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# Synthesis of platinum nanoparticles from relatively high initial concentrations and study of their effect in treating water pollution with via heavy metals

**Abdul Kareem H. Assaf [1*], Zena E. Slaiby [2], Abeer M. Enad[2], Mohammed Moslih Mahdi[2]**
1- Nanomaterials Research Centre, University of Anbar, Anbar, Iraq.
2- Department of Physics, College of Science, University of Anbar, Anbar, Iraq



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**Corresponding Author**

E-mail:
cds.kareem.assaf@uoanbar.edu.iq

Mobile: 07800080598

**Abstract**

Liquid platinum nanoparticles were prepared using a cold plasma jet method within a locally developed system, with a 40-minutesute exposure time, starting from relatively high initial concentrations (40 mg/L). This resulted in nanoparticle sizes ranging from 50 to 80 nm, as determined by a series of tests. These prepared nanoparticles were then used to purify water from inorganic pollutants (a group of heavy metals) via adsorption. The study demonstrated the promising efficiency and effectiveness of the platinum nanoparticles, achieving high purity levels ranging from 66% to 95%, depending on the type of pollutant. The study also showed that purification levels decreased only slightly with increasing temperature. Furthermore, the study confirms that the pollutant treatment was carried out using physical adsorption, a very safe method for treating water pollutants, especially heavy metals. This confirms the effectiveness of relatively large nanoparticles in the safe treatment of inorganic pollutants suspended in water.

## Introduction:

Platinum is an important metal due to its widespread use in many industrial, health, and environmental fields. It is highly catalytic and is used as a catalyst in some chemical and industrial reactions[1]. This encourages the production of nanoparticles, leading to more widespread applications across multiple fields. Likewise, the synthetic nanoparticles, which come in various sizes and shapes, will demonstrate greater feasibility and effectiveness; for instance, they can utilize their relatively large surface area to enhance their chemical activity. Similarly, the electronic properties change with the distribution of surface electrons, increasing reactivity and activity. All of this leads to high catalytic activity[2]. Platinum nanoparticles have good electrical conductivity[3]. They also have a high capacity for adsorption of various pollutants [4]. This research paper describes the fabrication of

nanoparticles using the cold plasma jet method, which is one of the safe methods for manufacturing nanoparticles. The properties of nanoparticles manufactured using the cold plasma jet technique were studied. This study compares these nanoparticles to platinum nanoparticles synthesized using the same method but with different exposure times and concentrations[5]. It also investigates the efficiency of the nanoparticles when prepared from relatively high concentrations and determines the effect of increasing the base material concentration on nanoparticle size and cold plasma exposure time[6]. It should be noted that platinum salts were used as the bulk material for synthesizing the platinum nanoparticles. To support global efforts in water sustainability and to find solutions to water scarcity through water recycling for reuse in agriculture or industry[7]. nanoparticles have been used in the field of water treatment to remove pollutants from it (water contaminated with heavy elements). These elements (lead, chromium, cadmium, and cobalt) are among the most dangerous pollutants affecting the environment in general, leading to soil degradation and loss of fertility and consequently changing its chemical and biological properties. It can also negatively affect plant absorption of these elements, leading to biocontamination of food crops[8]. Elements such as cadmium and lead hinder the absorption of natural plant nutrients (such as iron and zinc). Heavy metals have a particularly harmful effect on human health. Lead causes cognitive impairment and developmental disorders. Chromium is a carcinogen, and cadmium causes kidney disease and osteoporosis. Cobalt has a detrimental effect on the respiratory system and lungs, especially at relatively high levels[9]. Therefore, multiple, viable, and highly effective solutions must be found to eliminate these pollutants. High-cost methods: ion-exchange, precipitation, separation, membrane evaporation, are used for removing heavy metal ions[10] . Adsorption is a popular and easy method for treating water pollutants because it has no side effects and produces no unknown (unknown hazardous) chemical byproducts. Therefore, this method was used in this research as a method for water purification using nanoparticles (physical adsorption)[11]. Because physical adsorption occurs when heavy metal ions are bound to the surface of the adsorbent material by weak physical forces such as van der Waals forces, complex chemical reactions that could produce harmful byproducts [10][12][13]. Furthermore, this process does not significantly alter the chemical composition or pH of the water, unlike some chemical treatment methods that may add new chemicals to the water[14]. While chemical purification methods have drawbacks, perhaps the most prominent is that chemical treatments are less efficient when heavy metal concentrations are very low[15]. Chemical precipitation is certainly effective in converting heavy metal ions into insoluble precipitates[16].

**Experimental Methods**

**Prepare the Materials in the Laboratory**

Preparation of basic materials

A-. Aqueous solutions of ($H_2PtCl_6.6H_2O$) are prepared concentrations (40) mg/L which are equal (0.000205) molarity, By mixing the above substance with of deionized water Using equations (1)( 2)[17],To calculate that

$$w. = ((Con.)/(1\times10^3))\times\left(\frac{m.w.c.}{m.w.ele.}\right)\times(V/(1\times10^3)) \quad \ldots..(1)$$

Than:

V = Required volume
m.w.ele.= The molecular weight of the elements
m.w.c.= The molecular weight of the compound
Con.= concentration
w.= Weight in grams

$$\text{Concentration1}(N1) \times \text{volume1}(V1) = \text{Concentration2}(N_2) \times \text{volume2}(V_2) \quad \ldots(2)$$

B-Preparation (lead, cadmium, chromium, and cobalt) These are inorganic pollutants, in the laboratory at a concentration of (100) mg. $L^{-1}$. Using the equation (1) to find the weight of lead, cadmium, chromium, and cobalt. Required to obtain it at a concentration of (1000) mg $L^{-1}$ dissolved in its aqueous solution. and then the solution was diluted to (100) mg/L. Using the equation (2) .

Note that: (deionized water) was used as a solvent for the heavy elements mentioned above in order to ensure that there were no other substances that might affect the results.

