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The effect of liquid environment and magnetic field on optical properties of Pt nanoparticles colloidal prepared by pulsed laser ablation

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Abstract : In this research, we study the effect of the magnetic field and the liquid environment on the structure and optical properties of the platinum nanoparticles prepared in by laser ablation. Laser ablation pulse Method was used to preparation of platinum nanoparticles around (5-10) nm using a laser (Nd- YAG) pulse and different wavelengths (355, 532, 1064) nm, in different solvents such as Double Distilled and Deionized Water (DDDW), methanol and Sodium Dodecyl Sulphate (SDS) at different concentrations. Measured absorbance spectra and fluorescence, and check the scanner electron microscope (SEM) and Transmission Electron Microscope(TEM) were investigated. The results showed the possibility of preparation of colloidal solutions of platinum and granular sizes less than(10) nm. It's showed the absorption peak at the wavelength of (280) nm. The scanning electron microscope images are shown the formation of spherical shape nanoparticles using the method of laser ablation (PLA). When applied a magnetic field during the ablation laser process of Platinum nanoparticles noted that the absorption peak may become more apparent from the absorption peak without a magnetic field and this is a positive factor in improving the oscillation resonance surface Plasmon (SPR) for platinum in the water.
Keywords: liquid environment, magnetic, optical properties, nanoparticles, pulsed laser ablation.

Introduction

It is notable that the material properties are profoundly subject to the synthetic nature and the crystal structure, specifically, because of overlap the outer of nuclear orbitals or sub-atomic parts material.an solids comprising of countless, and highlight power packs, which are in charge of a large portion of the physical and compound properties of solid materials. Nanomaterial's, which range in grains size crystallized between the (10-100) nm, the group of atoms become too small to be modified electronic power packs interfere significantly and the different, which severely affects in change all the physical properties of materials[1,2]. These important characteristics of nanoparticles, such as electronic, chemical, mechanical and optical properties, highly and completely different from the material of microwave sizes or larger. There are two types of methods for the preparation of nano-sized nanoparticles, namely, (1) the method of Top down where this method are the removal of nanoparticles from the bulk material. (2)The method of bottom up and begin this method usually of atoms that combine to generate nanostructures include chemical materials and thermal and other[3,4].

It can be produced nanoparticles in the liquid in many ways. The evidence suggests that the method of laser ablation is superior to other methods. The laser ablation in liquids, which consists of the removal and fragmentation of solid material in the inside of the liquid, giving a new opportunity and a unique resolve the problems of transformation to a toxic substance and contrast with chemical methods of preparations, the method of laser ablation can be present material in a very clean environment such as deionized water and controlled efficiently, leading to the production of high purity nanomaterials. It can control the characteristics of nanoparticles, such as size and shape by the laser parameters such as (wavelength, pulse duration, and laser power), and also the liquid medium[5,6].

Metal nanoparticles have attracted considerable attention because of the adoption of optical and magnetic properties, on the particle size of the metal within the range of nanoscale[7,8]. In recent years, it attracted nanoparticles great interest in copper granules due to the possibility of their use in various applications such as use thin connector and in the lubrication and fluid nanoparticles as catalysts[9-11]. Where is due to the volatility resonant surface Plasmon(SPR),and optical properties of nonlinear of nanosolutions.

Platinum nanoparticles and its alloys have attracted a lot of attention because of the multi-purpose excellent stimuli[12-15] The chemical element Platinum and metal rich ,the color gray - white and atomic number (78), atomic weight (195.09), and the melting point (1768. 3) C^0, and the degree of boiling (3825) C^0 and characteristics that strong metal steel structural work and its luster when exposed to air because platinum no interaction with oxygen or sulfur compounds in the air, and the best way to dissolve it is to use a mixture of nitric acid and hydrochloric acid and combine easily with arsenic and silicon.

In this paper, we studied the influence of magnetic field on the optical properties of the platinum nanoparticles produced by laser ablation in the water, as well as study the effect of liquid environmenton the stability, and size of platinum nanoparticles.

Practical part

The preparation of platinum nanoparticles (NPs) through ablation laser for a piece of platinum high purity in different solvents such as Double Distilled and Deionized Water (DDDW), methanol and SDS at different concentrations, using a wavelengths (1064, 532,355) nm for (Nd: YAG), width pulse (7) ns, frequency (5) Hz ,and Number of pulses (100)pulse, use Baker glass where the solution situation and then piece platinum, with dimensions of (1 x 1) cm ^{2}, and the height of the liquid level in Baker up to (4 - 5) mm, used the lens to focus the laser beam with a focal length of (10)cm.We used a magnetic flux system during laser ablation process for platinum metal, type (Nivs Technologies Pvt, Ltd -india), which generates a magnetic up to (5- 1000)mT, and consists of a number of 2 coils, and Magnetic two poles with diameter of each one (25) mm, and is linked to the capacity equipped, current maximum endures Profile (3.5) A at (20) volts. figure**(1)**illustrates the practical preparations for the system of magnetic flux.

