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Synthesis, characterization and some optical properties of silver nanoparticles prepared by pulsed Laser ablation technique

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Abstract

The aim of the research is to prepare silver nanoparticles by laser ablation method in an aqueous medium to dements rate the important of laser in the production of silver nanoparticles , AgNPS prepared were distinguished by their structural , physical and optical properties . so we studied the properties of these nanoparticles prepared in this way . some optical examinations were performed on the colloidal silver solution , the structural properties were characterized by using X-Ray diffraction , the physical properties were analyzed by Field Emission Scanning Electron Microscopy(FESEM) and the optical Properties were analyzed by UV-Visible spectroscopy , and FTIR measurement in order to identify the dimensions , and shapes of the prepared AgNPS .and used Energy - Dispersive X- Ray Spectroscopy (EDX) , Fluorescence Spectrum measurement , these particles were prepared by means of a liquid-pulsed laser ablation technique (PLAL) using Nd:YAG laser with an energy of (500) mj . And a number 0f (100) pulses . this method is simple , pollution , free , stable , and has the ability to determine the specifications of the prepared particles. when examining the size and shape of the nanoparticles it was found that the nanoparticles are spherical shape , which dimensions ranging (46.55- 34.80) nm .The optical properties were also studied by UV-Visible spectroscopy ,the results showed that the absorption spectrum of silver was located at (534) nm . the height and decrease of the absorption peaks depend on the concentration of silver nanoparticles in the colloidal solution , as well as the shape of those particles . the results of X-

Ray diffraction examination showed that the film of the prepared AgNps at energy (500) mj is polycrystalline and of cubic type .

Key words: Silver nanoparticles , doule distilled deionized water , Nd:YAG laser ablation , colloidal solutions

Introduction

The reason for choosing the laser preparation method is that the resulting nanoparticles are crystalline to some extent , and these particles can be obtained in an easy and one – step way without any subsequent heat treatment due to the high efficiency of the scraped parte [1] . this method provides a unique opportunity to resolve the reported cytotoxic effects of nanoparticles resulting from chemical synthesis [2].the importance of the research lies in choosing a method
for preparing nanoparticles in an easy and inexpensive way , as the prepared particles show different properties from the properties of objects with traditional measurements , such as dielectric constant , and properties related to mass and heat transfer . thus we can use it in many applications such as killing cancer cells , biomedicine and drug delivery [3] . silver has been of great importance since ancient times
it has been used as a medicinal remedy since the 8^{th} century , silver used in blood urification and treatment of breath [4] . at present , the use of silver has appeared widely in the field of nanotechnology . the
word nano means small in size with the range (1-100) nm , and the presence of materials in nanoscale gives them many advantages , characteristics. the most important of which is increasing the surface area and surface a ctiving of the body , and thus showing different properties such as the melting point , the dielectric constant , which is called volumetric effect [5] . Solid materials consist a number of atoms are characterized by the presence of energy bundles , and these atoms are responsible for most of the chemical , and physical properties of solid materials and group of atoms becomes so small that the inter frence of these electronic bundles has been modified, which affects their physical properties [6] . these properties of nanomaterials differ from large material [7] . the laser ablation is a good method compared to other methods , as it treats the trans formation of the material into toxicity , and prepares the materials in a clean environment such as water ,

which makes the materials prepared in this way of a high degree of purity , these nanoparticles are controlled in size and shape through length control . wave from laser energy , pulse duration and liquid medium [8] . the method of laser ablation is done by using a solid target in liquid medium as the material is heated by the laser energy absorbed by the target , which causes evaporation or sublimation due to the high temperature , so the material turns into plasma , this temperature reaches (20000) Kelvin [9] . the properties of nanoparticles can be turned in a number of laser parameters including wavelength , pulse duration and fluency [10]and the choice of laser wavelength used can affect all the physical mechanisms by which nanoparticles are formed [11] . the duration of laser pulses varies from millisecond to femtosecond , this is what makes the method important and great value in industrial and research applications[12]laser ablation is an example of a top -down technique [13] . this method can produce silver nanoparticles important for medical and biological applications [14] .The simplest application of laser ablation is to remove materials from hard surfaces in controlled manner [15] . including tooth enamel . it is also used to efficiently remove rust from iron objects , and remove oils or grease from different surfaces [16].

