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BIOSYNTHESIS OF SILVER NANOPARTICLES FROM SILVER NITRATE SOLUTION USING AQUEOUS EXTRACT OF LEMONGRASS LEAVES

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Abstract: In this article, we report the biological synthesis of silver nanoparticles from silver nitrate solution using aqueous extract of lemongrass leaf as reducing agent. The influence of some factors such as the volume ratio of lemongrass leaf extract/$AgNO_3$ solution, pH, and temperature to he ynthesis of silver nanoparticles was investigated. The formation of silver nanoparticles was confirmed by the positioning of surface plasmon resonance in the UV–vis spectroscopic analysis. The characteristics of silver nanoparticles were studied using TEM, EDX and XRD. TEM analysis showed that the silver nanoparticles were predominantly in spherical shape with different average sizes of 10.0 - 36.1 nm. The EDX spectrum of silver nanoparticles confirmed the presence of the elemental silver signal. The XRD spectrum of silver nanoparticles exhibited 2θ values corresponding to the silver nanocrystals.

Key words: silver nanoparticles; lemongrass leaf; green synthesis; biosynthesis; plant extract.

1. Introduction

Nanotechnology is emerging as a rapidly growing field with its application in Science and Technology for the purpose of manufacturing new materials at the nanoscale level. The synthesis of metal nanoparticles has attracted considerable attention in physical, chemical, biological, medical, optical, mechanical and engineering sciences [1-2]. The properties of nanoparticles depend on size, shape, composition, morphology and crystalline phase. Among the various metal nanoparticles, silver nanoparticles have wide applications as antibacterial and antifungal agents in a diverse range of consumer products: air sanitizer sprays, detergents, soaps, shampoos, toothpastes and washing machine [3-5]. Many techniques of silver nanoparticles synthesis are extremely expensive and also involve the use of toxic, hazardous chemicals, which may pose potential environmental and biological risks [6]. Hence the development of reliable biosynthesis, an environment friendly approach for the synthesis of silver nanoparticles has added much importance because of its ecofriendly products. In recent years, green synthesis of silver nanoparticles has been achieved by using microorganisms and plant extract [7-9]. The plant contains a variety of phytochemical compounds such as polyphenols, flavones, saponins, sterols, triterpenoids,… and these molecules are expected to self-assemble and cap the metal nanoparticles formed in their presence, thereby inducing some shape control during metal ion reduction [10-12].

In this study, the silver nanoparticles were synthesized from the $AgNO_3$ solution using aqueous extract of lemongrass leaves as a reducing agent.

2. Materials and methods

2.1. Preparation of leaf extract

Fresh leaves of lemongrass were collected from local places of Da Nang City, Viet Nam. The leaves were washed thoroughly with distilled water and air-dried. A definite amount of leaves were cut into fine pieces and boiled with 100 mL of double distilled water

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at 80°C for t minutes. After the boiling process, the extract was filtered through Whatmann No.1 filter paper to obtain aqueous extract and was either directly used in the synthesis of silver nanoparticles or stored at 4°C for further experiments.

2.2. Synthesis of silver nanoparticles

For synthesis of silver nanoparticles, a definite volume of leaf extract was interacted with 20 mL of 1mM $AgNO_3$ in 100 mL Erlennmeyer flasks. The flasks were incubated for 24 hours at a desired temperature.

2.3. UV-Visible spectroscopy

The reduction of the Ag^+ ions by the supernatant of the aqueous extract of lemongrass leaves and the formation of silver nanoparticles were characterized by UV-visible spectroscopy monitored by sampling the aqueous component (2.0 mL) and measuring the UV-vis spectrum of solutions. The UV-VIS spectra of these samples were measured between 300 nm – 700 nm on a UV-2450 (Shimadzu) spectrophotometer operated at a resolution of 1 nm.

2.4. Transmission electron microscopy (TEM), and energy dispersive X-ray spectra (EDX) analysis

Samples for transmission electron microscopy (TEM) analysis were prepared by dropping coating biologically synthesized silver nanoparticles solution on to carbon-coated copper TEM grids. TEM measurements and the EDX analysis were carried out using HRTEM Tecnai G2 F20.

2.5. XRD measurement

The crystal phase identification of silver nanoparticles was characterized via powder X-ray diffraction using a Panlytical X Pert PRO Diffractometer. The diffracted intensities were recorded from 20° to 80° at 2 theta angles.

3. Results and discussion

3.1. Optimal conditions for the extraction of lemongrass leaf

3.1.1. The effect of extraction time

The effect of extraction time of lemongrass leaves to the formation of silver nanoparticles was conducted with the parameters as follows:

- The ratio of solid/liquid 40 gram lemongrass leaves / 100 mL of distilled water

- 5 mL aqueous extract of lemongrass leaves / 20mL of 1 mM $AgNO_3$ solution

- pH of the solution: pH = 8

- The time for extraction t = 5 minutes, 15 minutes, 20 minutes, 25 minutes, 30 minutes.

