Review Article

A Brief Review on Investigation of Synthesis and Antimicrobial Activity of Silver Nanoparticles

ABSTRACT

Introduction: Nano science and nano biotechnology provided enormous opportunities for exploring the bactericidal and fungicidal activities. Unfortunately, infectious diseases continue to be a major health burden on worldwide. Since ancient times, silver was known for its anti-bacterial effects and for centuries it has been used for prevention and control of disparate infections.

Aims: Our goal is to prepare silver nanoparticles since studies have shown that silver nanoparticles have efficient activity against bacterial biofilms.

Methodology: The silver nanoparticles were generally synthesized by non-aqueous sol-gel technique in the presence of different precursor by chelating agent.

Results: The structure, grain size, crystallite size, crystallinity, peak profiling investigated an outstanding approach by XRD. The morphology of the prepared nano particles has been revealed by SEM below 10nm and TEM is below 5nm in size of graphical presentation such as size, shape, surface etc. of the nanoparticles. DLS is a unique technique to discern particle size below 100nm and size distributions in aqueous or physiological solutions of the nanoparticles.

Conclusion: The potential benefits of nanoscience in industrial and biomedical applications have become widely accepted and are the most promising sector for the generation of new applications. The studies on the combined use of AgNPs with other antimicrobial agents generally help reduce the problem of toxicity and to avoid the potential for development of resistance and strongly enhance the microbicidal effect. This paper describes a short and very precise description about the chemical synthesis process of silver nanoparticles like no aqueous SGM. Also, this paper contains a brief description about different characterization technique of nanoparticles like X-ray Diffraction, Scanning Electron Microscope, Dynamic Light Scattering, Transmission Electron Microscope.

Keywords: Cell destruction (CD), Silver Nanoparticles (AgNPs), Sol-Gel Method (SGM), TEM Analysis (TA), XRD Technique (XRDT).

1. INTRODUCTION

Recently there has been a great scientific and technological interest in the synthesis and characterization of nano-sized materials of various ranges for diverse applications [1-7]. Nanotechnology is the study, control and manipulation of materials at the nanoscales, typically having dimensions less than 100 nm at least one dimension [8]. Metal nanoparticles have been enormously investigated because of their unique optoelectronic properties that are substantially different from bulk materials [9].