Properties of structure, size of nanoparticles, the shape and morphology of the deposition samples, were analyzed by using a scanning electron microscope (SEM), who made according to international standards, of the type (Model: LEO 1450 VP, voltage: 20 kv) (made in Germany), NPs samples characterized using Transmission Electron Microscope(TEM) (Model: LEO 912 AB), (Made in Germany), was measured spectra of absorption of the NPs solution by the optical spectrum double measure of ultraviolet visible (UV-Visible), with origin (CECIL CE 7200 ENGLAND), to measure the fluorescence spectra of NPs solution by fluorescence spectrum optical scale (Fluorescence), with origin F96 Pro (ENGLAND).

Figure 1 :The experimental setup preparation of nanoparticles by laser ablation process under the influence of a magnetic field.

Results and discussion

1 – laser ablation of Pt in water:

Figure (2) showed a transmission electron microscope (TEM) image, the size and distribution of particles size of colloidal platinum nanoparticles in water (DDDW),using (1064) nmwavelength, and ablation energy of metal (250) mJ. And deduce from the shape that get less grain size of Pt NP_S is when we used a wavelength (1064) nm, and the $NP_S$was a spherical shape. Where the laser ablationefficiency at the wavelength (1064) nm, lead to increasing the number of nuclei (Nucleus) leading into small granules with asize average of (23) nm.

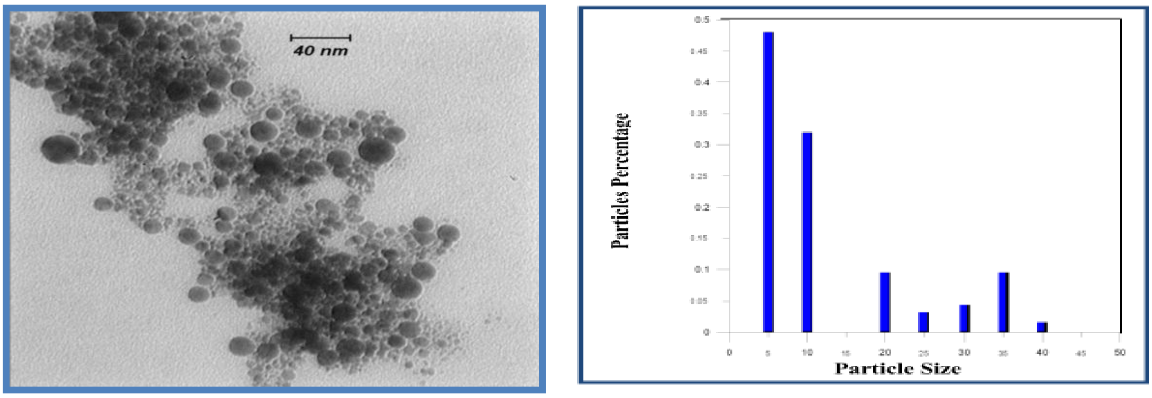


Figure 2 :TheTEM image,andthe statisticaldistributionofPt NP_Sin the water(DDDW)When usingthe following parameters(λ = 1064 nm), (E = 250 mJ), (pulse = 100).

It showed the absorbance of colloidal nanoparticles solution (Nano collide) by using different wavelengths of laser (Nd :YAG) (1064,532,355) nm, that there is a decline in the top of the broad absorbance with the decrease of the wavelength of the laser pulse in the case of the use of water (DDDW) as shown in Figure (3) . This was due largely to increased chance of conglomerate-grained (Aggregation) the fact that the deionized water, which leads to increased particle size when using wavelengths less than the (1064) nm wavelength. wherehappens partial overlap between (SPR) and transitions between packets and observed of figure(4) theabsorption and fluorescence spectrum of wavelength (1064) nm, where we note that the absorption peak of this length was at (280) nm and emission spectrum appeared at the borders of the visible region (395) nm, and this confirms the transition between the bands.

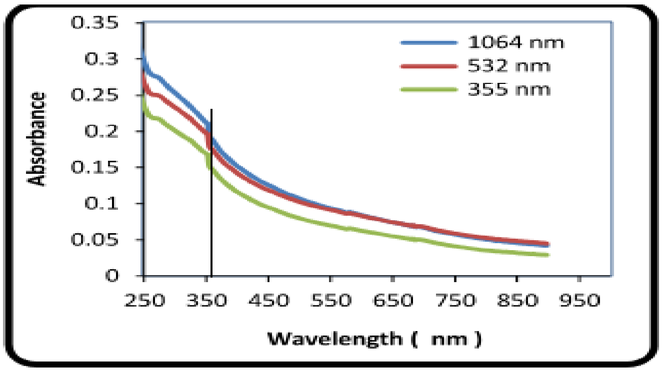


Figure 3:Theabsorption of thecolloidalnanoparticlesofplatinumwithdifferent wavelengthsin the water, at wavelength(1064) nm, and using the parameters(E = 250 mJ), (pules = 100).

