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Research Article

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Synthesis of Nano silver Using Zinc and Copper as Reducing Agents

Mohammed A Fayadh*

Department of Chemistry& Biochemistry, College of Medicine, University of Al-Fallujah, Iraq.

*Corresponding Author
Mohammed A Fayadh, Department of Chemistry& Biochemistry, College of Medicine, University of Al-Fallujah, Iraq.

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Abstract

New method to prepare silver nanoparticles (Ag-NPs) from reduces aqueous solutions of silver nitrate and a mixture of (i) Zinc (ii) Copper as reducing agents and guar gum as a stabilizer. At different temperature and pH=8. UV-Vis spectroscopy, zeta potential analysis, X-Ray diffraction (XRD), and scanning electron microscope (SEM) describe the structure and stability of Ag-NPs. According to SEM result, the particles have spherical shape with particle size 50±30 nm. The UV-Vis spectra of the result solution of Ag-NPs show an absorption peak at 429 nm and 440 nm for Zinc and Copper respectively. Nano silver showed stability for long periods of time to more than nine months.

Keywords: Silver nanoparticles, Surface Plasmon Resonance (SPR), Scanning Electron Microscope (SEM)

Introduction

Nano science and nanotechnology has provided solutions to many technological challenges like medicine and water treatment and other applications [1] they are deal with the synthesis, characterization, exploration, and exploitation of nanostructure materials among these Nano metals silver nanoparticle [2]. Silver (Ag) has important properties such as electrical, optical and chemical which have significant applications in catalysis, electronics, fuel cells, pigments and sensors [3]. Their unique optical, electrical and magnetic properties depend on the shape and size of the nanoparticles [4].

The preparation of Ag-NPs nanoparticles includes many methods such as chemical [5], physical [6], photochemical [7] and biological [8] routes. Among the existing methods, the chemical methods have been especially used for production of Ag-NPs. Chemical methods provide an easy route to synthesize Ag-NPs in solution. Many methods aiming at forming Ag-NP use an organic molecule to provide them with stability against oxidation and conglomerate or act like a matrix only. Polymer molecules have been broadly employed because their lengthy chain display many binding sites in which nanoparticles can be stabilized. The natural polymers are considerably important because many of them are biocompatible and nontoxic. Among such biochemical compounds are sucrose, maltose, chitosan, and Arabic gum [9].

Ag-NPs is a very effective antibacterial which plays an important role in inhibiting bacterial growth in aqueous and solid media. Ag comprising materials can be used to eradicate microbes on textile fabrics and also for treatment of waste water. The antimicrobial activity of colloid silver particles are effect by the particles size, the smaller particles has high activity on bacteria [10].The synthesis of Ag-NPs was characterized by UV-Vis spectrophotometry, Zeta potential, XRD-Diffraction. Their morphology was emission scanning electron microscopy (SEM).

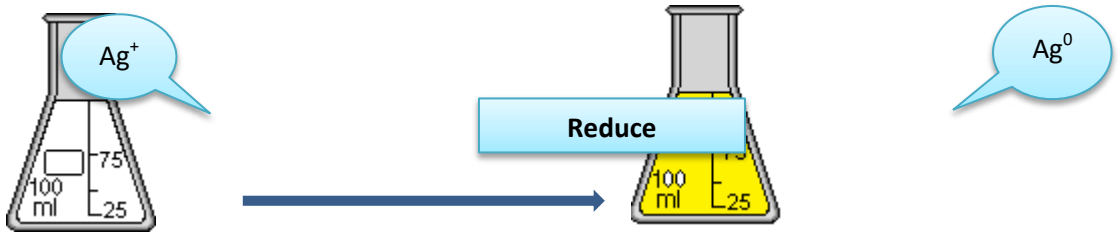
This paper focuses on sedentary silver nanoparticles using new reducing agents and guar gum as stabilizers. These preparations are economical and easy ways of available and cheap materials, and then continue with the stability of the particles over a period of time.

