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Synthesis and Characterization of Silver Nanoparticles as a Unique Adsorbent for Removal of Lead (II) Ions from Polluted Water

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Abstract: This study included the synthesis of silver nanoparticles using (oxidation – reduction) method. The plasmon bands of synthesized nanoparticles was given sign for nano silver at (410 nm). The sizer and the potential of the nanoparticles were studied using the Zetasizer analyzer and the size of silver nanoparticles in the nano range and zeta voltage presented stable nano silver solution at (-26.1 mV). It was found also by field emission scanning electron microscopy (FESEM) images that the diameter of the created nanoparticles in the range (11.35-17.75 nm). Moreover, images show the shape of silver nanoparticles are spherical. The ability of silver nanoparticles to adsorb heavy elements such as lead was studied, where the element's concentration was estimated before and after the addition of nanoparticles by using of atomic absorption spectroscopy (AAS). The adsorption percentage of solution of lead (II) ions at a concentration of (5 ppm) and (10 ppm) were (1.47%) and (5.39%) respectively.

Keywords: Silver nanoparticles, FESEM, Adsorption, Atomic absorption, lead (II) ions.

INTRODUCTION

Nanoscience has been established in recent times as a new interdisciplinary science. It can be defined as a whole knowledge on fundamental properties of nano-size objects. The word nano refers to one billionth or 10^{-9} units. It is widely accepted in the context of nanoscience and nanotechnologies, the

units should only be those of dimensions, rather than of any other unit of scientific measurement. It is widely agreed that nanoparticles are clusters of atoms in the size range of (1–100) nm [1]. Generally, specific control of shape, size, and size distribution is often achieved by varying the synthesis methods, reducing agents and stabilizers metal nanoparticles can be prepared by two routes. The first one is a physical approach which could be carried out by a tube furnace at atmospheric pressure, that utilizes several methods such as condensation, evaporation and laser ablation [2].

The second one is a chemical approach in which the metal ions in solution is reduced in conditions favoring the subsequent formation of small metal clusters or aggregates with respect to the nature of reducing agent, chemical methods may be subdivided into classical chemical, using the well-known chemical reducing substances (hydrazine, hydrogen and sodium borohydride) and radiation-chemical where the reduction process is initiated by solvated electrons generated by the ionizing radiation [3] .

Furthermore, chemical methods may be divided into those using in non-deleterious solvent and naturally occurring reducing agent such as polysaccharides or plants extract like (green tea leaves, banana peels and vitamin C [4 - 8] , or employs biological micro-organism such as bacteria and fungus as reductants [9].

Nanoparticles stabilization is usually discussed in terms of two general categories of stabilization, electrostatic and steric electrostatic stabilization is achieved by the coordination of anionic species, such as carboxylates, halides or polyoxoanions to metal particles. This results in the formation of an electrical double layer (really a diffuse electrical multilayer) which causes coulombic repulsion between the nanoparticles. Steric stabilization is achieved by the presence of bulky, typically organic materials that, due to their bulk, impede the nanoparticles from diffusing together. The best common approach is to keep the nanoparticles with capping agents that can be absorbed on or impasse onto the surface of nanoparticles, prevent their agglomeration.

The choice of stabilizer also allows one to tune the solubility of the nanoparticles [10], [11] . Silver nanoparticles are using in different way as an anti - bacterial and removal of organic dyes [12-14].

In this study our target is synthesis of silver nanoparticles by simple and rappid and inexpensive method and applied it for removing of heavy metals by adsorption these elements by directly and simply and fast method.

MATERIALS AND METHODS

Preparation of reducing agent: The preparation of reducing agent was done by dissolving of (0.1g) from D- Glucose in 100 ml of deionizes water.

Synthesis of silver nanoparticles : (0.1g) of mixture of (99% purity, BDH), siver nitrate, D-Glucose and tri sodium citrate dissolved in 100 ml of deionized water and stirred on a hot plate at 90°C for 30 min.

Preparation of lead (II) ions: Dissolved (0.1 g) from lead nitrate (II) in 100 ml deionizes water and then many concentrations in range (1-20) ppm was prepared by dilution.

RESULTS AND DISCUSSION

Characterization of UV –Vis spectrophotometer: Determination of the plasmon spectrum, as the absorption value was measured at (410 nm) these value is agreed with another data found in the literature. **Figure 1** shows this sign of finding of silver nanoparticles.

