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Review and Synthesis of Silver Nanoparticles, Characterization and Application

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Abstract: ***In recent years particularly silver nano particles have a demanding position because silver nano particle have very high interest in effective antibacterial agents without the toxic effects and various industrial application such as-inkjet inks containing well uniform dispersion of nano sized silver particles that are useful for products electronic circuits. This article are aims to provide synthesis, characterization and biological approach of silver nanoparticles (AgNps) and will also discuss for the future perspective what the more and more benefit of this AgNps.***

Keywords: Silver nanoparticles, Biological, biological, electronic circuits, antibacterial agents industrial, characterization

1.Introduction

Nanotechnology is the science that deals with matter at scale of one billionth of a meter (I. e, 10-9m=1nm) And is also the study of manipulating matter at the atomic and molecular a nanoparticle is the most fundamental component in the fabrication of nano structure and is far smaller than the world every day object that are described by Newton's law of motion but bigger than an atom or a simple molecule that are governed by quantum mechanics. The United States instituted the national nanotechnology initiative (NNI) back in 2000, which was soon followed (2001) by a plethora of projects in nanotechnology in nearly most of the U. S. Department and agency [1].

Currently silver nanoparticles have been widely used in agriculture commercial and industry applications [2]. Silver nanoparticles are used as an additive in vaccine adjuvant and in anti cancer therapy in medical application [3].

Previous discoveries have shown that the physical optical and catalytic properties of silver nanoparticles are strongly influenced by their size distribution morphological shape and surface properties which can be modified by drivers synthetic methods agent and stabilizer [4, 5]. Theshape of silver nanoparticles can be adjusted according to a specific application example-silver nanoparticle prepared for drug delivery are mostly greater than 100 nanometer to accommodate for the quantity of drugs to be delivered with different surface properties silver nanoparticles can also be formed into various shapes including roads, triangl, round, octahedral and polyhedral etc [6].

2.Synthesis and Characterization of AgNps

2.1 Methods of silver nanoparticles synthesis

There are basically three approachable methods of silver nanoparticles synthesis [7].

a) Biological synthesis

- Bacteria
- Fungi
- Algae
- Plants

Advantages of biological synthesis-

- Use of nontoxic chemicals
- Not expensive
- Ecofriendly
- Involving living organism
- Less energy is used to synthesis of AgNps

b) Physical synthesis

- Adsorption
- Silica gel
- Activated carbon
- Membrane filtration
- Irradiation

c) Chemical synthesis

- Oxidative process
- Ozonation
- Sodium hypochloride (NaOCl)
- Electrochemical destruction
- Photochemical

Drawback of physical and chemical synthesis-

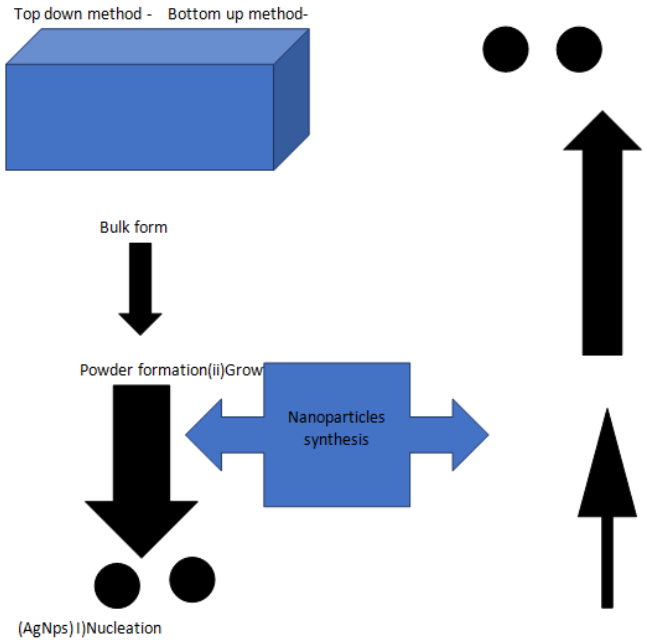
- Short life upto (20min)
- Formation of by-items
- Release of sweet smelling amines
- High cost of power
- Very costly

Synthesis from Bottom up and top down model

In various biomedical fields numerous types of silver nanoparticles have been used [8].

