feynman in his lecture in American Physical Society "There is a lot of space down there" that makes sense in the idea of creating possible nano sized products in the use of atom as building particle of nanomaterials. At year goes by, nanotechnology is introduced in 1974 in scientific world by N. Tanaguchi at the international conference in Tokyo. In order to recognize to the world, the processing of innovative materials from nanoparticles were continually developed [28].

This nanotechnology would pass from generation to another generation, since ancient times they were able to cultivate some natural fabrics such as: cotton, flax, wool, and silk. Then, they processed it into a product. According to them, they knew that natural fabrics possessed typical nanoporous materials [28]. The idea of using nanomaterials was already used by our ancestors in ancient time.

The development of nanotechnology starts when a number of discoveries and inventions were made that gives impact in the growing modern technology. Many inventions from nanomaterial's like silver nanoparticles made a lot of exponential growth and applications. In different fields silver nanoparticles creates an innovative material or application of sensors, optical probes, catalysts, electrical conductivity and anti-bacterial agents. Silver nanoparticles also compatible in different nanoparticles that make a new product or composite with more new uses and more efficient inventions. Here in nanotechnology, even a smallest thing nanoparticle could bring more efficient scientific result in different application due on the unique nano-properties that the possessed.

There are many ways and resources of synthesizing carbon and silver nanoparticles in different properties and specifications. Nano-objects can be classified in three categories, depending on their size and shape characteristics [6]

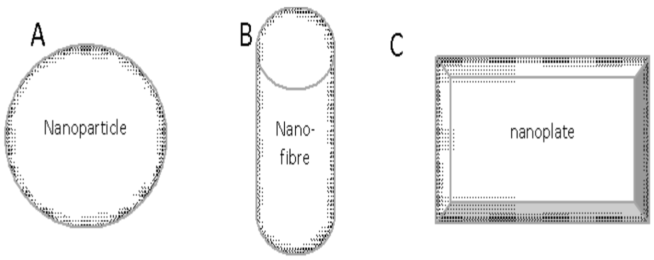


FIGURE 1 SCHEMATIC DIAGRAMS DISPLAYING SHAPE DESIGNATIONS FOR NANO-OBJECTS
(A) Nanoparticle, (B) Nanofiber (C) Nanoplate. This adapted from ISO 80004-2:20015 with permission from the American Standard Institute (ANSI) on behalf of ISO.

Nanoparticle (NP) is a type of nano-object with the external dimension that is the longest and shortest axes is insignificantly different (figure 1 A). Nanofiber is a type of nano-object with the two external dimensions is almost equal and the third dimension is significantly larger (figure 1 B). While, nanoplate (figure 1 C) who`s one external dimension is in nanoscale and the two dimensions are significantly equal and larger [6].

There are different approaches in synthesizing nanoparticles, including physical and chemical methods such as; adsorption, chemical ablation, green route chemistry, occlusion and many others. The physicochemical properties of nanoparticles are very important for their behavior and efficacy. Furthermore, it evaluates the functional aspects and the synthesizing particles in different resources. The silver nanoparticle and carbon nanotubes (CNT) based nanocomposites are characterized using a variety of analytical techniques, including UV-vis spectroscopy, X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), Dynamic light scattering (DLS), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), and atomic force microscopy (AFM) [37], [42].These analytical techniques are qualified in characterizing different king of nanoparticles. In the subsequent section this variety of some characterization are going to explain in detailed.

I.1.3 Nano science in Action: Silver and Carbon Nanoparticles

For many years' nanotechnology is remain established and continually grow and develop. Because of the compatibility and offers a lot of valuable applications that is eco-friendliness.

Many of the researchers caught their attention, because of the body benign or having an extensive application of the silver nanoparticles, new technologies in the areas of material sciences, electronics, and medicine arised by the used of nanotechnology [34], [39]. Silver nanoparticles have a lot of important application that is vital to humans and productive in the field of science. For example, as spectrally selective coating for solar energy adsorption, interpolation material for electrical batteries, it might be used as an optical receptor, as catalysts in chemical reactions and as an antimicrobial [34]-[35], [37].

In 1980's, the discovery of carbon nanoparticle (NP) is considered as one of the valuable discoveries of the last century. Further development shows more valuable practical application. Some important application of nanomaterials is food packaging, medical devices, pharmaceuticals, cosmetics, odor-resistant textiles and house appliances [40]. In addition, even small carbon nanoparticles can made superior biological properties in such a way that this would be low toxicity and good compatibility for potential applications in biosensor, bioimaging, and biomolecule/drug delivery [43].

As the introduction, discover and application of carbon, silver and silver-carbon nanoparticle composites is briefly stated, the next section will be more specific specially to mechanism underlaying to the synthesis of carbon, silver and silver-carbon nanoparticle composites.

II. Silver, Carbon and Silver-Carbon Nanoparticle Composites Mechanism and Synthesis

II.1 General reaction of Silver Nanoparticles

Various of methods are developed to produce certain kind of silver nanoparticle that range to 1 to 100nm in size [27]. In this review, both green and chemical synthesis of silver nanoparticle is featured and its mechanisms.

Silver Nanoparticle (AgNP)
Most of metal ions and metal oxides followed this mechanism,

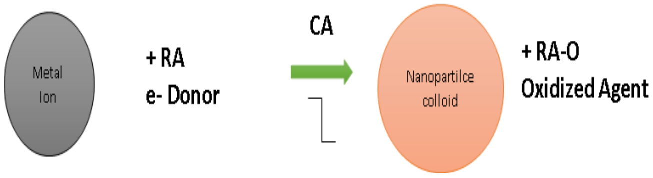


FIGURE 2 GENERAL MECHANISM OF METAL ION SOLUTION TO FORM NANOPARTICLES. Adapted from (German et al., 2011). The simplified reaction of metal ion with reducing agents (RA) and capping agent (CA) to form nanoparticle (colloid).

Any metal ion or metal oxide ion with the reaction to electron donor (RA) and capping agent (CA) will form nanoparticle colloid regardless of the procedure as figure 2 shows, but the character of the nanoparticle form is different from one another. The most commonly used as RA and CA are Sodium borohydride, citrate and ascorbate [10], as of today the reducing and capping agents are not only limited to synthetic chemical reducing agents, the development of new methods such as; electro chemical techniques, photochemical reactions in reverse micelles, and today`s trend via green chemistry synthesis [30] used variety of chemical reducing agents which is less harm to environment and hence, promotes eco-friendliness.

II.1.1 Brust – Schiffrin Method

One of the well-known Metal ion nanoparticle synthesis is Brust – Schiffrin Method; in this method the used of synthesized reducing agents such as sodium borohydride and thiol functionalized compound are used as reducing agents and further mechanism is performed such as nucleation, particle growth and capping [33].

The metal ions for example gold in the figure shows how it is reduced with thiol compound followed by sodium borohydride. The natural mechanism of ions is then followed to form nucleus by nucleation and then particle growth to form visible solids and finally capping for the nanoparticle stability. This procedure based on studies produce high efficiency but depicts from one ideality; eco-friendliness.

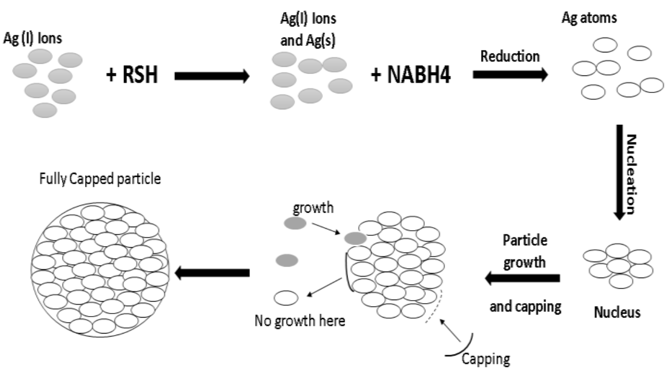


FIGURE 3 SCHEMATIC REPRESENTATION OF OVERALL BRUST – SCHIFFRIN METHOD. Adapted from [33]. From left to right, the reduction of metal ions (eg., silver) with thiol compounds to produce various ionic species, further reduction with sodium borohydride to form metal atoms and promptly followed by nucleation. Bottom left to right, the Nucleus formed by nucleation is undergoes particle growth and capping.