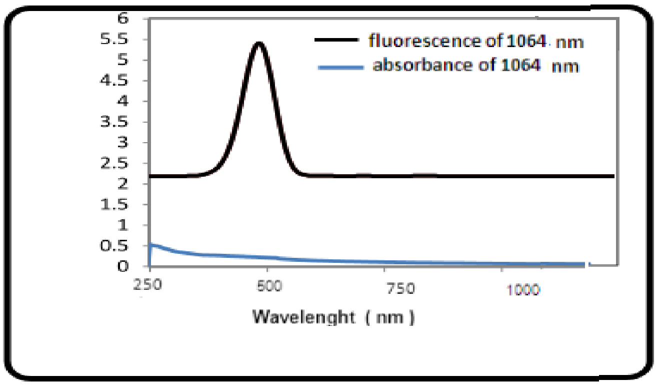


Figure 4: Theabsorption andfluorescencespectrumof theplatinum colloidalin water, at(1064) nm, (E = 250 mJ),and (pulse=100)

2 – Laser ablation of Pt in methanolsolution:

When we used ethanol Organic solution, Figure**(5)** showed images of transmission electron microscope (TEM)and size distribution ofcolloidalPtNP$_S$inmethanol solution withusing awavelength(1064) nm, andablation energy(250)mJ. We note fromFigure thatproducePt NP$_S$of a grainsizeless than (10) nm(G.S <10)andat a rate ofvolumetric(20.8) nm,thisconfirmsthe importance ofthe solutiontype, which includes nanoparticlesin the identification andcontrol onnanoparticlessize.

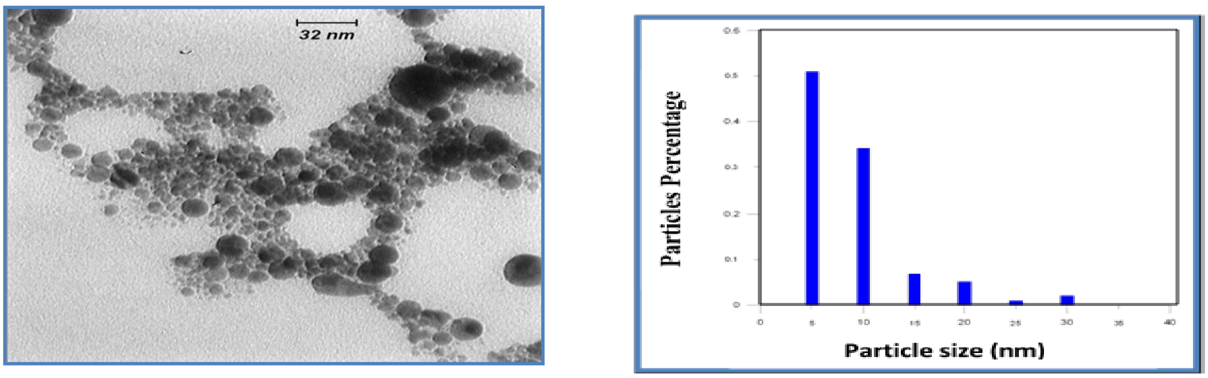
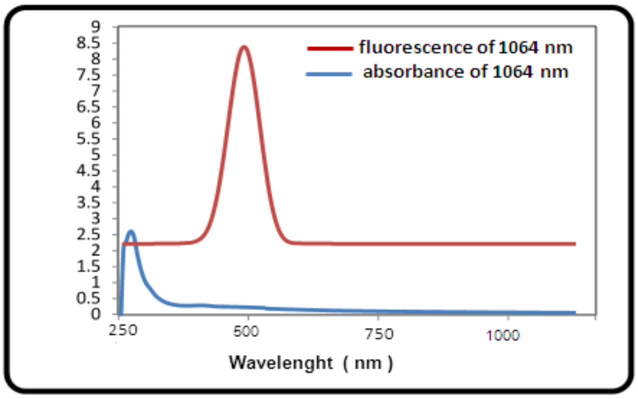
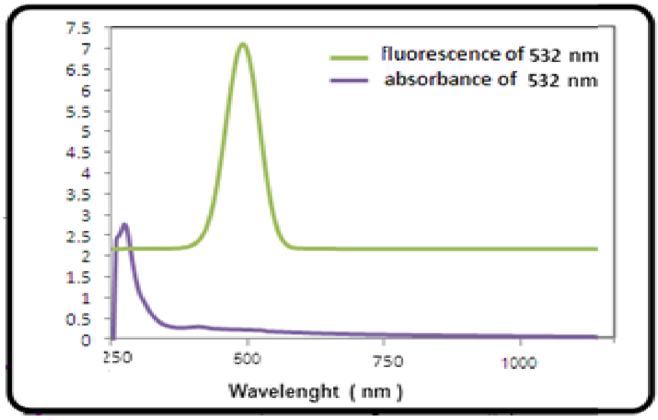


Figure 5: The TEM image,andthe statisticaldistributionofPt NPSinmethanolsolution, andwhen usingthe following parameters(λ = 1064 nm), (E = 250 mJ), (pulse = 100).

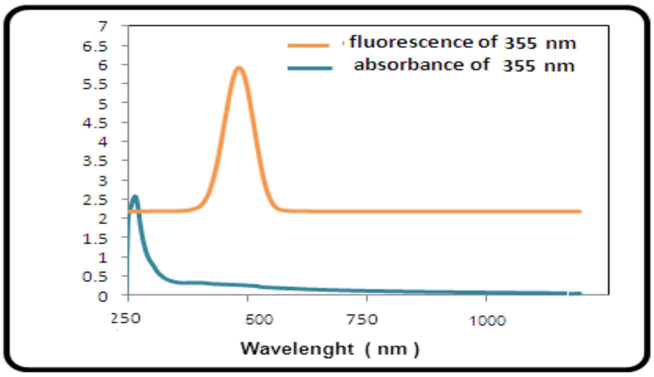
Figure (6 a, b, c) shows the absorption and fluorescencespectra of platinum collide in methanol solution, and using wavelengths (1064,532,355) nm respectively. We observedthat the absorption spectrum of colloidal nanoparticles at wavelengths(1064, 532, 355) nm respectively, absorbs at wavelength (280) nm and shift tothe visible region around (495) nm, and note that the top of the emission in the spectrum of fluorescence of (Pt NPs) in methanol solution be bigger than the peak of the emission in the water and that means NPs be smaller size in methanol, and this is what supports increasing the absorbance of (Pt NPs) in methanol described form (6 a, b, c) more than the absorbance of the (Pt NPs) in the water as shown in Figure (3).