Experimental Part

Materials

Silver nitrate ($AgNO_3$) (Sigma-Aldrich, p.a.), sodium hydroxide (NaOH) (Sigma-Aldrich, p.a.), small pieces from Zinc and Copper, and Guar Gum (HIMEDIA), India.

Preparation of Ag-NPs



Synthesis of $AgNO_3$ using zinc: 0.1 g of Guar gum was dissolved in 100 mL of distilled water at room temperature with stirring in a conical flask of 250 mL. To this solution, small pieces of zinc element were added with continuous stirring and then a few drops of 2% NaOH solution were added to adjust the result solution at pH=8. The solution was upon cooling to 150C. Finally, 100 mL of 2.35 mM silver nitrate $AgNO_3$ was added slowly and after 1 h the color of the solution was altered to yellow, which indicates the production of silver nanoparticles.

$$2AgNO_3 + Zn \longrightarrow Zn(NO_3)_2 + 2Ag^0$$

Synthesis of $AgNO_3$ using copper: 0.1 g of Guar gum was dissolved in 100 mL of distilled water at room temperature with stirring in a conical flask 250 mL. To this solution small pieces of copper was added with continuous stirring and then few drops of 2% NaOH solution was added to adjust the result solution at pH= 8. The solution was heated to 50 0C. Finally 10 mL of 5.8 mM silver nitrate $AgNO_3$ was added slowly and after 30 minutes the color of the solution was changed to yellow, which indicates the formation of silver nanoparticles.

$$2AgNO_3 + Cu \longrightarrow Cu(NO_3)_2 + 2Ag^0$$

Result and Discussion

Characterization of Silver Nanoparticles

Ag-NP_s were describe by Ultraviolet-Visible (UV-Vis) spectroscopy Spectrophotometer (UV-VISSP8001, Metertech, Japan) in a range of 200-800 nm, zeta potential analyzes (Malvern zeta seizer 2000, Malvern, UK), x-ray diffraction (XRD, 6000-Shimadzu X-ray Diffraction), and Scanning Electron Microscope (SEM) (VEGA3 LM/TESCAN).

UV-Vis spectroscopy: The UV-Visible spectra of Ag-NPs showed a well-defined surface Plasmon band centered at around (λ_{max}) 429 nm for using solution of zinc and 440 nm for copper which is typical for Ag-NPs solution as shown in diagram 1. The color of the resulted Ag-NPs solutions was yellow which indicates the formation of the silver nanoparticles. The absorbance band (λ_{max}) of the Ag-NPs happen in the range of 400- 500 nm according to the effect of the Surface Plasmon Resonance (SPR).

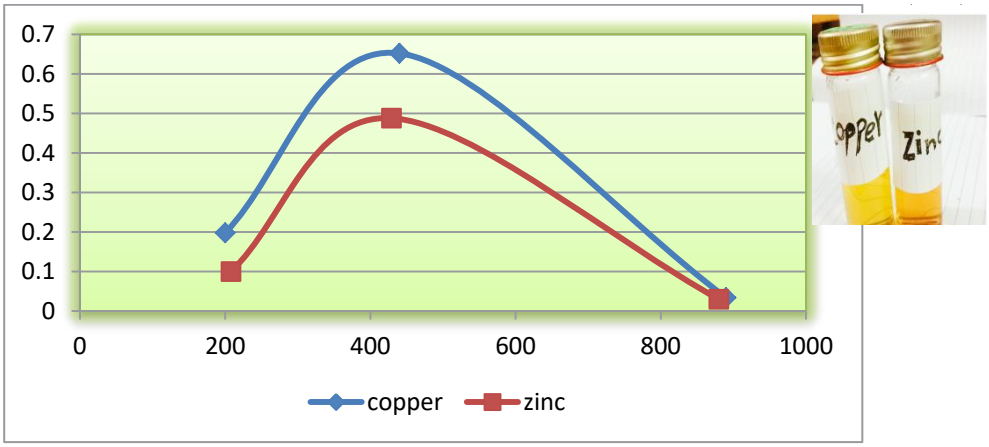
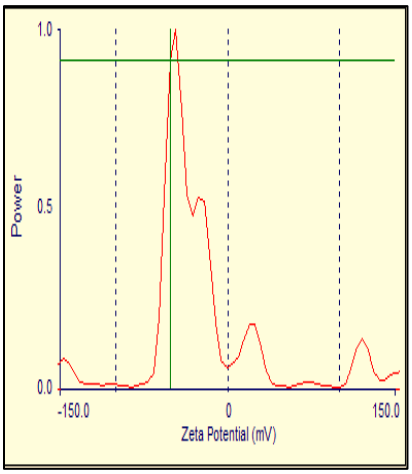