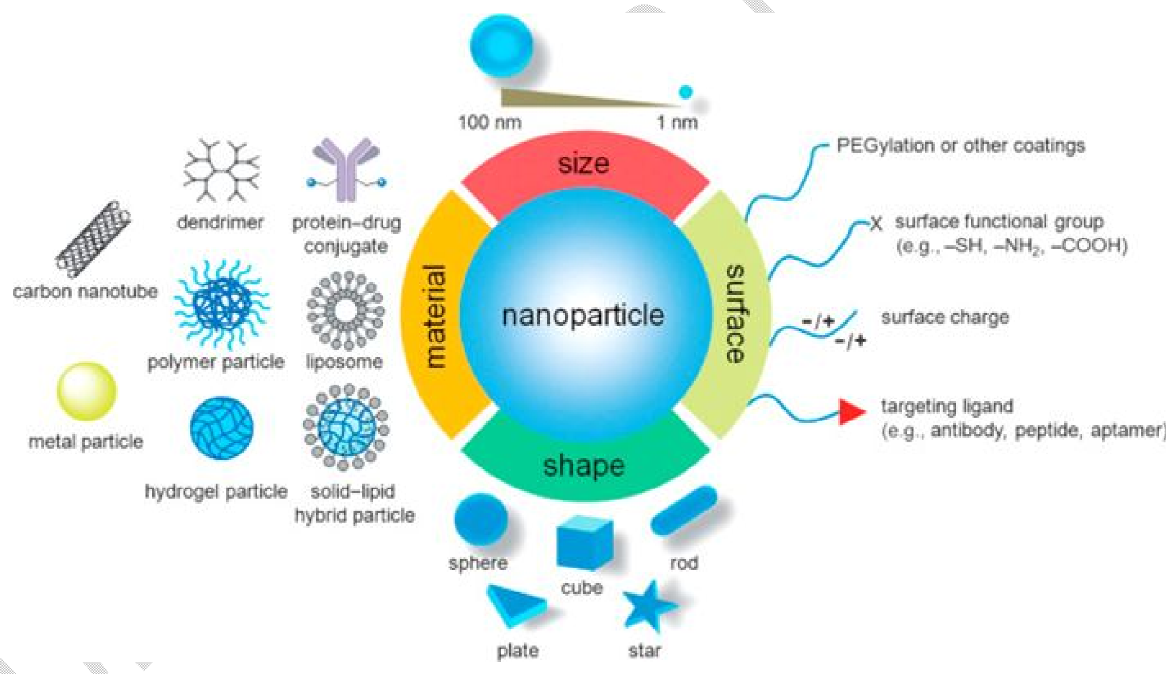

Figure.1: Over all graphical view of nanoparticle

Nanomaterials of silver species, both in pure and composite form have different graphical property as size (1 to 100nm), materials (different structure), shape (such as cube, rod, plate etc.) and surface properties are of particular interest due to their field of applications from chemical catalysis [10,11] to health care [12-17], or solar cells [18] to mention a few. Various routes have been employed to synthesize these compounds such as through impregnation [19,20], co-precipitation [19,21,22], sugar reduction [23] and sol-gel process [24-28], etc. This paper gives a short review including the convenient way of synthesizing AgNPs that are generally practiced within the researchers in this relevant field focusing on SGM.

2. INVESTIGATION OF ANTIBACTERIAL ACTIVITY MECHANISM

Antimicrobial resistance is a complex mechanism whose etiology depends on the individual, the bacterial strains and resistance mechanisms that are developed [29]. Non-traditional antibacterial agents are thus of great interest to overcome resistance that develops from several pathogenic microorganisms against most of the commonly used antibiotics [30]. In the past, silver found its uses as an antiseptic and antimicrobial efficacy against Gram-positive and Gram-negative bacteria [31-33] due to its low cytotoxicity [34]. In fact, the potent antibacterial and broad-spectrum activity against morphologically and metabolically different microorganisms seems to be correlated with a multifaceted mechanism by which nanoparticles interact with microbes [35]. AgNPs are capable to physically interact with the cell surface of various bacteria. In fact, the bactericidal activity of AgNPs of smaller dimensions (<30 nm) was found to be optimal against *Staphylococcus aureus* and *Klebsiella pneumoniae* [36].

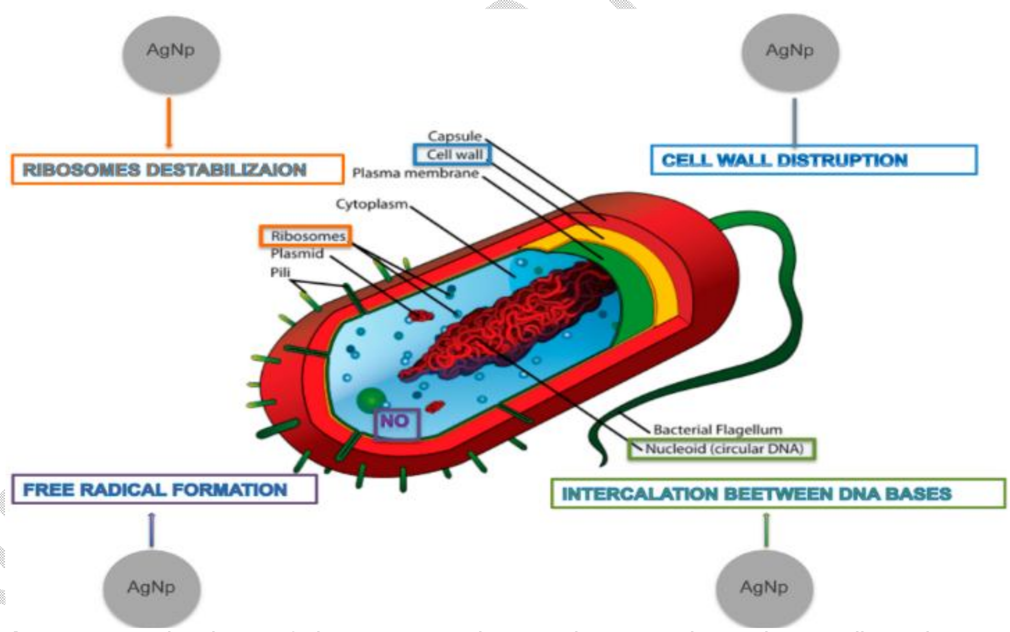

Figure.2: Mechanisms of silver nanoparticles actions on a bacterial cell disruption