Previous studies

The researcher (Ghaleb) prepared platinum nanoparticles by the method of laser ablation in different solutions such as deionized water with different concentrations , using a Nd:YAG laser , and the sizes of the particles were about (5-10) nm . and the spectra of absorption , fluorescence , TEM and transmittance (SEM) were measured , and the results showed the possibility of preparing colloidal platinum solutions with sizes less than (10) nm , and the nanoparticles are spherical in shape [17] . the researcher (Faysal) prepared silver and gold nanoparticles using the pulsed laser ablation method , and after studying the optical properties by ultraviolet spectroscopy , he noticed the appearance of sharp peaks as a results of plasmonic surface absorption at (405) nm for silver , and (523) nm for gold , and by examining the size and shape of the nanoparticles with atransmission electron microscopy (TEM) . it was found the particles of gold and silver are spherical in shape , their average diameter are (1,6) nm for gold and silver [18] . the researcher (Noor) also removed a metallic target of pure gold in water using a Nd:YAG laser . the optical

properties were studied by UV-Visible and observed the appearance of sharp peaks at (529 , 531 , 532) nm , the results of (AFM) examination showed that rate the size of the gold nanoparticles decreases with the increase of the pulsed laser energy and that it has a cubic crystal phase according to the results of (X-RAY) diffraction SEM results also showed that the gold nanoparticles have spherical shapes [19] . and the research (Adeleh) prepared of colloidal silver nanoparticles by laser ablation . research used a Q-switched Nd:YAG laser with a fluence of about 91 mj /cm^2 . these particles transmission
Electron microscopy (TEM) and (UV) . the average size of prepared nanoparticles is (20) nm [17]. (Raad) prepared silver nanoparticles by different pulse laser ablation , he used (Nd:YAG) laser with E=80 mj and wavelength (532) nm . the results XRD explain that silver nanoparticles have high quality from crystalline , he studied the optical properties with (uv-vis) and (AFM) [21].

Material and methods

Silver nanoparticles were prepared using high – purity silver metal where the metal is placed in a glass container immersed in distilled water , the laser was focused on the surface of the sample to produce silver nanoparticles colloids , the energy of the laser pulse used is (500) mj , and the number of constant pulses is (100) pulse . silver is bombarded with Nd:YAG (Neodymium : Yttrium Aluminum Garnet) laser [19] .with a wave length of (1064) nm by 1HZ to obtain nanoparticles the temperature of the laser device must be monitored so that it does not exceed (37)^0 . in order to preserve the device from damage .

Figure (1) shows solution of silver nanoparticles

Results and discussion

Field Emission Scanning Electron Microscopy

Field Emission Scanning Electron Microscopy (FESEM) the optical and structural properties , such as the diameter and shape of the particles were studied using (FESEM) and the image showed the formation of nanoparticles with a size less than (100) nm , the particles size within the nanoscale range , as (FESEM) showed that the silver particles are spherical in shape and average diameters of (46.55 – 34.80) nm . as figure (2) shows FESEM image of the formations the prepared on the glass were prepared at a wave length of (1064) nm a laser energy of (500) mj , a number of pluses of (300) .