Figure 1: UV-Visible spectra (λ_{max}) of Ag-NPs solutions using zinc and copper.

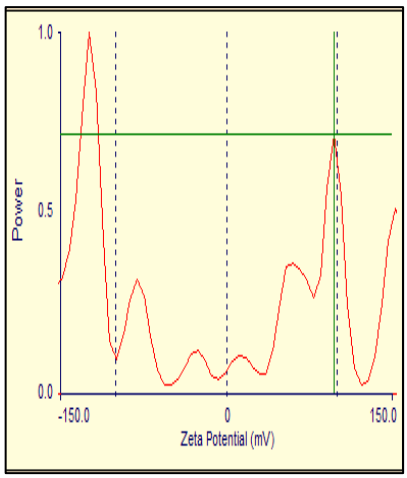
When the Ag-NPs conformed the electrons on the surface of Ag move freely, and that movement give raise to SPR absorption band, and the Ag collective oscillation electrons in resonance with light wave. The resonance results a strong absorption, which is the origin of the observed color. This absorption relies on the particle size, dielectric medium, chemical surroundings. Small globular, nanoparticles give a single surface Plasmon band [11].

Zeta Potential (ζ): As shown in diagram.2 the Ag-NPs obtained possess positive and negative zeta potential value for copper and zinc solutions.

Zeta potential is an essential parameter for the characterization of stability in aqueous Nano suspensions. A minimum ±30 mV zeta potential value is required for indication of stable Nano suspension [12]. The zeta potential was equal to (97.38 mV) for copper solution and (-51.27 mV) for zinc solution. So, this result obviously indicated that the particles are completely stable attributed to the electrostatic repulsion.



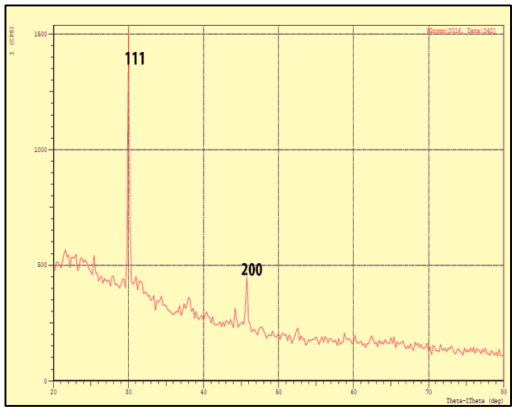
ζ= -51.27 mV using zinc



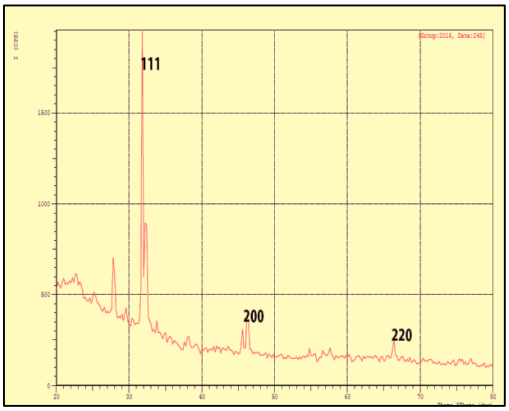
ζ= 97.38 mV using copper

Figure 2: Zeta potential of prepared Ag-NPs using zinc and copper.