II.1.2 Green Synthesis of Silver nanoparticle (AgNP) mechanism

As the stated mechanism in the figure 2 there are two important chemicals is needed in order to proceed in the reaction and formation nanoparticle; one is the reducing agents, and the other is capping agents. The two chemical requirements are responsible for reduction and stability of silver and its nanoparticle [10]. Plant extracts, nowadays caught the attention of the researchers for green synthesis of metal nanoparticles. Plant extracts contains potential reducing agents and capping agents such as; phenolic compounds, nitrogen compounds, vitamins, reducing sugar, terpenoids and some other metabolites [23]. These compounds are candidates for reducing and capping of silver and its nanoparticles respectively.

The sugar compound of the plant undergoes internal conversion to form an open chain that contains aldehyde functional group and serves as reducing agent to reduced silver nanoparticle and further, capping with sugar for its stability [10].

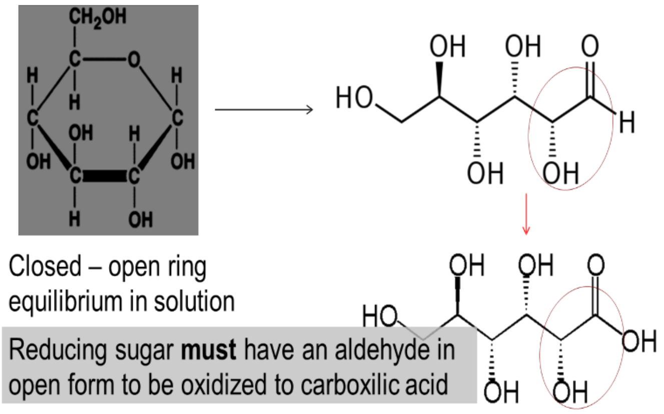


FIGURE 4 REDUCING SUGAR. Adapted from [10]. On the right shows the internal conversion of sugar to form an aldehyde functional group.

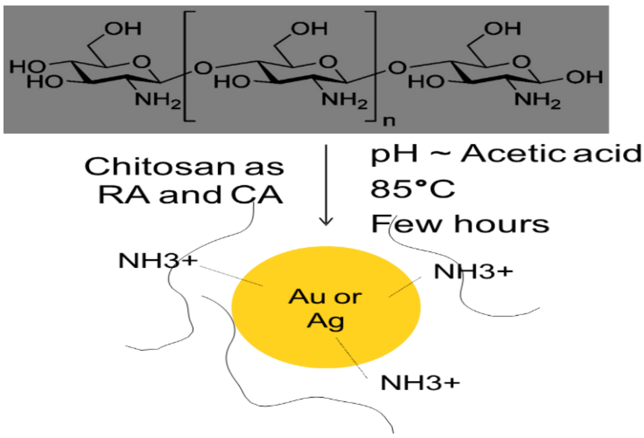


FIGURE 5 CHITOSAN AS REDUCING AND CAPPING AGENT OF SILVER OR GOLD NANOPARTICLES. Adapted from [10]. The figure shows chitosan terminates its bond to reduce and form complexation (as capping) with Gold or Silver nanoparticles.

The nitrogenous base compound together with sugar in plants also plays RA and CA roles for it to be qualified to form nanoparticles. As showed in the *Figure* the interconversion, bond termination and complexation of sugar and nitrogenous based compound example Chitosan [10].

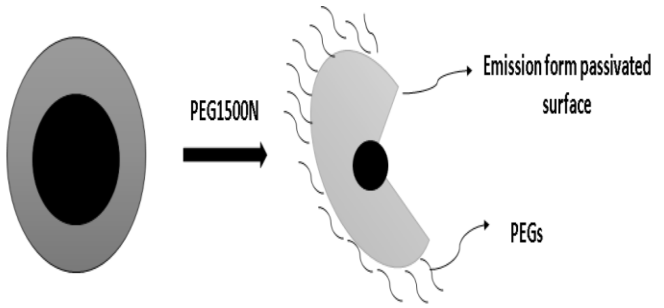
Hence, by upholding the conditions the synthesis of metal nanoparticles especially the silver nanoparticles regardless of the reducing agents, capping agents and methods will result silver nanoparticle; but with different characteristics. Furthermore, in performing different methods the certain parameters must be observed such as; temperature, pH, absorption capacity and etc. [23].

II.2. Carbon Nanoparticle Synthesis Mechanisms

Unlike metal ion nanoparticles, the reaction mechanism of carbon nanoparticles differs for every method its undergoes [29]. The importance of understanding some commonly known way of synthesizing carbon nanoparticles is featured in this review.

II.2.1 Laser ablation

Carbon dots sparingly range from 1 to 10nm in size [35], [37], commonly the synthesis of carbon dots was performed by laser ablation [16]. Laser ablation, were commonly used to produce inorganic species which can form nanoparticles by means of laser beam. Laser beam carries high energy that



make ablation or removal of particulates from the prospect substance; and these removed particulates shows nanoscale dimensions.

FIGURE 6 FUNCTIONALIZATION OF CQD SURFACE WITH (PEG). Surface passivation is required to make the Carbon-Dots luminescent. Adapted from [16].

Carbon dots from laser ablation do not fluoresce, but this nanoparticle can be level up to form quantum carbon dots with the help of polyethylene glycol (PEG) by means of surface functionalization this process is called passivation as depicted by figure. The main idea of the passivation is that, the adhesion to the surface of carbon dots to PEG helps to produce “surface defects” and results to discrete absorption of light, thus, produce photoluminescence carbon dots [29].

II.2.2 Electrochemistry

Other than laser ablation, carbon nanoparticles can also obtain through electro chemistry, the reduction and oxidation concepts of graphene is employing. Ionic liquids such as “imidazolium ion “are commonly used in this process in which it serves as electron acceptor and free radical that exfoliate carbon particles in the graphene sheets.

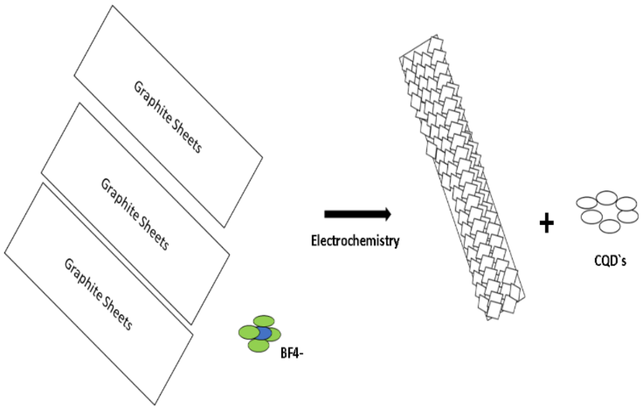


FIGURE 7 PRODUCTION OF CQD`S THROUGH EXFOLIATION OF GRAPHITE IN IONIC LIQUIDS. An illustration of the proposed mechanism: the ions (originated from the ionic liquid) penetrate between the graphite sheets, generating carbon nanotubes and Carbon-Dots. Adapted from [14].

As the figure depicted, the ions from ionic liquid penetrates the graphene surface and produce some carbon nanotubes and nanodots which are both part of carbon nanoparticles. Penetration is possible due role of ionic liquid to accept electron form the anode in the electrochemical cell. However, this procedure needs purification, if for example you only want carbon nanotubes (CNT`s) you need to separate it to carbon nanodots (CND`s) [14].

