

Synthesis and study silver nanoparticles by chemical method

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Abstract

In this paper, Ag nanoparticles with various sizes and forms are made by using reduction methods of Ag ions in aqueous solutions in the presence of strong reducing agents like hydrogen peroxide (NaBH_4) with different concentrations of silver nitrate AgNO_3 (1mM to 0.9mM) improving its effect on the stability of the nanoparticles. From the results, stability of the Ag nanoparticles is due to the ions of NaBH_4 that surrounding the nanoparticles and decreased from aggregating as demonstrated by using UV-VIS spectra, Particle size analyzer (PSA) , Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) to determine their behavior as catalyst materials and analysis the kinetics of reactions.

Keywords: Silver Nanoparticle (AgNPs), stability of the nanoparticles, strong reducing agent, chemical method

تحضير ودراسة جسيمات الفضة النانوية باستخدام الطريقة الكيميائية

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الخلاصة

في هذا العمل، تم تحضير جسيمات الفضة النانوية بأشكال مختلفة باستخدام الطريقة الكيميائية المختزلة لأيونات الفضة في المحاليل المائية بوجود عامل مختزل قوي مثل بيروكسي الهيدروجين NaBH_4 بتركيز مختلفة من نترات الفضة AgNO_3 من 1 mM إلى 0.9 mM مع توضيح اثره على استقرارية الجسيمات النانوية. ومن خلال النتائج التي تم التوصل اليها فان استقرارية جسيمات الفضة تعود الى دور ايونات بيروكسي الهيدروجين في احاطة الجسيمات النانوية ومنع التجمعات كما هو ملاحظ في مطياف الاشعة فوق البنفسجي UV-VIS وفحص محلل الجسيمات PSA و جهاز الماسح الالكتروني SEM بالإضافة الى جهاز النافذ الالكتروني TEM لغرض دراسة الفعل التحفيزي للعامل المختزل في حركية التفاعل

الكلمات المفتاحية: جسيمات الفضة النانوية، استقرارية الجسيمات النانوية، عامل الاختزال القوي، الطريقة الكيميائية

Introduction

nanomaterials have received considerable consideration with the recognition of their dramatically altered material properties as compared to their bulk materials. As a result, the nanoparticles have wide applications in civil and manufacturing fields. For example, they are used as micro-electronic materials, bactericidal materials, catalyst materials and Magnetic materials of Recording. Also, they have possible applications in detection of DNA and photo-detection [1]. The change of bulk material to nanomaterials results in distinctive features that are controlled by two main issues. First issue represented by decreasing in size of the particles, while the second issue including the number of atoms at the surface is increases noticeably as compared with the number of atoms in the center of the crystal and the broadly nanomaterials using is silver nanoparticles (AgNPs) [2]. Silver nanoparticles have attracted considerable interest because of their size and shape properties like optical, electrical, and magnetic properties beside to possible applications in a common of fields including plasmon, nano-electronics, chemical sensing and composite materials, cosmetic products, and electronic components. So far, many Ag nanostructures have been successfully synthesized with various morphologies [3-5]. Silver nanoparticles with different shapes, sizes and surface properties are created using a variety of methods because of the type of reducing and capping agents used to prevent their aggregation [6]. Silver nanoparticles are often created by using silver nitrate dissolving in Distill Water (DW) with NaBH_4 or citrate as reducing agents or as capping agents

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resulting mostly in negatively charged surfaces [7]. In the past, a number of processes are used to form silver nanoparticles, consist of reduction method of Ag ions in aqueous solvent with or without surfactants, electro-chemical reduction, heat evaporation, thermal decomposition in aqueous solvents, as well as poly procedure like chemical and photo-reduction, and radiation chemical reduction. All these procedures of synthesis include reduction of noble metals in the presence or absence of surfactants that is essential in control the formation of metal colloids during agglomeration [8-10]. The synthesis of silver nanoparticles is well documented and usually, the nanoparticles are obtained by bottom-up methods where atoms are self-assembly into nanoparticles [11]. Therefore, chemical reduction route has been intensively used and many reducing agents have been tested such as trisodium citrate [12], ethylene glycol [13], or sodium borohydride [14]. Besides, solution temperature, concentrations of the metal salt, reducing agent and reaction time also control particle size. Since, controlling size and shape of metal nanoparticles remains a challenge [15]. This study concerns the formation of silver nanoparticles using chemical reduction reaction by changing the concentration of AgNO_3 from 1mM to 0.9mM while the concentration of NaBH_4 which is a strong reducing agent is kept constant. Then, the micrograph and average particle size of the Silver nanoparticles obtained from each sample was observed by Scanning Electron Microscope (SEM), Transmission Electron Microscopy (TEM) and Particle size analyzer (PSA). The absorbance of solution containing Ag nanoparticles was measured using UV -Vis absorption spectroscopy at room temperature in the wavelength ranging from 300 to 900 nm improving Ag nanoparticles stability with changing the AgNO_3 concentration and keeping the concentration of reducing agent constant.

