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Review

Synthesis, Characterization And Anti Microbial Activity Of Silver Nanoparticles By Using Plant Sources.

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Abstract

Silver has been recognized as a nontoxic, safe inorganic antibacterial/ antifungal agent used for centuries. Silver demonstrates a very high potential in a wide range of biological applications, more particularly in the form of nanoparticles. Environmentally friendly synthesismethods are becoming more and more popular in chemistry and chemical technologies and the need for ecological methods of synthesis is increasing; the aim is to reduce polluting reaction by-products. Another important advantage of green synthesis methods lies in its cost- effectiveness and in the abundance of raw materials. During the last five years, many efforts were put into developing new greener and cheaper methods for the synthesis of nanoparticles.The cost decrease and less harmful synthesis methods have been the motivation in comparisonto other synthesis techniques where harmful reductive organic species produce hazardous by- products. This environment-friendly aspect has now become a major social issue and is instrumental in combatting environmental pollution through reduction or elimination of hazardous materials. This review describes a brief overview of the research on green synthesisof silver nanoparticles using natural sources.

Keywords: Antimicrobial activity, nanoparticle

INTRODUCTION

A nanoparticle or ultrafine particle is a particle of matter 1 to 100 nanometres (nm) in diameter. The term is sometimes used for larger particles, up to 500 nm, or fibers and tubes thatare less than 100 nm in only two directions. At the lowest range, metal particles smaller than 1 nm are usually called atom clusters instead. Nanoparticles are distinguished from microparticles (1-1000 µm), "fine particles" (sized between 100 and 2500 nm), and "coarse particles" (ranging from 2500 to 10,000 nm), because their smaller size drives very different physical or chemical properties, like colloidal properties and ultrafast optical effects or electric properties. Being much smaller than the wavelengths of visible light (400-700 nm), nanoparticlescannot be seen with ordinary optical microscopes, requiring the use of electron microscopes ormicroscopes with laser. For the same reason, dispersions of nanoparticles in transparent mediacan be transparent,[6] whereas suspensions of larger particles usually scatter some or all visiblelight incident on them. Nanoparticles also easily pass through common filters, such as common ceramic candles, so that separation from liquids requires special nanofiltration techniques. nanoparticles and the influence of the method on their size and morphology.[1]

CLASSIFICATION OF NANOPARTICLES

NPs are broadly divided into various categories depending on their morphology, size and chemical properties. Based on physical and chemical characteristics, some of the well- known classes of NPs are given as below.

CARBON BASED NANOPARTICLES

Fullerenes and carbon nanotubes (CNTs) represent two major classes of carbon-based NPs. Fullerenes contain nanomaterial that are made of globular hollow cage such as allotropicforms of carbon. They have created noteworthy commercial interest due to their electrical conductivity, high strength, structure, electron affinity, and versatility (Astefanei et al., 2015).These materials possess arranged pentagonal and hexagonal carbon units, while each carbon issp2 hybridized.

METAL NANOPARTICLES

Metal NPs are purely made of the metal precursors. Due to well-known localized surface plasmon resonance (LSPR) characteristics, these NPs possess unique optoelectrical properties. NPs of the alkali and noble metals i.e. Cu, Ag and Au have a broad absorption bandin the visible zone of the electromagnetic solar spectrum.

CERAMIC NANOPARTICLES

Ceramics NPs are inorganic non-metallic solids, synthesized via heat and successive cooling. They can be found in amorphous, polycrystalline, dense, porous or hollow forms (Sigmund et al., 2006). Therefore, these NPs are getting great attention of researchers due to their use in applications such as catalysis, photocatalysis, photodegradation of dyes, and imaging applications. (Thomas et al., 2015).

SEMICONDUCTOR NANOPARTICLES

Semiconductor materials possess properties between metals and nonmetals and therefore they found various applications in the literature due to this property (Ali et al., 2017,Khan et al., 2017a). Semiconductor NPs possess wide bandgaps and therefore showed significant alteration in their properties with bandgap tuning. Therefore, they are very important materials in photocatalysis, photo optics and electronic devices.