II.2.3 Pyrolysis

Compare to two mechanisms above which is mostly one step or much simple, pyrolysis is quite complex. The use of polymer composites with silica and carbon matrix is subjected to carbonization.
The silica composites are first undergone to resols to make a resin, and then subjected to pyrolysis and polymerization in this step the composite of carbon and silica is form, due to surface adhesion of silica the carbon remains in the surface. Further treatment, like etching of C/SiO2 composites removes the carbon dots that adhere in the surface of the composite and this nanoparticle do not fluoresce. As discuss in laser ablation to produce photoluminescent carbon passivation and oxidation is occurred [42]. Though this procedure is quite specific the multiple steps of the process may first the purity and second the carbon character. Furthermore, the procedure requires great laboratory skills and proficiency.

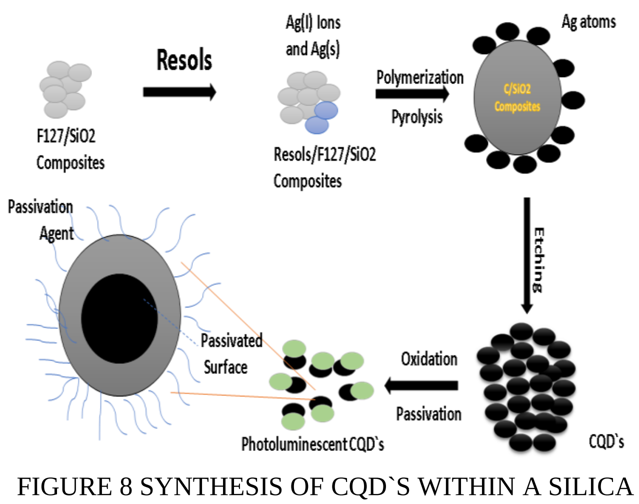


FIGURE 8 SYNTHESIS OF CQD`S WITHIN A SILICA MATRIX. Adapted from John Wiley & Sons (2009) cited from [42]. From left to right, the silica composites undergo

Resols to produce resins then pyrolysis and polymerization to produce C/SiO2 composite. Downward, is etching to remove carbon dots in the surface of the composite. Bottom left to right, is the passivation to produce photoluminescent carbon dots.

II.2.4 Carbon oxidation: Acids

This procedure requires same mechanism with laser ablation when it comes to passivation but differ in harnessing carbon nanoparticles. The mechanism involves strong oxidation of acids to activated carbon that pushes it to produce carbon nanoparticle as dots and then passivate to produce photoluminescent carbon.

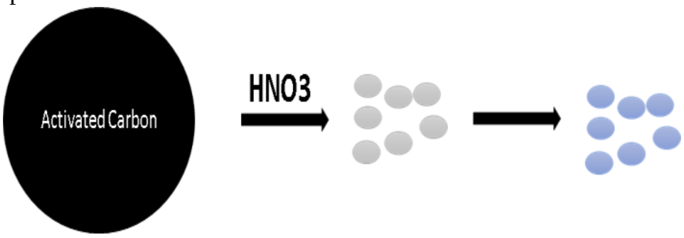


FIGURE 9 SYNTHESIS OF CQD`S FROM ACTIVATED CARBON. Adapted from [10]. From left to right, activated carbon washed with strong acid (eg., nitric acid) to produce carbon nanoparticles (as dots) the passivation to produce photoluminescent carbon.

The process skips the pyrolysis to achieve activated carbon, it assumes that activated carbon is purchased and process to nitric acid for oxidation to produce carbon dots and passivation to produce photoluminescent carbon [10].

II.2.5 Sulfur Doped Carbon Nanoparticles

Compared to other procedure mechanism this is one of the simplest. For it involves single step and common chemicals, concentrated sulfuric acid and the sample that contain carbon (eg., sugars). In this mechanism the strong capacity of sulfuric acid to fully hydrolyze the sugar and produce sulfur doped carbon nanoparticles.

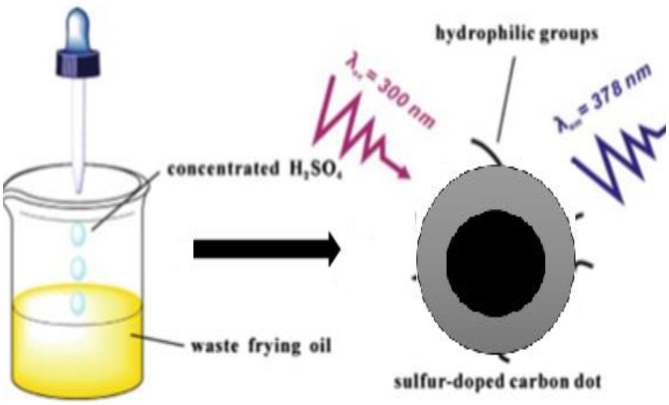


FIGURE 10 PREPARATION OF SULFUR-DOPED CQD`S FROM WASTE FRYING OIL. Adapted from [12]. From left to right, the beaker containing waste frying oil is heated around 100°C for five minutes while adding drops of sulfuric acid to produce sulfur-doped carbon nanoparticle as dot.

The strong capacity of concentrated sulfuric acid to hydrolyze the waste frying oils enables the process to produce sulfur-doped carbon dot. Though the process is quite simple, it produces more aggregate composite of sulfur and carbon, and hence larger surface are, but with these the excess sulfate ions may trap inside the surface of the carbon nanoparticles synthesized and hence may hinder the adsorption capacity of the synthesized carbon nanoparticles.

II.3 Silver-Carbon Nanoparticle Composites Synthesis Mechanism

As we have viewed the synthesis of carbon and silver separately to form nanoparticles, the researchers try to make a composite for better application and purposes. Carbon nanoparticles have larger surface area and adsorption capacity compare to silver nanoparticles. This reason why in the *figure* shows that silver nanoparticles ions are adsorb or adhere in the surface of the carbon nanoparticles. Plus, the large surface is of the carbon make it feasible with capping for more stable nanoparticle composites [18].

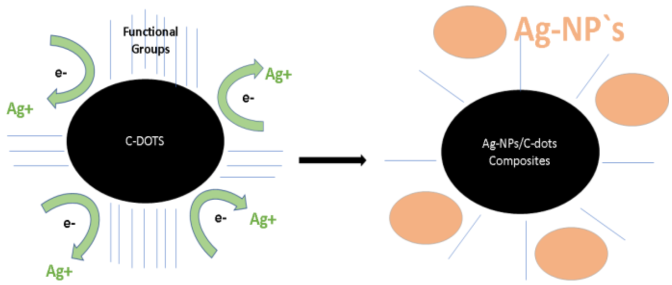


FIGURE 11 SCHEMATIC REPRESENTATION OF SILVER-CARBON NANOPARTICLE COMPOSITES. Adapted from (Shen et., al 2013). From left to right, the Carbon nanoparticle as dots is undergo to adsorption and heated with 50°C in 5 mins to produce Silver-Carbon nanoparticle composites.

Other methods involve carbon nanoparticles coating to silver to produce composite [42], silver-carbon nanoparticle composite by reduction in aqueous solution [41], silver nanoparticle decorated with carbon nanotubes to form composites and any other methods existing used the concept of adsorption capacity and large surface are of carbon nanoparticle to form composites.

As the fundamental reaction mechanism are discus in this review text section, the next part of the paper will talk about first the silver nanoparticles, then the carbon nanoparticles and Silver-Carbon Nanoparticle Composites. Furthermore, it focuses on the present methods for synthesizing silver and carbon nanoparticles and their composites; and comparison of each methods including our method used in the study and their advantages and disadvantages.

