ADVANCED JOURNAL OF SCIENCE AND ENGINEERING
Spring 2020, Volume 1, Issue 2, Pages 48-51. DOI: 10.22034/AJSE.2012048

Original Research Article

https://adv-j-sci-eng.com

eISSN: 2717-0705

Synthesis and Characterization of Gold Nanoparticles

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Received: May 06, 2020 / *Accepted*: May 14, 2020 / *Published Online*: June 30, 2020

ABSTRACT. Various methodologies are currently available for synthesis of gold nanoparticles; chemical reduction method is among the interesting ones. Gold chlorauric acid ($H[AuCl_4]$) could be reduced by sodium hydroxide (NaOH) in aqueous solution. Within this work, poly diallyl dimethyl ammonium chloride (PDDA) was used as a capping agent for synthesis of gold nanoparticles. Characterization techniques including scanning electron microscopy (SEM), atomic force microscopy (AFM) and UV-visible spectroscopy approved the obtained gold nanoparticles.

Keywords: Gold nanoparticle; Chemical reduction; PDDA; SEM; AFM; UV.

INTRODUCTION

Nano-scale materials have been distinguished due to dependency of their electronic and structural properties on the geometrical features. Currently, metallic nanoparticles are under investigations because of their attractive properties such as optical and electromagnetic properties suitable for various applications.[1-10] Nanotechnology is indeed an evolving science combining physics, chemistry, biology, material science and electronics by creating new materials, devices and systems. From gadgets and mechanical autonomy to genetics, nanotechnology has been expanded for several types of applications. In addition, magnetic nanoparticles have been seen very much interesting for different purposes.[2] Gold nanoparticles are among the most important nano-scale particles for various applications, in which its deposition at the SiO_2 surface could increase higher absorption of radiation and photoelectron generation.[1-3] Gold nanoparticles have been used as alternative to the conventional hyperthermia methods by quick converting the absorbed energy into heat energy making them exceptional agents for hyper thermic cancer treatment.[4] It is possible to investigate the absorption and scattering of near infrared region (NIR) and visible region of light on gold nanoparticles depending on size and shape of these nanoparticles.[4, 5] Nanotechnology also plays a main role in laser surgery; a combination of gold nanoparticles with femtoseconds laser microsurgery (FLMS) could lead to the development of less invasive hyper thermic treatment.[4] Gold nanoparticles have been also used as biomarkers embedded into damaged tissues located by X-ray fluorescence.[5] Nanoparticles are also important in the fields of biomedicine research, in which gold nanoparticles have been used in drug delivery and analysis purposes.[6]

In chemistry, gold nanoparticles are commonly used as reducing agents as well as catalyst in different chemical reactions Achievements of modern research show that the gold quantum dots are used as single electron switch, transistor and sensor as great approaches in the field of electronics.[7] Gold nanoparticles are highly thermal stable if they are combined with Au-Dy and Au-SAPO18 materials.[8] Fabrication of gold nanoparticles at the silicon thin film could effect on the resistivity of silicon thin film and there is an increase in absorption rate of light intensity.[9] In the present study, we used chemical reduction method to synthesize gold nanoparticles in which poly diallyl dimethyl ammonium chloride (PDDA) was used as a capping agent to

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stabilize the size and shape of gold nanoparticles. For characterization of these nanoparticles, atomic force microscopy (AFM), scanning electron microscopy (SEM) and UV-visible spectroscopy were used. The characterized sizes and shapes of these nanoparticles could suggest further works on these particles in different applications. It is worth to note that careful investigations are still required for nanomaterials.

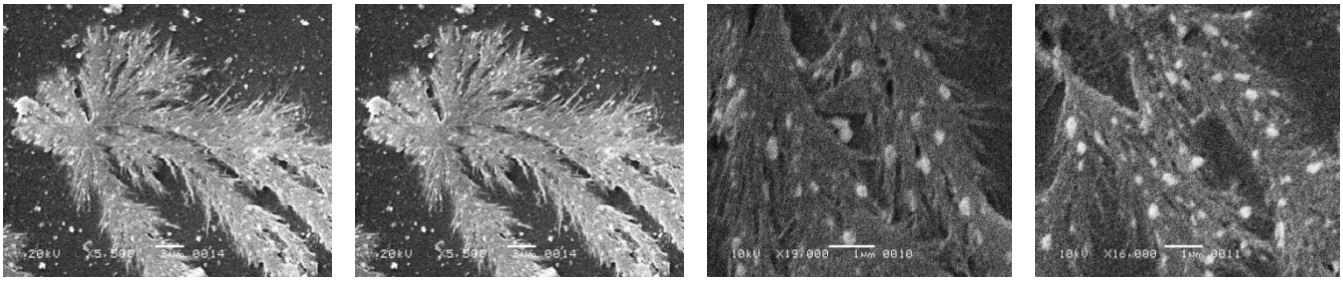

Fig. 1: SEM image of arranged gold nanoparticles by PDDA (with different sizes at 20 kV applied voltage).

MATERIALS AND METHODS

The experiments were carried out in the lab of nano sciences at HEJ research institute of chemical science, university of Karachi. Characterization of these nanoparticles was also carried out in University of Karachi. By using a chemical reduction method, Gold nanoparticles were obtained in a liquid state. Gold chloroauric acid ($H[AuCl_4]$) solution was used as the main source of gold nanoparticles formation, which was mixed with sodium hydroxide (NaOH) to reduce gold solution into neutral gold atom.[10] After 30 min, PDDA was added in this solution as capping agent stabilizing the sizes and shapes of gold nanoparticles. After that, methylene blue was added in that solution as ligand. During whole process, color of solution changing continuously from yellow and end up at wine red. And the process was performed at 75^{o}C.

