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PULSE LASER ABLATION IN LIQUID INDUCE GOLD NANOPARTICLE PRODUCTION

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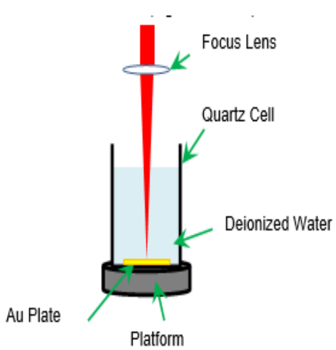
Graphical abstract



Abstract

Over recent years, there has been an explosive growth of interest in the development of novel gel-phase materials based on small molecules. It has been recognized that an effective gelator should possess functional groups that interact with each other via temporal associative forces. This process leads to the formation of supramolecular polymer-like structures, which then aggregate further, hence gelating the solvent. Supramolecular interactions between building blocks that enable gel formation include hydrogen bonds, interactions, solvatophobic effects and van der Waals forces.

Keywords: Laser ablation, gold nanoparticle, solvatophobic effects

Abstrak

Kebelakangan ini, terdapat pertumbuhan letupan kepentingan dalam pembangunan novel bahan fasa gel berdasarkan molekul kecil .Ia telah diiktiraf bahawa elator yang berkesan perlu mempunyai kumpulan berfungsi yang berinteraksi antara satu sama lain melalui daya zahir bersekutu. Proses ini membawa kepada pembentukan struktur polimer seperti supramolecular, yang kemudiannya agregat lagi iaitu gelating pelarut. Interaksi Supramolecular antara blok bangunan yang membolehkan pembentukan gel termasuk ikatan hidrogen, interaksi, kesan solvatophobic dan van der Waals.

Kata kunci: Ablasi laser, nanopartikel emas , kesan solvatophobic

1.0 INTRODUCTION

There are many known methods to produce small AuNPs, including the chemical reduction method, electrochemical, hydrothermal syntheses, microwave, γ-rays and X-rays. Pulse laser ablation in liquid (PLAL) has recently become among the convenient top-down approaches for the simplicity to generate fine gold nanosphere particles with an outstanding purity, and highly stable colloids [1, 2]. The high peak power of the laser pulses allows a 'brute force' method for synthesizing novel materials that have hitherto been inaccessible using milder and other orthodox techniques. The interesting feature of this technique that distinguishes it from the conventional wet-chemical methods is the possibility to produce AuNPs without the use of any chemical surfactants and does not necessarily produced waste which compatible with the 12 principles of green chemistry [3]. The different structure and morphological of the suspended AuNPs fabrication are strongly dependent on the applied optical focusing elements [4, 5]. A few investigations have been conducted to enhance the gold nanoparticles formation by simply changing the laser fluence, wavelength, pulse width, liquid species and repetition rate. Unlike bulk gold, nano-sized spherical gold has a distinctive band in the visible region whose diameters of >2 nm show a strong absorption band in the visible region of the spectrum at the peak position λmax about 520 nm [6]. This absorption peak is known as the surface plasmon resonance band. In this present paper, the nanoparticle generation experiment based on a Q-switched Nd-YAG laser system used to ablate the gold plate immersed in distilled water inside the chamber cell is briefly discussed. The absorption profile as well as the size and shape of gold nanoparticle produced are measured based on UV-Visible Spectroscopy and Transmission Electron Microscopy (TEM) respectively.

2.0 EXPERIMENTAL

2.1 Pulse Laser Ablation in Liquid (PLAL)

A schematic diagram of gold nanoparticles preparation is depicted in Figure 1. Gold nanoparticles were synthesized by laser ablation of a pure gold metal plate (99.99%) placed at the bottom of a quartz cell (dimension of 3 x 3 x 3 cm^3) filled by 10 mL deionized. Prior immersing the gold plate was cleaned in a Branson ultrasonic bath and thoroughly washed with acetone (Sigma-Aldrich) in order to remove organic contamination. The last rinse always carried out with the pure water. A Q-switched Nd: YAG laser (pulse width, 10 ns; repetition rate, 5 Hz, operating in the fundamental wavelength of 1064 nm) with energy of 100 mJ per pulse was focused on the metal plate through a lens of 100 mm focal length. The depth of the water layer above the target was fixed at 10 mm.