The UV-vis spectrum (Fig. 1) shows effect of extraction time of lemongrass leaves in the silver nanoparticles synthesis. Characteristic surface plasmon absoption was observed at 420-460 nm for the brown coloured silver nanoparticles synthesized from 1 mM $AgNO_3$.

Fig. 1 shows that the absorption was increased while increasing the extraction time of lemongrass leaves from 5 minutes to 25 minutes, and it reached the highest absorption at the extraction time 25 of minutes.

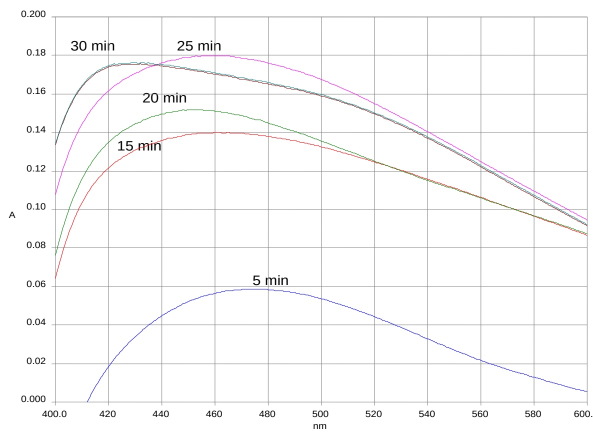

Fig. 1. *UV spectrum shows effect of extraction time of lemongrass leaf in the silver nanoparticles synthesis.*

3.1.2. The effect of the solid / liquid ratio

The effect of the ratio of lemongrass leaves weight/distilled water volume to the formation of silver nanoparticles was conducted with experimental parameters as 3.1.1. The time of extraction was 25 min and the weight of lemongrass leaves varies: m = 5 g, 10 g, 15 g, 20 g, 25 g, 30 g, 35 g, 40g.

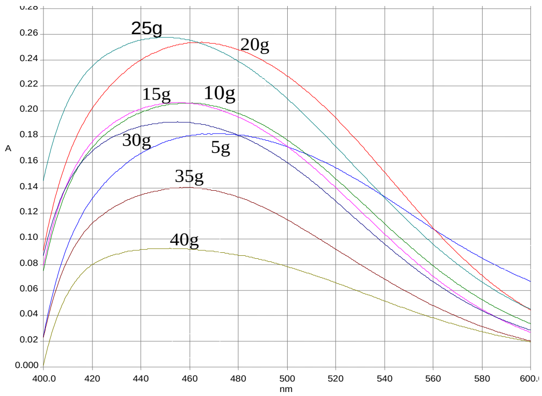

Fig. 2. *UV spectrum shows effect of the ratio of lemongrass leaves weight/distilled water volume in the silver nanoparticles synthesis.*

Fig. 2 shows that the absorption was increased while increasing the weight of lemongrass leaves from 5 g to 25 g/100 mL of distilled water, and reached the highest absorption at 25 g of lemongrass leaves / 100 mL distilled water.

3.2. Factors affecting the synthesis of silver nanoparticles

3.2.1. The effect of mixing ratio on the formation of silver nanoparticles

In order to study the mixing ratio, five situations were tested (from the mixing ratio 1:1 to 1:5 of the extract volume / 1 mM $AgNO_3$ solution volume). The samples subsequent to colour change was measured by Spectroscopy within wave length 400 - 600 nm (Fig. 3)

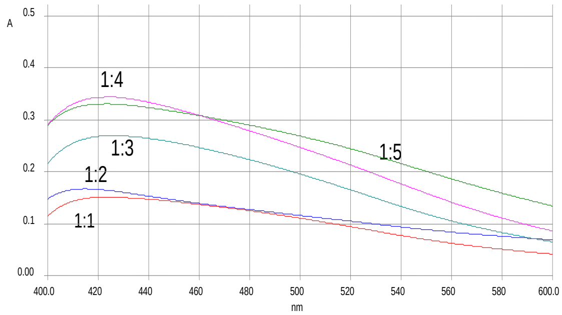

Fig. 3. *UV spectrum shows effect of the mixing ratio of extract volume/ 1 mM $AgNO_3$ solution volume in the silver nanoparticles synthesis*

With a change in the mixing ratio in similar environmental conditions, the observed wave length of maximum peak (λ_{max}) does not change much and it is between wave lengths of 415 - 425 nm. However, via an increase in the extract volume, the increased peak intensity became highest at the mixing ratio 1:4 (5 mL of extract / 20 mL of 1 mM $AgNO_3$).

