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Journal of Chemical and Pharmaceutical Research

J. Chem. Pharm. Res., 2010, 2(3):478-483

ISSN No: 0975-7384
CODEN(USA): JCPRC5

Synthesis of silver nanoparticles: a safer alternative to conventional antimicrobial and antibacterial agents

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ABSTRACT

We present the synthesis of spherical silver nanoparticles by simple and low cost chemical route. Well-dispersed silver nanoparticles were prepared by reducing silver nitrate ($AgNO_3$) with glucose in presence of protective agent polyvinyl pyrrolidone (PVP). Sodium hydroxide was used to enhance the reaction velocity. The prepared nanoparticles were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM) and transmission electron microscopy (TEM). XRD pattern showed the face centered cubic structure of silver nanoparticles. The crystallite size was found to be 18 nm using Scherrer formula. The spherical morphology of silver nanoparticles was confirmed from SEM image. The transmission electron microscopy (TEM) image showed the average particle size of silver nanoparticles was about 15 nm. Silver nanoparticles can kills bacteria when spreads on shoes, socks, phone and even computer keyboard. A preliminary test shows that silver nanoparticles are highly active against S. aureus, E. coli, *and* P. aeruginosa. This reveals that *silver nanoparticles could provide a safer alternative to conventional antimicrobial and antibacterial agents.*

Keywords: Silver; Nanoparticles; Antimicrobial; Antibacterial.

INTRODUCTION

Metal nanoparticles have attracted much attention in the fields of physics, chemistry, electronics and biology [1-3] because of their unique electrical [4], chemical [5], optical [6] and photo-electrochemical [7] properties, which are strongly dependent on the sizes and shapes of metal nanomaterials [8–12]. Metal nanoparticles have a high specific surface area and a high surface to

volume ratio. Nanostructured noble metals are potentially used in catalysis, optoelectronics, microelectronics etc. Metal nanoparticles are particularly interesting systems because of the ease with which they can be synthesized and modified chemically [13, 14]. Silver particles play an important role in an electronic industry. In recent years, with higher integrated density of the electronic components (small size and precision of the electronic components), there is growing demand for a thin conductive films and a further reduction in printed circuits. Powders of nanoparticles form the conductive films and thereby reducing the dimensions of the printed circuit [15].

Silver has been known to have antibacterial properties since ancient times. Many new industries involves in production of antibacterial gels using silver nanoparticles [16]. Recently, it was found that aqueous chloroaurate ions may be reduced extracellularly to generate extremely stable gold or silver nanoparticles in water. These particles can be incorporated in materials and cloth becoming them sterile. The sterile materials are important in hospital, where often wounds are contaminated with microorganisms [17]. Silver nanoparticles acts like antimicrobial agents to reduce or prevent infections. [18]. Ag nanoparticles can be used as effective growth inhibitors in various microorganisms, making them applicable to diverse medical devices and antimicrobial control systems. The antimicrobial effects of silver (Ag) ion or salts are well known, but the effects of Ag nanoparticles on microorganisms and antimicrobial mechanism have not been revealed clearly. This paper presents the synthesis of spherical silver nanoparticles by simple and low cost chemical route. A preliminary test shows that silver nanoparticles are highly active against *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* and could act as a safer alternative to conventional antimicrobial and antibacterial agents [19-20].

EXPERIMENTAL SECTION

The chemical reduction method is one of the commonest methods to synthesize colloidal metal particles because of its convenient operation, ease of control and simple. We have used chemical reduction method to synthesize the silver nanoparticles. Well-dispersed silver nanoparticles were synthesized by reducing silver nitrate ($AgNO_3$) with glucose in presence of protective agent PVP. Sodium hydroxide (NaOH) is used to enhance the reaction velocity.

2.1 Chemical Reagents

All the chemicals used in the experiment were analytical reagent (AR) grade. Silver nitrate ($AgNO_3$) was provided by Glaxo SmithKline Pharmaceutical Ltd. Glucose and PVP were obtained from Merck. The sodium hydroxide (NaOH) pellets was purchased from Loba Chemie. Deionized water was used through out the experiment.