RESULTS AND DISCUSSION

SEM Characterization

The obtained images of SEM, as a useful technique for nanomaterials characterization, are presented in Fig. 1. It is obvious from the SEM images that gold nanoparticles arrange themselves on PDDA because of promoting adhesion and coating at the top of substrate surface. It is quite useful to have such capping specially regarding the study of the optical properties as it creates uniform optical quality coating. As an alternative, thiol could be also used; however the use of thiol is more important if one is trying to understand magnetic properties; it is not the aim of present study. The obtained gold nanoparticles are in the range of 50-80 nm. In addition, the large size reveals that bunches of particles is stuck together.[10]

AFM Characterization

For further confirmation and to supplement the SEM results, AFM images (Fig. 2) were taken for the synthesized gold nanoparticles. These images could give clearer idea regarding the size as well as distribution of the gold nanoparticles at the surface. Characterized morphology of gold nanoparticles by AFM from solution on to substrate surface is regarded as reliable methodology to establish the state of nanoparticles in solution.

UV-VIS Spectroscopic Characterization.

UV-visible spectroscopy technique was also employed to study the variation of amount of PDDA affecting the size of the particles with five different samples. Fig. 3 shows the visible spectrum of five different solutions which are differentiated by varying amount of PDDA. As shown in Fig. 3, we got strong surface Plasmon resonance peaks at 590 and 560 nm, which indicates that the prepared gold nano particles are spherical. SEM and AFM images confirm these results. Surface Plasmon absorption curves depends on particles size, shape and the dielectric constant of the medium which surround them. There is a blue shift in the absorption peak to 560 nm and a smooth shoulder near 450 nm.[10]

CONCLUSION

Based on the obtained results, gold nanoparticles were very well synthesized employing the reduction method. Moreover, characterization techniques of SEM, AFM and UV approved the existence of synthesized nanoparticles. It is noted that size and shape are dominant factors for properties of gold nanoparticles, which were shown in this work.

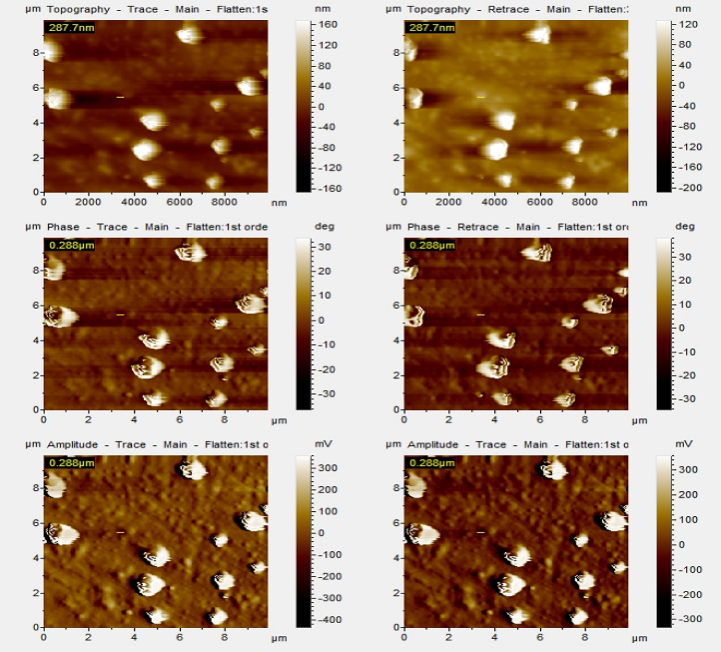

Fig. 2: AFM images of gold nanoparticls arranged in PDDA.

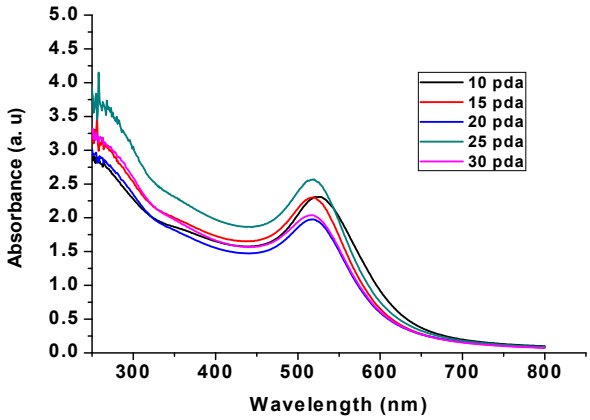

Fig. 3: UV-visible spectroscopy spectra for gold nanoparticles with varying concentration of PDDA.

ACKNOWLEDGEMENTS

The authors acknowledge the support of administrative staff from Department of Physics and HEJ Research Institute of Chemistry, University of Karachi for their support. The authors also acknowledge the support provided by Mr. Yosuf Khan from Centralized Science Lab of University of Karachi for his valuable suggestions and contribution regarding SEM studies.

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How to cite this article: Ulfat I,Ahmed SA, Iqbal SMZ, Kamaluddin S, Mehmood Z, Kanwal S. Synthesis and characterization of gold nanoparticles. Adv. J. Sci. Eng. 2020;1(2):48-51. DOI: 10.22034/AJSE.2012048