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ARTICLE

Removal of Pb(II) and Cu(II) From Water Using Silver Nanoparticles Prepared using Extract Plant (*Albizia odoratissima*)

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Abstract

This work concerns the research on the use of silver nanoparticles prepared using extract plant "*Albizia odoratissima*" as a highly active and economical adsorbent for the removal of Pb^{+2} & Cu^{+2} ions from their aqueous solutions. The (AgNPs) are produced using a green, environmentally friendly, non-toxic method that does not use harmful chemicals substances using a plant extract as a reducing agent. The (AgNPs) checked is characterized using "Scanning Electron Microscope (SEM) and Fourier Transform Infrared Spectrometry (FTIR)". The results showed that the equilibrium time of adsorption was 40 min, at pH = 6, pH = 8 for Pb^{+2} & Cu^{+2}, respectively and at the temperature (30 °C), which represents the optimal conditions for elimination of the two ions. Adsorption capacity of AgNPs was as follows: Pb(II) > Cu(II). The products can be an effective material for removing heavy metals from polluted water.

Keywords: Silver nanoparticles, Cu(II) & Pb(II), Adsorption, *Albizia odoratissima*, Characterization, Agricultural bio products

1. Introduction

Nanomaterial's are materials with very small dimensions, measured in nanometers (a fraction of 1,000,000,000 m), almost a hundred thousand times smaller than the diameter of a human hair [1].

Nanotechnology can be used in the development of some drugs (e.g. anti-cancer) that target only specific organs, cells or tissues of the body, this reduces side effects and increases the effectiveness of the treatment. It can be used to remove environmental pollutants and can also be added to concrete, clothing and various other materials, making them durable, small and very practical in the electronics industry, has divided nanomaterial's into four sections: (Zero, one, two & three) dimensional materials [2].

Due to the chemical composition and atomic arrangement of nanomaterial's, they can consist of a single chemical element, such as carbon nanotubes. It may consist of a chemical compound and this material is amorphous and has no particular order of atoms and the arrangement is quite random, or it may appear as a single crystalline material which has a particular and constantly repeating arrangement of the atoms, or as polycrystalline materials, where they have more than a random series of atoms [3].

Nanotechnology is an advanced scientific field that can solve various environmental problems by controlling the shape and size of materials at the Nano scale. Carbon nanomaterial's are unique due to their non-toxic nature, particularly easier biodegradation, beneficial environmental remediation and large surface area. Carbon nanomaterial's have great potential for removing heavy metals from water. Water pollution caused by heavy metals is a serious problem and poses a major threat on human health. Carbon nanomaterial's are becoming increasingly popular due to their excellent physical and chemical properties and can be used for advanced purification of water contaminated with heavy metals. Indeed, due to their large surface area, availability of various functions and

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Nano size [4]. The persistence of heavy metals in wastewater has proven to be a challenge. Therefore, more purification technologies need to be developed to remove heavy elements to a harmless level, including photolysis, chemical precipitation, ion exchange, flotation, membrane, adsorption and technologies electrochemical treatment. Each of these processes is up to date and a cutting-edge. In generally speaking, the required cost and the characteristics of the wastewater are the key factors in choosing the most suitable wastewater treatment process [5]. Over the past two decades, extensive research has been conducted on metal and metal oxide nanoparticles and their applications in various fields. However, nanoparticles are toxic and affect the environment, human and animal health. Bacteria, fungi, algae, and plant extracts are used to manufacture metal nanoparticles. Over recent years, scientists and researchers have turned to preparing plant extracts to produce stable and effective, inexpensive nanoparticles [6].

Divalent copper is a very toxic heavy element that can have effects on living organisms even in low concentrations. Therefore, the development of highly effective, highly selective and cost-effective materials is crucial for controlling toxic Cu^{2+} ions. In this study, a ligand-based composite material was developed to detect and remove Cu^{2+} ions at the same time from wastewater. The results showed that the manufactured material was not affected by other foreign ions present the intensity of the removal tendency was observed only in the direction of the Cu^{2+} ion. The composite material has virtually no ability to adsorb other ions at this pH. Therefore, the new synthetic material is highly effective and inexpensive and can be considered a viable alternative for the effective detection of the Cu^{2+} ions toxic from water [7].