2.2 Preparation

1.27 g of PVP, 0.96 g of NaOH and 5.94 g of glucose were dissolved in 15 ml deionized water and heated to 60 °C with constant stirring. 0.01 M (in 5 ml water) of silver nitrate solution was added to PVP solution drop by drop. After all the silver nitrate solution is added, the solution was further stirred for 10 min. The particles were separated by centrifugation and washed with distilled water several times until no NO_3^- could be traced. The particles were dried at 80 ºC. Grey colored silver nanoparticles were obtained in the form of powder. Figure 1 shows the flowchart for the preparation of silver nanoparticles.

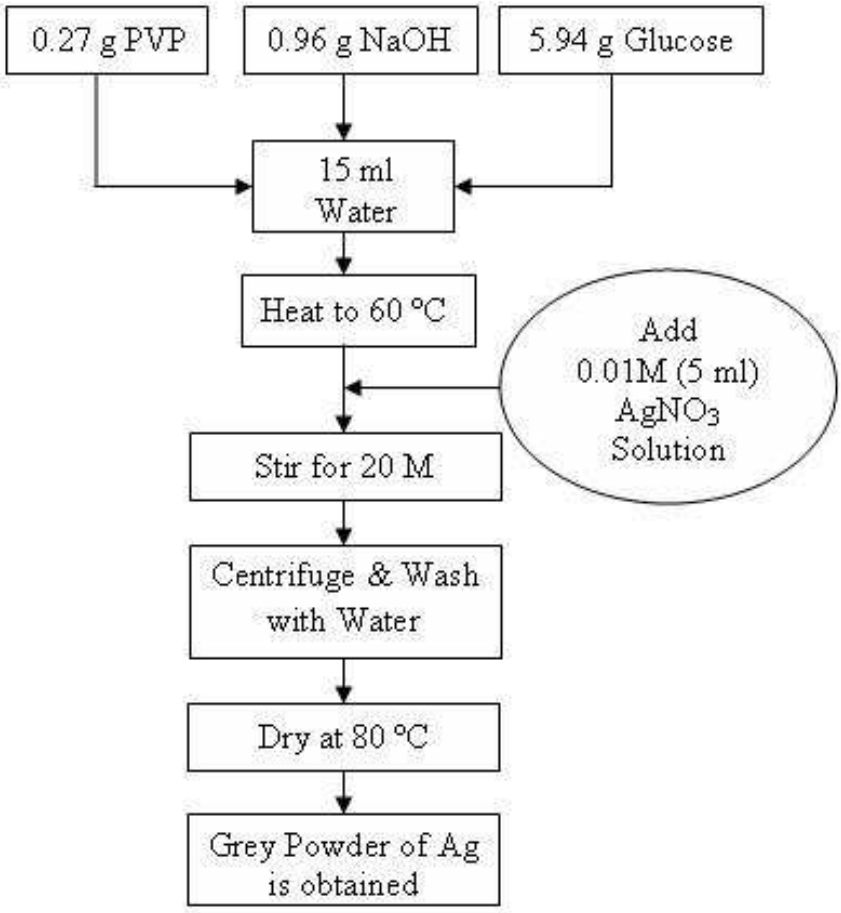

Figure 1: Flowchart for the preparation of silver nanoparticles.

2.3 Characterization of Silver nanoparticles

The powder X-ray diffraction (XRD) was performed using Philips Holland, XRD system PW 1710 with nickel filtered CuK_α (λ = 1.5405 Å) radiation. The average crystallite size (t) has been calculated from the line broadening using the Scherrer's relation: $t = 0.9\lambda/B\cos\theta$, where λ is the wavelength of X-ray and B, the half maximum line width. The scanning electron microscopy (SEM) studies were performed with JEOL JSM 5600. The transmission electron microscopy (TEM) studies were performed with Tecnai 20 G^2 under 200 KV. Samples are prepared by dispersing drop of colloid on copper grid, covered with the carbon film and the solvent is evaporated.