Experimental procedures

Preparation silver nanoparticles (AgNPs) using various concentrations of AgNO_3 and its effect on sodium borohydride as strong reducing agent

The synthesis of Ag nanoparticles, using reduction reaction, involved the reduction of AgNO_3 by strong reducing agents such as NaBH_4 . In the first approach, a colloidal of 2 mM NaBH_4 is

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formed by dissolving 0.0079 g of NaBH_4 in 100 mL of Distill Water (DW) and 1 mM AgNO_3 is formed dissolving 0.019 g of AgNO_3 in new baker of 100 mL of Distill Water (DW). Then the solutions are mixed collectively by adding 5.0 mL of 1mM AgNO_3 drop-wise about 2 minutes to 30 mL of cold 2.0 mM NaBH_4 . The forming solution is regularly stirred. Then 5 minutes later, a yellow color colloidal of Ag nanoparticles is achieved. In the second approach of formation Ag nanoparticles, the concentration of AgNO_3 is changed by decreasing to 0.90 mM, but the concentration of NaBH_4 used is kept. A colloidal of AgNO_3 is prepared dissolving 0.017g of AgNO_3 in 100 mL of Distill Water (DW). Then 10 mL of 0.9 mM AgNO_3 is added to 30 mL of 2 mM cold NaBH_4 . After 5 minutes with stable stirred, Ag nanoparticles of a darker yellow colloidal is formed.

Characterization of prepared AgNPs

The synthesis of Ag nanoparticles is characterized by UV- Vis spectral analysis (SP8001, Metertech) and Particle size analyzer (PSA, NanoBrook 90Plus Particle Size Analyzer) to predict the size of the Ag nanoparticle and their stability. Scanning Electron Microscopy (SEM) was performed for studying the surface morphology and structure of silver nanoparticles and Transmission Electron Microscopy (TEM, EM208, Philips, Day Petronic Co., Tehran, Iran) to demonstrate the typical shape and size of AgNPs.

Results and Discussion

UV-VIS spectra

Ag nanoparticles of different types were characterized by UV/Vis spectroscopy, as their Surface Plasmon Resonances (SPR) cause different peaks in their absorption spectra. The absorbance of UV-Vis spectra for various concentrations AgNO_3 aqueous solution with reducing agents like sodium borohydride, is shown in Fig 1. For the first approach, UV-visible absorption spectra shows a maximum of absorption peak at 407 nm with the average particle size from 25 to 200 nm with small spherical shapes when the concentration sodium borohydride 2mM and

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AgNO_3 1mM, yellow silver nanoparticle solution was obtained which implies the effect of NaBH_4 as reducing agent and its stability for more than one month.

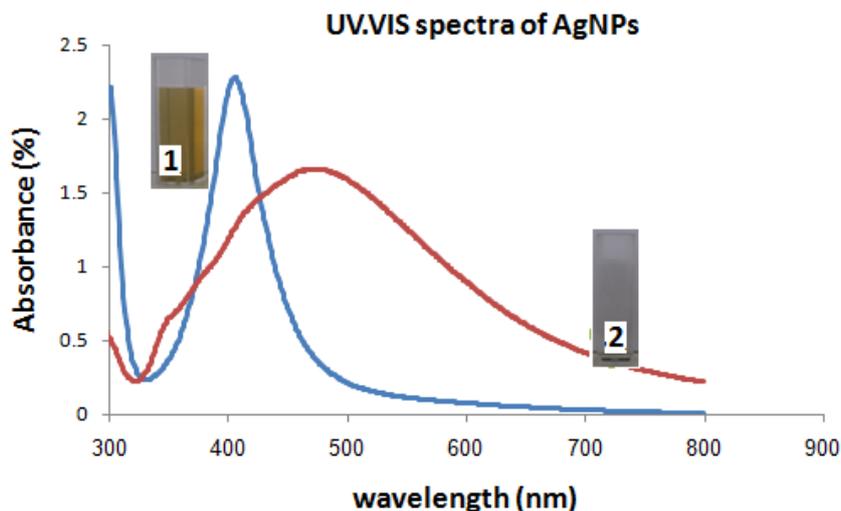


Fig 1: UV-Vis spectra of Ag nanostructures using a) 1mM of AgNO_3 and b) 0.9mM of AgNO_3

Then, the absorbance of plasmon peak is shifted towards longer wavelength as the sizes increase, 473.25 nm with changing the concentration of AgNO_3 from 1mM to 0.9mM that point to decompose or aggregate Ag nanoparticle solution and forming large spherical shapes with deep yellow color of the colloidal solution and one month as shown in Fig (1b) with average particle size greater than 50nm.

