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doi:10.1017/S1431927620021091
Microsc. Microanal. 26 (Suppl 2), 2020

Effect of Temperature on the Green Synthesis of Gold Nanoparticles by *Cuphea aequipetala* Plant Extract

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Over the past two decades, nanomedicine has experienced unprecedented expansive growth based on the development of nanomaterials [1]. The processing of nanomaterials must be highly reproducible that controls its composition and biocompatibility [2]. Synthesis methods through plant extracts mean a solution to reduce the use of pollutants for the environment. Moreover, due to its low toxicity, it can be used in some medicinal treatments [3].

In this work, the synthesis of Au nanoparticles was performed using *Cuphea aequipetala* plant extract, and the precursor salt used was tetrachloroauric acid ($HAuCl_4$). The extract was prepared using the whole plant, which was triturated to obtain fine powders. Later, the infusion was processed to mix 100 ml of deionized water with 1 g of plant powder heating at 60 ° C for 25 min. The resultant solution was filtered and used for Nps preparation. The gold precursor solution was elaborated at 5 mM in deionized water. For the synthesis process, 1 ml of *Cuphea aequipetala* extract was mixed with 1 ml of gold solution, generating a volume ratio of 1:1. As an essential part of this study, the temperature was modified, so the different conditions were room temperature, 40°C, 50°C and 60°C without agitation. After the synthesis procedure, the first indication of the formation of the nanoparticles was the color change from yellow to light purple. The size and size distribution was analyzed in an Ultraviolet-Visible spectrophotometer (Cary 5000, Varian), the morphology and size of the nanomaterials were observed by Scanning Electron Microscopy (JEOL JSM- 7600F), and the composition and crystal structure of the nanoparticles were determined using X-ray diffraction (Bruker D8 Advance, DAVINCI Lynx eye).

Figure 1 shows the UV-Vis spectra of gold nanoparticles, the peaks are located between 500 and 600 nm, and it is characteristic of Au nanostructures. In section a), the formation of AuNps is observed presenting a band with low absorbance (25°C), and it is extended when the temperature is increased, indicating an increment in the size of the synthesized nanostructures. It is noticeably appreciated in the temperature at 40 ° C, 50 ° C and 60 ° C. In section b), the sample synthesized at room temperature was used for the analysis of diffraction of X-rays, which demonstrates the crystally structure of the gold being FCC denoted with planes 111, 200, 220, 311. Figure 2 presents Scanning Electron Micrographs of AuNps with the synthesis temperature modification. In subsection a) corresponding to the synthesis of AuNps at room temperature, it is appreciated that the nanoparticles are spherical and dispersed, having a size less than 20 nm. In subsection b) by using a temperature of 40 ° C, spherical particles with sizes close to 50 nm are distinguished, presenting coalescence. In section c) using a temperature of 50 ° C, it is observed that the particles are still spherically shaped but size close to 80 nm, and finally in subsection d) are distinguished faceted and quasi-spherical particles with a size close to 100 nm, which is due to the increase in temperature to 60 ° C.

In conclusion, in this work, it was observed that the *Cuphea aequipetala* plant is capable of synthesizing gold nanoparticles from its reducing and stabilizing agents. In addition to the fact that the increase in temperature generates an acceleration of the reaction producing larger structures, that is to say, higher production of nuclei and an accelerated coalescence, emphasizing that at room temperature, the smallest particles were produced with a spherical shape [4].