RESULTS AND DISCUSSION

3.1 XRD study

Figure 2 (a) shows the X- ray diffraction pattern (XRD) of as prepared silver nanoparticles synthesized using chemical reduction method. A number of Bragg reflections corresponding to the (111), (200), (220), (311) and (222) sets of lattice planes are observed. These peaks are matched with the face centered cubic (fcc) structure of silver (JCPDS file No. 04-0783) as shown in figure 2 (b).

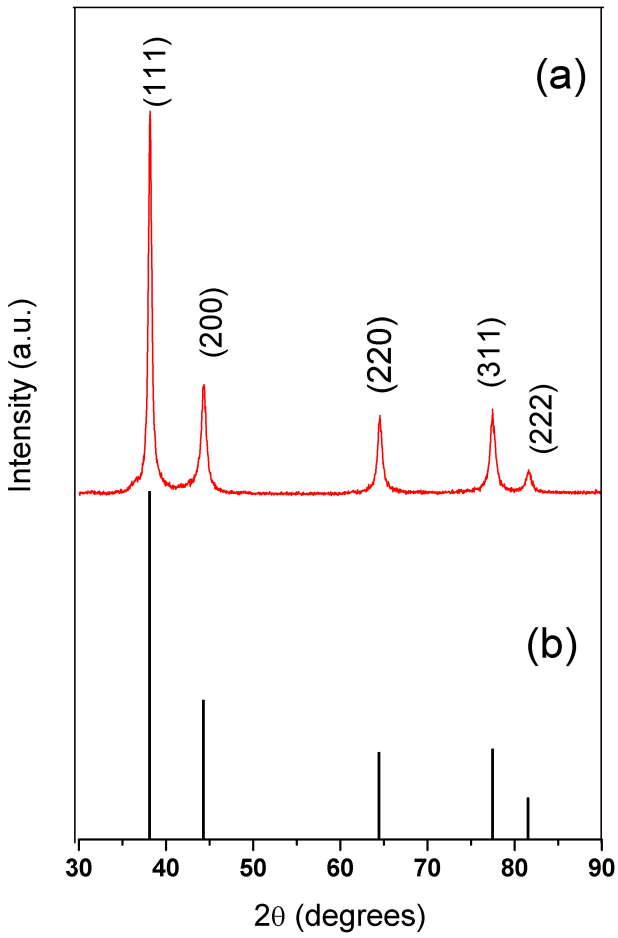

Figure 2: (a) XRD pattern of prepared silver nanoparticles
(b) JCPDS file No. 04-0783

The calculated lattice parameter is a = 4.086 Å and unit cell volume V = 68.20 Å^3. The diffraction profiles of as-prepared silver are obviously broadened as compared with bulk silver, revealing the formation of silver nanoparticles. The XRD pattern thus, clearly shows that the silver formed by reducing silver nitrate with glucose in the presence of protective agent PVP, Ag+ ions is crystalline in nature. The crystallite size of silver nanoparticles was found to be 18 nm using Scherrer equation.

3.2 SEM and TEM Study

Figure 3 shows SEM image of silver nanoparticles. It reveals that silver nanoparticles were spherical and particles form cluster. Figure 4 shows the TEM image of silver nanoparticles. It shows the particle size was around 15 nm which agrees with crystallite size using X-ray diffraction pattern. Inset of figure 4 shows selected area electron diffraction (SAED) pattern which agrees with crystalline and face centered cubic structure of silver nanoparticles.