C- The system used in producing plasma jets, with detailed specifications below:

• The direct current power supply provides the system with 6000 volts of energy.

• It is necessary to have an inert gas (argon) source with a regulator to manage the argon flow rate. We employed a titration at a rate of 2.25 liters per minute in our investigation. The argon gas runs through a rubber tube linked to a hollow metal needle with an internal diameter of 1 mm. The needle is positioned 1.2 cm above the liquid's surface and attached to the power source's cathode end.

• While the anode end is connected to a stainless steel foil cell submerged in the liquid solution to a depth of about 2 cm to be exposed to plasma for the purpose of synthesizing a nanomaterial from ($H_2PtCl_6.6H_2O$) hydrated platinum salts dissolved in their aqueous solution.

**Adsorption Experiments**

Heavy metals dissolved in aqueous solutions at a concentration of 100 mg/L were treated as described below:

Adsorption processes were carried out for the inorganic pollutants (lead, cadmium, chromium, and cobalt). After dissolving them in their aqueous solutions, and to establish the adsorption equation for the prepared solutions, 6 ml of colloidal material containing the prepared platinum nanoparticles (as previously described) was placed in 25 ml volumetric bottles for each sample. An additional 6 ml of the prepared solutions (inorganic pollutants) at a concentration of 100 mg/L was added to each sample. The volumetric bottles were tightly sealed and then placed in a shaking water bath at approximately 25°C for varying durations of continuous shaking (10-60 minutes). The samples were approximately half-submerged in the water bath. Then the samples were taken one after the other and for periods (every 10 minutes), and the above samples were separated by centrifuge (4500) rpm for only (5) minute.

• The concentrations of the adsorbed materials (lead, cadmium, chromium, and cobalt) were calculated using an atomic absorption spectrometer located in the laboratories of the Desert Studies Center, University of Anbar.

• The percentage of pollutant removal (the percentage of pollutant concentration after treatment) was calculated to determine the adsorption efficiency according to mathematical[18] .

**Calculation of Thermodynamic Functions**

The equilibrium constant ($K_{eq}$) of adsorption for the adsorbent (the amount of contaminant removed) was calculated at different temperatures (10, 20, 30, 40, and 50 °C), as shown in the results discussion, when equilibrium was reached between the adsorbent and the residual (i.e., the non-adsorbent) in the solution. The value of the equilibrium constant can be found using the adsorption equations[18].

By knowing the values and quantities of the thermodynamic functions, we can determine the nature and type of adsorption process, whether it is physical or chemical. This, in turn, leads us, through their calculation, to understanding the behavior of the prepared platinum nanoparticles within the aqueous solution. One of the most important of these functions is:

- Gibbs energy (active or free energy): a thermodynamic property that combines the entropy and enthalpy of the system to determine whether the reaction is spontaneous and is denoted by (ΔG)[19].
- The value of the enthalpy function, denoted by ΔH, representing the enthalpy of the system, can also be determined. ΔH is calculated using the van't Hoff equation[20].
- The value of entropy, denoted by ΔS, can also be calculated. Its value equals the amount of work done on the system, the greatest randomness of the system[20].

From knowing the values of these functions (thermodynamics), it is possible to determine whether the reaction is chemical or physical. In other words, if no new products or compounds are formed, it is a physical reaction, meaning it is safe. However, if new products or compounds are formed during the adsorption process, it is a chemical reaction, meaning it is unsafe[21].

**Results and Discussion:**

**Color change of solution**

Platinum hydrate salts ($H_2PtCl_6.6H_2O$) at a concentration of (40) mg/L, equivalent to (0.2) mil-limolarity, were exposed to plasma for (50) minutesutes. A color change appeared from a colorless solution to a dark yellow solution gradually, as shown in Figure (1) due to the principle of chemical reduction. This is considered one of the important initial indicators of nanoparticle synthesis [22]. It was also observed that when exposed to cold plasma for forty minutes, the color change was at its greatest, indicating, as an initial indicator, the synthesis of nanoparticles at its peak (maximum possible). However, when the exposure time was increased to fifty minutes, we observed that the dark yellow color began to recede,

and this is due to agglomeration or clumping, in other words, the nanomaterial has begun to clump together, meaning the nanoscale size has started to exceed its range (more than 100nm) [23].

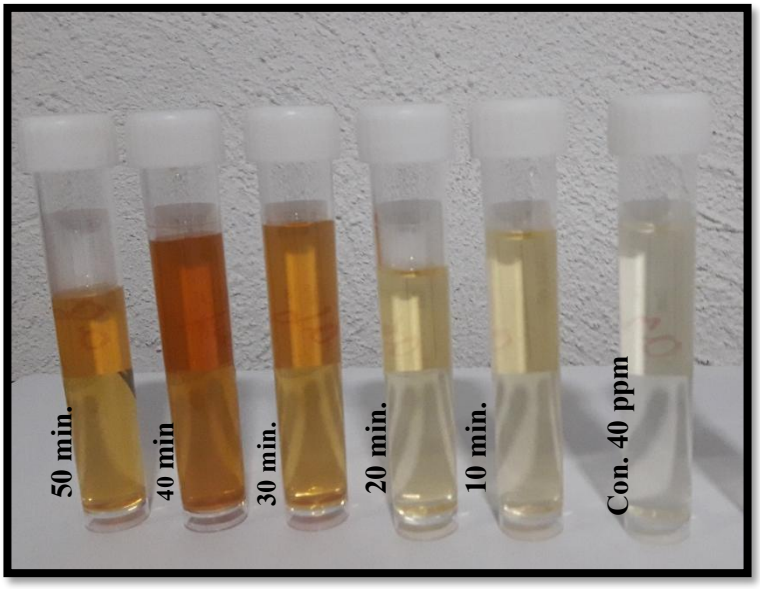


**Fig. 1.** *Color change of solution*

**Spectroscopic Analysis:**

**UV-Vis Spectroscopy**

The absorption spectra of platinum nanoparticles were measured after exposure to cold plasma for periods of (10–50) minutes, at intervals of 10–50 minutes, using a (UV-Vis spectrometer). The wavelength range was (190-500) nm, as shown in Figure 2. It is noteworthy that the absorption peak of the nanoparticles occurred at two locations, 264 nm and 216 nm. This indicates the presence of longitudinal and transverse resonance of the prepared nanoparticles with each time increment exceeding 10 minutes, consistent with[24] [25],as show in Figure (2).