a-Laser wavelength=1064 nm



b- Laser wavelength = 532 nm



c - Laser wavelength = 355 nm

Fig.(6): Theabsorption andfluorescencespectrumof theplatinum colloidalin methanol, at a-(1064) nm, b- (532) nm, c- (355) nm

We were also observed inversely behavior than in the water where increasing values of absorbance with the decrease in the length of the laser wave, its attributed to the fact that the organic solution limits and reduces the possibility of Aggregationbecause of Shipping grain Static to lead to disharmonies and not collected. And also TEM image in Figure (5), where shown the average particle size (20.8) nm, which is smaller than the average particle size of nanoparticles of platinum in the water, and this confirms the importance of the solution type on the nanoparticles size.

3 – Laser ablation of Pt in SDS solution:

Figure **(7)**shows the transmission electron microscope images (TEM) and size distribution of colloidal platinum nanoparticles in solution (c = 0.01 SDS). And using a wavelength (1064) nm, ablation energy of metal (250)mJ. We note from Figure (7), Pt NP_Sproduce of a grain size less than (10) nm , andthe average granular size of (15)nm, and concluded that the highest concentration of (Pt NP_S) sized nanoscaleat least (10) nm,in three solutions (Water, methanol, SDS) ,and this is attributed to the NP_S be more stabilizing than the other solutions, because the SDS solutionparticles, be more polar than the other solutions, and this in turn leads to reduce the chance of conglomerate-grained (Aggregation) This is due to the large nature of the SDSparticles. This is the best result for (Q .D_S) for platinum in SDS solution.

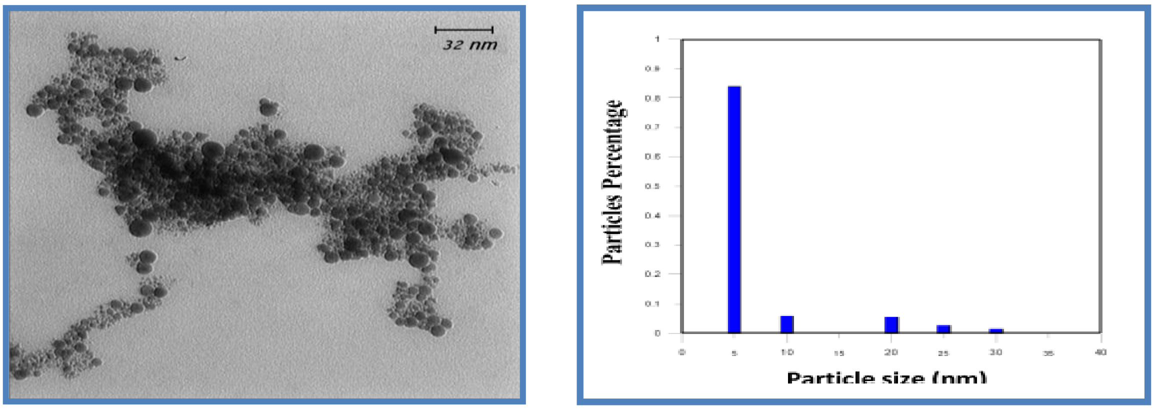


Figure7: The TEM image, and the statistical of distribution of Pt NP_S in the SDS solution and the concentration of(0.01) molar, when using the following parameters(λ = 1064 nm), (E = 250 mJ), (pulse = 100).

Images of (SEM) as shown in Figure **(8 a)** turned out to be a kind of forms of granulated nanoparticles, a spherical shape in the (c = SDS 0.09) solution with wavelength (1064) nm, and ablation energy (250) mJ. Figure**(8 b)**shows EDX matching striped tops show for platinum and the chemical elements that are prepared to rule such as (Cl, Na, O).