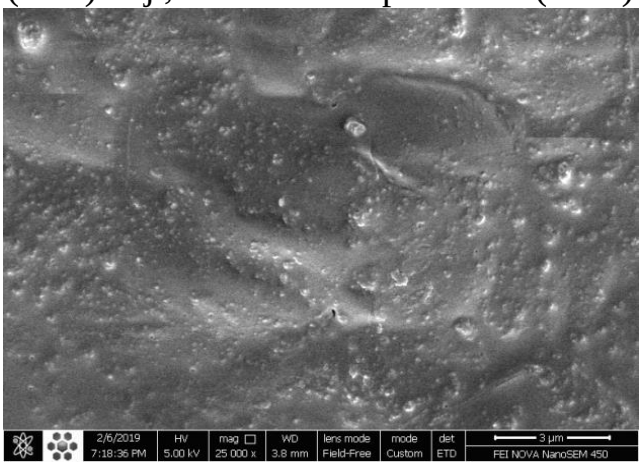
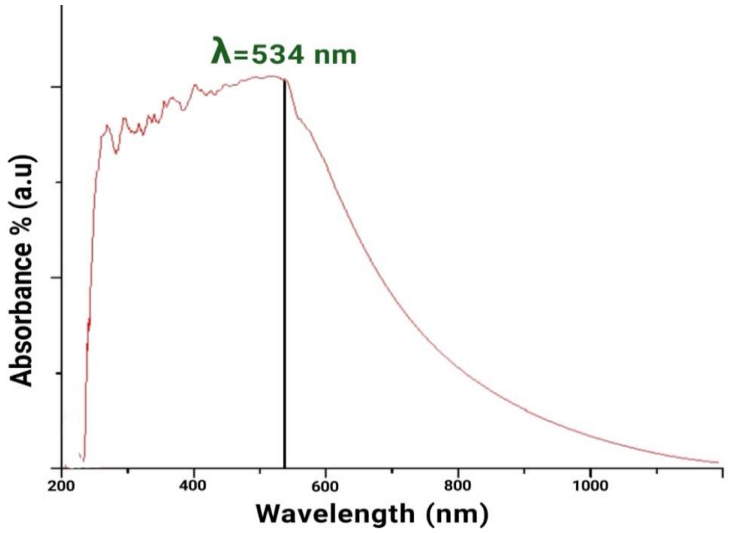


Figure (2) shows FESEM image of silver nanoparticles.

UV-Visible spectroscopy

optical properties were measured by UV-Visible , the spectrometer showed the appearance of a shape peak as a results of plasmonic surface absorption at (534) nm . UV analysis is an effective way to know the shape and size of NPS . the prepared suspensions of silver nanoparticles in water were examined by a pulsed Nd:YAG laser with power of (500) mj by means of visible absorption of ultraviolet rays . fig (3) shows the production of nanoparticles at the spectral emission peak of (534) nm .



Figure(3) shows UV-Vis spectra of the AgNPS

Fourier Transform Infrared (FTIR)

Infrared spectroscopy is one of the important measurement , as it is an important tool for obtaining information about the locations of ions in the crystal structural [23] . this measurement identifies the molecules responsible for identifying and reducing the factor of AgNPs that have been ablated by the pulsed laser , it is used to identify the compounds , and shows how chemical bonds are absorbed , and we note through figure (4) that the absorption bond at wave number (3414.89) cm^{-1} is caused by the vibration of the bond (0-H) and the absorption bond at wave number (1767.44) cm^{-1} is caused by the vibration of the bond (C=O) . (1634.49) cm^{-1} to the bond (C=C)
(1356.08) cm^{-1} to the bond (C-O) . (1074.74)CM^{-1} To the bond (C-N) [24] .