Exploring the possibility of using nanomaterial's to remove coexisting or multiple water pollutants opens a new path that is free of secondary pollutants and cost-effective. River water in the aquatic environment contains many ions that can affect the adsorption removal technique. In this experiment, a range of heavy metal ions, (Cd^{2+}, Pb^{2+}, Ni^{2+} & Cu^{2+}) these heavy metals were successfully removed from the river water at same time using magnetite nanoparticles (Fe_3O_4) (UFMNPs), depending on the affinity of these mineral ions present in river water towards UFMNP. In addition to its unique porous structure that makes the adsorption process very easy. The results of the study showed the high efficiency of wastewater treatment using UFMNPs, especially in removing many heavy elements ions at the same time [8].

2. Experimental

2.1. Instrumentals

Laboratory equipment of German and Japanese origin was used, such as "Flame Atomic Absorption Spector Photometer (AAS), Centrifuge, Sensitive balance, Electronic oven, FTIR spectroscopy and Scanning Electron Microscopy (SEM)".

3. Procedures

3.1. Characterized of (AgNPs)

1. The surface shape of nanoparticles and the size of nanoparticles were determined using a Scanning Electron Microscopy (SEM).
2. The (AgNPs) sample was used to conduct heavy elements adsorption experiments on various water samples.

3.2. Characteristic and analysis of (AgNPs)

3.2.1. FT-IR

A Fourier transform infrared spectroscopy (FT-IR) study was performed on An amount silver nanoparticles prepared using extract plant "*Albizia odoratissima*" after a disk was made of nanomaterial and potassium chloride salt (KBr) for examination.

3.2.2. SEM

An amount silver nanoparticles prepared using extract plant "*Albizia odoratissima*" was dissolved in 2.0 mL of methanol, a certain amount of solution was take and then the (AgNPs) sample was analyzed using a scanning electron microscopy (SEM).

3.3. Removal of the heavy metals using (AgNPs)

Adsorption procedures using (AgNPs)

1. The adsorption of heavy metals from solutions was carried out by the experimental method of periodic adsorption (25 mL) of a heavy metal solution of Cu^{2+} & Pb^{2+} of known concentration (3.0, 6.0, 9.0, 12 & 15 $mg \cdot L^{-1}$).
2. Adsorbent 0.5 g (AgNPs) was added to the vials separately at a temperature (30 °C), contact time (40 min) and pH = 8, pH = 6 for Cu^{2+} & Pb^{2+}, respectively and in an incubator with shaking shaken for the required equilibrium time. The mixtures were then separated by centrifugation instrumental at (6000 rpm) for (10 min).
3. The equilibrium concentrations were measured by AAS.

4. Application

The optimal conditions obtained in previous adsorption experiments for the removal of heavy metals Pb^{2+} & Cu^{2+} using silver nanoparticles prepared using extract "*Albizia odoratissima*" plant were applied to different water samples of wastewater treatment plants and industrial wastewater. Water samples are collected in clean 10 L polyethylene bottles for physical and chemical testing. The nozzles were tightly closed to prevent air entry after pre-filling the sample collection bottles with water, adding a few drops of chloroform as a preservative.

5. Results and discussion

5.1. Characteristic and analysis of (AgNPs)

5.1.1. The Fourier transform infrared spectroscopy (FTIR)

The (AgNPs) sample was analyzed using FT-IR to determine the active groups in the sample that play an important role in the removal process, as shown in the following Fig. 1.

5.1.2. Scanning electron microscopy (SEM)

"A Scanning Electron Microscopy (SEM)" is a type of electron microscope that produces meaningful images by scanning with a focused beam of electrons. Electrons it contains interact with the atoms of the sample and generate various signals that provide information about the depth & nature of surface. Electron radiography is generally performed using a raster scan between beam positions where the image is created. A distance of more than 1 coulomb can be achieved, as shown in the Fig. 2.