II. 4 Various Methodological Synthesis of Silver, Carbon and Silver-Carbon Nanoparticle Composites

II.4.1 Silver Nanoparticles Synthesis

Green synthesis of silver nanoparticles using white sugar [27]

Materials

All materials except white sugar used in the experiment were analytical grade. The chemicals were mostly purchased in Hi-Media, Mumbai, India and from market in Camp, Amaravati, Maharashtra State, India. All the preparations used double-distilled water as solvent.

Synthesis of AgNP`s

For the synthesis of AgNP`s, the 50mL of 0.5% of sugar solution was mixed with 25mL of 1mM silver nitrate in 250mL conical flask and mixed vigorously. After sometime, gradual addition of 1mL of 0.1M NaOH were added in the flask and continuously mixed. The resulting solution were

kept for 10mins in the sunlight and the color changed observed.
The synthesis used is quite ideal for it simply because its green route, the use of sugar as a reducing agent makes it more ecofriendly. Also, the time it takes to form the nanoparticle is really fast for it became ideal to use in industry. The potential drawback of this method is the total harnessed silver nanoparticle from the silver nitrate solution, the character of nanoparticle, the activation of nanoparticle if the sugar does not interconvert to open chain to form aldehyde functional group as showed in the figure.

Synthesis of Silver Nanoparticles using Leaf Extract of Andrographis paniculate [34]

Materials
Common materials in the laboratory were used in the experiment except for Andrographis paniculate were picked October to December 2011, from the campus of Rajah Serfoji Govt. College in Thanjavur (DT) Tamil Nadu.

Preparation of the Extract
The collected Andrographis paniculate were prepare for the aqueous extract that will used in the experiment. For this experiment work, the leaf weighed 25g were washed thoroughly with distilled water, afterwards, dried and cut into fine pieces and crushed and dissolve to 100mL sterile distilled water and filtered with 0.6µm pore sized filter.

Synthesis of Silver Nanoparticles
Silver nanoparticle synthesis is simple. 10mL of extracted Andrographis paniculate were mixed with 90mL 1mM silver nitrate solution. The addition of plant extract reduced Ag^+ ion and keep at room temperature for 5hrs.
The used of green route chemistry synthesis was totally virtue here that is why the procedure is more ecofriendly compare to synthesis using white sugar. But when it comes to productivity, the process is really slow compare to the methodology of white sugar synthesis and hence, less advisable to perform industrially. On the other hand, the forwardness of the reaction to produce carbon nanoparticle as a product is not a big problem, for plants contains phenolic compounds, nitrogen compounds, vitamins, reducing sugar, terpenoids and some other metabolites (Nurul et al., 2014) which are all candidates for reducing and capping agents to proceed the reaction. The drawback of the white sugar synthesis when it comes to harnessing of silver nanoparticle from silver nitrate is address by the used of plant extract.

Biological Synthesis of Silver Nanoparticle by using Onion (Allium Cepa) Extract and their Antibacterial Activity. [5]

Materials
The materials used such as; onion (Allium Cepa), silver nitrate ($AgNO3$), E. coli, Salmonella typhimurium were purchased from market, Merck limited, India, Microbial Type Culture Collection Center (MTCC) in Institute of Microbial Technology (IMTECH), Chandigarh, India.

Synthesis of Silver Nanoparticles
The onion extract used in the experiment was prepared by weighing 25g of it, thoroughly washed with water then crush to finely pieces and dissolve with 100mL deionized water in 500mL Erlenmeyer flask. The resulted solution was subjected to heat for boiling in 10mins and finally decanting it. For the formation of silver nanoparticles, 10mL of onion extract was gradually added to 50mL of 0.1mM silver nitrate that is constantly heated with 500-600°C and then the color changed is observed.
Green chemistry plus biological route is the main advantage of this procedure, for it used an ecofriendly way of synthesis by using onion and biological way using E. Coli and Salmonella [5]. The natural synthesis of microorganism of silver nanoparticle were featured and enhanced with onion extract for further formation of silver nanoparticle. Plus, in terms of time fidelity it almost the same with green synthesis of silver nanoparticle with white sugar [27]. The potential draw back here is the ability of the experimenter to isolate and culture E. Coli and Salmonella and high proficiency in performing the experiment.

Fabrication of Hydrogen Sulfide Detector Empowered by Silver-Carbon Nanoparticle. (Reviewer`s.,2018)

Materials
The materials used in the synthesis of silver nanoparticles were, 30% (w/w) sucrose, 1 mM silver nitrate and 1 M sodium hydroxide.

Synthesis of Silver Colloidal Nanoparticles
The method we used in synthesizing the silver nanoparticle is the same with green synthesis of silver nanoparticle with white sugar but differs in the concentration of reagents and procedure. 10 mL of 1 mM silver nitrate were placed in 100mL beaker, then addition of 20 mL of 30% (w/v) sucrose. Vigorous stirring is observed, after doing so, gradually add 1 M sodium hydroxide until the clear solution turns to yellowish. Approximately 10 mins is consumed during the experiment.

II.4.2 Carbon Nanoparticles Synthesis

One-pot synthesis of carbon dots using two different acids and their respective unique photoluminescence property. [12]

Materials
For the synthesis of carbon dots using two different acids, the concentrated phosphoric and sulfuric acid were used as hydrolyzing agents, stock solution f 1 M of sucrose and sodium hydroxide as pH neutralizer.

Synthesis of Carbon Nanoparticles
Carbon dots as one of the carbon nanoparticles character, synthesized through the use of acid hydrolysis. For the experiment work, addition of 1.0 mL concentrated sulfuric acid and phosphoric acid were gradually added to a beaker containing 1.0 mL of 1M sucrose. The beaker is then covered with aluminum foil and gently homogenized before letting stand to oven for 30 mins with ambient temperature of 100°C. After these, the resulted brown solution is neutralized with sodium hydroxide (NaOH). The neutralized solution is volume up to 5.0mL using ultra-pure water and mixed thoroughly to disperse the carbon dots.
The procedure is quite simple and fast enough to perform and has a potential to apply industrially. Furthermore, the use of sucrose as a source of nanoparticle promotes eco-friendliness to the process. This is also costly effective, at the same time with higher confidence of carbon nanoparticles formation. The disadvantage of this method is that, the formation of carbon nanoparticle is much aggregated or not finely dispersed in the aqueous solution, hence it would result to larger size and

surface volume of carbon nanoparticle. In which, at some application the large size and surface volume perform drawbacks.

A green synthesis of carbon nanoparticles from honey and their use in real-time photoacoustic imaging. [20].

Materials
All the chemicals used in the study such as; honey and sorbitan, mono-9- octadecenoate poly (oxy-1,2- ethanediyl) used in the experiment were purchased from Aldrich Chemical Co. at St. Luis, MO.

Synthesis of Carbon Nanoparticles
For the synthesis of luminescent carbon nanoparticles, the (x)-sorbitan mono-9-octadecenoate poly (oxy- 1,2- ethanediyl) or polyethylene glycol was purged with argon gas and then heated in microwave oven for 30mins. The microwave is calibrated to produce 1,200 W with an output of 50%. The resulted output is visually changed from light yellow to dark brown to black. For the purification, the product is repeatedly centrifugated with water.

The method promotes green chemistry route for synthesis of carbon dots while upholding its time efficiency integrity. This kind of method is suit for industrial production and assurance of carbon nanoparticle formation. But this is cost efficient compared to the method presented above. The same drawback as above.

Growth and Stabilization of Silver Nanoparticles on Carbon Dots and Sensing Application. [18].

Materials
All the chemicals used in the study such as; chitosan, acetic acid, H2N(CH2)10C00H, citric acid, activated carbon, and NaoH are purchased from (Sinopharm Chemical Reagent Co.). The said reagents were used as it is and therefore no purification is performed.