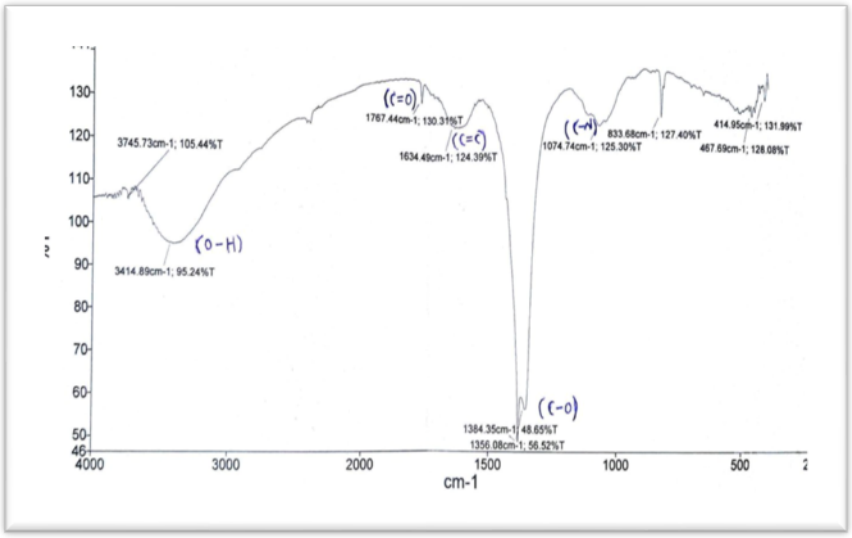


Fig (4): FTIR spectrum of AgNPS

Table1: The FTIR analysis information of silver nanoparticles

Functional groups	Absorbance peak (cm^{-1})
O-H	3414.89cm^{-1}
C=O	1767.44cm^{-1}
C=C	1634.49cm^{-1}
C-O	1356.08 cm^{-1}
C-N	1074.74 cm^{-1}

X-RAY Diffiraction

The XRD analysis is used to determine the phase distribution and crystallization of the composite nanoparticles , in order to know the X-RAY diffraction patterns of the nanoparticles that were prepared by pulsed laser ablation , and the results of the XRD assay showed

hat these particles have a polycrystalline structure , and they contain a group of peaks , and these peaks respresent the structural of silver that has a cubic crystal phase (FCC) with angles of (2Ɵ) at (32.50) , (37.50), (44.20) and crystal levels appear at those peaks which are (111), (200), (220).

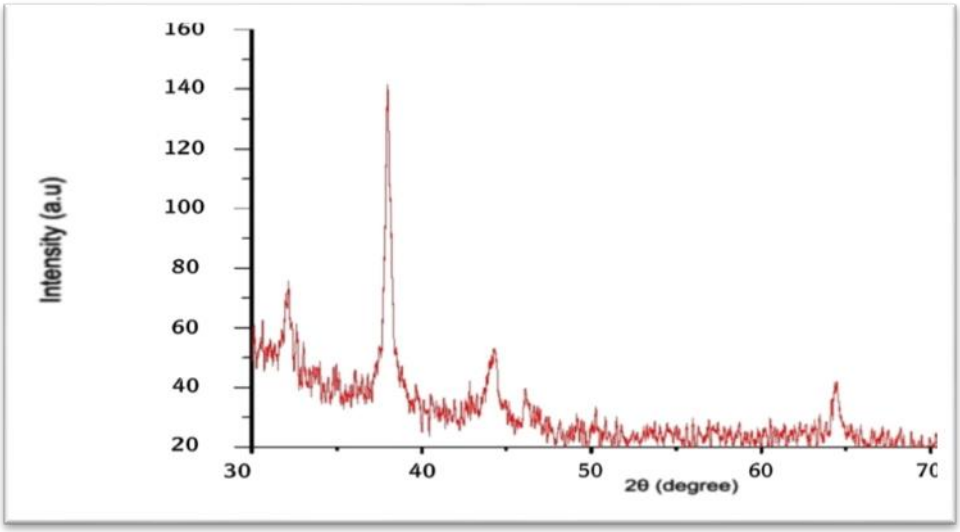


Figure 5 shows the x-ray diffraction of silver nanoparticles

Energy – Dispersive X- Ray Spectroscopy (EDX)

Energy- dispersive of x- ray diffraction "EDX" was used to study the element analysis of silver nanoparticles and reveals to the formation of silver nanoparticles was a showed in Figure (6) . fig (5) shows that silver nanocrystals shows atypical absorption peak at energy (0.22) Kev, (2.9) Kev for silver and then a peak for O2 at energy (0. 5) Kev and apeak for Cat energy (0.23) Kev , table (2) shows the percentage of elements in the silver nanoparticles.