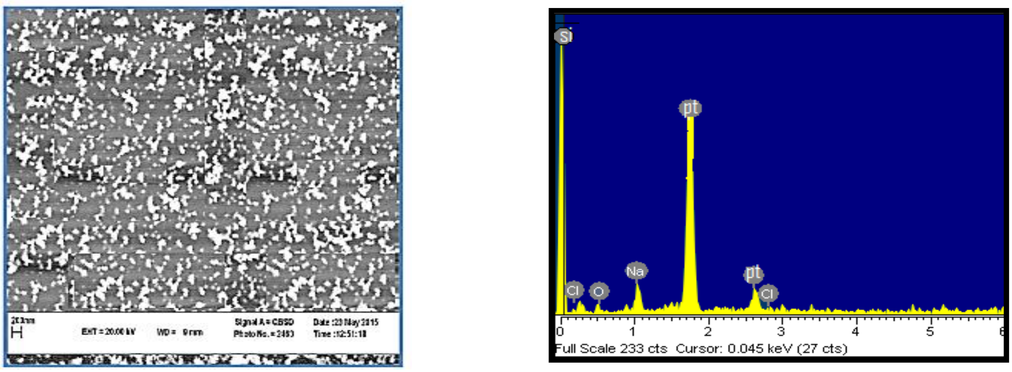
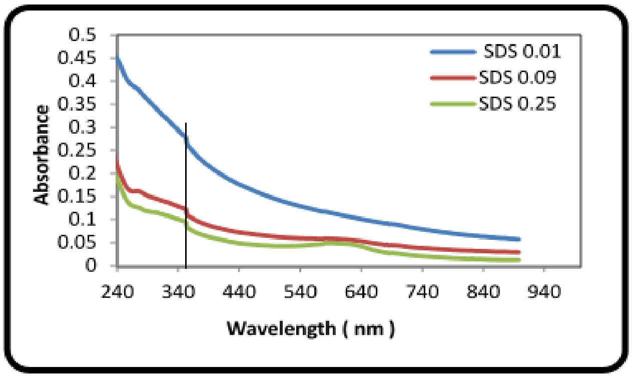


Figure8: The SEM images and EDX scheme of nanoparticles in colloidal (SDS0.09) solution, and when(λ = 1064 nm), (E = 250 mJ), (pules = 100).

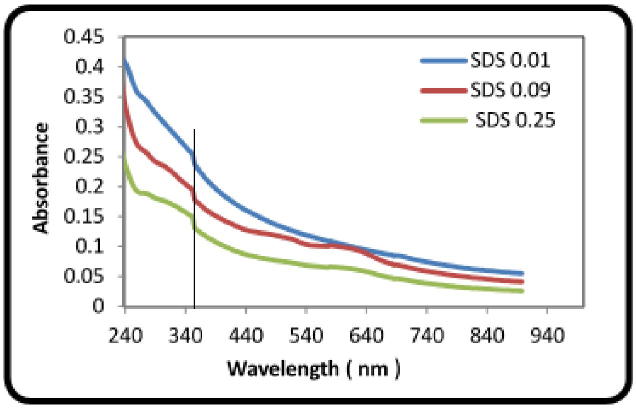
The effect of solution concentration as the absorbance results showed of (SDS) solution Pt NP_Sas shown in Figure (9) there was an inverse relationship between the concentration of (SDS) solution and the values of absorbance at wavelengths (1064,532, 355) nm where increasing absorbance with decrease of concentration (SDS)solution, where the concentrationbest is when (0.01) molar . Becausethe reduced concentration will be to avoid the role of the roots of chlorine, which is one of the chemical compounds of (SDS)solution.

On the other hand, we note the emergence of seconds absorption peak at value of (600)nm in the visible region due to some secondary compounds will be(impurity) as a result ofthe presence of(Cl)also showin Figure**(8)**, We also note that the highest absorbency of (PtNPs) are at the wavelength (355)nm and when the concentration is (0.01) molar.

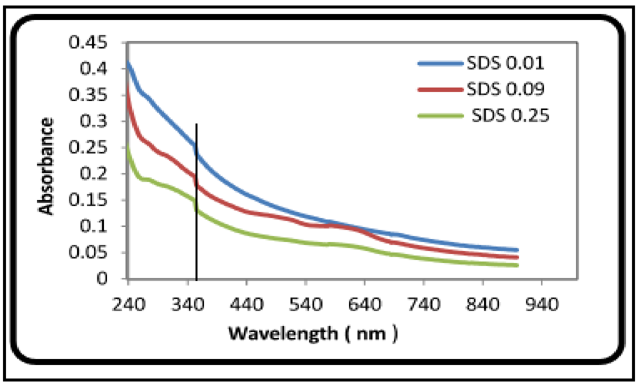
(a) λ = 1064 nm



(b) λ = 532 nm



(c) λ = 355 nm



Figure(9): the absorption spectra of the colloidalplatinum nanoparticles with different wavelengths in different concentrations of (SDS) solution, when(E = 250 mJ), (pulse = 100).

4 – The Effect of magnetic field on Laser ablation process:

We discussed the effect of magnetic field on the Laser ablation process in the solution ,from the absorbance spectrum as in Figure **(10)**and **(11)**we noted at low ranges of magnetic field (10-30)mT increase the proportion of absorbance which that represents an increase in efficiency of laser ablation, But when the more extents than (30)mT, the influence of magnetic field will be different where leads to disorder in the plasma formation process, leading some granules merger and the formation of (coalescence), as well as notes from Figure **(11)**,the absorption peak at the magnetic field presence has improved Summit landmarks and emerged more clearly, and this is an important factor to improving the (SPR).