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SEM analysis

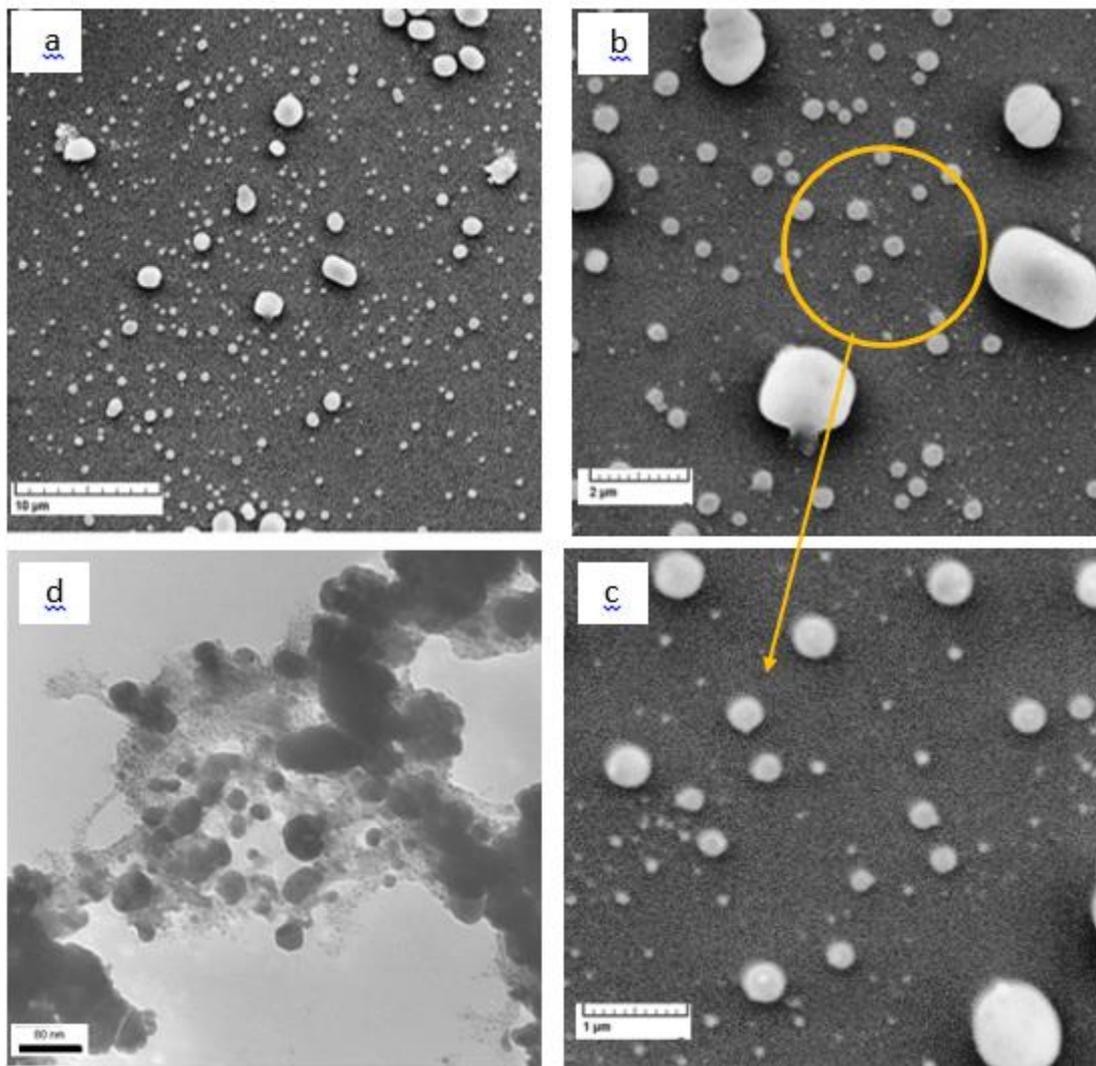


Fig 2: SEM micrograph of Ag NPs using 2 mM of NaBH_4 with 1mM of AgNO_3 at different magnification a) 10 μm , b)2 μm , 1 μm and d)TEM micrograph of Ag NPs with 1mM at magnification 80nm