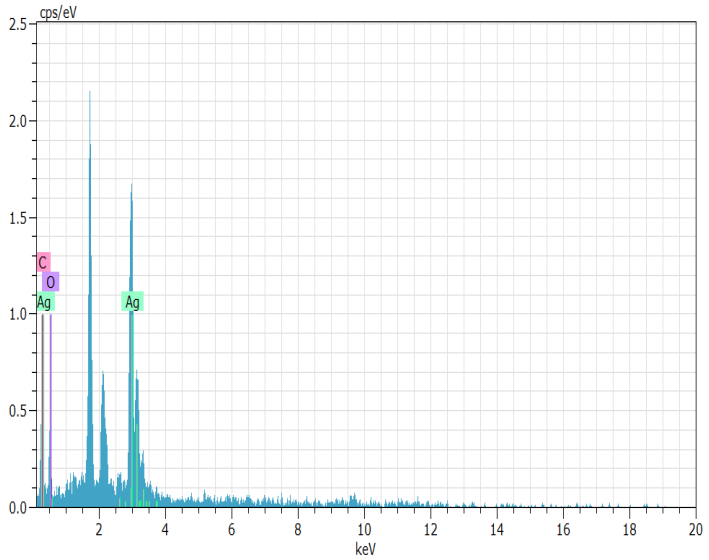


Fig (6): shows EDX analysis spectrum of silver nanoparticles

Table2: EDX results shows percentage of elements in resulting suspension

		[wt.%]	[wt.%]	[at.%]	[wt.%]
Ag	**47 L-series**	**29.06**	**62.63**	**18.45**	**1.40**
O	**8 K-series**	**12.20**	**26.29**	**52.23**	**6.27**
C	**6 K-series**	**5.14**	**11.08**	**29.32**	**2.64**
Total:		**46.40**	**100.00**	**100.00**	

Fluorescence Spectrum Results

The fluorescence is the process of emitting light from a substance due to the absorption of energy by this substance , and this energy is light or electromagnetic radiation , that is , it is aluminous emission resulting from the flow of one of the froms energy inside the lit body , and this emission stops [25] . the fluorescence process depends on the light absorbed by the sample,so the intensity of fluorescence is diretly
proportional to the absorbed light , and this is true only for low concentrations $F=\Phi C$ [26].and the fluorescence is primarily concernd with electronic and vibrational states[27].from the figure (7) we note that the highest excitation that can be obtained is at (365) nm , which is the wavelength of excitation . This is almost identical to the results

of the absorption spectrum of Silver nanoparticles solution as in fig (7) .it show the fluorescence excitation and emission spectra for silver
emission spectra for silver nanoparticles with an energy of (500) mj . And a number 0f (100) pulses. The fig (7) shows that the peak value is at (365nm) . and the emission spectra were recorded for system . This is almost identical to the results of the absorption spectrum of Silver nanoparticles solution as in figure (7) .Through fluorescence testing , colloidal solutions of silver nanoparticles were examined .