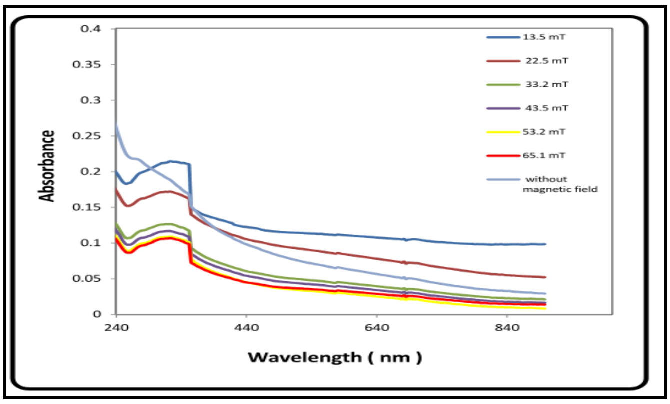


Fig.(10):Theinfluence of the magnetic field on the absorbency of colloidal nanoparticles in water, and when (λ = 355 nm), (pulse = 100), (E = 250 mJ).

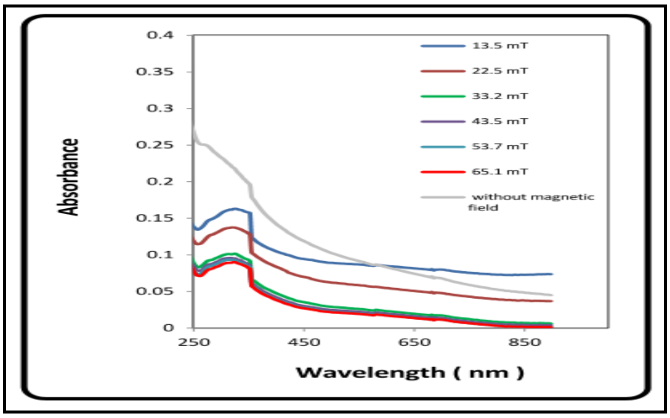


Fig.(11):The influence of the magnetic fieldon the absorbencyof colloidal nanoparticles in water, at(λ = 532 nm), (pulse = 100), (E = 250 mJ).

5 – Optical properties of platinum collide.

Discussion on optical properties include such(absorption coefficient, refractive index, extinction coefficient)for platinum ablation in water at different wavelengths. From Figure**(12)**, we noted that the absorption coefficient(α)of Pt NP_S at(1064, 532 355) nm wavelengths, decreases with decreasing laser wavelength, because the concentration of NP_S least, and therefore absorption coefficient least because the absorption coefficient depends on the absorbance values. From Figure(13)that the Extinction Coefficient of $PtNP_S$ in water increasingly greater the wavelength, and this leads to increased absorption.

It Figure (14)we noted that the refractive index (n) of Pt NP_S in the water at three different wavelengths (1064, 532 355) nm, increasing the refractive index (n) whenever increased wavelength, because the increase in wavelength leads to increased concentration of NP_S and thus to increase the refractive index because the refractive index depends on the density. The Figures(15),(16)shows the real and imaginary dielectric constants (ε_r,ε_i) ofPt NP_S in the water at three different wavelengths, and noted of the Figures that increase the wavelength increases NP_S concentration and thus dielectric constant increase the real and the imaginary, because they depend on the refractive index.

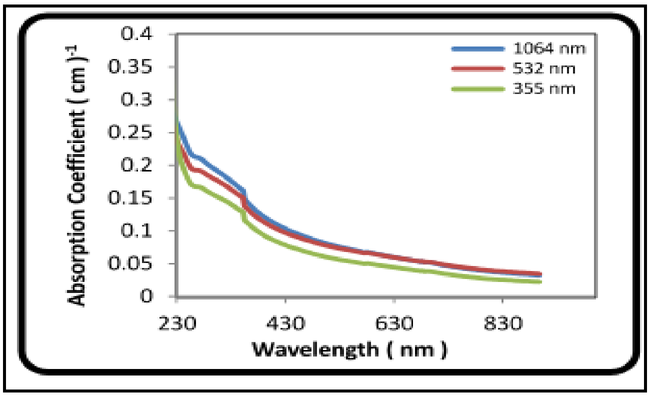


Fig.12:The absorption coefficient as a function of wavelength for $PtNP_S$,in water and at different wavelengths.

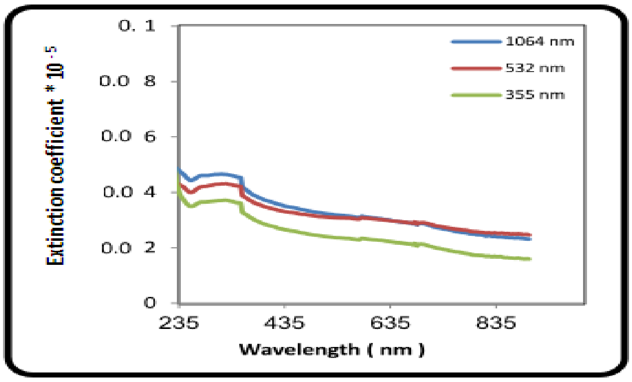


Figure13:The spectral extinction coefficient as a function of wavelength for $PtNP_S$,in water and at different wavelengths.