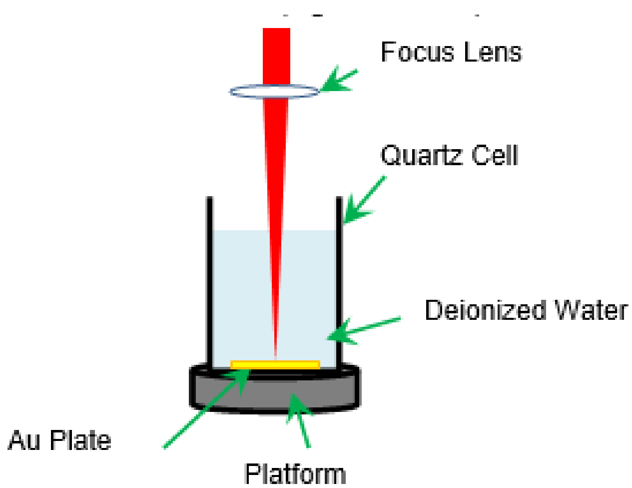


Figure 1 Schematic diagram of the PLAL setup

2.2 Characterization of AuNP

The gold nanoparticles sample was characterized with UV-Vis spectroscopy technique by illuminating a broadband white light source across the quartz cuvette which perpendicular to the Nd:YAG pulse laser beam. The light source was coupled to an optical fiber (P400-1-SR, Ocean Optics) through a collimator lens (74-UV, Ocean Optics) and connected to a broad-band probe light, via an USB2000 + detector (miniature fiber-optic spectrometer, Ocean Optics). The intensity of the spectrum was measured precisely with the aid of Spectrasuite software (Ocean Optics).Average size and size distribution of gold nanoparticles were characterized by an energy filtered transmission electron microscopy (EFTEM) model Libra 120-Carl Zeiss, at an accelerating voltage of 120 kV. TEM samples were prepared by depositing some gold colloid drops on a copper grid to completely dried out at room temperature and allow the liquid evaporate in air. Particle with mean diameter and dispersivity having the equivalent surface area were determined automatically using "ImageJ Tool" software.

3.0 RESULTS AND DISCUSSION

Figure 2 (a) shows the absorption spectra of gold nanoparticles prepared by pulse laser ablation process obtained at 2000 number of pulses in deionized water. The surface plasmon peak, λ_{max} is located at 520 and blue-shifted that included with the bandwidth, ΔR_{SPR} (grey region). These latter parameters would provide an important mean toward determining the average size, shape and concentration since it depends highly on the surface plasmon resonance band. Figure 2 (b) represents the size distribution of gold nanoparticles generated fitted with a log-normal curve (red line) from EFTEM image (Figure 2 c).The mean diameter calculated according to the TEM analysis is found at 14 nm with standard deviation of 2.1 nm. As seen in the EFTEM image, the sample consist of mostly spherical shapes particles which is observed when seen in much smaller scale. Since the ablation process is conducted in a free-functional medium without the use of any capping agent, some of the particles were witnessed overlapping among each other and aggregation can also been seen occurring within the solution. Nucleation of gold atoms in the plasma based on the laser-matter interaction in liquid could generate small sphere gold nanoparticle suspension. Although the pulse energy was applied at lower value, the plasma induced due to the laser ablation still provides a powerful and energetic tool to fabricate gold nanoparticles within the grain size below 20 nm in diameter.

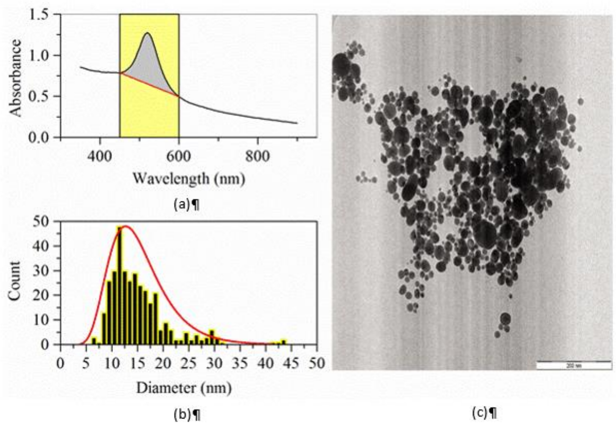


Figure 2 (a) Absorption spectrum of AuNPs synthesize by PLAL process at 2000 number of pulses. (b) The AuNPs size distribution fitted with a log-normal curve (red line) from EFTEM image (c) from the same solution

4.0 CONCLUSION

The capability of pulse laser ablation process to generate fine gold nanostructured was deliberated. Small sphere gold nanoparticles were effectively generated at low fluence threshold in a free functional medium. The sample was successfully characterized with UV-Vis Spectroscopy and EFTEM.

Acknowledgement

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