POLYMERIC NANOPARTCLES

These are normally organic based NPs and, in the literature a special term polymer nanoparticle (PNP) collective used for it. They are mostly nanospheres or nano capsular shaped(Mansha et al., 2017). The former are matrix particles whose overall mass is generally solid and the other molecules are adsorbed at the outer boundary of the spherical surface. In the lattercase the solid mass is encapsulated within the particle completely (Rao and Geckeler, 2011). The PNPs are readily functionalize and thus find bundles of applications in the literature (Abd Ellah and Abouelmagd, 2016, Abouelmagd et al., 2016).

LIPID BASED NANOPARTCLES

These NPs contain lipid moieties and effectively using in many biomedical applications. Generally, a lipid NP is characteristically spherical with diameter ranging from 10 to 1000 nm. Like polymeric NPs, lipid NPs possess a solid core made of lipid and a matrixcontains soluble lipophilic molecules. Surfactants or emulsifiers stabilized the external core ofthese NPs (Rawat et al., 2011). Lipid nanotechnology (Mashaghi et al., 2013) is a special field,which focus the designing and synthesis of lipid NPs for various applications such as drug carriers and delivery (Puri et al., 2009) and RNA release in cancer therapy (Gujrati et al., 2014)[2].

BENEFITS OF NANOPARTICLES

Here are some of the benefits associated with nanotechnology:

IMPROVED MATERIALS

Nanomaterials can be stronger, lighter, and more durable than traditional materials. By tailoring material structures at extremely small scales, nanotechnology enhances properties such as strength, conductivity, and reactivity

EVERYDAY COMMERCIAL PRODUCTS

Many everyday products already rely on nanoscale materials and processes

Fabrics: Nanoscale additives or surface treatments make fabrics lightweight, resistant to wrinkles, stains, and bacterial growth.

Eyeglasses and Displays: Clear nanoscale films on eyeglasses, displays, and windows can make them water-repellent, antireflective, and resistant to UV or infrared light.

Smart Fabrics: Nanoscale sensors and electronics enable washable, durable "smart fabrics" for health monitoring and energy harvesting.

Light weighting: Nanoscale additives in composite materials contribute to lightweight, stiff, and resilient products like baseball bats, automobile parts, and power tool housings.

HEALTH AND MEDICINE

Nanomedicine offers targeted drug delivery, imaging, and diagnostics at the cellular level. Nanoparticles can enhance cancer treatment by selectively targeting tumor cells. Biosensors based on nanotechnology enable rapid disease detection and monitoring.

ENERGY EFFICACY

Nanotechnology can improve energy storage, conversion, and distribution. Lightweight materials reduce fuel consumption in transportation. Nanoscale solar cells and energy-harvesting devices enhance renewable energy sources.

ENVIRONMENTAL CONDITIONS

Nanotechnology contributes to water purification, air filtration, and pollution control. Nanoscale catalysts improve industrial processes and reduce emissions.

FOOD SAFETY AND AGRICULTURE

Nanoscale sensors detect contaminants in food. Nanoparticles improve crop yield and nutrient absorption. Nanotechnology enhances food packaging and preservation.

INFRASTRUCTURE AND CONSTRUCTION

Nanomaterials strengthen concrete, reduce corrosion, and improve durability. Self-healing materials repair cracks and damage. Nanotechnology contributes to large-scale infrastructure fabrication [3].

SYNTHESIS OF NANOPARTICLES

Various methods can be employed for the synthesis of NPs, but these methods are broadly divided into two main classes i.e. (1) Bottom-up approach and (2) Top-down approach(Wang and Xia, 2004) as shown in Scheme 1 (Iravani, 2011). These approaches further divideinto various subclasses based on the operation, reaction condition and adopted protocols. [2]