3.2.2. The effect of pH on the formation of silver nanoparticles

To study pH effect, four containers containing 20 ml silver nitrate of 1 mM at four different pH of 6, 7, 8, and 9 were prepared. Then, 5 mL of lemongrass leaves extract was added to each container.

The UV-vis spectrum (Fig. 4) shows the effect of pH in the silver nanoparticles synthesis. Fig. 4 shows the pH increases from 6 to 7, the absorption intensity values has increased and reached the highest value at pH = 7, meaning that the amount of synthesized silver nanoparticles were almost well. However, at pH 8 and 9, the amount of silver nanoparticles was formed too fast, leading to coagulation; silver nanoparticles are large in size, which reduces the peak intensity values.

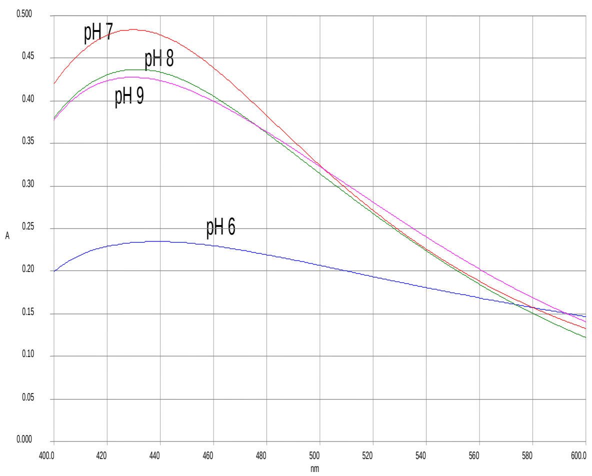

Fig. 4. *UV spectrum shows effect of pH on the formation of silver nanoparticles*

3.2.3. The effect of temperature on the formation of silver nanoparticles

To study temperature effect, six containers containing 20 mL of 1 mM $AgNO_3$ together with 5 ml extract were put at six different temperatures of 30°C, 40°C, 50°C, 60°C, 70°C and 80°C.

The UV-vis spectrum (Fig. 5) shows the effect of temperature in the silver nanoparticles synthesis.

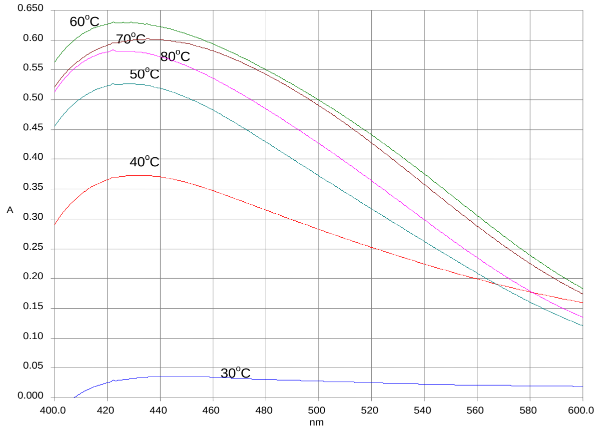

Fig. 5. *UV spectrum shows effect of temperature in the silver nanoparticles synthesis*

The obtained results show that when the temperature increases from 30°C to 60°C, the absorption intensity values increase and reach the temperature of 60°C. If temperatures continue to rise, the absorption amount decreases.

3.3. TEM analysis of silver nanoparticles

The TEM technique was employed to visualize the size and shape of silver nanoparticles. The TEM image of the produced silver nanoparticles are shown in Fig. 6. The formation of silver nanoparticles as well as their morphological dimensions in the TEM study demonstrated that the average size was from 10.0 - 36.1 nm. The shapes of the silver nanoparticles proved to be spherical.

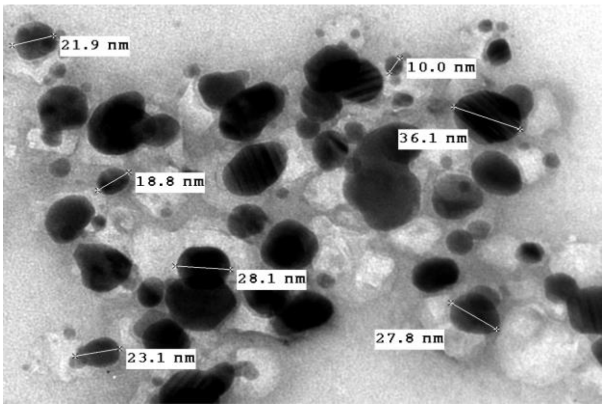

Fig. 6. *TEM micrograph of silver nanoparticles synthesized by aqueous extract of lemongrass leaves*

3.4. EDX analysis of silver nanoparticles

The EDX spectra recorded from the silver nanoparticles were shown in Fig. 7.

