OPTICAL AND ANTIBACTERIAL PROPERTIES OF COLLOIDAL GOLD NANOPARTICLES

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Abstract

Colloidal gold nanoparticles in spherical shape had been synthesized from chloroauric acid ($HAuCl_4$) by one of the solution method such as chemical reduction method. The colloidal gold nanoparticles were characterized with scanning electron microscopy (SEM) for morphological properties, X-ray diffraction method (XRD) for structural analysis and UV-VIS absorption spectroscopy for optical properties. It was found that the concentration of the precursors solution affected the size of the nanoparticles. In this nanoparticles fabrication method, the size of nanoparticles could be controlled by varying amount of sodium citrate. The antibacterial properties of gold nanoparticles had been studied.

Keywords: Colloidal, $HAuCl_4$, SEM, XRD, Antibacterial properties

Introduction

Chemistry of gold colloids began from the 19^{th} century, when Michael Faraday performed his well known experiments for gold colloids generation. His experiments yield deep red gold solution by reduction of tetrachloroaurate with the help of white phosphorus [Schmid G, Corain B.]. At the start of the 20^{th} century, Wilhelm Ostwald pointed out that in the nm range, the properties of metal particles were mainly defined by surface atoms and he reasoned that these nanoparticles, called colloids, should show novel properties with respect to bulk particles. The trimness of gold to the nanometer range has dramatic consequences for its physical and chemical properties [Khan I, Saeed K,]. These consequences are also well-founded for other metals however, Gold is an outstanding example.

Gold nanoparticles are very attractive because of their size and shape dependent properties [Eustis S]. For example, gold nanoparticles have a characteristic red color, but anisotropic gold nanorods dramatically changed in color. The color changing properties is due to the collective oscillation of the electrons in the conduction band, known as the surface plasmon oscillation [Liz Marzan L]. The oscillation frequency of gold is usually in the visible region and so it has the strong surface plasmon resonance absorption in visible region. Gold nanoparticles can generate and enhance electromagnetic fields that affect its environment. It can be used in many applications such as solar cell, photocatalytics and biomedicine. Gold nanoparticles have been prepared using various methods such as chemical reduction method, photochemical using UV irradiation method, sonochemical method, sonoelectrochemical, etc. In this research work gold nanoparticles were synthesized as size and shape controlled synthesis with the help of chemical reduction method. Structural, morphology and absorption spectra of the gold nanoparticles were analyzed.

Experimental Procedure

Gold foil (99.99%, ~250mg), hydrochloric acid, nitric and trisodium citrate dihydrate ($Na_3C_6H_5O_7.2H_2O$) were used as starting materials for gold nanoparticles synthesis. Deionized water was used as the reaction solvent. 15 ml of Hydrochloric acid and 1 ml of nitric acid were mixed and stirred at 400 rpm for 15 min in a beaker. 250 mg of gold foil was placed in the acids

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solution and stirred under fume hood at 50 °C until all of the gold dissolved. The resulting solution of tetrachloroauric acid could be used without further treatment for nanoparticle synthesis. 7 ml of aqueous tetrachloroauric acid was diluted with deionized water to make 1.00 mM solution in a chemically cleaned glass beaker. The obtained diluted solution was vigorously stirred at 70 °C. While stirring vigorously, as prepared various amount of tri-sodium citrate solution were quickly added to the each tetrachloroauric acid solutions. The color of solution changed within several minutes from orange to dark brown and then to red or purple color depending on the size of the nanoparticles. The obtain colloidal solution were filtered and washed with deionized water and centrifuged at 3500 RPM for 15 min and the liquid was decanted and fresh DI water was added to disperse the sediment. This step was repeated until the decanting liquid had a pH ≈ 5. The obtained nanoparticles were annealed at 100 °C for 30 min. The structural and morphological properties of the obtained nanoparticles were characterized with XRD and SEM. Surface Plasmon resonance (SPR) absorption properties were analyzed with UV-Vis spectroscopy.

Results and Discussion

XRD analysis

X-ray diffraction (XRD) was conducted on RIGAKU multiflex X-ray diffractometer in 10°-70° 2θ range. Fig. 1. showed the XRD profiles of gold nanopartilces synthesized form 2 ml, 2.5 ml, 3 ml, 3.5 ml and 4 ml, respectively. It could be seen from the profile that all the diffraction peaks corresponding to the diffraction planes (111), (200), and (220) were indexed to the gold metal with face centered cubic structure. Lattice constants obtained from XRD patterns were observed to be a = 4.078 Å in good agreement with the standard diffraction pattern of cubic gold metal (JCPDF 04-0784).

