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Caracterización de nanopartículas de plata sintetizadas por vía verde

Characterization of silver nanoparticles synthetized by green alternative

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Abstract:

In this research the green synthesis of silver nanoparticles (AgNPs) was developed using the extract of Thuja orientalis. The nanoparticles were characterized by: UV-Vis spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, particle size by DLS and zeta potential by electrophoretic light. Through UV-Vis spectroscopy a peak at 420 nm was observed, that is attributed to silver nanoparticles (AgNPs) due to their Surface Plasmon Resonance (SPR). The Fourier transform infrared spectra was used to observe characteristic functional groups of phyto molecules involved in the silver-ion binding process such as R—O—H (3,335), O=C-OH (2314)and C-C=C (1,450). Zeta potential showed the size and electrophoretic light stability of the NPs showed values of 86.82 nm and -19.6 mV respectively. These results showed that *Thuja orientalis* infusion is an efficient reducer in the synthesis of nanometre-sized particles.

Keywords:

Nanoparticles, green technology, synthesis, silver, Thuja orientalis

Resumen:

En esta investigación se desarrolló síntesis verde de nanopartículas de plata (AgNPs) utilizando el extracto de *Thuja orientalis*. Se caracterizaron las nanopartículas mediante: espectroscopía UV-Vis, espectroscopía infrarroja por Transformada de Fourier (FTIR), tamaño de partícula por DLS y potencial zeta. La espectrometría UV-Vis reveló la formación de un plasmón de resonancia superficial (PRS) cerca de los 420 nm característico de la presencia de AgNPs. El espectro de FTIR mostró los grupos funcionales característicos de las fitomoléculas tales como R—O—H (3,335), O=C-OH (2314), C-C=C (1,450). El potencial zeta evidenció el tamaño y la luz electroforética la estabilidad de las NPs mostrando valores de 86.82 nm y -19.6 mV respectivamente. Estos resultados demostraron que la infusión de *Thuja orientalis* es un reductor eficiente en la síntesis de partículas con tamaño nanométrico.

Palabras Clave:

Nanopartículas, tecnología verde, síntesis verde, plata, Thuja Orientalis

INTRODUCTION

Nanotechnology is the ability to work at a scale of 1-100 nm to create, characterize and use structures, materials, devices or systems with new properties derived from nanostructures [1]. Nanomaterials designed through conventional physicochemical pathways are not friendly with the environment. It has led to the evolution of competent green pathways for the development of new methods for nanoparticle synthesis. The use of plant extracts has been an alternative, since it has been reported that organic agents such as amino acids, flavonoids, aldehydes, ketones, amines, carboxylic acids, phenols,

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proteins or alkaloids can provide electrons that function as reducer and stabilizer agents [2, 3].

MATERIALS AND METHODS

Material: *Thuja orientalis* extract, which were obtained in University Technologic Tulancingo Bravo´s in Hidalgo State and $AgNO_3$.

Synthesis NPs: An $AgNO_3$ solution at 20 ppm in 10 mL of deionized water was prepared. 100mL of Thuja Orientalis extract at 80°C with constant stirring were the initial conditions of synthesis, 2mL of previously prepared $AgNO_3$ solution were added in 10-minute intervals in order to achieve synthesis in a 60-minute time scale.

UV-Vis spectroscopy: A Perkin Elmer Lambada 45 UV/VIS spectrophotometer was used in the study of the optical properties of the synthesized particles. The UV-visible spectra ranged from 200 to 700 nm wavelengths.

Fourier-transform infrared spectroscopy: FT-IR analysis was performed using a Frontier FT-IR Perkin Elmer, MA USA spectrophotometer equipped with attenuated total reflectance (ATR). The samples were studied at the wavelength interval of 400 a 4,000 cm-1 at room temperature.

Dynamic Light Scattering particle size analysis: Hydrodynamic radius and zeta potential sample analysis were recorded three times each by the DLS (Dynamic Light Scattering) and electrophoretic light respectively method using a Zetasizer Nano Malvern S90 WR United Kingdom. The dispersant used was water at a 25°C.

Statistical Analysis: The statistical analysis of data was carried out through a variance analysis by using the software SPSS 22 (SPSS, Inc., U.S.A.). The Tukey´s test was applied at $\alpha<0.05$.

DISCUSSION OF RESULTS

UV-Vis spectral analysis

Figure 1 shows the absorption spectra during 50 minutes of synthesis. It reveals the presence of SPR (Surface Plasmon Resonance) peaks in the absorbance bands, throughout the progression of the synthesis absorption increased, as so to that at 50 minutes elapsed synthesis time the SPR exhibited absorption at 424 nm approximately. The absorption peak at 400nm is characteristic of spherical NPs [4]. The SPR in the 420 nm region confirms the presence of AgNPs [5], the absorption band is also linked to confirm the reduction of Ag^+ ions to Ag^0 [6].

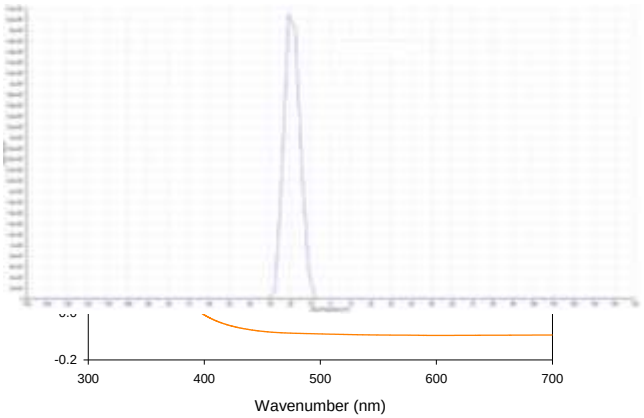

Figure 1. Absorption bands during silver nanoparticle synthesis as a function of time.