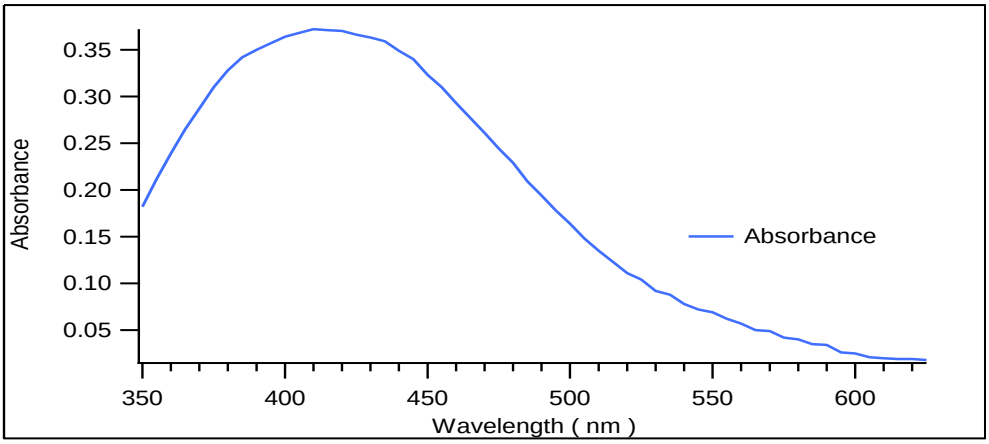

Figure 1: Plasmon spectra of silver nanoparticles.

Field Emission Scanning Electron Microscopy and EDX: The structure of the prepared silver nanoparticles was studied using field emission scanning electronic microscope (FESEM) and the size of the nanoparticles within the diameter in the range (11.35-17.75 nm). **Figure 2** shows these results. From figure 2 its clear that silver nanoparticles with homogeneous spherical shape were appeared.

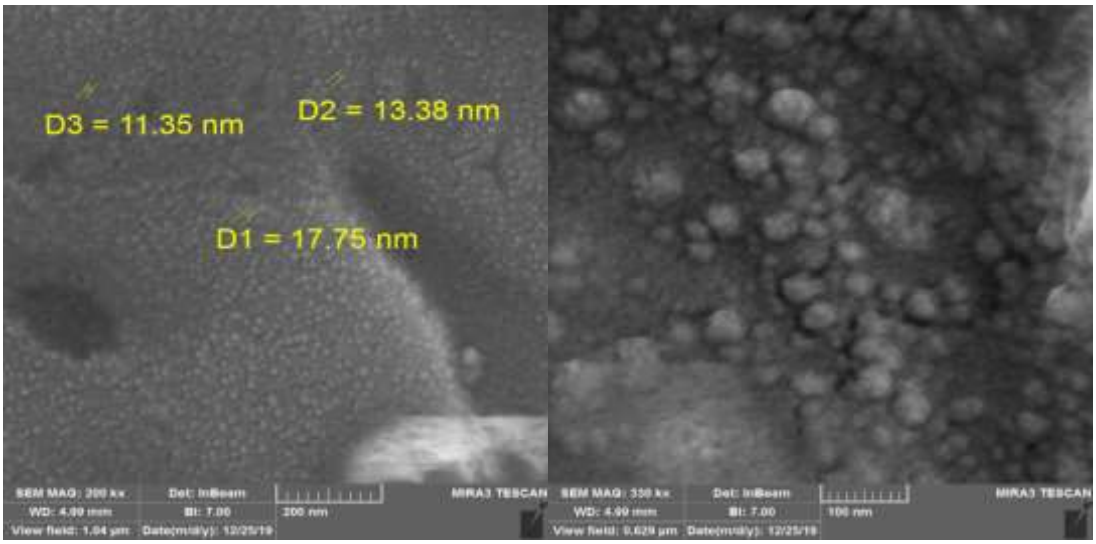

Figure 2: FESEM images of silver nanoparticles

Energy Dispersive x-ray technology was used in this diagnosis. When a beam of directed electrons with high energy is shed, the atom causes the electrons to be extracted from their orbital field and move towards a higher energy level, leaving a gap. These gaps are filled by the nearby electrons and when the excited electron returns, it emits a distinct specific energy for each element through which the element can be diagnosed and estimated quantitatively and qualitatively, as the intensity of fluorescence is directly proportional to the amount of the element in the sample, and in this study (FESEM) was used and that the EDX analysis includes the generation of x-rays in the scan area and in the device itself. The EDX spectrum represents the silver nanoparticles created, the X-axis represents the elemental energy level and the excitation energy, and the Y axis represents the number of X-rays that were received and processed. **Figure 3** and **Table 1** shows these analysis.