In particular silver nanoparticles of varying sizes and shapes have been utilised in a broad range of applications and medical equipment such as electronic devices, paints,

soaps, detergent and bandages etc [9]. Nowadays The synthesis approaches are categorized into physical chemical and biological, green synthesis. The physical and chemical synthesis tend to be more labor-intensive and hazardous compared to the biological synthesis of silver nano particles which exhibit attractive properties such as-high yield solubility and stability. Top down approach dis incorporate bulk materials to generate the required nano structures while the bottom up method assemble single atoms and molecules into larger nano structure to generates nano sized particles [10].



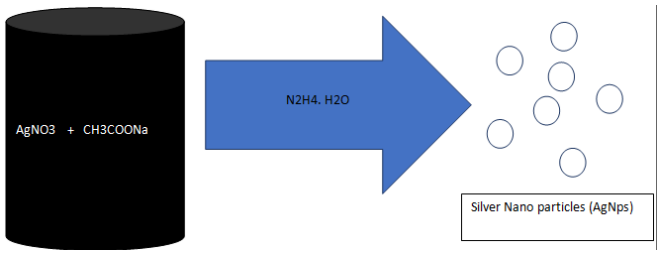
A) Physical Method: The physical synthesis of silver nano particles includes the evaporation condensation approach and the laser ablation technique [11, 12]. The most important physical method are evaporation condensation and laser ablation [13, 14].

A.1) Evaporation and Condensation:

The evaporation-condensation method requires the use of an atmospheric pressure tube furnace or a small ceramic heater to synthesise silver nanoparticles (AgNps). This technique is frequently used to synthesize silver nanoparticles. The evaporation-condensation process is comprised of 3 major steps.

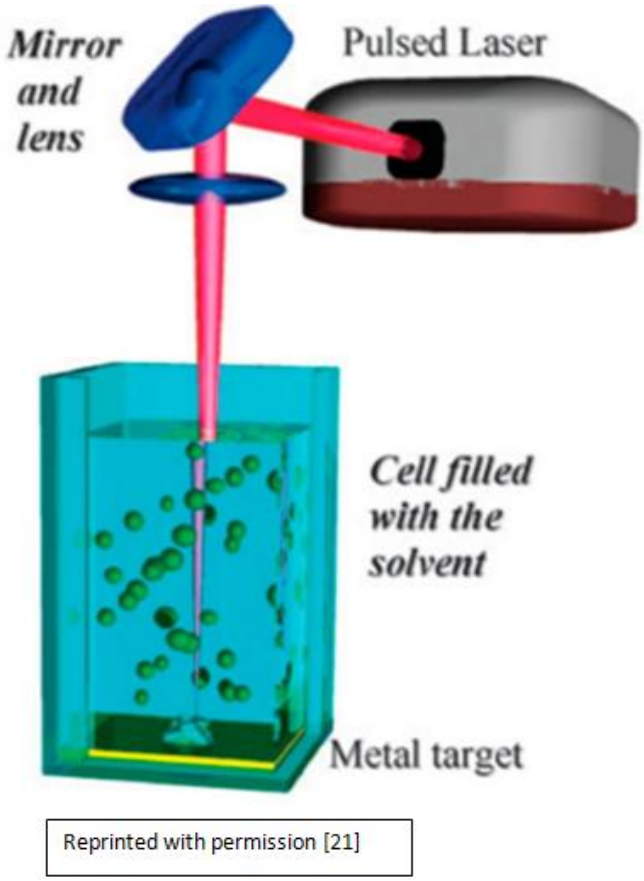
a) Material is evaporated or sublimated to form a vapour phase
b) Material is transported from the source to the substrate
c) Particle or films are formed through nucleation and then followed by growth the vapour rapidly cools forming small silver nanoparticles in high concentration [15].