Synthesis Carbon Nanoparticles
Carbon dots as one of carbon nanoparticles characters is derived from chitosan in the study. For the experiment work, 2g of chitosan is mixed with 18mL of 2% acetic acid in a Teflon coated stainless steel and autoclave at 180°C for about 12 hrs. After doing so, the solution is cooled to room temperature, the product produce has dark brown color and subjected to centrifuge at a high speed (1200rpm) for 25 min to separate the less-fluorescent deposit. The upper brown solution is separated by filtering with 0.22µm filter membrane. The resulting product was first neutralized with NaOH (0.45g) to get sodium 11-amino-undercanoate, and the amine groups were protonated with 2g of citric acid to form ammonium carboxylate salt. This salt is a precursor, heated with 300°C and openly oxidized with air for 2hrs with a heating rate of 10°C min-1 in a muffle oven. The crude product was extracted with 25mL hot water in sonicating bath and centrifuged to separate insoluble particles. The supernatant was collected and the pH is adjusted to 2 with HCl to result a bulk precipitate, and dissolved with 0.2g of NaOH after washing with water. The final solution has deep brown colloidal dispersion which is the carbon nanodots.
The procedure like the two above promotes green chemistry, time efficiency and industrial applicability. But this is not costly effective and simple because of its multiple steps and used of chemicals.

Fabrication of Hydrogen Sulfide Detector Empowered by Silver-Carbon Nanoparticle. (Reviewer`s.,2018)

As for the reviewer's method of synthesizing carbon nanoparticles, the concentrated sulfuric acid and 30 % (w/v) sucrose were used as reagents. The gradual addition of 30mL from 30%(w/v) sucrose to 100 mL concentration sulfuric acid in a Florence flask while it is heated and stirred by magnetic stirrer. Afterwards, the solution forms slurry precipitate and stored for 1 to 7 days. Next the slurry was wash with distilled water, 1M NaOH until the pH greater than 5 is achieved. The slurry was wash again by distilled water to flash out the sulfate ion that traps inside the slurry precipitate due to fast particle growth of the carbon nanoparticle. Finally, the solution was washed with 95% ethanol to wipe out all the organic contaminants that is occluded inside the slurry.
The concept of the procedure (as acid hydrolysis) is the same with the first method showed above, hence the drastic formation of black precipitate is also observed by the reviewers.

II.4.3 Silver-Carbon Nanoparticle Composites Synthesis

Carbon Nanotube-Silver Composite for Mercury Capture and Analysis. [14]

Materials
For the carbon nanotube-silver composite synthesis, carbon nanotubes and AgNO3 is used in the study. The study does not state where they but the chemicals.

Synthesis of Ag-CNP Nano Composite
For the experiment work, exactly 0.1mg of CNT was transfer in 20mL glass vial, and 10mL of ethanol was mixed into it. The solution is sonicated for 2hrs to finely disperse CNT in the ethanol, while waiting, the 0.1 M of AgNO3 is prepared. The suspended CNT in the ethanol is transfer to 50mL beaker and 10mL of stock AgNO3 solution is added. The beaker containing the solution is sonicated for 5 mins to allow the fine adsorption of CNT to silver particles, and the composite is vacuum filtered using glass filter press. The resulted product is oven dried in 200-240°C for 8 hrs. The resulted output is Ag-CNT composite.

Synthesis of Carbon Nanotube/Silver Nanocomposites by Ultrasonication. [36]

Materials
All the chemicals used in the study such as; silver oxide, CNT`s, ethanol, carboxylic polymeric surfactant and dodecyl amine were purchased from Wako Pure Chemical Industries, Ltd., and Kao Co., Ltd., respectively.

Synthesis of Ag-CNP Nano Composite
For the synthesis of Ag-CNT nano composite, 0.1 or 0.5g of surfactant is dissolved with 200mL ethanol, and 0.0213g of CNT`s were added to it. For fine dispersion of CNT, the solution is ultrasonicated (100W and 20kHz) for 60 mins in pulse mode. After doing so, gradual addition of 4g Ag2O is added to the solution and ultrasonicated again. The resulted output is subjected to furnace at 300°C for 60mins to produce pure Ag-CNT nano composite.

Synthesis and Characterization of Silver Nanoparticle-Multiwalled Carbon Nanotube Composites. [8]

Materials

The synthesis of silver nanoparticle-MWCNT used, MWCNT and AgNO3 as key player in the experiment. All the chemicals used in the study does not stated form it purchased.

Synthesis of Ag-CNP Nano Composite

For the experiment work, 2.3% wt of ferrocene is subjected to pyrolysis at 850°C and produce MWCNT. For silver nanoparticle decoration process, 25mg of pristine MWCNT`s were mixed in 1.0% wt of sodium dodecyl sulfate (SDS) and sonicated for one hour. The resulting suspension of MWCNT`s were subjected to Tollen`s reagent and then addition of 0.5mL formaldehyde to it with continuous stirring at 60°C for 45mins. The resulted product is subjected to centrifuge and washed with water to obtained AgNP-MWCNT.

Fabrication of Hydrogen Sulfide Detector Empowered by Silver-Carbon Nanoparticle. (Reviewer`s.,2018)

Synthesis of Ag/CNP Composite

1g/L of carbon nanoparticle were dissolved to 100mL boiling distilled water, while stirring, 20mL of 1mM silver nitrate is added to the solution and afterwards, addition of 40 mL of 30% (w/v) sucrose is added. Then gradual addition of 1M sodium hydroxide is applied until the yellow to orange colloidal precipitate is observed. The solution is stand for certain time until the carbon nanoparticle turns back to slurry precipitate. The solution is oven dried at 120 °C, the resulted dried powder is considered as Ag-CNP composite.
After common mechanisms and methods are presented, it`s discussion is featured in the next section. Afterwards, the review yields its focus to common application of carbon, silver, and silver-carbon nanoparticle composites. But, the said section deals more on the application of Silver-Carbon Nanoparticle composites.

III. Application

Carbon Quantum Dots in Biomedicine

"Fluorescence" among any other carbon nanoparticle, only CQD shows high quantum yield to promote fluorescence and was first to proposed to be a candidate for bioimaging [29]. As time goes by, present studies in CQD`s proved that the fluorescence activity of CQD`s can actually use in bioimaging [16]. Until 2012, Tao et al. experimented the mice injected with various concentration of CQD and check in fluorescence imaging with seven different wavelengths from 455 nm to 704 nm. The most vivid contrast of fluorescence is at 595 nm (figure). The figure clearly shows the potential of CQDs for bioimaging, recent studies pursue its potential to produce much detailed optical imaging as MRI does.

Carbon Quantum Dots in Chemical Sensors

Due to high absorption capacity and fluorescence activity of CQDs its application for sensing chemicals such as glucose [21], DNA [14], pH [16], Ag+ [13], H2S [13] and etc. The recent studies show the capability of FRET to detect H2S in aqueous media through reduction of the probe by H2S and exhibits absorption at 425 nm.
The change in color or the solution of CQDs indicates the presence of H2S in the aqueous media (figure). This is quantified by means of intensity ration of the two samples or by getting the absorbance of the solution.

Silver Nanoparticle in Biomedicine

Silver nanoparticle was greatly known for its antimicrobial and antifungal activity [30]. Due to its natural occurrence to some type of microorganism [5] that shows antibacterial property were caught the attention of the researchers in the past years. The usual experiment of antibacterial or antifungal property of silver nanoparticles is to plating. The colloidal silver nanoparticle is challenge with the known bacteria, the dispersion or hallo like around the colony proves the antifungal property of silver nanoparticle.