The stability of the nanoparticles was monitored for a period exceeding (72) hours by observing the location of the absorption peak. No significant change in the absorption peak location was observed. That the highest peak occurs at the time of exposure to cold plasma jet (40) minutes and then at the time of exposure to plasma (30) minutes and then at the time of exposure (50) minutes and this is consistent with the interpretation and figure of number (1)

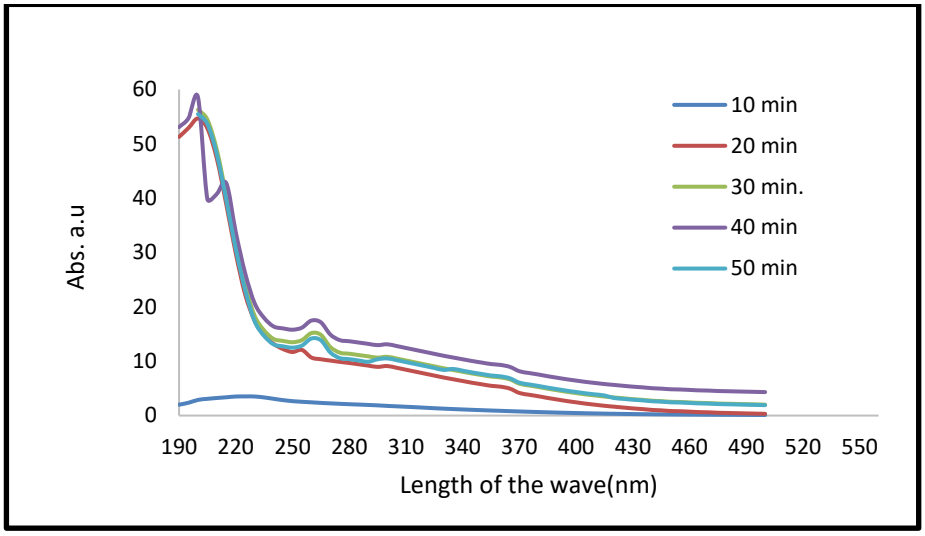


**Fig. 2.** *The intensity of the nanoparticle absorbance at 40 mg/L of hydrated platinum salts*

**X-Ray Diffraction (XRD) Analysis:**

In this experiment, X-ray diffraction (XRD) analysis revealed that the manufactured particles were hexagonal structural nanoparticles, prepared from hydrated platinum salts ($H_2PtCl_6 \cdot 6H_2O$) in the liquid state at an initial concentration of 40 mg/L. After exposure to a cold plasma jet for 40 minutes, these particles transformed into platinum nanoparticles (PtNPs) in their liquid phase. It should also be noted that face-centered cubic (FCC) nanostructures were also obtained see Figure 3.

Platinum nanoparticles in their liquid phase were a distinctive material. According to Figure (3), there were five different diffraction values for platinum, specifically (111, 200, 220, 311, and 322), each corresponding to different symmetry levels at angles of (almost), (38.5°, 47.6°, 67.3°, 81.4°, and 83.7°), respectively. It should also be noted that a single diffraction peak for platinum oxide was obtained at a diffraction angle of 31.98° with a symmetry level of (101), according to the card number. JCPDS 00-004-0784 [26]