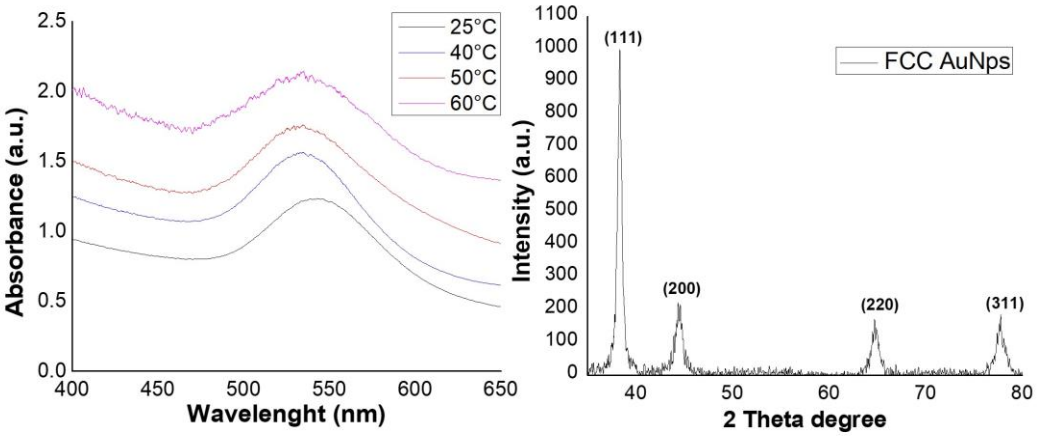

Figure 1. a) UV-Vis spectra of gold nanoparticles by modifying the temperature at 25°C, 40°C, 50°C and 60°C. b) X-ray diffraction pattern of AuNps sample synthesized at 25°C.

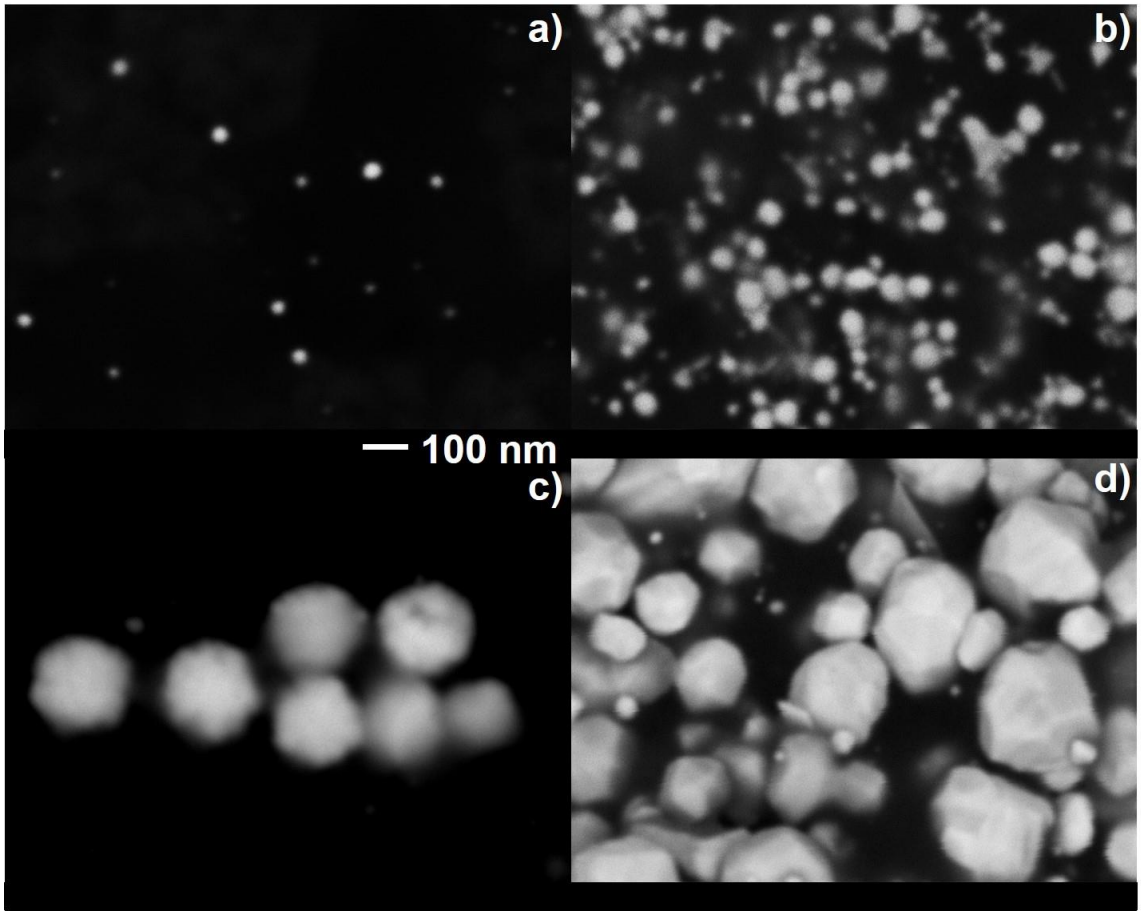

Figure 2. SEM images at 100 000 X, showing gold nanoparticles synthesized by modifying the temperature of a) room temperature, b) 40 ° C, 50 ° C, and d) 60 ° C.

https://doi.org/10.1017/S1431927620021091 Published online by Cambridge University Press

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https://doi.org/10.1017/S1431927620021091 Published online by Cambridge University Press