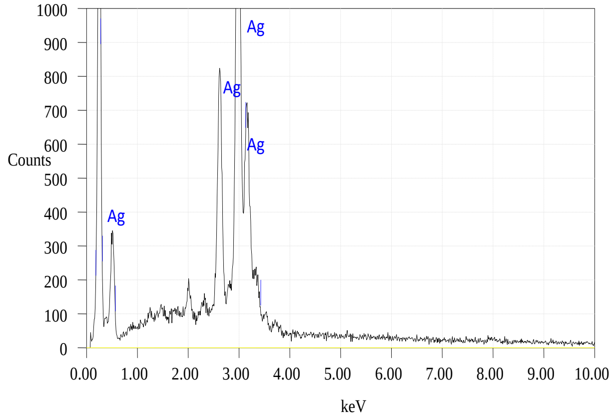

Fig. 7. *EDX micrograph of silver nanoparticles synthesized by aqueous extract of lemongrass leaves*

The EDX spectra clearly proves the presence of the elemental silver signal of the silver nanoparticles. The vertical axis displays the number of x-ray counts whilst the horizontal axis displays energy in KeV. Identification lines for major emission energies for silver (Ag) are displayed and these correspond with peaks in the spectrum, thus giving confidence that silver nanoparticles have been synthesized.

3.5. XRD analysis of silver nanoparticles

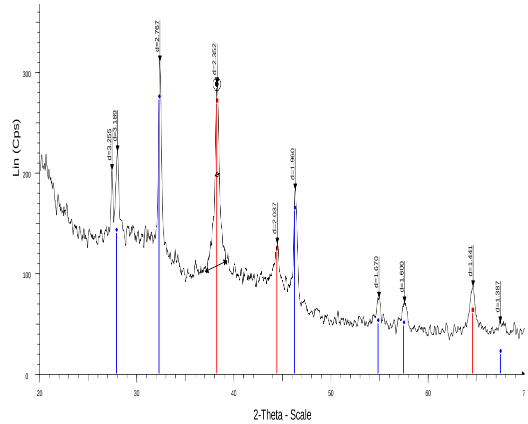

Fig. 8. *XRD pattern of silver nanoparticles synthesized by aqueous extract of lemongrass leaves*

Figure 8 shows the XRD pattern obtained for silver nanoparticles synthesized by lemongrass leaf extract. The diffraction peaks at 2θ = 38.23°, 44.40°, 64.60° and correspond to the {111}, {200}, {220} faces of the fcc crystal structure, respectively. The peak corresponding to the {111} plane is more intense than the other planes, suggesting that the {111} plane is the predominant orientation.

4. Conclusions

The bio-reduction of the aqueous Ag^+ ion by the extract of lemongrass leaves has been demonstrated. The reduction of Ag^+ ions through lemongrass leaf extract lead to the formation of silver nanoparticles of fairly well-defined dimensions. The average crystal size of synthesized silver nanoparticles was found to be 10.0 – 36.1 nm and almost in spherical shape. Synthesis of silver nanoparticles using green resources like lemongrass leaf extract is a better alternative to chemical synthesis, since this green synthesis is pollutant free and eco-friendly.

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SINH TỔNG HỢP NANO BẠC TỪ DUNG DỊCH NITRAT BẠC SỬ DỤNG TÁC NHÂN KHỬ DỊCH CHIẾT NƯỚC LÁ SẢ

Tóm tắt: Trong bài báo này, chúng tôi trình bày quá trình sinh tổng hợp nano bạc bằng tác nhân khử dịch chiết nước lá sả. Ảnh hưởng của một số yếu tố như ảnh hưởng của tỉ lệ thể tích dịch chiết nước lá sả/ thể tích dung dịch AgNO3 1 mM, pH, nhiệt độ đến quá trình tổng hợp đã được khảo sát. Sự hình thành nano bạc được khảo sát bằng phổ UV-VisNano bạc tổng hợp được đặc trưng bằng phương pháp TEM, XRD, EDX. Kết quả phân tích TEM cho thấy hạt nano bạc thu được có dạng hình cầu với kích thước từ 10,0 - 36,1 nm. Kết quả phân tích XRD cho thấy nano bạc thu được có dạng tinh thể lập phương tâm mặt. Phổ EDX xác nhận thành phần chính của sản phẩm là bạc và đồng thời có mặt các chất hữu cơ bao bọc nhằm ngăn chặn quá trình keo tụ.

Từ khóa: nano bạc; lá sả; tổng hợp xanh; sinh tổng hợp; dịch chiết thực vật.