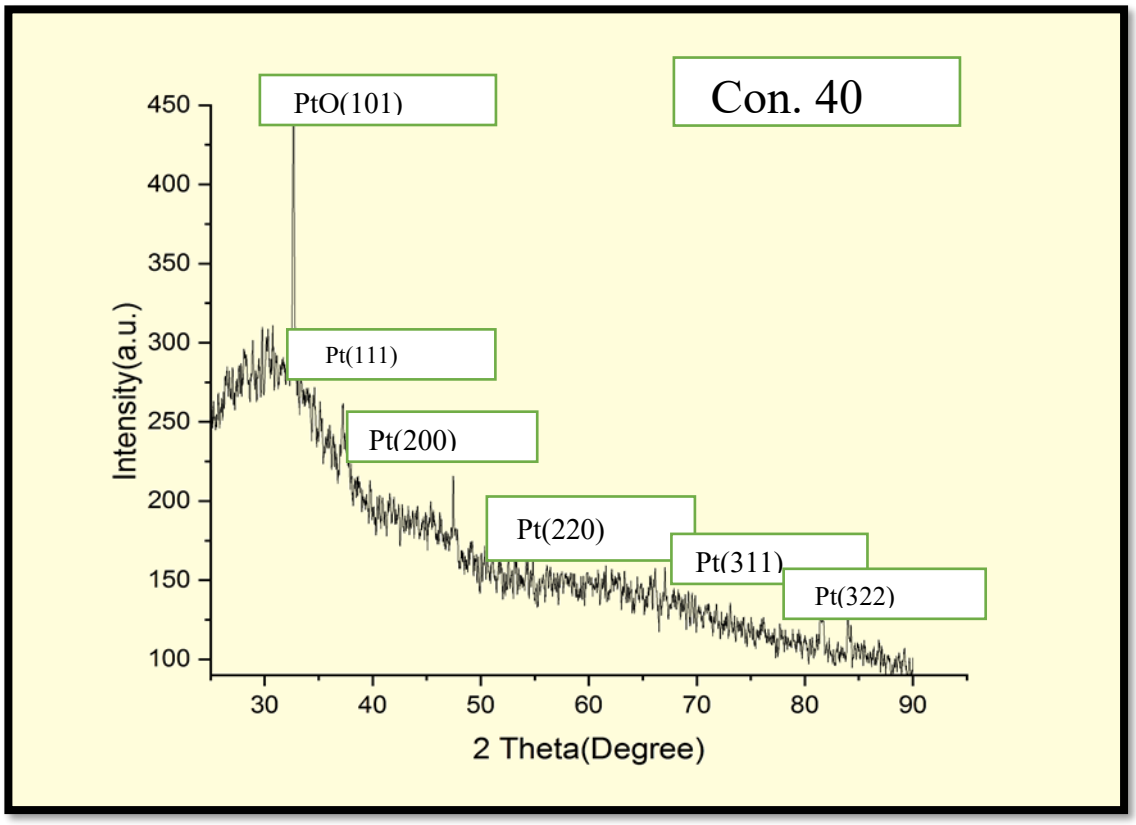


**Fig. 3.** *XRD patterns of Pt nanoparticles at a concentration 40 mg/L of aqueous platinum salts.*

The predominant phase was 111 for platinum nanoparticles and platinum oxide nanoparticles (101). The crystal sizes of the platinum nanoparticles in their liquid state were calculated using the Scherrer equation[5], and these sizes are shown in Table (1). The average size of these nanoparticles was approximately (74 ) nm (Table 1).

**Table 1.** Values 2θ, FWHM and Particle size of Pt nanoparticles at a concentration 40 mg/L of aqueous platinum salts for 40 minutes

| **Concentration Bulk (mg/L)** | **2Θ (Deg.)** | **FWHM (Deg.)** | **Crystal size (nm)** | **Nanoparticles Average (nm)** |
|---|---|---|---|---|
| 40 | 38.5 | 0.1026 | 85.73 | 74.1 |
| | 47.6 | 0.126 | 72.03 | |
| | 67.3 | 0.14 | 71.25 | |
| | 81.4 | 0.113 | 96.93 | |
| | 83.7 | 0.201 | 55.46 | |
| | 31.98 | 0.138 | 62.59 | |

**Scanning Electron Microscopy (SEM):**

These images were acquired using scanning electron microscopy. When hydrated platinum salts ($H_2PtCl_6 \cdot 6H_2O$) were exposed to a cold plasma jet for (40) minutes at a concentration of (40) mg/L, platinum nanoparticles were obtained as particles suspended in an aqueous solution. It was observed that the atoms of the nanoparticles aggregated due to their instability to form specific sizes. This instability, resulting from their high surface energy and relatively large surface area, led to their aggregation. In other words, surface atoms link to nearby surface atoms in order to stabilize themselves, which causes the high-concentration nanoparticles to aggregate [27], as illustrated in Figure (4).

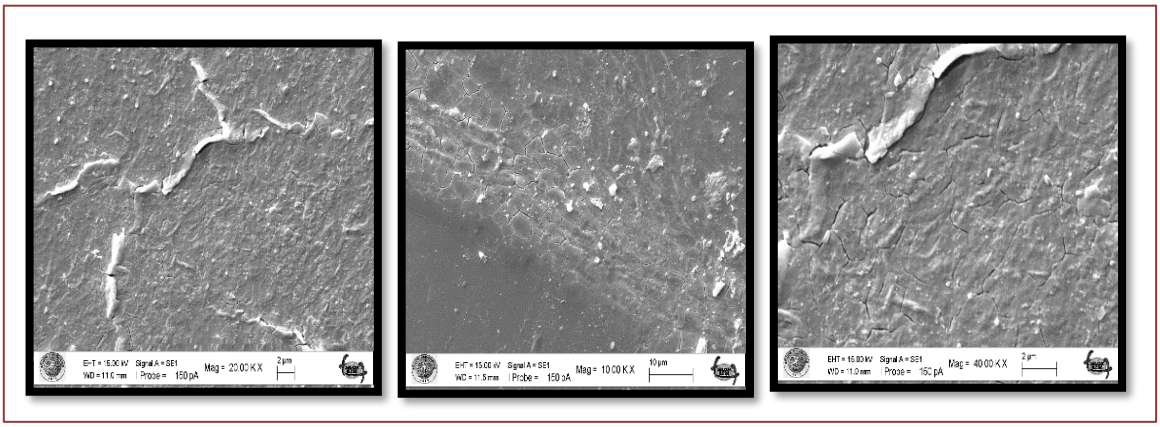

**Fig. 4.** *exposed to cold plasma jet for a time (40) minutes and a concentration (40) mg/L*

**A Field Emission Scanning Electron Microscope (FE-SEM)**

Field-emission scanning electron microscopy (FE-SEM) revealed that the prepared particles are platinum nanoparticles of material ($H_2PtCl_6 \cdot 6H_2O$), as shown in Figure (5), which is consistent with the X-ray diffraction (XRD) results, and (SEM). The results showed that the prepared nanoparticles have irregular spherical shapes in clusters and chains, with an average size of (74-80) nm. As can be seen from the figures, the nanoparticles are clustered, and when these clusters are between a few atoms, the particle size is mostly less than 100 nm. It is worth noting here that the shape of the nanoparticles affects their effectiveness and mechanism of action.