This method was used to synthesize silver nano spheres from a variety of metal materials including silver [16]. The Synthesis of silver nano particles by evaporation condensation through the tube furnace has numerous drawbacks the tube furnace occupies a large space, consumes high energy elevating the surrounding temperature of the metal source and a longer duration to maintain its thermal stability to overcome these disadvantages jung et al demonstrated that a ceramic heater can be utilised efficiently in the synthesis of silver nano particles (AgNps) with high concentration [17].



A.2) Laser Ablation

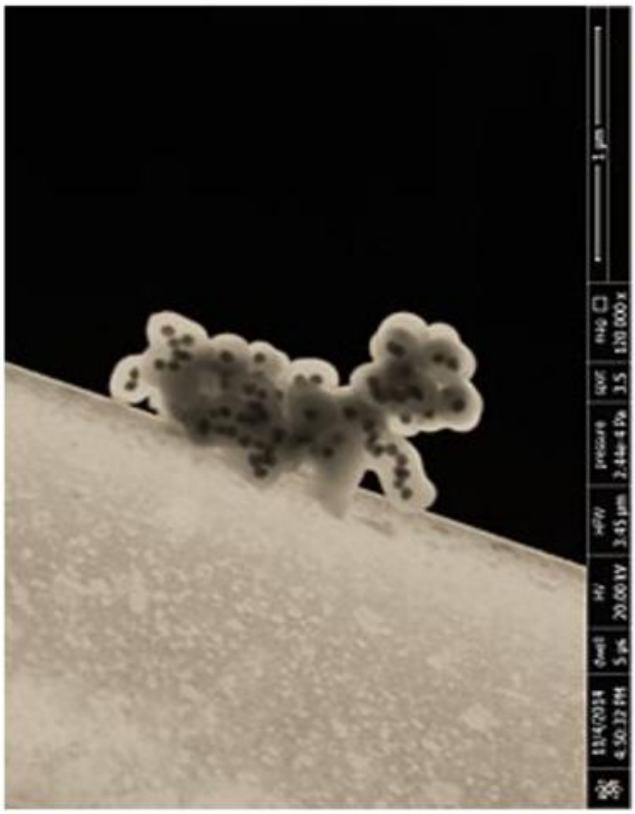
The laser ablation method is a method to obtain metal colloids without using chemical reagents in this method intense laser pulses are focused on silver target immersed in a solvent [18]. Silver nanoparticles could be synthesized via laser ablation of metallic bulk materials in solution [19]. After irradiating with a pulsed laser the liquid environment only contains the silver nano particles of the base metal source, Deaned from other ions, components or reducing agents [20]. This method uses mild surfactants in the solvent without involving any other chemical reagents [20].



B) Chemical Method

Chemical reduction method is the most common approach for synthesis of silver nano particles by organic and inorganic reducing agents. In general different reducing agents such as-sodium citrate, Ascorbate,

sodiumborohydrate (NaBH4) elemental hydrogen, polyol process, N, N-dimethyformamide (DMF) and poly ethylene glycol block Copolmer are used for reduction of silver ions (Ag+) and lead to the formation of metallic silver (Ag0), which is Followed by Agglomeration into Oligomeric clusters, these clusters eventually lead to the formation of metallic colloidal silver particles. [22, 23, 24]. The silver nanoparticles are chemically synthesized mainly through the brust-schiffrin synthesis (BSS) or the Turkevich method [25, 26, 27]. Nucleation and growth of nanoparticles are governed by various reaction parameters including reaction temperature, pH, concentration, type of precursor reducing and stabilising agent and molar ratio of surfactant or stabilizers and precursor [28].