XRD analysis: Figure 3 shows X-ray diffraction (XRD) patterns. The XRD patterns mark that the structure of Ag-NPs is facing center cubic (FCC) (JCPDS file No. 00-004-0783) [13]. All the reflections refer to pure silver metal at 2θ of 38.0739^0, 46.4^0, and 66.3157^0 could be attributed to the 111, 200, and 220 crystallographic planes of FCC of Ag for copper, and at 2θ of 37.920^0, and 45.7617^0 refer to 111 and 200 crystallographic planes of FCC for zinc. Silver is the main crystalline phase and there were no clear other phases as impurities were found in the XRD patterns (Ag XRD Ref. No. 01-087-0719).



X-ray of Ag-NPs using zinc

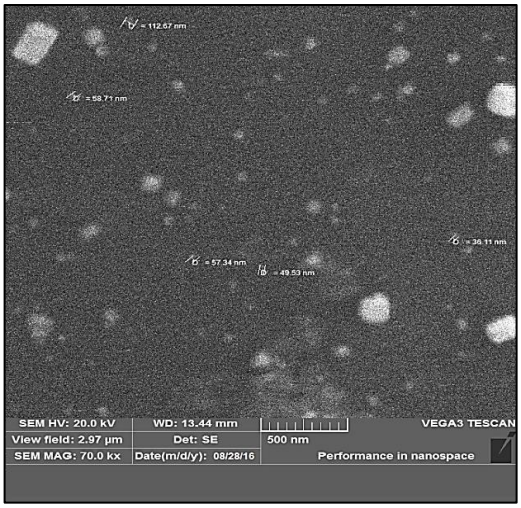


X-ray of Ag-NPs using copper

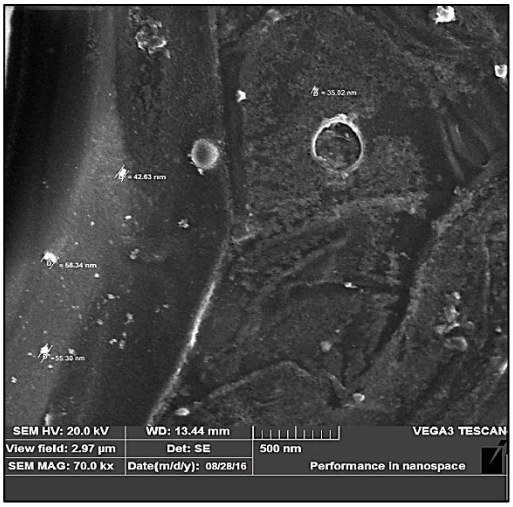
Figure 3: X-Ray Diffraction pattern of Ag-NPs using zinc and copper.

Scanning electron microscope (SEM): The scanning electron micrograph of Ag-PNs is depicted in figure 5. The micrograph result showed tight particle size distributions, with diameters in the range of 50±30 nm for both solutions and spherical shapes. These results assure that guar gum can effectively control the shape and size of the Ag-NPs.

In this study we synthesize Ag-NPs by using guar gum as a capping agent (stabilizing agent) after reacting with silver nitrate. It was observed uniform in diameter, there is a few large Ag aggregated due to the combination between different Ag-NPs together. The thick layer of guar gum prevented agglomeration of Ag-NPs, resulting in well-dispersed Ag-NPs. These Ag-NPs would find their useful applications in several areas [14].



Using zinc



Using copper

Figure 5: SEM for Ag-NPs from both solutions.

Conclusion

In summary, silver nanoparticles were prepared by reduce of silver nitrate solution and zinc, with copper as the reducing agents with guar gum which act as a stabilizer agent. The Ag-NPs were about 50±30 nm diameter and spherical in shape. UV-Vis spectra show the characteristic Surface Plasmon Resonance (SPR) peak for the silver nanoparticles solution at 429 nm by using zinc and at 440 nm with copper as reducing agents. No shift was observed in the peak position over a period time of six months by adding guar gum, which provided a good indication of the stability of Ag-NPs. Zeta potential indicate the stable of Ag-NPs to be -51.27 mV for zinc solution and 97.38 mV for copper solution. Guar gum is a natural polymer molecule. Use them very important because they are biocompatible and nontoxic, and they have long chain which show many binding sites, therefore Ag-NPs can be stabilized.

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