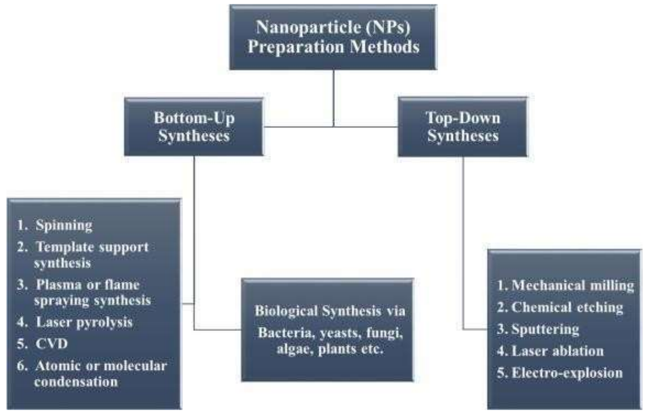

Fig 1: Typical synthetic methods for NPs for the (a) top-down and (b) bottom-upapproaches.

TOP-DOWN SYNTHESES

In this method, destructive approach is employed. Starting from larger molecule, whichdecomposed into smaller units and then these units are converted into suitable NPs. Examplesof this method are grinding/milling, CVD, physical vapor deposition (PVD) and other decomposition techniques (Iravani, 2011). This approach is used to synthesized coconut shell (CS) NPs. The milling method was employed for this purpose and the raw CS powders were finely milled for different interval of times, with the help of ceramic balls and a well-known planetary mill. They showed the effect of milling time on the overall size of the NPs through different characterization techniques. It was determined that with the time increases the NPs crystallite size decreases, as calculated by Scherer equation. They also realized that with each hour increment the brownish color faded away due to size decrease of the NPs. The SEM results were also in an agreement with the X-ray pattern, which also indicated the particle sizedecreases with time (Bello et al., 2015).[2]

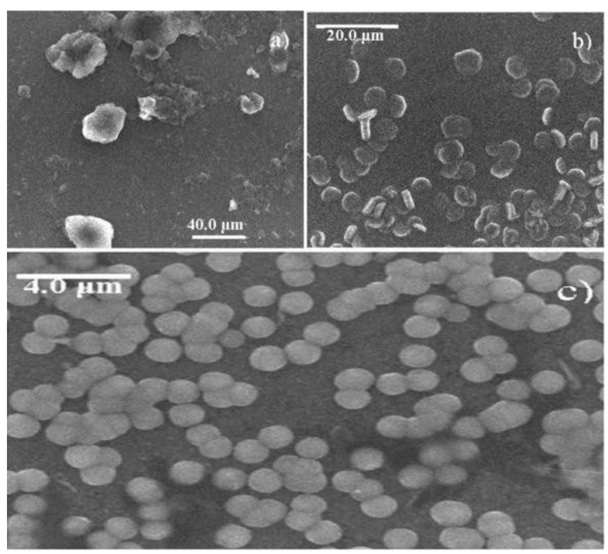

Fig 2: SEM images of (a) The untreated carbon black, (b) and (c) 10 min and 1 hultrasonication in POM solution (Garrigue et al., 2004).

BOTTOM-UP SYNTHESES

This approach is employed in reverse as NPs are formed from relatively simpler substances, therefore this approach is also called building up approach. Examples of this case are sedimentation and reduction techniques. It includes sol gel, green synthesis, spinning, andbiochemical synthesis. (Iravani, 2011). Mogilevsky et al. synthesized TiO_2 anatase NPs with graphene domains through this technique (Mogilevsky et al., 2014). They used alizarin and titanium isopropoxide precursors to synthesize the photoactive composite for photocatalytic degradation of methylene blue. Alizarin was selected as it offers strong binding capacity with TiO_2 through their axial hydroxyl terminal groups. The anatase form was confirmed by XRD pattern. The SEM images taken for different samples with reaction scheme are provided in scheme 2. SEM indicates that with temperature elevation, the size of NPs also increases (Mogilevsky et al., 2014).[2]