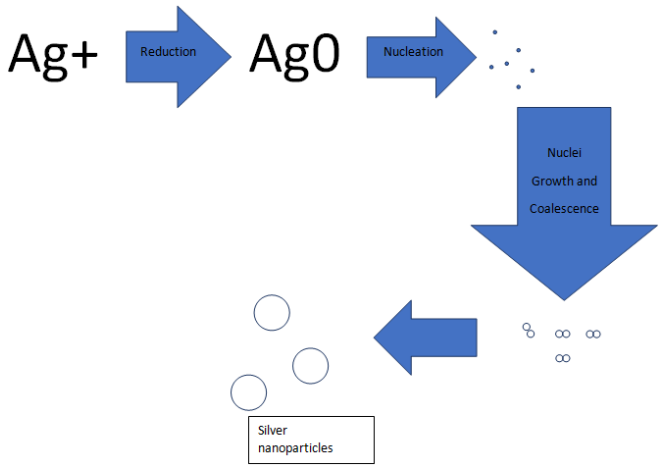
Electron micrograph of core-shell nanoparticles, which comprise dark silver cores and light silica shells

By using the various chemical reductants including glucose (C6H12O6, hydrazine, ethylene glycol (C2H6O2) we can accomplish the metal salt of the chemical reduction [29, 30].

All of the above approaches we have discussed, chemical method is one of the most convenient method to synthesize silver nanoparticles at low cost and high yield in this we are going to describe various chemical method of synthesis of silver nano particle mainly.

By previous research what conclusion to come out for the synthesis of silver nanoparticles (AgNps):

We have discussed physical, biological and chemical method to preparing silver nanoparticles. In all of them chemical method is one of the most simple and convenient. By the size shape and crystal structure of silver nano particles we can determine their internal property and also controlled this one during the chemical synthesis [31]. D. Radziuk et al who had prepared AgNps By reduction of silver nitrate in an excess of aqueous sodium Boro hydride which used as a reducing agent. The nano particles with a diameter of 20 nm are obtained [32]. C Luo et al Who have prepared silver nano particles under mild conditions by exploting polyethylene glycol (PEG) and the dramatic effect of polyethylene glycol to the formation of silver nanoparticles [33]. Hsu et al Synthesized silver nano particle suspension by chemical reduction from silver nitrate in a formaldehyde reluctant and PVP stabilizer using organic bases as the reaction promoter [34].



B.1) Microemulsion Technique

Microemulsion is thermodynamically stable isotropic dispersion of two immiscible liquids (oil and water) in which a Mono layered film of surfactant molecules stabilizes each micro domain of both liquids [35]. The word microemulsion was originally proposed by schulman et al (1959). They prepared a quaternary solution of water, benzene, hexanal and k-oleate which was stable homogeneous and slightly opalescent. Microemulsion is the synthesis of silver nano particles when surfactant is used to thermo dynamically stabilize the dispersion of two immiscible liquid such as oil in water or water in oil. Reyes et al. [36]Demonstrated the microemulsion synthesis of silver nano particles using toluene as organic phase, silver nitrate (AgNO3) solution and a mixture of surfactants sodium dodecyl sulfate sodium bis (2-ethyl hexyl) sulfo succinate.