Silver Nanoparticle in Chemical Sensors

Like carbon nanoparticles, silver has also promising absorption capacity, optical activity and selectivity for it to use as chemical sensor. Nguyen et al. study the ability of silver nanoparticle based colorimetric sensor for hydrogen peroxide and glucose.
The oxidation of Silver nanoparticle with hydrogen peroxide makes the composite of AgNP-GQDs to form new optical activity and result to new absorbance at certain wavelength. Furthermore, this absorbance was used to quantify the glucose present in the certain sample.

Silver-Carbon Nanoparticles in Chemical Sensors

Bothe Silver and Carbon nanoparticles show vast potential as chemical sensor [24], [44]. The factors limiting the capabilities of each nanoparticles was answered by nanotech composite. More methods were stablished to produce a more stable composite that can challenge the limiting factors of silver and carbon nanoparticles such as; pH, temperature, presence of other elements or compounds [26].
Karadas et al., in 2013 study the Functionalized carbon nanotubes – With Silver nanoparticles to fabricate a sensor for the determination of zolmitriptan in its dosage forms and biological samples. In their study, the adsorption of carbon nanoparticle to zolmitriptan were quantified by its potential difference. The potential difference of composite and the composite that adsorbs zolmitriptan were compared to see how significant the potential change and set is as standard.

Silver-Carbon Nanoparticles in Water Disinfection

The antibacterial property of silver particles was commonly present in its study. But the extent of its antibacterial capability is enhanced with the used of carbon nanoparticles [21]. Carbon nanoparticle, with its high adsorption capacity and large surface area, enable it to lock up enough the bacteria present in the water. Combing the two nanoparticles make it feasible for removal of bacteria. The figure below shows the TEM of Ag-CNP decorated with pyrrole, the image simply shows how the structure from visible perspective enables the composite to cater the bacteria in its surface.

Silver-Carbon Nanoparticle Composites in Bioengineering

The modification of cells and drugs are essential in medicine, the use of silver-carbon nanoparticle composite used as carrier or input in cells for better delivery or active killing of foreign cells [40]. Also because of the optical activity and fluorescence capability of both carbon and silver makes it capable to identification of calf thymus DNA [17]. The phenomena happened due to injecting of Ag-CNP`s composite to the DNA and see its fluorescence activity with fluorometer or any other devices related to it. Bioengineered cells with Ag-CNP composite makes it to inhibit inferno gamma activity and tumor necrosis factor alpha, this phenomenon cause anti-inflammatory effect in the mouse [46].

We have seen from part of this section the mechanisms, synthesis and applications of silver, carbon and silver-carbon nanoparticles composite. In the final chapter of the paper the reviewers present the summary, results and discussion in accordance to three categories: ecofriendly, industrially applicable and cost efficiency. Furthermore, there advantages and disadvantages are tackled.

IV. Results and Discussion

IV. 1 Silver Nanoparticle Synthesis

Some methods of silver nanoparticle synthesis are presented in this review, for the quick comparison the reviewers formulate a table that shows their findings in this review.

The table1 below does not really reflect for the wholesomeness of each methods; however, the reviewers only judge the methods in accordance to the understanding of the reviewers to the journals they have reviewed, the criteria of judging are based on its eco-friendliness, industrial application and cost efficiency which are timely requirements for synthesis nowadays.

Table 1 Comparison of Silver Nanoparticles Synthesis Based on three factors: Eco-friendliness, industrially applicable, and cost efficient.

Concept of synthesis	Ecofriendly	Industrially Applicable	Cost Efficient	Author/Reference
Green Chemistry Route RA-Sugar	Yes	Yes	Yes	Meshram et al., 2012 and Reviewer
Green Chemistry Route RA-Plant Extract	Yes	No	Yes	Sulochana et al., 2012
Biological Chemistry Route RA-Microorganism	Yes	Yes	Yes	Saxena et al., 2010

table 1 above reveals that in the criteria of judging only green chemistry route (RA-Sugar) and biological chemistry route got perfect yes`s. On the other hand, green chemistry route (RA-plant extract) got no for being industrially applicable and chemical reduction have two No`s from ecofriendly and cost -efficient criteria.

Table 2 Comparison of some physical properties of resulted Silver Nanoparticle from different method of synthesis

Concept of synthesis	Silver Nanoparticle Physical Properties			
	Formation	Color	Size	Author/Reference
Green Chemistry Route RA-Sugars	Colloidal	Yellowish	1-100nm	Meshram et al., 2012 and Reviewer
Green Chemistry Route RA-Plant Extract	Colloidal	Yellowish	1-100nm	Sulochana et al., 2012
Biological Chemistry Route RA-Microorganism	Colloidal	Yellowish	1-30nm	Saxena et al., 2010

The table 2 shows that some physical properties of different synthesis produce likeness specially in formation and color of silver nanoparticles. The major difference between the methods is the size of silver nanoparticles which determines the character of the formed nanoparticle.

IV. 2 Carbon Nanoparticle Synthesis

Table 3 Comparison of some physical properties of resulted Carbon Nanoparticle from different method of synthesis.

Concept of synthesis	Carbon Nanoparticle Physical Properties			
	Formation	Color	Size	Author/Reference
Acid Hydrolysis	Slurry Precipitate	Black	1-100nm	Loi et al., 2016 and Reviewer`s
Hydrothermal	Solid Precipitate	Black	1-30nm	Wu et al., 2013
Chemical Ablation	Solid Precipitate	Black	1-10nm	Shen et al., 2013

The table 3 shows the physical properties of carbon nanoparticle formed from different methods presented in this review. It reveals that all the method produced a black final product. However, different carbon nanoparticle formation which are slurry and solid precipitate produced by acid hydrolysis, chemical ablation and hydrothermal synthesis respectively. With regards to sizes, the largest size of carbon nanoparticle produced by method are acid hydrolysis while the smallest are chemical ablation.

Table 4 Comparison of Carbon Nanoparticles Synthesis Based on three factors: Eco-friendliness, industrially applicable, and cost efficient.

Concept of synthesis	Ecofriendly	Industrially Applicable	Cost Efficient	Author/Reference
Acid Hydrolysis	Yes	Yes	Yes	Loi et al., 2016 and Reviewer`s
Hydrothermal	Yes	Yes	Yes	Wu et al., 2013
Chemical Ablation	No	Yes	Yes	Shen et al., 2013

Table 4 shows the beneficial judgment to synthesis which are based from Eco friendliness, industrial application and cost-efficiency. The table depicts that almost all present synthesis of carbon nanoparticles is ideal except for chemical ablation which is not eco-friendly.

IV. 3 Silver-Carbon Nanoparticle Synthesis

For quick comparison, the table 5 presented some factor that can consider as advantage and disadvantage of the methods presented for silver-carbon nanoparticle composite synthesis. Please take note that the comparison made by the reviewers are non-bias and not meant for their convenience or comfortability.

The table 5 sums up the major advantages and disadvantages of different synthetic methods in preparation of Ag-CNP composites. Advantages and disadvantages written in the table 5 is simplified and based on the literature presented. Adsorption and adsorption: ultrasonication have advantages for being accessible and step simplicity however both have a disadvantage for low composite stability. On the other hand, spray pyrolysis, adsorption coating, nucleation-adhesion and particle growth occlusion have same advantages in high composite stability but nucleation and occlusion both have step simplicity as addition for their advantages. The disadvantages of spray pyrolysis and adsorption coating is that it involves multiples steps and few resources. While nucleation has few resources, and costly as it disadvantages. Finally, the particle growth-occlusion produce large interference, poor control and over sizes are its disadvantages.