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The SEM micrograph of the Ag nanoparticles formed by reduction 2 mM of sodium borohydride with 1Mm of AgNO₃ solution are shown in Fig (2 a,b,c). Small-sized and spherical Ag nanoparticles with average particle size from 25 to 200 nm are formed due to the borohydride method as shown in Fig (2 a,b,c). In addition to SEM analysis, Fig (2d), shows the TEM micrograph as high resolution to investigate in more detail the formation of spherical shape of Ag nanoparticles with average particle size range from 20-200nm which improved the role of NaBH₄ in reaction with AgNO₃ 1mM. While Fig (3 a,b,c), indicates the existence of agglomerated nearly spherical shaped of Ag nanoparticles with average particle size greater than 50 nm when the concentrations of AgNO₃ change from 1mM to 0.9mM while the concentration of sodium borohydride is kept constant which indicating the stability of silver nanoparticles is decreased and there is no reaction take place as improved by using TEM micrograph as shown in Fig (3d), which reveals forming large size of AgNPs greater than 50nm. Since, the reduction of Ag ions is not complete because of the concentration of NaBH₄ was becoming more excessive (2mM) than the concentration of AgNO₃ (0.9mM). Since a small particles begin to aggregate into large particles as deals with our results in UV-visible absorption spectra.

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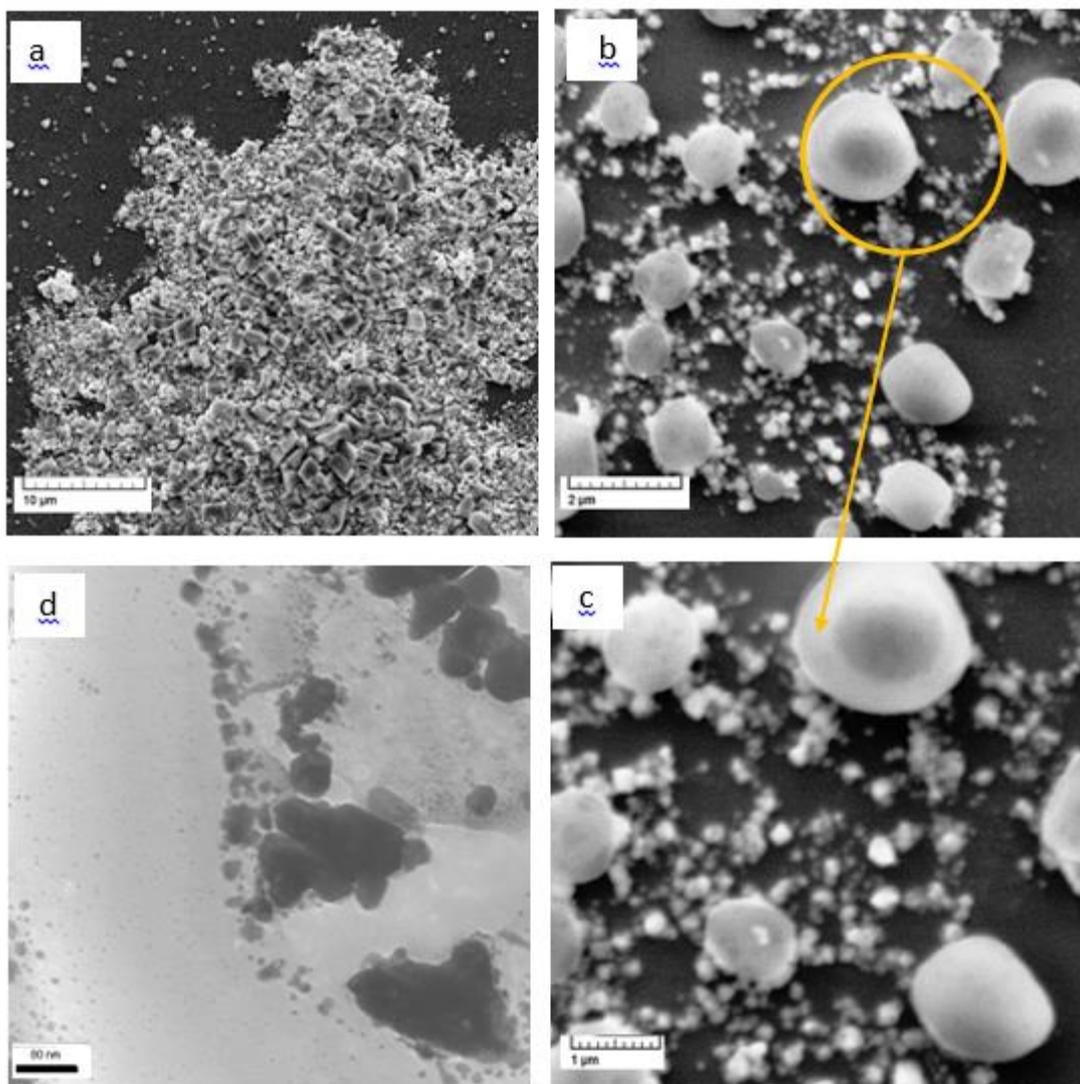