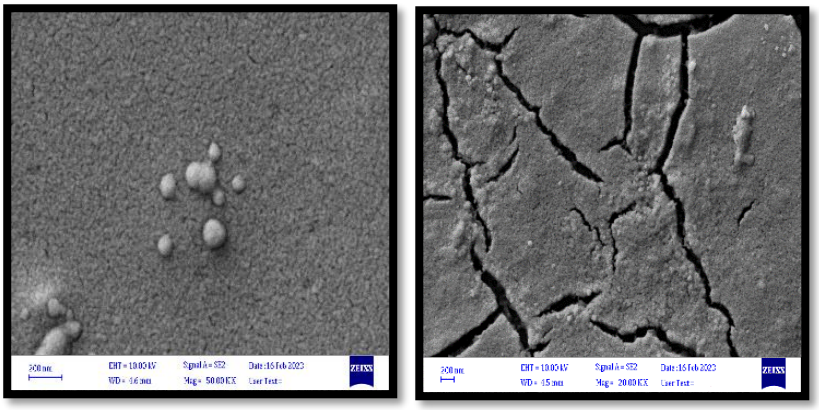

**Fig. 5** *The sizes and shapes of the connected nanoparticles from an exposure time of 40 minutes and a concentration of 40 mg/L.*

**Transmission Electron Microscopy (TEM) Analysis**

Small nanoparticles were identified using transmission electron microscopy (TEM). They were prepared from hydrated platinum salts to obtain platinum nanoparticles (PtNPs). The morphology and other properties of the nanoparticles were studied using TEM. Based on the results of the measurements and analyses, the following was observed: The particles have a compact spherical shape and are arranged in chains (stiff chains), which is consistent with the FS-SEM test. The shape of the particle planes is face-centered cubic (FCC), which is consistent with X-ray diffraction (XRD) tests . The average size of the prepared nanoparticles is (80) nm. This relatively small size of the prepared nanoparticles confirms the reason for the peak creep in the UV-Vis test, which is consistent with [28]. This confirms that the cold plasma method for synthesizing nanoparticles is a simple and highly efficient approach. As can be seen from this diagram, the particles have a distinct cubic shape and are assembled into nano-necklaces with promising applications. As shown in Figure (6).

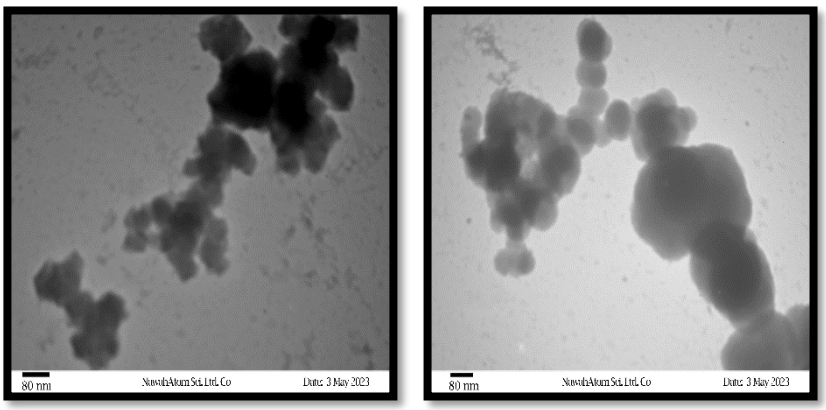


**Fig. 6.** *The sizes and shapes of the connected nanoparticles from an exposure time of 40 minutes and a concentration of 40 mg/L.*

**Removal of Inorganic Pollutants (Lead, Cadmium, Chromium, and Cobalt)Effect of time on the removal of the pollutant**

The removal percentage of inorganic pollutants (lead, cadmium, chromium, and cobalt) dissolved in water was measured at a concentration of 40 mg/L and a temperature of 25 °C. Each pollutant was then mixed with a solution containing PtNPs at a 1:1 mixing ratio to achieve pollutant adsorption. The adsorption time of the pollutant ranged from 10 to 60 minutes. The adsorption efficiency and equilibrium concentration of the pollutants in their aqueous solutions were calculated, as shown in Tables 2,3,4 and 5, respectively.

The size and charge of heavy metal ions play a significant role in their adsorption onto nanoparticles. Lead ions ($Pb^{2+}$) are larger and have a higher positive charge compared to the other pollutant ions[29]. The larger size and higher charge of lead ions allow for stronger electrostatic interactions and better coordination with the nanoparticle surface, resulting in higher adsorption capacities[30]. Stability and solubility: The stability and solubility of heavy

metal ions can also affect their adsorption behavior. Lead ions tend to form less soluble compounds compared to other pollutant ions.

**Table 2**: Removal percentage (lead) with an initial concentration of 100 mg/L as a function of time.

| Adsorption time (minutes) | Concentration before adsorption (mg/L) | Equilibrium concentration (mg/L) | Removal Efficiency (R%) |
|---|---|---|---|
| 10 | 100 | 4.113 | 95.887 |
| 20 | 100 | 7.219 | 92.781 |
| 30 | 100 | 10.037 | 89.963 |
| 40 | 100 | 9.640 | 90.360 |
| 50 | 100 | 12.803 | 87.197 |
| 60 | 100 | 13.773 | 86.227 |

**Table 3**: Removal percentage (cadmium) with an initial concentration of 100 mg/L as a function of time.

| Adsorption time (minutes) | Concentration before adsorption(mg/L) | Equilibrium concentration (mg/L) | Removal Efficiency (R%) |
|---|---|---|---|
| 10 | 100 | 15.966 | 84.034 |
| 20 | 100 | 18.099 | 81.901 |
| 30 | 100 | 20.111 | 79.889 |
| 40 | 100 | 21.583 | 78.417 |
| 50 | 100 | 22.195 | 77.805 |
| 60 | 100 | 22.176 | 77.824 |

**Table 4:** Removal percentage (chromium) with an initial concentration of 100 mg/L as a function of time.

| Adsorption time (minutes) | Concentration before adsorption(mg/L) | Equilibrium concentration (mg/L) | Removal Efficiency (R%) |
|---|---|---|---|
| 10 | 100 | 26.891 | 73.109 |
| 20 | 100 | 27.152 | 72.848 |
| 30 | 100 | 29.594 | 70.406 |
| 40 | 100 | 32.335 | 67.665 |
| 50 | 100 | 33.129 | 66.871 |
| 60 | 100 | 33.225 | 66.775 |

**Table 5:** Removal percentage (**Cobalt**) with an initial concentration of 100 mg/L as a

function of time.