Fourier Transform Infrared Radiation (FT-IR) analysis

FTIR spectra have been used to identify functional groups of the components found in the extract of the plant *Thuja Orientalis*. Figure 2 exhibits a peak at 3335 cm^{-1} identified with symmetric bending of R—O—H [7]. At 2932 cm^{-1} can be observed bending vibrations of C-H [8]. The peak found at 2854 cm^{-1} corresponds to bending of the OH bond [9]. The peak 2314 cm^{-1} match with the group O=C-OH [10]. Also, 1730 cm^{-1} and 1450 cm^{-1} peaks were correlated with C=O and C—C=C groups [11]. The peaks between 1459 cm^{-1} and 1641 cm^{-1} were identified in relation to C=C [12]. 1078 cm^{-1} and 1023 cm^{-1} were assigned to C-OH and to the bending mode of C-O-C respectively [8].

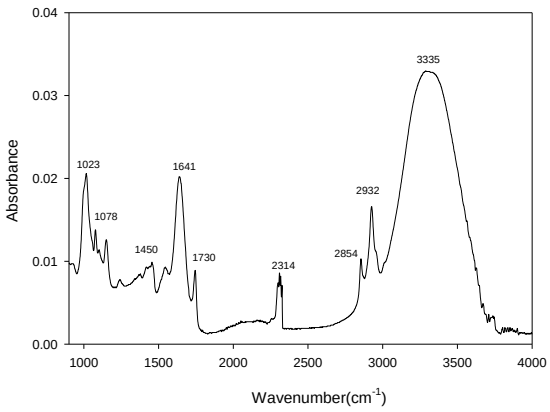

Figure 2. Fourier Transform spectra of *Thuja orientalis* extract showing characteristic functional groups of the plant before synthesis.

Particle size analysis

Dynamic light scattering (DLS) was used to determine the particle size distribution in colloidal suspension or emulsion by studying their Brownian behavior [13]. As displayed in figure 3, at time 0 min, the size was observed at 259.81 nm. However, at the end of synthesis (50 min)

the final nanoparticle size obtained was 86.82 nm. The dotted line represents the nanometric range of materials considering those between 1 to 100 nm [14]. Similar results in literature [15] showed that AgNPs have been synthesized by using plant extract of *Clitoria ternatea* obtaining particle size from 62.51 nm. In contrast, other researchers[16] used cyanobacteria extracts (*Oscillatoria sp*) as a bioreductors obtaining nanoparticles with 558.1 nm. These results suggest that *Thuja orientalis* plant extracts were more efficiently to synthesize NPs with lower nanometric size.

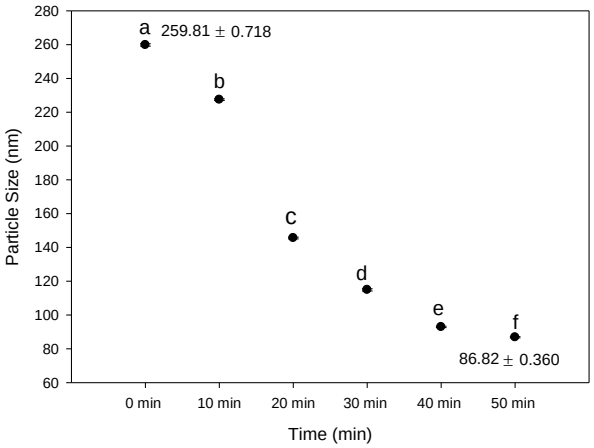

Figure 3. Particle size analysis by DLS in function of synthesis time, at 40min time the particles studied exhibited nanometric dimensions. Different letters represent significant differences. Error bars represent ± 1SD of 3 replicates.

Zeta Potential analysis

The zeta potential of the AgNPs synthesized is shown in figure 4. The zeta potential value obtained was at -19.6 mV which indicates a beneficial electrical surface charge in the NPs. This can be observed as a repulsion charge among the particles in solution, which is directly related to the stability of the solution retarding coalescence between particles [17]. Through green synthesis of nanoparticles, values of -24.5 mV and -24.6 mV have been obtained using *Thunbergia grandiflora* [18] and *Clitoria ternatea [15]* extracts respectively. Through the use of surfactants such as dodecyl trimethylammonium bromide (BDTA), tetradecyltrimethylammonium bromide (TTAB) and hexadecyltrimethylammonium bromide (CTAB), values between +40 to +65 mV have been obtained in all their models, proving that the use of surfactants in stabilization increases zeta potential value and thus providing higher stability in nano dispersions. Stabilization of NPs with cysteine was reported in literature [19] with a value of +44 mV. It also helped to retard the precipitation of nanoparticles in solution.

Figure 4. Zeta potential distribution of AgNPs synthesized from Thuja Orientalis extract.

CONCLUSIONS

The infusion of *Thuja orientalis* proved to be an effective reducing agent in the synthesis of silver particles, evidencing the colour change characteristic of PN formation and a nanometric size. It also represents an environmentally friendly alternative.

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