Fig 3: SEM micrographs of silver nanostructures using 2 mM of NaBH_4 with 0.9mM of AgNO_3 at different magnification a)10μm, b)2 μm and 1 μm d)TEM micrograph of Ag NPs with 0.9mM at magnification 80nm

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The Particle Analyzer test

Particle Size Analysis (PSA) of Ag nanoparticles as illustrated in Fig (4 a), represents the Particles diameter range in size from 5 to 5000 nm with average diameter 12.55 nm when the concentrations of AgNO_3 was about 1mM which represent the formation a few but large Ag nanoparticles in 1mM AgNO_3 reduction with 2mM NaBH_4 .

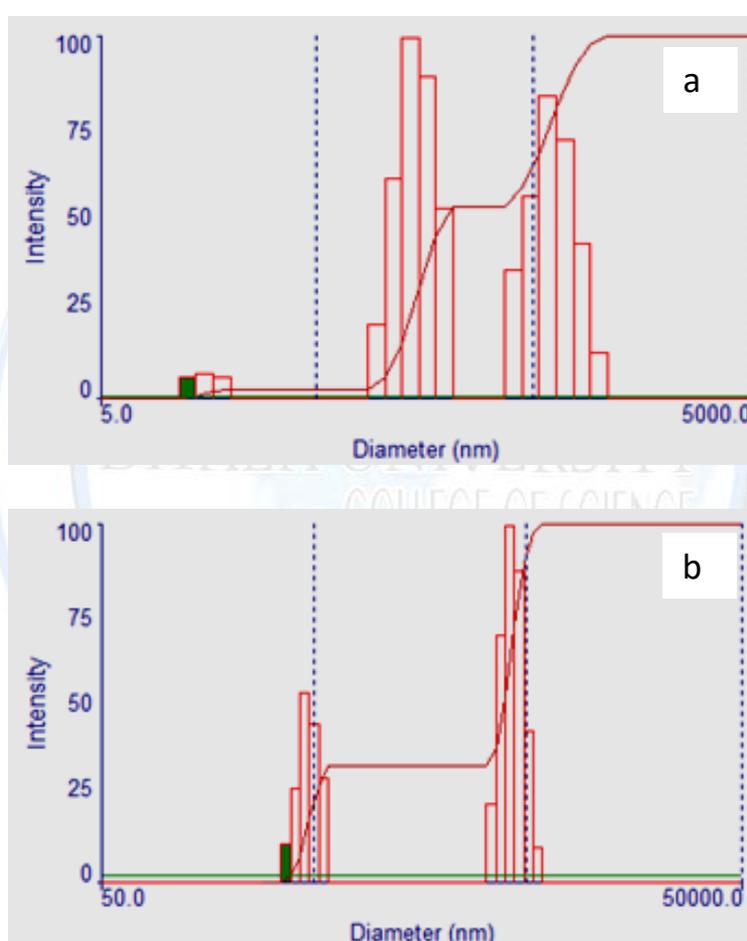


Fig 4: Particle Size of the Ag nanoparticles formation using 2 mM of NaBH_4 with a) 1mM of AgNO_3 and b) 0.9mM of AgNO_3

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In Fig (4 b), the particle size analysis (PSA) shows silver nanoparticles diameter range from 50 to 50000 nm with mean diameter 366 nm when the concentrations of AgNO_3 is decreased to 0.9 mM as compared to NaBH_4 concentrations 2 mM and leads to reduction of Ag ions was not complete which results in aggregation of particles producing and a great quantity of Ag nanoclusters while a few quantity of nanoparticles were produced.

Conclusions

In summary, the results indicate that the particle size can be ranged from small size to bigger size depending on the concentration of reducing agent and AgNO_3 which is a limiting feature in Ag nanoparticles stability. In addition, the stability of Ag nanoparticles results from the fact that Ag nanoparticles created from NaBH_4 ions are surrounding the nanoparticles and preventing them from agglomerates while the excessive NaBH_4 concentration leads to prevent the reduction of Ag ions which results in aggregation of the particles and a large amount of Ag nanoclusters are formed as improved in UV. Vis, SEM, TEM and particle size analysis (PSA).

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