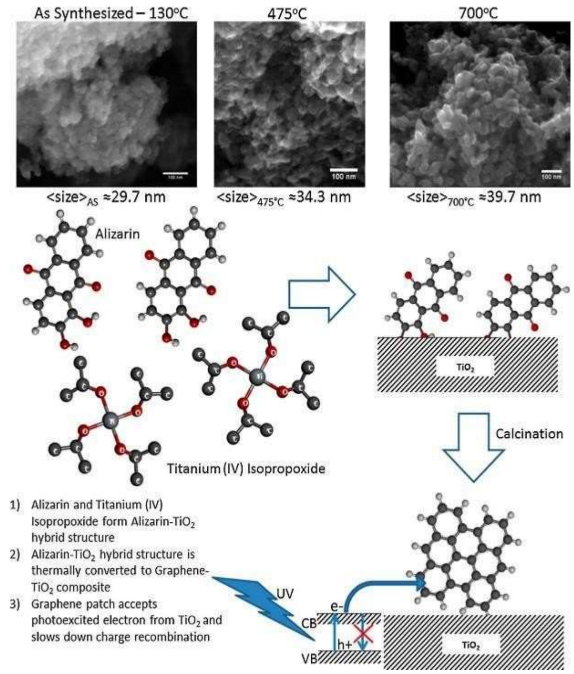

Fig 3: Synthesis of TiO2 via bottom-up technique. SEM images showing the TiO2 NPs (Mogilevsky et al., 2014).

CHARACTERIZATION OF NANOPARTICLES

The physicochemical properties of nanoparticles are important for their behaviour, bio-distribution, safety and efficacy. Therefore, characterization of nanoparticles is important in order to evaluate the functional aspects of the synthesized particles. Characterization is performed 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). [2]

ANTIMICROBIAL ACTIVITY

Antimicrobial susceptibility testing can be used for drug discovery, epidemiology and prediction of therapeutic outcome. Antimicrobial technologies employed for preservation, disinfection, and sterilization are widely used for industrial and medical purposes in reducing or eliminating microorganisms. But in the development and application of these technologies, there are at least two major considerations: the desired antimicrobial effects (the most obviousreason behind employing these technologies) and safety requirements. Therefore, the objective of the desired end point with an antimicrobial process is important in its choice and application.This can range from the unique control of an individual type of microorganism (eg, in a biosafety or research laboratory that may only be used for a certain type of microorganism), tothe control of a range of potential pathogenic or spoilage microorganisms (eg, in environmental disinfection requirements in food production, research laboratory, general microbiology detection laboratories, and health care facilities), and to the complete eradication of all types of harmful or product degrading microorganisms in higher risk situation (as during the administration of injectable drugs or surgical intervention with devices). Safety requirements will also vary depending on the use of the antimicrobial technology. These can include materialcompatibility, safety to those using the technology, safety to the end consumer or patient, and safety for the environment. [4]

INTRODUCTION TO SILVER NANOPARTICLES

Silver nanoparticles (AgNPs) are increasingly used in various fields, including medical,food, health care, consumer, and industrial purposes, due to their unique physical and chemicalproperties. These include optical, electrical, and thermal, high electrical conductivity, and biological properties. Due to their peculiar properties, they have been used for several applications, including as antibacterial agents, in industrial, household, and healthcare-relatedproducts, in consumer products, medical device coatings, optical sensors, and cosmetics, in the pharmaceutical industry, the food industry, in diagnostics, orthopedics, drug delivery, as anticancer agents, and have ultimately enhanced the tumor-killing effects of anticancer drugs. Recently, AgNPs have been frequently used in many textiles, keyboards, wound dressings, andbiomedical devices. Nanosized metallic particles are unique and can considerably change physical, chemical, and biological properties due to their surface-to-volume ratio; therefore, these nanoparticles have been exploited for various purposes. In order to fulfill the requirementof AgNPs, various methods have been adopted for synthesis. Generally, conventional physicaland chemical methods seem to be very expensive and hazardous. Interestingly, biologically- prepared AgNPs show high yield, solubility, and high stability. The biological activity of AgNPs depends on factors including surface chemistry, size,size distribution, shape, particle morphology, particle composition, coating/capping, agglomeration, and dissolution rate, particle reactivity in solution, efficiency of ion release, andcell type, and the type of reducing agents used for the synthesis of AgNPs are a crucial factor for the determination of cytotoxicity. The physicochemical properties of nanoparticles enhancethe bioavailability of therapeutic agents after both systemic and local administration and otherhand it can affect cellular uptake, biological distribution, penetration into biological barriers, and resultant therapeutic effect. Recently, AgNPs have been shown much interest because of their therapeutic applications in cancer as anticancer agents, in diagnostics, and in probing. [11]

DIFFERENT METHODS OF PREPARATION OF SILVER NANOPARTICLES.