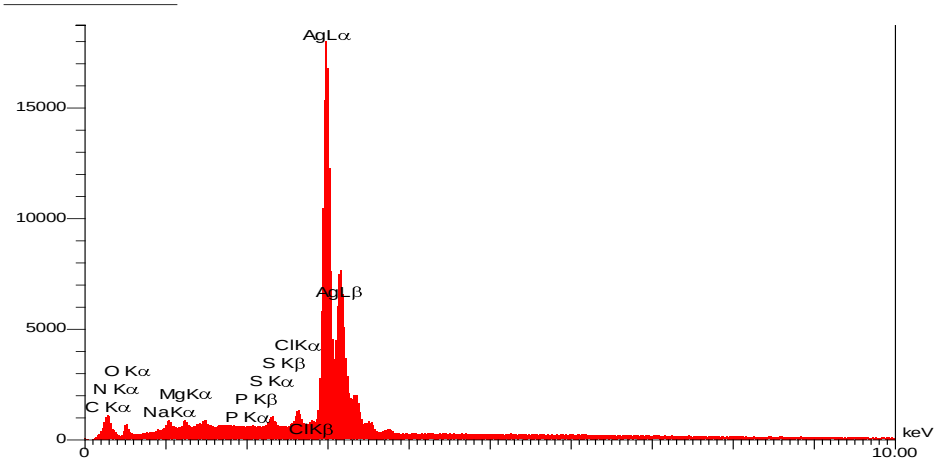

Figure 3: EDX spectra for silver nanoparticles

Table 1: EDX analysis of elements show the percentage of silver is 73.22%.

Element	**Weight %**	**Absorbance%**
C	5.17	21.33
N	2.08	7.35
O	2.22	6.88
Na	4.74	10.22
Mg	2.92	5.96
P	2.68	4.29
S	4.01	6.20
Cl	2.96	4.13
Ag	73.22	33.63
SUM∑	100	_

The primary elements in the synthesized sample are determined by diagnosing EDX. The spectroscopy of EDX shows the main product obtained is silver and its ratio is 73.22%.

Zeta Analyzer: The nanoparticle diameter and average size distribution and zeta potential values were studied in the nano zetasizer / Malvern device. The surface charge of the nanoparticles is determined by measuring the zeta potential, as the device measures within the range (0.3 nm - 10 µm). The sample was injected into a U-shaped cell at a temperature of (25 ◦C). The electric charge transfer of the nanoparticles is measured, and the zeta potential is often used to find the stability of the sample.

Where the index measurement depends on the amount of electrical repulsion between the particles and the velocity of those particles, meaning there is a direct relationship between the zeta potential and the stability of the nanoparticles, that is, the higher the zeta potential values, regardless of the negative signal, the nanoparticles are more stable because the particles have less agglomeration. But when the value of the zeta potential is equal to zero, it means that it is neutral, not charged, and reaches the point (Iso Electric) and there is no electrical repulsion between the nanoparticles, so it is unstable. As for the pdI value, the fewer the particles, the more regular. As shown in **Table2.**

Table 2: Zeta sizer and zeta potential to silver nanoparticles.

Sample	Zeta potential (Mv)	Zeta sizer (d. nm)	PdI
Silver Nanoparticles	26.1-	30.97	0.617

Figure (4, A) presents the value of zeta voltage indicates the stability and non-clustering of the prepared nanoparticles and is equal to (-26.1) mV, this value of the voltage indicates for the stability of the silver nanoparticles in the solution. As the silver ion is positive, the voltage of zeta is found to have a negative value. The size of the silver nanoparticles from **Figure (4,A, B)** is (30.97 nm) and the intensity of their density in the solution is 14.2%.

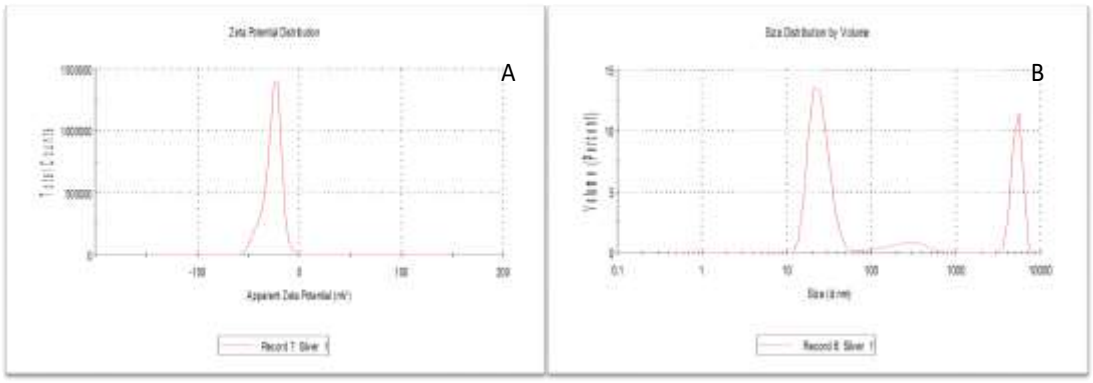

Figure 4: (A) Zeta potential (B) sizer for created silver nanoparticles.