AgNPs have a surface to volume ratio much greater than the corresponding bulk material; therefore, modalities and amount of the interactions with the bacterial surfaces are facilitated and determine a higher antibacterial activity with penetration the cell wall disruption [35]. The following figure shows generally how AgNPs can damage and CD of bacterial cell disruption. The antibacterial effect appears to be conferred by their ultra-small size and increased surface area, through which they destroy the membrane, cross the body of the microbe and create intracellular damage. Silver ions (Ag+), released by

AgNPs, are likely to interact with chloride (Cl−) which is often present in bacterial growth media and exhibits a strong affinity for oxidized silver to damage [35].

3. EXPERIMENTAL PROCEDURE

3.1. MATERIAL

The experiment proceeds to the following reagent and condition [37]. Reagent use as silver nitrate (99%+ metals basis Alfa-Aesar, use as a precursor), citric acid (99+% Alfa-Aesar, use as a chelating agent) and ethanol (Fisher Scientific, use a s a medium) and De Ionized water (use as a solvent).

3.2. METHOD AND PREPARATION

Silver nanoparticles had been synthesized through a non-aqueous SGM [37]. Typically, silver nitrate was dissolved in about 100 mL of ethanol and stirred until complete dissolution. Citric acid was then added in a 1:1 molar ratio to allow complexation. Under constant stirring, the solution was then heated at about 120 ℃ until the formation of a gel. The latter was then heated under different atmospheres at different temperatures with variable dwelling times.

3.3. CHARACTERIZATION AND DISCUSSION

3.3.1. X-RAY DIFFRACTION

X-ray diffraction (XRD) is a popular analytical technique which has been used for the analysis of both molecular and crystal structures [38,39], qualitative identification of various compounds [40], quantitative resolution of chemical species [41], measuring the degree of crystallinity [42], isomorphous substitutions [43], crystallite sizes [44], etc. Each material like organic and inorganic crystalline substances has a unique diffraction beam which can define and identify it by comparing the diffracted beams with the reference database in the Joint Committee on Powder Diffraction Standards (ICDD) library [45].

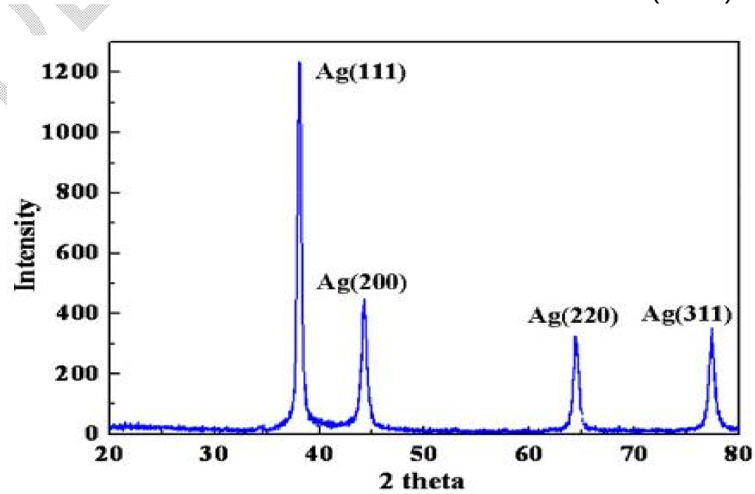

Figure.3: X-ray diffraction pattern of silver nanoparticles

The working principle of X-ray diffraction is Bragg's law [39,46]. Typically, XRD is based on the wide-angle elastic scattering of X-rays [39,47,48]. From figure.3, Main four diffraction was observed on the AgNPs diffractogram of reflection angle with miller indices is (111), (200), (220) and (311) that was conformed the formation of crystalline phase of AgNPs.

3.3.2. DYNAMIC LIGHT SCATTERING

Dynamic light scattering is a method that depends on the interaction of light with particles [45]. This method can be used for the measurement of narrow particle size distributions, like in the range of 2–500 nm [51]. DLS is mainly used to determine particle size and size distributions in aqueous or physiological solutions [52]. DLS measures the light scattered from a laser that passes through a colloid, that relies on Rayleigh scattering from the suspended nanoparticles [49].