PREPARATION OF SILVER NANOPARTICLES USING CAMELLIA SINENSIS EXTRACT (TEA LEAVES).

Weigh 10gm of tea leaves. Tea leaves was added with 100ml of distilled water in a beaker. Now boil it for 10min at 60c. After 10min, the tea extract was filtered using0.45micro metre Millipore membrane filter and followed by0.2 micrometre Millipore membrane filter. It indicating that, should be done the double filtered. Now 12ml of tea extractwas added into 1mm of AgNo3 [silver nitrate] in a beaker at room temperature. Colour change of the solution was observed. It indicates the formation ofsilver nano particles.[8]

PREPARATION OF SILVER NANO PARTICLES USING LEAVES EXTRACT OF HIBISCUS ROSASINENSIS.

Weigh 10gm of Hibiscus leaves. Wash thoroughly with distilled water, toremove surface contamination. Then, crushed the leaves. The paste of leaves was refluxed by adding 100ml of distilled water at 100cfor 60min. From this, the saturated solution of leaves extract was obtained. Reflux solution was cooled at room temperature. Now, filtered using whatman filter paper no.41. Hence obtained filtrate wasused as plant extract. Now, 10ml of AgNO3 [Silver nitrate] with different concentrations was added with 15ml of plant extract. Having different PH atdifferent temperature and reaction time. Different parameters were optimized for synthesizing of AgNPs including,PH, reaction time, temperature and concentration of AgNO3. PH & Temperature was one of main factors which has a major role innanoparticles synthesis. The AgNPs were synthesized with optimized parameters. At PH 3, there is no change in colour of plant extract solution. Indicates noAgNPs development at acidic PH. And at PH 10 colour changes was rapid. Hence, the change in colour of plant extract solution, from Green to yellowishbrown. Indicates the formation of silver nanoparticles [AgNO3].[9]

PREPARATION OF SILVER NANOPARTICLES BY USING SVENSONIA HYDEROBANDENSIS AND THE STEM BARKS OF BOSWELLIA, SHOREASPECIES.

Leaves of Svensonia hyderobadensis and the stem barks of Boswellia, Shoreaspecies were collected.

The bark and leaves were air dried for 10 days and kept in the hot air oven at600C for 24-48 hours. The dried barks and leaves were ground to a fine powder. 1 mM silver nitrate was added to the plant extracts separately to make up a finalsolution of 200 ml and centrifuged at 18,000 rpm for 25 min. The supernatants were heated at 50 to 950C. A change in the colour of the solutionwas observed during heating of process within 10-15 minutes. The colour changes indicate the formation of silver nanoparticles (SNPs). The reduction of pure Ag2+ ions were monitored by measuring the UV-Vis spectrum of the reduction media at 5 hours after diluting a small aliquot of the sample in distilled water by using systronic 118 UV- Vis Spectrophotometer.[5]

RAPID BIOLOGICAL SYNTHESIS OF SILVER NANOPARTICLES USING PLANTLEAF EXTRACTS.