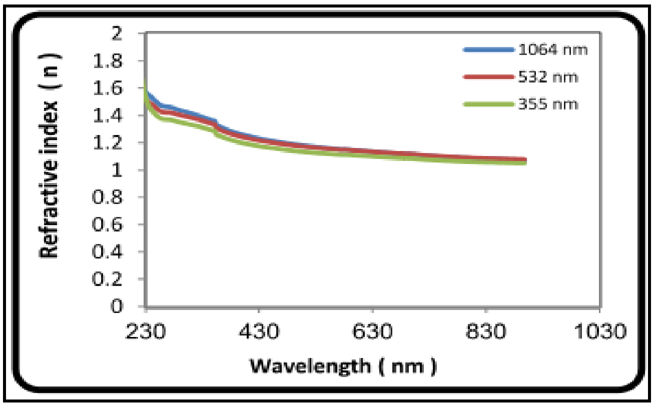


Fig.(14):The spectral refractive index as a function of wavelength for Pt NP_S , in water and at different wavelengths.

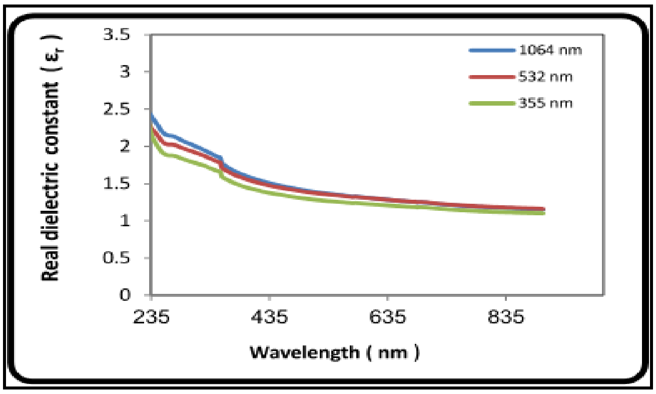


Fig.(15):The real spectral dielectric constant as a function of wavelength for Pt NP_S , in water and at different wavelengths.

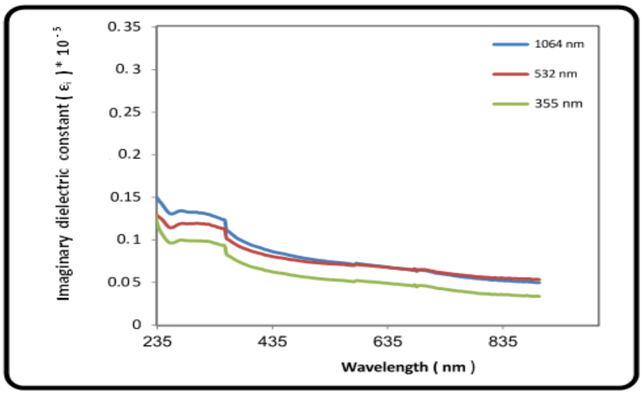


Fig.(16) :The spectral imaginary value dielectric constant as a function of wavelength for Pt NP_S , in water and at different wavelengths.

6 - Optical properties of the platinum presence of a magnetic field.

Figure(17)shown that the absorption coefficient (α) of the Pt NP_S at wavelength(355) nm, decrease at magnetic flux intensity decreasing, because the concentration of NP_S least, and therefore absorption coefficient least because the absorption coefficient depends on the absorbance values. Notes form Figure(18) that the Extinction Coefficient of PtNP_S in waterdecreases when the magnetic fluxintensitydecrease. Figure(19),shownthat the refractive index of PtNP_S in the water at wavelength (355) nm, the values increasing of the refractive index (n) to increase the intensity of magnetic flux, because the increase in the intensity of magnetic flux lead to increased concentration of NP_S and thus to increase the refractive index because the refractive index depends on the density. The Figures **(**20), (21)shows the real and imaginary dielectric constants (ε_r , ε_i) of PtNP_S in the water, we noted from shapes, the magnetic flux intensity increase because the increase of NP_S concentration and therefore real and imaginary dielectricconstantsincrease because they depend on the refractive index.

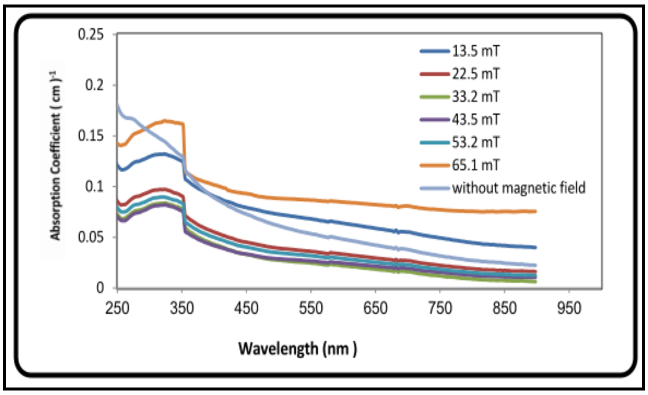


Fig.(17):The absorption coefficient as a function of wavelength for Pt NP_S , in water and at different magnetic flux intensity , and at (λ = 355 nm), (pulse = 100), (E = 250 mJ).

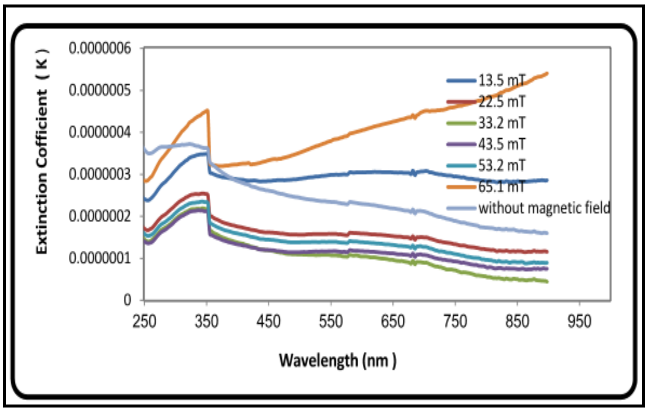


Fig.(18): The spectral extinction coefficient as a function of wavelength for $PtNP_S$,in water and at different magnetic flux intensity , and at (λ = 355 nm), (pulse = 100), (E = 250 mJ).