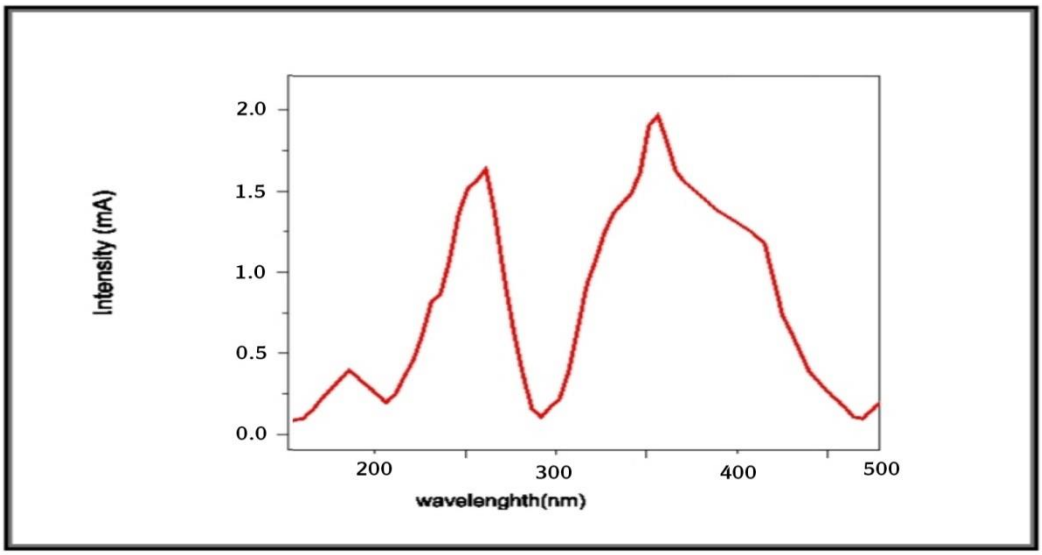


Figure (7) The Fluorescence Spectrum of Silver Nanoparticles

Conclusion

The liquid phase laser ablation has advantages , including the nanoparticles are somewhat crystalline , and they can be obtained in an easy and one –step way without any heat treatment . the interaction of the laser with the target , and in this research , the method of preparation was carried out using a pulsed Nd:YAG laser with wavelength (1064) nm for pure silver metal immersed in ionic water the optical properties were studied by UV-vis spectroscopy , as the spectra showed the appearance of a sharp peak as a results of plasmonic surface absorption at (534) nm , and the size , shape of the nanoparticles were examined by FESEM device . the chemical bonds were absorbed , the phase distribution was determined , and XRD diffraction patterns of the prepared nanoparticles

were known by the pulsed laser ablation method . the results showed that the nanoparticles are polycrystalline , and have a cubic crystal phase . as the results Fluorescence Spectrum of Silver Nanoparticles showed the peak value is at (365nm).

Further Work

Using lasers of different energies are used , and studying their optical properties of silver nanoparticles (AgNPS) by using transmission electron microscopy (TEM) , and Gismos measurement and Raman measurement for the prepared nanoparticles

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مستخلص البحث:

الهدف من البحث هو تحضير جسيمات الفضة النانوية بطريقة الاستئصال بالليزر في وسط مائي لتقدير أهمية الليزر في إنتاج جزيئات الفضة النانوية ، وقد تميزت المحضرة بخواصها التركيبية والفيزيائية والبصرية . لذلك قمنا بدراسة خصائص هذه الجسيمات النانوية المحضرة بهذه الطريقة . تم إجراء بعض الفحوصات الضوئية على محلول الفضة الغروية ، وتم تمييز الخصائص الهيكلية باستخدام حيود الأشعة السينية ، وقد تم تحليل الخصائص الفيزيائية عن طريق الفحص المجهري الإلكتروني لمسح الانبعاث الميداني تم تحليل الخصائص عن طريق التحليل الطيفي للاشعة) FESEM (والميكروسكوب البصري. فوق البنفسجية المرئية ، وقياس من أجل تحديد أبعاد وأشكال المحضرة واستخدام الطاقة - مطيافية الأشعة السينية المشتتة وقياس الطيف الفلوري، وكانت هذه الجسيمات قد تم تحضيرها عن طريق تقنية الاستئصال بالليزر النبضي السائل، وذلك باستخدام ليزر بطاقة (٥٠٠) ميغا جول . وعدد النبضات في هذه الطريقة بسيطة ، ملوثة ، خالية ، مستقرة ، ولها القدرة على تحديد مواصفات الجزيئات المحضرة.