Table 5 Comparison for the different synthetic method used for the preparation of Ag-CNP Composites

Concept of Synthesis	CNP Characterization	Advantages	Disadvantages	Reference
Adsorption	CNT	Accessible, Step Simplicity	Low Composite stability	Luo et al., 2009
Adsorption: Ultrasonication	CNT	Accessible, Step Simplicity, Fine dispersion of composite	Low Composite stability	Yamada et al., 2010
Spray Pyrolysis	MWCNT	High Composite stability	Multiple steps, few resources	Larrude et al., 2014
Adsorption: Coating	MWCNT	High Composite stability	Multiple steps, few resources	Daoush et al. 2012
Nucleation-Adhesion	CNT	High Composite stability, Step Simplicity	Few resources, costly	Zhang et al., 2017
Particle Growth-Occlusion	CNP	High Composite stability, Step Simplicity, Accessible	Large interference, poor control over sizes	Reviewer`s, 2018

Notice the difference of carbon nanoparticle character used in different synthesis; CNT (Carbon Nanotubes), MWCNT (Multi-Walled Carbon Nanotubes) and CNP (Carbon Nanoparticle). Notice that the CNP does not characterized for the reason that it was formed from acid hydrolysis as stated in table 3, which carbon nanoparticle formed ranges 1-100nm and considering the fact that it has the highest agglomeration in form and the general nanoparticle size is expected.

All the presented table includes the reviewer`s methods of synthesis, this is made because the reviewers itself want to counter check the confidence of their synthesis, explore other methods, and compare the physical property of the product they have produce. Furthermore, the reviewer`s also want to see their advantages and disadvantages compare to other existing methods with no bias and conflict of interest.

V. Reference

[1] A.A. Ensafi, N. Zandi-Atashbar, B. Rezaei, M. Ghiaci, M. Taghizadeh, Silver nanoparticles decorated carboxylate functionalized SiO2, New nanocomposites for nonenzymatic detection of glucose and hydrogen peroxide, Electrochimica Acta, 214 (2016)

[2] A.B.Castle,E.Gracia-Espino,C.Nieto-Delgado,H.Terrones, M. Terrones, and S. Hussain, "Hydroxyl-functionalized and N-doped multiwalled carbon nanotubes decorated withsilvernanoparticlespreservecellularfunction,"ACSNano,vol.5,no. 4,pp.2458–2466,2011

[3] A. Kausar, and M. Siddiq, Carbon nanotubes/silver nanoparticles/poly(azo-thiourea) hybrids: Morphological, tensile and conductivity profile, *Journal of Composite Materials 2014, Vol. 48*(26) 3271-3280, Retrieved from http://dx.doi.org/10.1177/0021998313508994

[4] A. Roch, M. Greifzu, E. Roch Talens, L. Stepein, T. Roch, J. Hege, N. V. Nong, …& A. Leson, Ambient effects on the electrical conductiviry of carbon nanotubes; *Carbon 95* (2015): 347-353 Retrieved from http://dx.doi.org/10.1016/j.carbon.2015.08.045

[5] A. Saxena, R.M. Tripathi, & R.P. Singh, Biological synthesis of silver nanoparticles by using onion (allium cepa) extract and their antibacterial activity, *Digest Journal of Nanoparticles and Biostructures* Vol. 5, No. 2 April-June 2010, 427-432, Retrieved from http://chalcogen.ro/427_Tripathi.pdf

[6] B. Calderón-Jimenez, M. E. Johnson, A. R. Montoro Bustos, K. E. Murphy, M. R. Winchester, & J. R. Vega Baudrit (2017), Silver nanoparticles: technological advances, societal impacts, and metrological challenges, *Front. Chem. C* 5:6. Retrieved from http://dx.doi.org/10.3389/fchem.2017.00006

[7] C. Yu, X. Li, F. Zheng and S. Wu, Chem. Commun., 2013, 49, 403.

[8] D. G.Larrude, Marcelo E. H., Maia da Costa, and F. L. Freire Jr., Synthesis and Characterization of silver nanoparticle-multiwalled carbon nanotube composites, Journal of *Nanomaterials* Volume 2014, Article ID 654068, 7 pages Retrieved from http://dx.doi.org/10.1155/2014/654068

[9] D. Macias-Ferrer, J.A. Melo-Banda, R. Silva-Rodrigo, U. Paramo-Garcia, J.Y. Verde-Gomez, & P. Del-Angel-Vicente, Synthesis of Micro/nanostructured carbon from refined sugar its electrochemical performance, *Int. J. Electrochem. Sci.* 13 (2018) 708-718 Retrieved from http://dx.doi.org/10.20964/2018.01.65

[10] D. Wei, & W. Qian Facile synthesis of Ag and Au nanoparticle utilizing chitosan as a mediator agent, *Colloids and Surfaces B: Biointeferences 62*(2008) 136-142 Retrieved from http://dx.doi.org/10.1016/j.colsurfb.2007.09.030

[11] D. G.Larrude, Marcelo E. H., Maia da Costa, and F. L. Freire Jr., Synthesis and Characterization of silver nanoparticle-multiwalled carbon nanotube composites, Journal of *Nanomaterials* Volume 2014, Article ID 654068, 7 pages Retrieved from http://dx.doi.org/10.1155/2014/654068

[12] E. Loi, R. W. Chao Ng, M. M. Fung Chang, J. F. Yee Fong, Y. Huey Ng, & S. Muk Ng, One-pot synthesis of carbon dots using two different acids and their respective unique photoluminescence property, *Luminescence 2016*, Retrieved from http://dx.doi.org/10.1002/bio.3157

[13] Esawi A and Morsi K 2007 Dispersion of carbon nanotubes (CNTs) in aluminum powder Compos. Part A: Appl. Sci. Manufac. 38 646–50
G.I. Kang, F.S. Abbott & R. Burton, Synthesis and mass spectrometry of deuterated methadone and methadone metabolites, *Biomedical Mass Spectrometry*, Vol. 6, No.5 (1979): 179-186 Retrieved from http://dx.doi.org/10.1002/bms.1200060502

[14] G. Luo, H. Yao, M. Xu, X. Cui, W. Chen, R. Gupta, Z. Xu, Carbon nanotube-siver composite for mercury capture and analysis, *Energy Fuels 2010*; 24: 419-429; Retrieved from http://dx.doi.org/10.1021/ef900777v

[15] Hayelom Dargo Beyene, Adhena Ayaliew Werkneh, Hailemariam Kassa Bezabh, Tekilt Gebregergs Ambaye , Synthesis paradigm and applications of silver nanoparticles (AgNPs), a review, *Sustainable Materials and Technologies* (2017), Retrieved from Retrieved from http://dx.doi.org/10.1016/j.susmat.2017.08.001

[16] H. Li, Y. Zhang L. Wang, J. Tian and X. Sun, Chem. Commun., 2011, 47, 961M.J. Krysmann, A. Kelarakis, P. Dallas and E.P. Giannelis, J. Am. Chem. Soc., 2011, 134, 747.