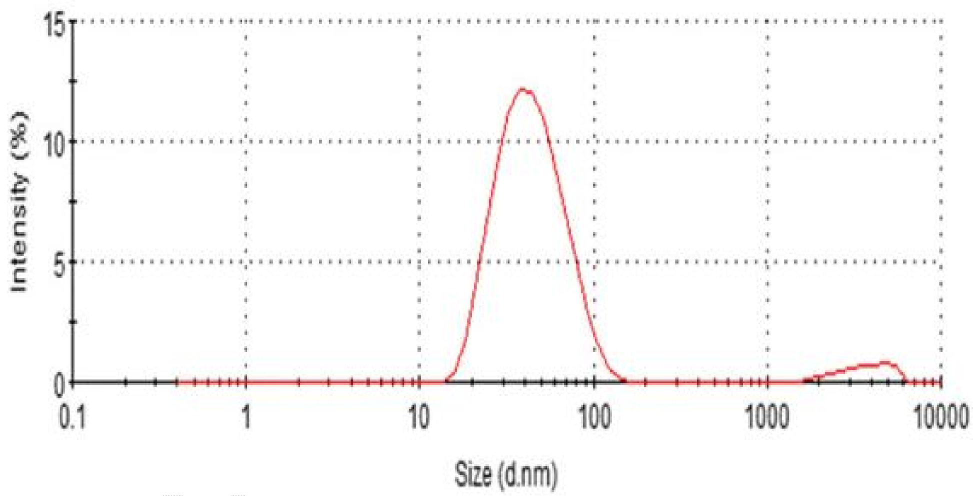

Figure.4: Silver nanoparticles size showing in dynamic light scattering

Characterization of any nanomaterial in solution is essential to evaluate the toxic potential [53]. On figure.4, DLS is a nondestructive method used to obtain the average diameter of nanoparticles dispersed in liquids as well as the zeta potential that was conformed the stability of nanoparticles in a solution or medium. The AgNPs average size is below 100.00nm conformed the formation of nano.

3.3.3. SCANNING ELECTRON MICROSCOPE

Among various electron microscopy techniques, SEM is a surface imaging method, fully capable of resolving different particle sizes, size distributions, nanomaterial shapes, and the surface morphology of the synthesized particles at the micro and nanoscales [49,50]. The modern high-resolution SEM is able to identify the morphology of nanoparticles below the level of 10 nm, The limitation of SEM is that it is not able to resolve the internal structure, but it can provide valuable information regarding the purity and the degree of particle aggregation [45]. Using SEM, we can prove the morphology of particles and derive a histogram from the images by either by measuring and counting the particles manually, or by using specific software [51]. From figure.5, the image shows that, silver nanoparticles are mono-dispersive and

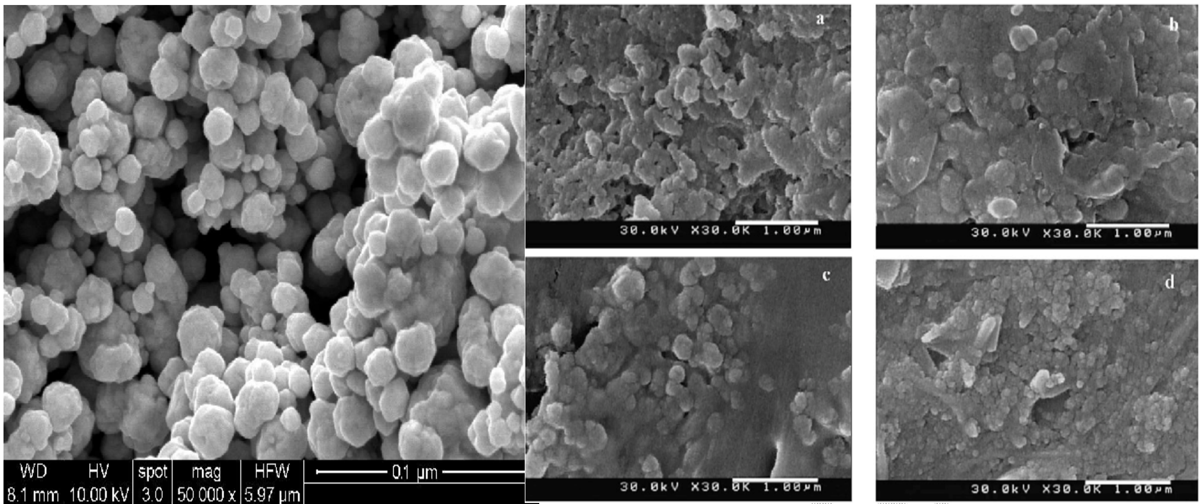

Figure 5: Scanning electron microscope images of silver nanoparticles surface

highly crystalline. The grain sizes of the samples obtained from the SEM images are larger than that obtained from XRDT data (crystallite size).