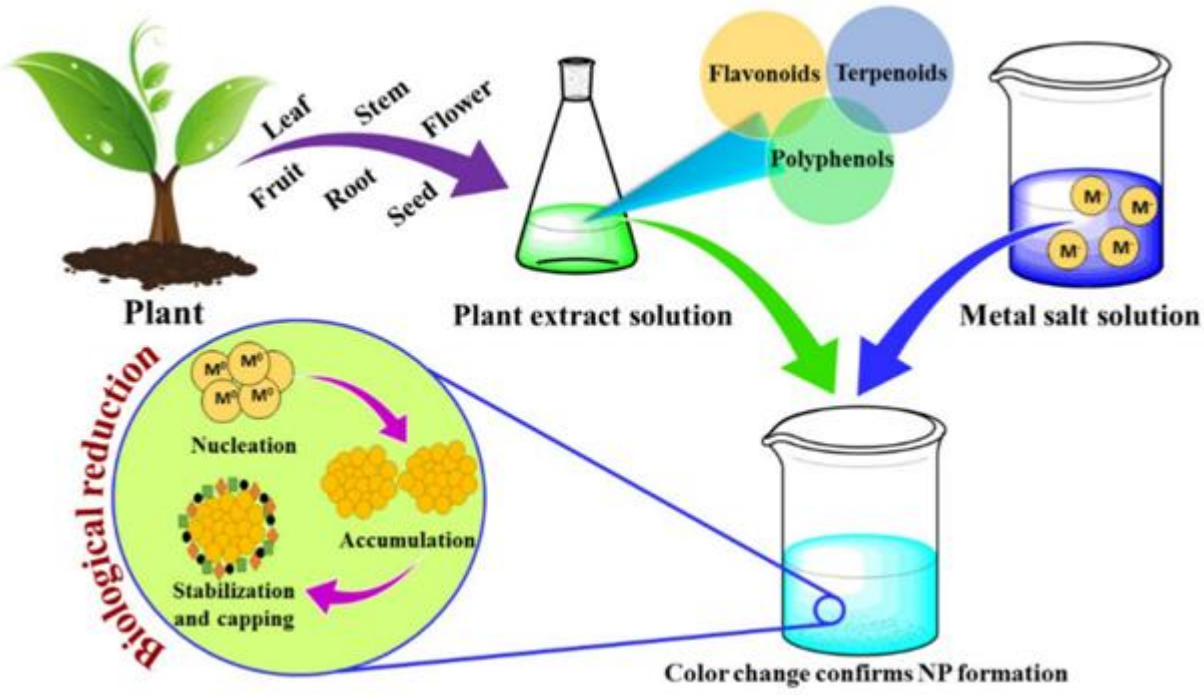
B.2) Sonochemical Method

By sonochemical method we can synthesize silver nano particles by the ultrasonic radiation which produced a local hot spot. Initially this method was used to synthesize iron nanoparticles but it has since been applied to the synthesis of different metals including silver [Ag] [37]. For Sono chemical method synthesis there are several method the most important of which are the formation, growth of the particles. When the solution is exposed to ultrasonic radiation, acoustic fields may cause the bubbles

in the solution to implode. The collapse of the cavitation bubble generates a shockwave, which has a rapid impact on the particles surface [38]. In this type of synthesis as temperature and concentration increases the rate of synthesis will also be increases.

C) Biological Route of Synthesis of Silver Nanoparticles

This Method is the simplest no toxic at most eco friendly and produces high quality and high yield of nanoparticles in comparison to chemical and physical this method is the advantages for synthesis of nanoparticles by biological route we uses safe, non toxic and eco-friendly reagents only in a single step silver nanoparticles material can synthesize such as biological Synthesis have a higher degrees of stability, diversity and adequate dimensions [39]. Living Organism is required for functioning biological synthesis such as bacteria, fungi, plants and algae. A. R. Vilchis-Nestor et all used green tea (camellia sinensis) extract as reducing and stabilizing agent to produce gold, silver nanoparticles in aqueous solution at ambient condition [40].



C-1) Bacteria Based Biosystem: We can synthesize AgNps either Extracellularly or Intracellularly by through this biosystem. AgNps produced by bacteria by Bioreduction process. In which reduction of AgNO3 precursor from Ag+ ions to Ag° forming AgNps by Nicotinamide adenine dinucleotide (NADH) – dependent enzymes [41]. Thomas et al [42] synthesized AgNps Intracellularly. However extracellular Biosynthesis mode was preferred due to easy recovery of AgNps.

2) Use of Fungi: Fungi are well known for their ability to decompose organic matter. Recent data indicate that approximately 5.1 million fungal species exist [42]. Most fungi have high wall binding and intracellular metal uptake, whereas several species grow fast, thus making it easy to culture and keep them in a laboratory [43]. Fungi can synthesize AgNps intracellular or extracellularly, depending on the location of the synthesized AgNps. Certain fungi are capable of synthesizing AgNps in both ways [44]. Fungi reduce Ag+ ions to Ag° forming AgNps. Fungi secretes extracellular enzymes such as protease, cellulose, chitinaseand beta glucosidase to degrade cellulose, protein, starch, Hemicellulose and animal compounds as a food source [45].