[17] I. Sur, D. Cam, M. Kahraman, A. Baysal and M. Culka, Interaction of multi-functional silver nanoparticles with living cells, *Nanotechnology 21* (2010), pp. 175104. Retrieved from http://dx.doi.org/10.1088/0957-4484/21/17/175104

[18] L. Shen, M. Chen, L. Hu, X. Chen, and J. Wang, Growth and stabilization of silver nanoparticles on carbon dots and sensing application, *Langmuir 2013*, *29*, 52, 16135-16140. Retrieved from http://dx.doi.org/10.1021/la404270w

[19] L. Theodore, & R.G. Kunz Hoboken (2015) Nanotechnology: Environmental Implications and Solutions. Retrieved from http://dx.doi.org/10.1002/0471711705

[20] L. Wu, X. Cai, K. Nelson, W. Xing, J. Xia, R. Zhang, A. J. Stacy, …and D. Pan, A green synthesis of carbon nanoparticles from hone and their use in real-time photoacoustic imaging, *Nano Research 2013*, 65: 312-325 Retrieved from http://dx.doi.org/10.1007/s12274-013- 0308-8

[21] M. A. Salam, A. Y. Obaid, R. M. El-Shishtawy and S. A. Mohamed, synthesis of nanocomposites of polypyrrole/ carbon nanotubes/silver nanoparticles and their application in water disinfection, *RSC Adv.*, *2017*, 7, 16878 Retrieved from http://dx.doi.org/10.1039/c7ra01033h

[22] M. C. Roco, (1990) Nanoparticles and nanotechnology research, *Journal of Nanoparticle Research 1:1-6.* Retrieved from https://link.springer.com/content/pdf/10.1023/A:1010093308079.pdf

[23] M. Scarselli, L. Camilli, P. Castrucci et al., "In situ formation ofnoblemetalnanoparticlesonmultiwalledcarbonnanotubes and its implication in metal-nanotube interactions," Carbon, vol.50,no.3,pp.875–884,2012

[24] N.D. Nguyen, T.V. Nguyen, A.D. Chu, H.V. Tran, L.T. Tran, C.D. Huynh, A label-freecolorimetric sensor based on silver nanoparticles directed to hydrogen peroxide and glucose, *Arabian Journal of Chemistry*(2018),doi: https://doi.org/10.1016/j.arabjc.2017.12.035

[25] N. J. Hargreaves & S. J. Cooper, Nanographite synthesized from acidified sucrose microemulsions under ambient conditions, *Cryst. Growth Des. 2016*; 16: 3133-3142, Retrieved from http://dx.doi.org/10.1021/acs.cgd.5b01753

[26] N. Karadas, B. Bozal-Palayibik, B. Uslu, & S.A. Ozkan, Functionalized carbon nanotubes- with silver nanoparticles to fabricate a sensor for the determination of zolmitriptan in its dosage forms and biological samples, *Sensors and Actuators B 186*(2013): 486-494 Retrieved from http://dx.doi.org/10.1016/j.snb.2013.06.055

[27] N. K. Tolochko, History of nanotechnology, *Nanoscience and Nanotechnologies*. Retrieved from https://www.eolss.net/sample-chapters/C05/E6-152-01.pdf

[28] Prabhu and Poulose: Silver nanoparticles: mechanism of antimicrobial action, synthesis, medical applications, and toxicity effects. *International Nano Letters 2012* 2:32. Retrieved from http://dx.doi.org/10.1186/2228-5326-2-32

[29] R. Jelinek, Carbon quantum dots synthesis, properties and properties (2017): 121 Retrieved from http://www.springer.com/978-3-319-43909-9

[30] S. Aashrita. Synthesis of silver nanoparticles by chemical reduction method and their antifungal activity. *Int. Res. J. Pharm. 2013*; 4(10): 111-113, Retrieved from http://dx.doi.org/10.7897/2230-8407.0410 24

[31] S. C. Ray, A. Saha, N. R. Jana, and R. Sarkar, Fluorescent carbon nanoparticles: synthesis, characterization, and bioimaging application, *J. Phys. Chem. C* 2009, 113, 18546-18551 Retrieved from http://dx.doi.org/10.1021/jp905912n

[32] S. K. Bhunia, L. Zeiri, J. Manna, S. Nandi, and R. Jelinek, Carbon-dot/silver-nanoparticle flexible SERS-active films, *ACS Appl. Mater. Interfaces*, 2016, 8, (38), pp 25637-

25643 Retrieved from http://dx.doi.org/10.1021/acsami.6b10945

[33] S. Rama, K. Perala, & S. Kumar, On the mechanism of metal nanoparticle synthesis in the burst-schiffrin method, *Langmuir, 2013*, 29(31) pp 9863-9873 ; Retrieved from http://dx.doi.org/10.1021/la401604q

[34] S. Sulochana, P. Krishnamoorthy, and K. Sivaranjani, Synthesis of silver nanoparticles using leaf extract of Andrographis paniculate, *Journal of Pharmacology and Toxicology* 7 (5) 2012; 251-258 Retrieved from http://dx.doi.org/10.3923/jpt.2012.251.258

[35] Till T. Meiling, Piotr J. Cywiński, & Ilko Bald, White carbon: fluorescent carbon nanoparticles with tunable quantum yield in a reproducible green synthesis, *Scientific Reports 6*, Article No. 28557. Retrieved from http://dx.doi.org/10.1038/srep28557

[36] T. Yamada, Y. Hayashi and H. Takizawa, Synthesis of carbon nanotubes/silver nanocomposites by ultrasonication, *Material Transactions*, Vol. 51 No. 10 (2010) pp. 1769-1772 Retrieved from http://dx.doi.org/10.2320/matertrans.MJ201012

[37] Till T. Meiling, Piotr J. Cywiński, & Ilko Bald, White carbon: fluorescent carbon nanoparticles with tunable quantum yield in a reproducible green synthesis, *Scientific Reports 6*, Article No. 28557. Retrieved from http://dx.doi.org/10.1038/srep28557

[38] V. Ganesan, and A. Deepak, Synthesis, Characterization and Applications of Some Nanomaterials, *International Conference on Advanced Nanomaterials and Emerging Engineering Technologies* (ICANMEET 2013)., pp 1-6, Retrieved from http://dx.doi.org/10.1109/ICANMEET.2013.6609219

[39] V. K Rangari, G. M Mohammad, S. Jeelani, A. Hundley, K. Vig, S. R. Singh and S. Pillai, .Synthesis of Ag/CNT hybrid nanoparticles and fabrication of their nylon-6 polmer nanocomposite fibers for antimicrobial applications, *Nanotechnology 21, 9* (2010) 095102 Retrieved from http://dx.doi.org/10.1088/0957-4484/21/9/095102

[40] V. Thamilselvi, & K.V. Radha, A review on the diverse application of silver nanoparticle*; IOSR Journal of Pharmacy*, Vol. 7: 21-27 Retrieved from http://iosrphr.org/papers/v7i1V1/E0701012127.pdf
W.Shi, Q. Wang, Y. Long, Z. Cheng, S. Chen, H. Zheng and Y. Huang, Chem. Commun., 2011, 47, 6695
.
[41] Walid M. Daoush & Soon H. Hong (2013) Synthesis of multi-walled carbonnanotube/silver nanocomposite powders by chemical reduction in aqueous solution, *Journal of Experimental Nanoscience, 8*:5, 742-751. Retrieved from http://dx.dpoi.org/10.1080/17458080.2011.604959

[42] X.F Zhang, Z.G. Liu, W. Shen, & S. Gurunathan, Silver nanoparticles: synthesis, characterization, properties, applications, and therapeutic approaches, *Int. J. Mol. Sci. 2016, 17,* 1543. Retrieved from http://dx.doi.org/10.3390/ijms17091534

[43] Y. Aimin, Q. Wang, J. Yong et al., “Silver nanoparticle-carbon nanotube hybrid films: preparation and electrochemical sensing,”ElectrochimicaActa,vol.74,pp.111–116,2012

[44] Y. Wang, & A. Hu, Carbon quantum dots: synthesis, properties and applcations, *J. Mater. Chem. C*, 2014, 2, 6921 Retrieved from http://dx.doi.org/10.1039/ctc00988f

[45] Y. Yuan, Q. Chen, S. Zhou, L. Zhuang, & P. Hu, Bioelectricity generation and microcystins removal in a blue-green algae powered microbial fuel cell, *Journal of Hazardous Materials 187* (2011) 591-595 Retrieved from http://dx.doi.org/10.1016/j.jhazmat.2011.01.042

[46] Y.Zhang, K. Zhang, and H. Ma, Electrochemical DNA Biosensor based on silver nanoparticles/ poly(3-(3pyridyl acrylic acid)/ carbon nanotube modified electrode, *Analytical Biochemistry 387* (1) (2009), pp 13-19. Retrieved from http://dx.doi.org/10.1016/j.ab.2008.10.043