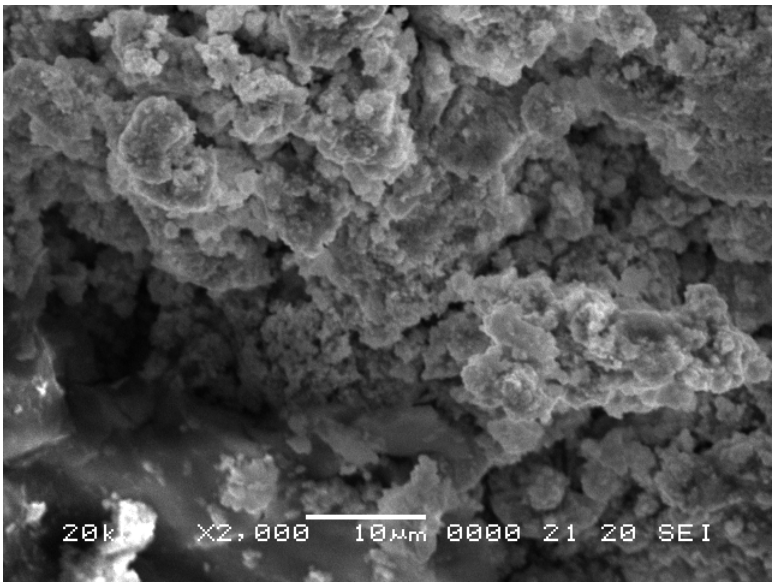

Figure 3: SEM image of silver nanoparticles.

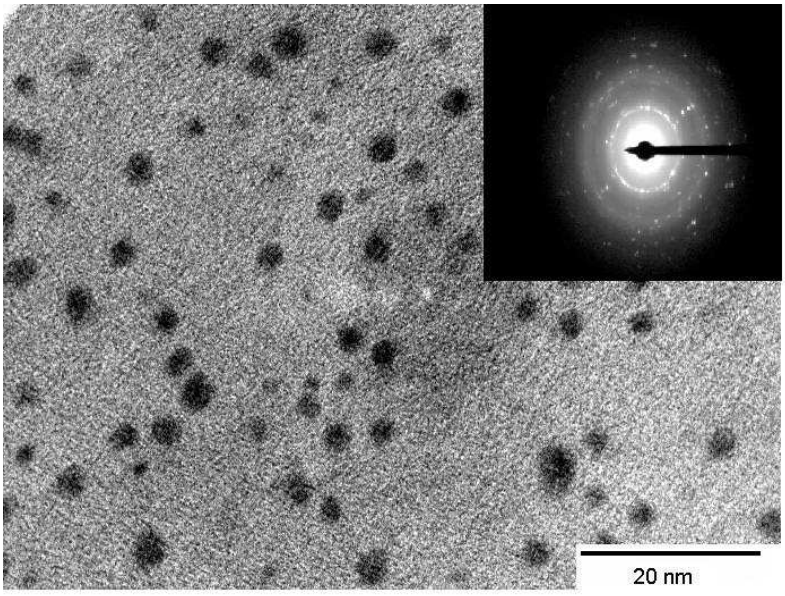

Figure 4: TEM image of silver nanoparticles. Inset shows selected area electron diffraction (SAED) pattern of silver nanoparticles

3.3 Silver nanoparticles as a Antimicrobial and antibacterial agent

Silver nanoparticles reduced by silver nitrate solution with an electron beam are more effective at killing all kinds of bacteria, including gram-negative species that are not harmed by conventional antibacterial agents. When we spread the silver nanoparticles on shoes, socks, phone and even computer keyboard can kill bacteria, keep the smelling sweet and prevent the spread of infection among the computer users. Silver nanoparticles are not only antibacterial against so-called gram-positive bacteria, such as resistant strains of *Staphylococcus aureus* and *Streptococcus pneumoniae* but, also against gram-negative *Escherichia coli* and *Pseudomonas aeruginosa*. Silver nanoparticles can also fight against infected skin wounds by reducing antimicrobial activities. These results clearly indicate that silver nanoparticles could provide a safer alternative to conventional antimicrobial and antibacterial agents.

CONCLUSION

Well-dispersed silver nanoparticles were synthesized by reducing silver nitrate ($AgNO_3$) with glucose in presence of protective agent PVP. Sodium hydroxide is used to enhance the reaction velocity. Spherical particles of having average size 15 nm were confirmed from TEM. Silver nanoparticles could provide a safer alternative to conventional antimicrobial and antibacterial agents.

Acknowledgments
The authors wish to acknowledge financial support from UGC, New Delhi, for present research work. Authors are also grateful to Dr. Ajay Gupta and his colleagues, UGC-DAE Consortium for Scientific Research Center, Indore for providing SEM and TEM facilities. We also thanks to Dr. Raghumani S. Ningthaujam, Chemistry Division, BARC Mumbai and Dr. R. R. Dahegaonkar, Principal, Dr. Ambedkar College, Chandrapur for their partial support.

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