| Adsorption time (minutes) | Concentration before adsorption(mg/L) | Equilibrium concentration (mg/L) | Removal Efficiency (R%) |
|---|---|---|---|
| 10 | 100 | 28.717 | 71.283 |
| 20 | 100 | 28.658 | 71.342 |
| 30 | 100 | 34.894 | 65.106 |
| 40 | 100 | 35.0136 | 64.9864 |
| 50 | 100 | 36.001 | 63.999 |
| 60 | 100 | 36.169 | 63.831 |

**The effect of temperature on the removal of inorganic pollutant**

Samples of platinum nanoparticles in their liquid state, prepared in cold plasma, were taken to study the effect of temperatures (10, 20, 30, 40, and 50 °C) on the amount of adsorbent for 10 minutes. Table (6,7,8, and 9) show the percentage of contaminant removal at different temperatures, with the removal rates presented as a function of temperature. The optimal removal rate was found at the lower temperatures (10 and 20 °C). At higher temperatures, a decrease in removal rates was observed, indicating a decrease in adsorption efficiency. This is because:

Higher temperatures increase the energy of the adsorbed particle, which helps it detach from the adsorption surface and return to the solution[31].

**Table 6:** Removal percentage and equilibrium concentration of the pollutant (lead) at an initial concentration of 100 mg/L as a function of temperature.

| temperature at adsorption (°C) | Concentration before adsorption(mg/L) | Equilibrium concentration (mg/L) | Removal Efficiency (R%) |
|---|---|---|---|
| 10 | 100 | 5.132 | 94.868 |
| 20 | 100 | 4.265 | 95.735 |
| 30 | 100 | 4.572 | 95.428 |
| 40 | 100 | 5.667 | 94.333 |
| 50 | 100 | 8.440 | 91.560 |

**Table 7:** Removal percentage and equilibrium concentration of the pollutant (cadmium) at an initial concentration of 100 mg/L as a function of temperature.

| temperature at adsorption (°C) | Concentration before adsorption(mg/L) | Equilibrium concentration (mg/L) | Removal Efficiency (R%) |
|---|---|---|---|
| 10 | 100 | 16.223 | 83.777 |
| 20 | 100 | 16.112 | 83.888 |
| 30 | 100 | 15.878 | 84.122 |
| 40 | 100 | 16.989 | 83.011 |
| 50 | 100 | 17.556 | 82.444 |

**Table 8:** Removal percentage and equilibrium concentration of the pollutant (Chrome) at an initial concentration of 100 mg/L as a function of temperature.

| temperature at adsorption (°C) | Concentration before adsorption(mg/L) | Equilibrium concentration (mg/L) | Removal Efficiency (R%) |
|---|---|---|---|
| 10 | 100 | 27.011 | 72.989 |
| 20 | 100 | 26.980 | 73.020 |
| 30 | 100 | 26.793 | 73.207 |
| 40 | 100 | 27.870 | 72.130 |
| 50 | 100 | 28.118 | 71.882 |

**Table 9:** Removal percentage and equilibrium concentration of the pollutant (Cobalt) at an initial concentration of 100 mg/L as a function of temperature.

| temperature at adsorption (°C) | Concentration before adsorption(mg/L) | Equilibrium concentration (mg/L) | Removal Efficiency (R%) |
|---|---|---|---|
| 10 | 100 | 31.332 | 68.668 |
| 20 | 100 | 28.997 | 71.003 |
| 30 | 100 | 29.107 | 70.893 |
| 40 | 100 | 30.745 | 69.255 |
| 50 | 100 | 31.552 | 68.448 |

**Thermodynamic Functions**

In Table (10) below, the thermodynamic functions were calculated as an indicator of the type and effectiveness of adsorption, and the results are shown below[32]:

1- Calculating the reaction constant (k): High values (greater than zero) for the rate (k) indicate that the adsorption efficiency is good, as shown in the table (10). From observing this table,

we find that the values of the reaction rate (k) decrease with increasing temperature because the rise in temperature helps the adsorbed material to return from - the adsorbent surface to the solution. This is consistent with the physical nature of exothermic adsorption [33].

2- Gibbs energy (ΔG): also called activation free energy values. The negative values (Table 10) indicate that the reaction proceeds spontaneously and through a physical reaction process to obtain the products during adsorption processes. This is consistent with[34] .

3- Enthalpy or (ΔH): By examining Table (10), we find that the (ΔH) values were negative, which confirms that the reaction is exothermic (physical) during the adsorption processes.

4- Entropy values (ΔS): The random or disordered state in a system is observed through the values of change (ΔS). From observing the table (10), the entropy values are relatively close, whether as negative or positive values. This indicates that there are cases of adsorption at good levels that lead to a reduction in randomness after the adsorption process. It indicates that the values of ((ΔS in Table (10) almost do not change (there is no significant change) because the disordered state for a single compound does not change within the studied range of temperatures [35].

**Table (10):** the thermodynamic functions were calculated as an indicator of the type and effectiveness of adsorption

| Element symbol | K | ΔG | ΔH | ΔS |
|---|---|---|---|---|
| Pb | 18.486 | -6863.277 | -18750.7 | -11.128 |
| | 22.447 | -7578.748 | | -8.306 |
| | 20.872 | -7654.215 | | -7.783 |
| | 16.646 | -7318.062 | | -8.609 |
| Cd | 5.164 | -3862.761 | -3040.84 | 7.020 |
| | 5.207 | -4019.204 | | 7.315 |
| | 5.298 | -4200.250 | | 7.671 |
| | 4.886 | -4128.279 | | 7.196 |
| Cr | 2.702 | -1158.31 | -211.679 | -2.1258 |
| | 2.706 | -1158.31 | | 3.9533 |
| | 2.732 | -1158.31 | | 3.8228 |
| | 2.588 | -1158.31 | | 3.7007 |
| Co | 2.192 | -1846.158 | -3453.8 | 4.070 |
| | 2.449 | -2181.512 | | 5.075 |
| | 2.436 | -2242.523 | | 5.109 |
| | 2.253 | -2113.230 | | 4.533 |