Five plant leaves were collected and dried for 2 days at room temperature. They were Pine (Pinus desiflora), Per- simmon (Diopyros kaki), Ginkgo (Ginko biloba), Magnolia (Magnolia kobus) and Platanus (Platanus orientalis). The plant leaf broth solution was prepared by taking 5 g of thoroughly washed and finely cut leaves in a 300 mL Erlenmeyer flask with 100 mL of sterile distilled water and then boiling the mixture for 5 min before finally decanting it. They were stored at 4 °C and used within a week. Typically, 10 mL of leaf broth was added to 190 mL of 1 mM aqueous AgNO3 solutionfor reduction of Ag+ ions. The effects of temperature on synthesis rate and particle size of the prepared silver nanoparticles were studied by carrying out the reaction in water bath at 25–95 °C withreflux. The concentrations of AgNO3 solution and leaf broth were also varied at 0.1–2 mM and 5–50% by volume, respectively. The silver nanoparticle solution thus obtained was purified by repeated centrifugation at 15,000 rpm for 20 min followed by redispersion of the pellet in deionized water. UV-vis spectra were recorded as a function of reaction time on a UV-1650CP Shimadzu spectrophotometer operated at resolution of 1 nm. After freeze drying of the purified silver particles, the structure and composition. were analyzed by scanning electron microscopy (SEM, Hitachi S-2500C), field emission transmission electron microscopy (FE-TEM, Tecnai F30 S-Twin, FEI), energydispersive X-ray spectroscopy (EDS, Sigma), and X-ray photoelectron spectroscopy (XPS, ESCALAB 210). Silver concentrations and conversions were determined using inductively coupled plasma spectrometry (ICP, JY38Plus). Average particle size and distribution were measured using particle analyzer (NICOMPTM 380 ZLS).[7]

PREPARATION OF SILVER NANOPARTICLES USING M. BALBISIANA(BANANA), A. INDICA (NEEM) AND O. TENUFLORUM (BLACK TULSI)

Aqueous solution (1 mM) of silver nitrate (AgNO3) was prepared in 250 mL Erlenmeyer flasks and leaf extract was added for reduction into Ag+ ions for each typeof leaf extract. The composite mixture was then kept on turntable of the microwave oven for completebioreduction at a power of 300 W for 4 min discontinuously to prevent an increase of pressure. In the mean-time, the colour change of the mixture from faint light to yellowish brown to reddish brown to colloidal brown was monitored periodically (timeand colour change were recorded along with periodic sampling and scanning by UV- visible spectrophotometry) for maximum 30 min. This was separately performed with each type of plant extract. The reactions werecarried out in darkness (to avoid photoactivation of AgNO3) at room temperature. Suitable controls were maintained all through the con- duction of experiments. Complete reduction of AgNO3 to Ag+ ions was confirmed by the change in colour fromcolourless to colloidal brown. After irradiation, the dilute colloidal solution was cooled to room temperature and keptaside for 24 h for complete bio reduction and saturation denoted by UV-visible spectrophotometric scanning. Then, the colloidal mixture was sealed and stored properly for future use. The formationof Ag NPs was furthermore confirmed by spectrophotometric analysis.[6]

PREPARATION OF SILVER NANOPARTICLES BY EXTRACTS OF ABELMOSCHUS ESCULENTUS.

The freshly collected flowers (250 grams) were dried at room temperature, and the dried flowers were blended as a fine powder. Five grams of the powder was soaked in100 mL of double distilled water (DH2O) for 24 h. The collected aqueous flower extract (AME) was filtered using Whatman No 1 filter paper, and the extract was dark black in colour. Then, 1 mM silver nitrate (AgNO3) was added to 250 mL of double distilled water and thoroughly mixed until AgNO3 was dissolved. Then, 5 mL of AME was added and thoroughly mixed. The mixed solution was observed, and the colorless solution turned dark brown in colour in 72 h, indicating theformation of AME-AgNPs.[10]

CONCLUSION

In this review, we presented a detail overview about NPs, their types, synthesis, characterizations, physiochemical properties and applications. Through different characterization techniques such as SEM, TEM and XRD, it was revealed that NPs have size ranges from few nanometer to 500 nm. While the morphology is also controllable. Due to theirtiny size, NPs have large surface area, which make them suitable candidate for various applications. Beside this, the optical properties are also dominant at that size, which further increase the importance of these materials in photocatalytic applications. Synthetic techniquescan be useful to control the specific morphology, size and magnetic properties of NPs. ThoughNPs are useful for many applications, but still there are some health hazard concerns due to their uncontrollable use and discharge to natural environment, which should be consider for make the use of NPs more convenient and environmental friendly. Synthesis of nanoparticles by using plants like neem, amla, citrus sinesis, moringa oleifera are useful and these plants shows good anti-microbial actions.

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