3.3.4. TRANSMISSION ELECTRON MICROSCOPE

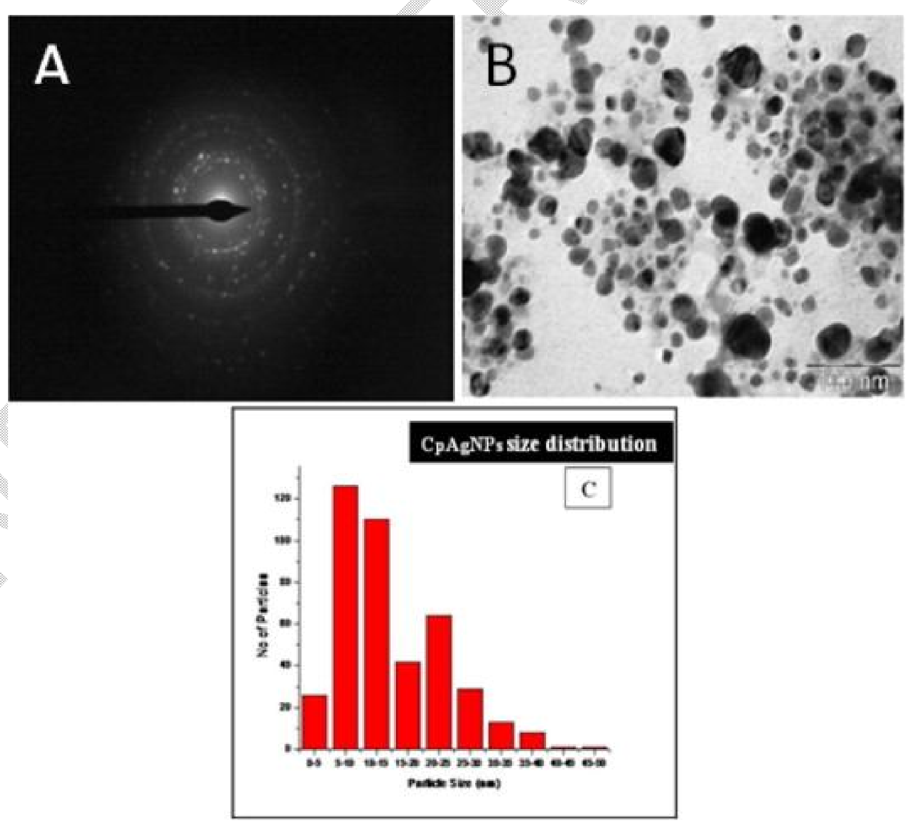

Figure 6: Transmission electron microscope images silver nanoparticles

From the figure.6, the Transmission Electron Microscope (TEM) analyses showed the internal morphology of AgNPs which particle size between 50 and 200 nm (histogram) and average size of silver nanoparticles between 5 and 40 nm with a spherical morphology, very a less agglomeration of the internal morphology and selected area electron diffraction (SAED) planes (111), (200), (220) and (311) observed which conform crystal planes of AgNPs [54]. Which was previously proved by X-ray Diffractometer (XRD) with miller indices of (111), (200), (220) and (311).

4. CONCLUSION

The potential benefits of nanoscience in industrial and biomedical applications have become widely accepted and are the most promising sector for the generation of new applications. The studies on the combined use of AgNPs with other antimicrobial agents generally help reduce the problem of toxicity and to avoid the potential for development of resistance and strongly enhance the microbicidal effect. This paper describes a short and very precise description about the chemical synthesis process of silver nanoparticles like no aqueous SGM. Also, this paper contains a brief description about different characterization technique of nanoparticles like X-ray Diffraction, Scanning Electron Microscope, Dynamic Light Scattering, Transmission Electron Microscope. Further investigation will be continuing the antimicrobial activity test of AgNPs with ceramic coating.

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