## Conclusions

This research demonstrated that high concentrations of the substance (bulk) produce larger nanoparticles, which also require a longer time to transform into a nano-solution (nanoparticles suspended in their aqueous solution). Using larger nanoparticles in their aqueous solution achieves relatively greater efficiency in removing or treating water pollutants heavy metals (lead, cadmium, chromium, cobalt) ranging from 66% to 95%, than using smaller nanoparticles of the same type under the same conditions. This is attributed to the larger surface area and the resulting clustered shape of the nanoparticles. This challenges the prevailing notion that smaller nanomaterials are more efficient. Therefore, it should be noted that the efficiency of nanoparticles is primarily determined by their application.

**References**


[1] A. E. Hughes, N. Haque, and S. A. Northey, "Platinum Group Metals : A Review of Resources , Production and Usage with a Focus on Catalysts," pp. 1–40, 2021.

[2] N. Sciences, F. Findik, and S. A. Sciences, "Nanomaterials and their applications," vol. 9, no. 3, pp. 62–75, 2021.

[3] Y. Takamura, "Platinum nanoparticle induced nanoionic effects on electrical conduction in strontium cerate and zirconate," pp. 953–963, 2019.

[4] K. Sekioka and J. Fournier, "ScienceDirect ScienceDirect Adsorption and and Cooling onto aluminutesum ferrocyanide in spent fuel solution Assessing the feasibility of using the heat demand-outdoor temperature function for district heat forecast," *Energy Procedia*, vol. 131, pp. 151–156, 2017, doi: 10.1016/j.egypro.2017.09.421.

[5] A. H. Assaf, "Eco - friendly synthesis of platinum nanoparticles using cold plasma method : the effect of concentration and time exposure," vol. 1, no. 1, 2022.

[6] A. Taloni, M. Vodret, G. Costantini, and S. Zapperi, "Size effects on the fracture of microscale and nanoscale materials", doi: 10.1038/s41578-018-0029-4.

[7] A. H. Assaf, M. A. Gharbi, and A. F. M. Al-Enzy, "Evaluation of the Resulting Pollution of the Euphrates River, from Sewage Water and Valleys in the City of Hit," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1449, no. 1, 2025, doi: 10.1088/1755-1315/1449/1/012122.

[8] S. Mitra *et al.*, "Journal of King Saud University – Science Impact of heavy metals on the environment and human health : Novel therapeutic insights to counter the toxicity," vol. 34, 2022, doi: 10.1016/j.jksus.2022.101865.

[9] A. K. H. Assaf, A. Obaid, E. M. Salih, and A. S. M. Khalaf, "OF ENGINEERING SCIENCE AND The Effectiveness of Removing Water Pollutants by NC ( Platinum / Graphite ) Prepared by Cold Plasma E-mail :," vol. 2, pp. 1–11, 2024.

[10] Z. J. Shanan, L. A. Yaaqoob, M. A. Hussein, and A. S. Jassim, "Biogenic $MnO_2$ nanoparticles for heavy metal removal," vol. 01050, pp. 1–13, 2025.

[11] A. R. and A. M. M. Abdulkareem Hammoodi Assaf 1, "Removal of Phenol from Water Using ZnO Nanoparticles," *Int. J. Nanoelectron. Mater.*, vol. 13, pp. 41–54, 2020.

[12] R. Jeffrey, J. Michael, M. Sebastian, S. Noel, and D. Version, "Competition of van der Waals and chemical forces on gold-sulfur surfaces and nanoparticles," 2017, doi: 10.1038/s41570-0017.

[13] Z. Raji, A. Karim, A. Karam, and S. Khalloufi, "Adsorption of Heavy Metals : Mechanisms , Kinetics , and Applications of Various Adsorbents in Wastewater Remediation — A Review," pp. 775–805, 2023.

[14] A. H. Mhemeed, "REVIEW ARTICLE A General Overview on the Adsorption * Address for Correspondence," vol. 9, no. 51, pp. 16127–16131, 2018.

[15] M. Zaim, A. Zaimee, and M. S. Sarjadi, "Heavy Metals Removal from Water by Efficient Adsorbents," 2021.

[16] D. Radi and A. Hadi, "A review of treatment methods used to remove heavy metals from industrial wastewater," 2022.

[17] D. Harvey, *C h e m i s t r y (K. A. Peterson (ed.)*. 1956.

[18] R. Ragadhita, A. Bayu, and D. Nandiyanto, "Indonesian Journal of Science & Technology How to Calculate Adsorption Isotherms of Particles Using Two-Parameter Monolayer Adsorption Models and Equations," vol. 6, no. 1, pp. 205–234, 2021.

[19] C. S. Jia *et al.*, "Prediction of entropy and Gibbs free energy for nitrogen," *Chem. Eng.*