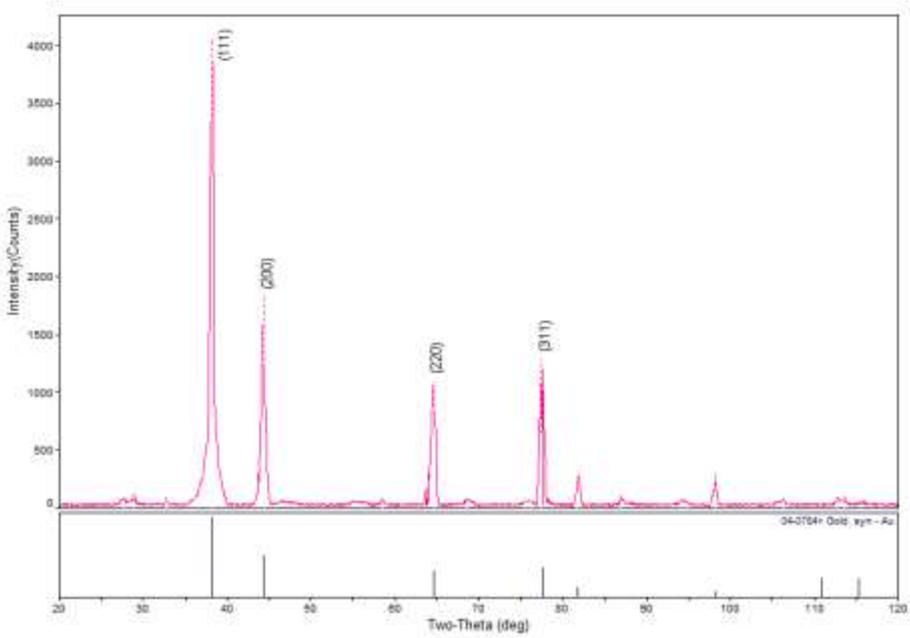

Figure 1 XRD profile of obtained gold nanoparticles.

SEM analysis

SEM microscopy was conducted to investigate the surface morphological properties of the obtained gold nanoparticles. The SEM micrograph of obtained nanoparticles was shown in Fig. 2. The SEM micrograph indicates that the shape and morphology of gold nanoparticles changed with increasing tri-sodium citrate amount. These images revealed that the individual particles were composed by the agglomeration of particles of various shapes. This indicates that amount of tri-sodium citrate solution influences strongly on morphology of gold nanoparticles.

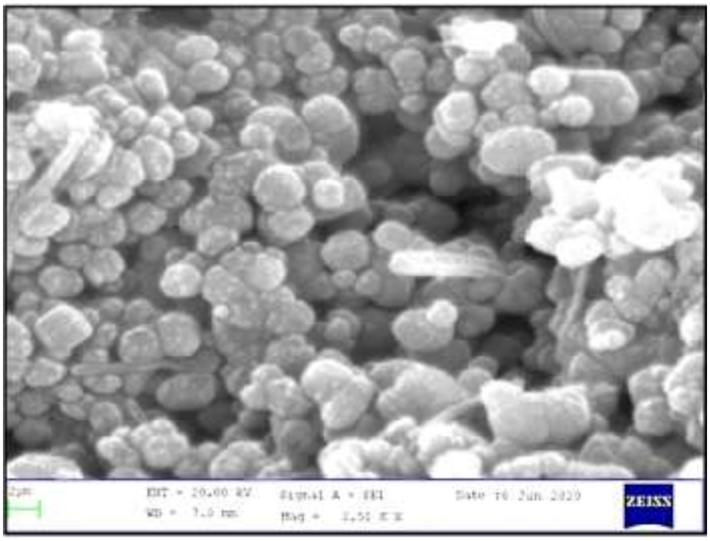

Figure 2 The SEM micrograph of obtained gold nanoparticles.

UV-Vis Analysis

Surface plasmon absorption spectra of gold nanoparticles prepared with different amounts of trisodium citrate solution were shown in Fig 3. It could be seen from the figure, the maximum absorption peaks were shifted to the shorter wavelength (from 539.9 to 521.1 nm) and the full width at half maximum (FWHM) of the spectrum is decreased with increasing amount of trisodium citrate from 2 ml to 4 ml. Therefore, the amount of citrate solution determines the size of the nanoparticles. As amount of trisodium citrate solution increased, the SPR bands increasingly broaden and a red shift occurred. In the case of gold nanoparticles, a red shift of plasmon resonances was caused by the increasing size of the nanoparticles, for example, from 520 nm for a ~30 nm particles to 540 nm for a ~50 nm particles.The UV-Vis results were also confirmed by the SEM observation

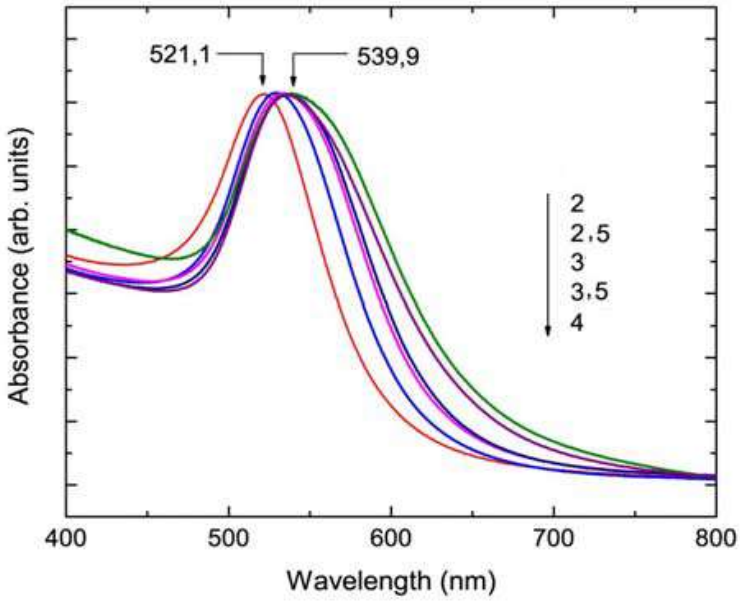

Figure 3 Surface plasmon absorption spectra of gold nanoparticles.

Conclusion

The colloidal gold nanoparticles had been prepared by chemical reduction method. In this present work reported a significant advance in terms of the realization of a simple chemical method, which could synthesize the size-controlled gold nanoparticles rapidly under ambient conditions. From XRD data it was confirmed that all the samples were good crystalline in nature with face center cubic structure. Synthesized gold nanoparticles were considered to have a wide range of applications in nanotechnology, catalyst, pharmaceutical, and energy industries.

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