Adsorption of lead (II) ions using silver nanoparticles: Treated water and soil from heavy metallic like lead (II) was done a lot using AAS [15]. Here in, the adsorption of heavy elements in water polluted such as lead (II) ions was done by silver nanoparticles. This study was carried out by preparing a series of solutions with known concentrations of lead nitrate in the range (1-20 ppm). The standard curve in **Figure 5** shows these results, the results are observed also in **Table 3**. Two concentrations of lead (II) ions **(**5 and 10 ppm) respectively were examined before and after adding of silver nanoparticles.

Table 3: Adsorption of lead (II) by Silver Nanoparticles .

Standard solution (ppm)	Absorbance Theoretical data (y)	Absorbance Lab data (x)	Absorbance after add Ag nanoparticles	Adsorption% A° - At / A°) *100(
1	0.003	0.172		
5	0.030	2.03	2.0	1.47
10	0.057	3.89	3.68	5.39
15	0.087	5.96		
20	0.152	10.44		

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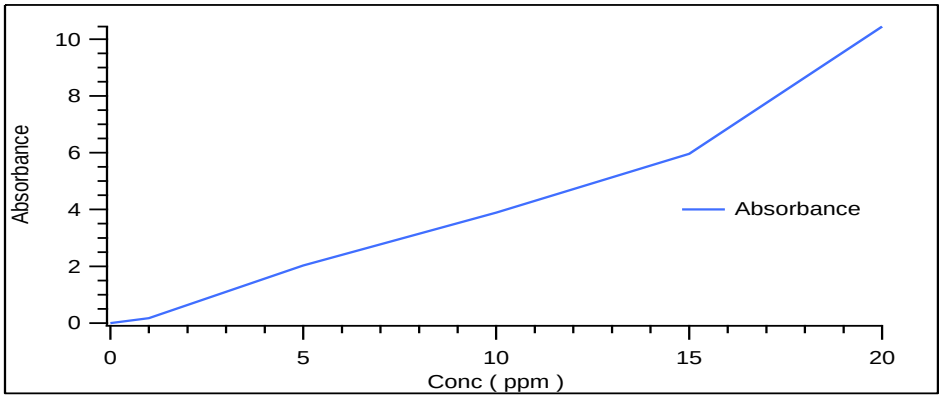

Figure 5: Standard curve of lead (II) ions using atomic absorption spectroscopy.

The removing percentage of lead (II) ions were calculated by using equation (1).

$$\%\ Removal = \frac{(A^{\circ} - A_t)}{A_t}\ 100 \qquad \ldots.(1)$$

Where A° = initial absorbance, A_t = absorbance at time (t).

It is noted from the results of **Table (3)** that the silver nanoparticles adsorbed 1.47% of the lead (II) ion from its original concentration of (5 ppm) and 5.39% from the original concentration of (10 ppm) because the silver nanoparticles are characterized by their ability to adsorb heavy elements from water. Nanoparticles with high surface area to volume ratio are promising in adsorption, thus silver nanoparticles as a Nano adsorbent is promising materials for releasing different pollutants from the environment.

CONCLUSION

The present study demonstrates simple and fast method for preparation of silver nanoparticles. The presence of surface plasmon resonance peak at (410 nm) provides a fitting spectroscopic mark for the formation of silver nanoparticles. FESEM images display silver nanoparticles in spherical form and the particle size have average diameters of about (11.35-17.75 nm). These new importance provides a capable method to release inorganic polluted materials by silver nano product from polluted water. The synthesized silver nanoparticles was applied to remove of lead (II) ions. The ability of silver nanoparticles to adsorb heavy metals such as lead was studied, therefore the adsorption rate for concentrations of (5ppm) and (10ppm) was (1.47%) and (5.39%) respectively which is reasonable. Accordingly, silver nanoparticles are promising materials for adsorption of heavy polluted metals from aqueous solution.it is easy method and quick. At the same time silver nanoparticles is not toxic materials for the environment.

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