*Sci.*, vol. 202, pp. 70–74, 2019, doi: 10.1016/j.ces.2019.03.033.
[20] N. P. Kobelev and V. A. Khonik, "On the Enthalpy and Entropy of Point Defect Formation in Crystals 1," vol. 126, no. 3, pp. 340–346, 2018, doi: 10.1134/S1063776118030032.
[21] J. M. Honig, *Thermodynamics Principles Characterizing Physical and Chemical Processes*, Fifth Edit. 2020.
[22] M. Z. H. Khan, F. K. Tareq, M. A. Hossen, and M. N. A. M. Roki, "GREEN SYNTHESIS AND CHARACTERIZATION OF SILVER NANOPARTICLES USING CORIANDRUM SATIVUM LEAF EXTRACT," vol. 13, no. 1, pp. 158–166, 2018.
[23] A. Manuscript, "Environmental Science," 2016, doi: 10.1039/C5EN00155B.
[24] E. Gharibshahi, E. Saion, R. L. Johnston, and A. Ashraf, "Theory and experiment of optical absorption of platinum nanoparticles synthesized by gamma radiation," *Appl. Radiat. Isot.*, vol. 147, no. June 2018, pp. 204–210, 2019, doi: 10.1016/j.apradiso.2019.02.015.
[25] I. G. Koo, M. S. Lee, J. H. Shim, J. H. Ahn, and W. M. Lee, "Platinum nanoparticles prepared by a plasma-chemical reduction method," *J. Mater. Chem.*, vol. 15, no. 38, pp. 4125–4128, 2005, doi: 10.1039/b508420b.
[26] and M. A. K. Adil, Ban H., Kadhim A. Aadim, "Synthesis and spectroscopic characterization of Platinum nanoparticles by plasma jet method," *Int. J. Nanosci.*, vol. 20.03, no. 2150030., 2021.
[27] S. V. Gudkov *et al.*, "Influence of the Concentration of Fe and Cu Nanoparticles on the Dynamics of the Size Distribution of Nanoparticles," *Front. Phys.*, vol. 8, no. November, pp. 1–7, 2020, doi: 10.3389/fphy.2020.622551.
[28] B. Van Eerdenbrugh, D. E. Alonzo, and L. S. Taylor, "Influence of Particle Size on the Ultraviolet Spectrum of Particulate-Containing Solutions : Implications for In-Situ Concentration Monitoring Using UV / Vis Fiber-Optic Probes," pp. 1643–1652, 2011, doi: 10.1007/s11095-011-0399-4.
[29] T. G. Ambaye, M. Vaccari, E. D. van Hullebusch, A. Amrane, and S. Rtimi, "Mechanisms and adsorption capacities of biochar for the removal of organic and inorganic pollutants from industrial wastewater," *Int. J. Environ. Sci. Technol.*, vol. 18, no. 10, pp. 3273–3294, 2021, doi: 10.1007/s13762-020-03060-w.
[30] Y. Zhang *et al.*, "Ultrafast adsorption of heavy metal ions onto functionalized lignin-based hybrid magnetic nanoparticles," *Chem. Eng. J.*, vol. 372, no. March, pp. 82–91, 2019, doi: 10.1016/j.cej.2019.04.111.
[31] Z. Wang, X. Wang, W. Zuo, X. Ma, and N. Li, "The influence of temperature on methane adsorption in coal: A review and statistical analysis," *Adsorpt. Sci. Technol.*, vol. 37, no. 9–10, pp. 745–763, 2019, doi: 10.1177/0263617419890235.
[32] M. . M. A. A. and H. . M. Najim, "Application Of Some Thermodynamic Parameters Of Zinc Adsorption With Four Soil Samples From North Of Iraq," *Tikrit Univ. J. Agric. Sci. Vol.*, vol. 1, no. 1813–1646, 2016.
[33] and M. J. C. Lucas, S., "Study and modeling of furfural adsorption on activated Carbon under supercritical conditions," *journal, Available E-Mail Susana 19*, 2003.
[34] D. M. Y. Gorges, "Study of The Factors Affecting on The Adsorption of Some Substituted Phenol and Aniline Using Different Adsorbents," A Thesis Submitted to The Council of the College of Education University of Tikrit, 2008.
[35] L. H. and A. J. Al-Sammrae, "Study of The Factors Affecting The Adsorption of Some Azo Dyes By Using Different Adsorbents," University of Tikrit, Physical Chemistry, 2006.

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# تخليق جزيئات البلاتين النانوية من تراكيز أولية عالية نسبياً ودراسة تأثيرها في معالجة تلوث المياه بالمعادن الثقيلة

**عبد الكريم حمودي عساف[1]*، زينة عكاب صليبي[2]، عبير محمد عناد[2]، محمد مصلح مهدي**

1- مركز بحوث المواد النانوية، جامعة الانبار، العراق
2- قسم الفيزياء، كلية العلوم، جامعة الانبار، العراق

**معلومات البحث:**

تأريخ الاستلام:
تاريخ التعديل:
تأريخ القبــول:
تاريخ الـنشر:

**الكلمات المفتاحية:**

*البلاتين النانوي، البلازما الباردة، المعادن الثقيلة،ثرموداناميك، معالجة ملوثات*

**معلومات المؤلف**

الايميل:
cds.kareem.assaf@uoanbar.edu.iq
الموبايل:07800080598

**الخلاصة:**

تم تحضير جسيمات نانوية من املاح البلاتين المائية باستخدام طريقة نفث البلازما الباردة ضمن منظومة مطور ومصنعة محليًا، بزمن تعريض 40 دقيقة، بدءًا من تركيزات أولية عالية نسبيًا (40 ملغم/لتر). نتج عن ذلك أحجام جسيمات نانوية تتراوح بين 50 و80 نانومترًا، وذلك وفقًا لسلسلة من الاختبارات. استُخدمت هذه الجسيمات النانوية المُحضّرة لتنقية المياه من الملوثات غير العضوية (مجموعة من المعادن الثقيلة) عن طريق الامتزاز. أظهرت الدراسة كفاءة وفعالية واعدة لجسيمات البلاتين النانوية، حيث حققت مستويات نقاء عالية تتراوح بين 66% و95%، اعتمادًا على نوع الملوث. كما أظهرت الدراسة انخفاضًا طفيفًا فقط في مستويات التنقية مع ارتفاع درجة الحرارة. علاوة على ذلك، تؤكد الدراسة أن معالجة الملوثات تمت بالامتزاز الفيزيائي، وهي طريقة آمنة للغاية لمعالجة ملوثات المياه، وخاصة المعادن الثقيلة. وهذا يؤكد فعالية الجسيمات النانوية الكبيرة نسبيًا في المعالجة الآمنة للملوثات غير العضوية (المعادن الثقيلة) العالقة في الماء.