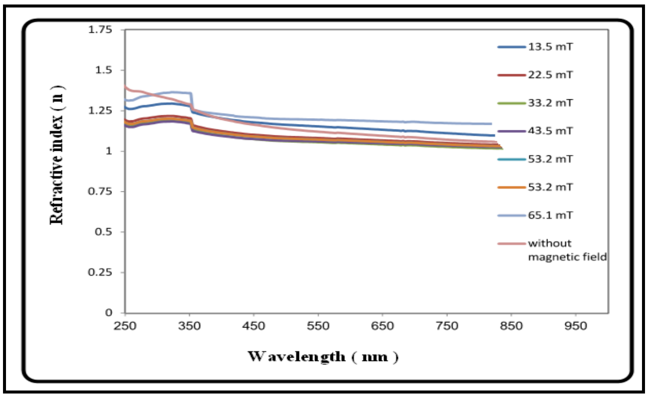


Fig.(19): The spectral refractive index as a function of wavelength for $PtNP_S$, in water and at different magnetic flux intensity , and at (λ = 355 nm), (pulse = 100), (E = 250 mJ).

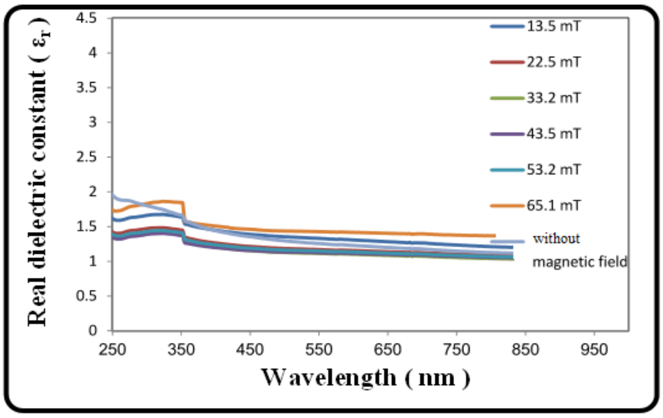


Fig.(20): The real spectral dielectric constant as a function of wavelength for PtNP$_S$,in water and at different magnetic flux intensity , and at (λ = 355 nm), (pulse = 100), (E = 250 mJ).

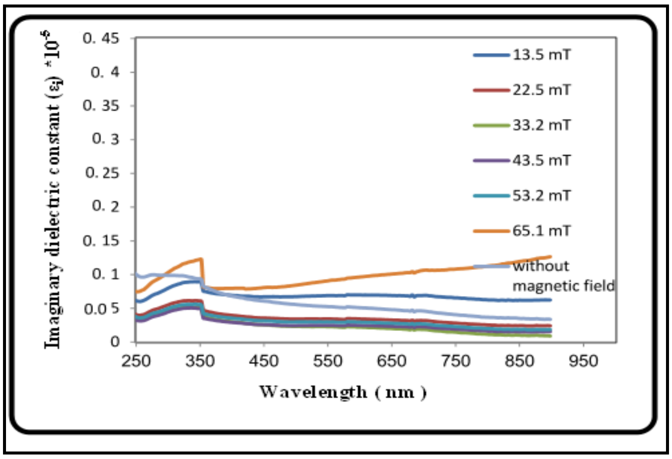


Fig.(21): The spectral imaginary value dielectric constant as a function of wavelength for Pt NP$_S$, in water and at different magnetic flux intensity , and at (λ = 355 nm), (pulse = 100), (E = 250 mJ).

Conclusions:

1. We can control on the nanoparticles size and continuity by selecting the appropriate laser parameters such and the surrounding medium (liquid).
2. Laser ablation of platinum metal showed the efficiency best at the wavelength (355) nm, in the SDS solution and concentration (0.01) M.
3. Was obtained granular size less than (10) nm ofcolloidalPt NP$_S$ at wavelength (1064) nm, and in the SDS solution, at the energy (250) mJ.
4. Applied Magnetic field during the laser ablation process, leading to an increase in the concentration and size of nanoparticles, which led to the increase absorbance, and higher efficiency of removal was with the magnetic field strength (13.5) mT.
5. Applied magnetic field during the laser ablation process is a positive factor in improving the volatility surface Plasmon resonance (SPR) for platinum in the water.
6. Applied magnetic field during the laser ablation process enhancement the all optical parameters especially at magnetic field strength (13.5) mT.
7. The reported very much controlled development of colloidalnanoparticles are of an extraordinaryenthusiasm for further improvement ofbunch based components of photonics, for examplegradient materials, periodicstructures/photon crystals, also films with the required optical properties.
8. The optical properties of the Ptcolloidalnanoparticles are shown to change as a function of their liquid environment and magnetic field parameters in a highly predictable way.

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