3.Characterization of Silver Nano Particles (AgNps)

Silver nanoparticles have an unique properties that will determine their potential and application. A variety of measurement techniques can be used to characterize silver nano particles. Researchers employ a variety of classification schemes. Occasionally researchers classified the characterization of nanoparticles they prepared according to their structure, optical or electrical properties.

Some of the common characterization techniques of AgNps

(a) X-ray diffraction (XRD)

One of the most conventional techniques is the X ray diffraction technique and characterises the silver nanoparticles X ray diffraction technique used to determine the crystallographic structure and morphology which include crystalline structure lattice parameter, nature of phase and crystalline size. The intensity can be effects by the number of constituents x-ray have much shorter wavelength compared to light they are produced when decolouration of electrically charged particles occurs [46] this method is unsuitable for amorphous materials and particles with a size below 3 nanometer as

xray diffraction peaks produced are too broad crystalline size is calculated using scherrer equation [47].

(b) Transmission Electron Microscopy (TEM)

Transfer electron microscope is a technique that uses an electron beam to image a nano particles sample, providing much higher resolution than is possible with light based Imaging technique. Tem is the preferred method to directly measure nanoparticle size, grain size size distribution and morphology.

In this the beam of electron interacts with the sample and transform into Unscattered electrons, in elastically scattered electrons or elastically scattered electrons. Transfer electron microscope provides detailed quantitative chemical information of particles size distribution and high resolution images. AgNps was characterized using TEM and it revealed spherical shape with the size ranging from 13 to 14 nm [48].

Application of Silver Nano Particles (AgNps) –

- For commercialization application silver metal is one of the most favoured nano particles. They have various uses like as-electronic products in the industry and in the health sector as a antibacterial agents, textile coating and a no. of environment application and also in food storage.

- As a antibacterial agents silver nano particles were used for a wide range of application from disinfecting medical devices and home appliances to water treatment [49].

a) Sensor-Peptide capped silver nano particles for calorimetric sensing has been mostly studied in past years, which focus on the nature of the peptide and silver interaction and the effect of the peptide on the information of the silver nano particles. Besides the efficiency of silver nano particles based fluorescent sensors can be very high and overcome the detection limits.

b) Catalyst-Silver nano particles have been demonstrated to present catalytic redox properties for biological agents such as-dyes as well as chemical agents such as – benzene. The chemical environment of the nano particle plays an important role in their catalytic properties. In addition, it is important to know that complicated catalysis takes place by Adsorption of the reactant species to the catalytic substrate. When polymers, complex ligands or surfactants are used as the stabilizer or to prevent coalescence of the nano particles, the catalytic ability is usually deceased.

Due to reduced Adsorption ability. In general, silver nano particles are mostly used with titanium oxide as the catalyst for chemical reaction. Recently, inkjet technology has been used to produce flexible electronic circuits at low cost and many studies regarding this application has been reported in recent years [50].

To fabricate flexible electronic displays via inkjet printing, it is necessary to develop suitable inks. Nano-sized metal particles such as - Au Or Ag are useful for producing electronic circuits because of the uniformity of small metal particles dispersed in the inks and their high electrical conductivity. For ex. Using our methods described above, AgNps with small size and uniform can be prepared easily and have high electrical conductivity indicating that they are useful for producing electronic circuits.

4.Conclusion

In this review article, get to discuss different methods of synthesis of silver nano particles, and also their characterization and the application of silver nano particles. We have to discuss here that the importance of AgNos in various fields such as industrial, health and even in biomedical sector have been acknowledged.

The comprehensive research regarding AgNps has been explored in this review to understand the synthesis and the characters of the silver metal. Biomedical method is the most Ecofriendly and environmentally sustains the property to human beings and a nontoxic for the organism. The main purpose of this review to come into light is that to provide comprehensive details about the unique silver nano particle in the regarding future this will be on high potential in different fields by their unique mostly antique property.

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