5.2. Removal of heavy metals using (AgNPs)

In this study, an effective, silver nanoparticles prepared green and eco-friendly synthesis using extract plant "*Albizia odoratissima*", to remove lead and copper ions from water through adsorption. Optimal conditions such as acid number, contact time, adsorbent mass and initial concentration were achieved.

5.2.1. The acidity function (pH)

Changing the acidity of the solution during the adsorption process affects the nature of the active

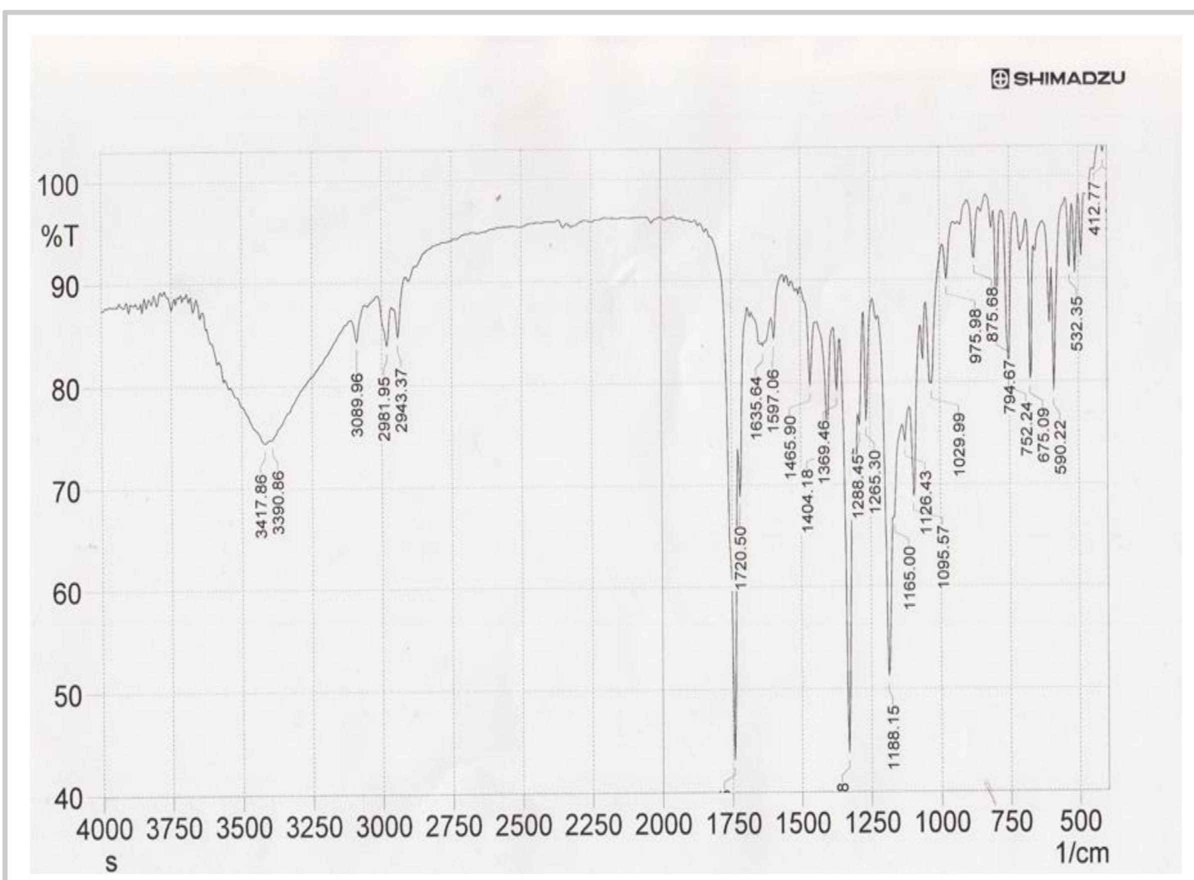

Fig. 1. Analysis spectrum (FTIR) for the (AgNPs) sample.

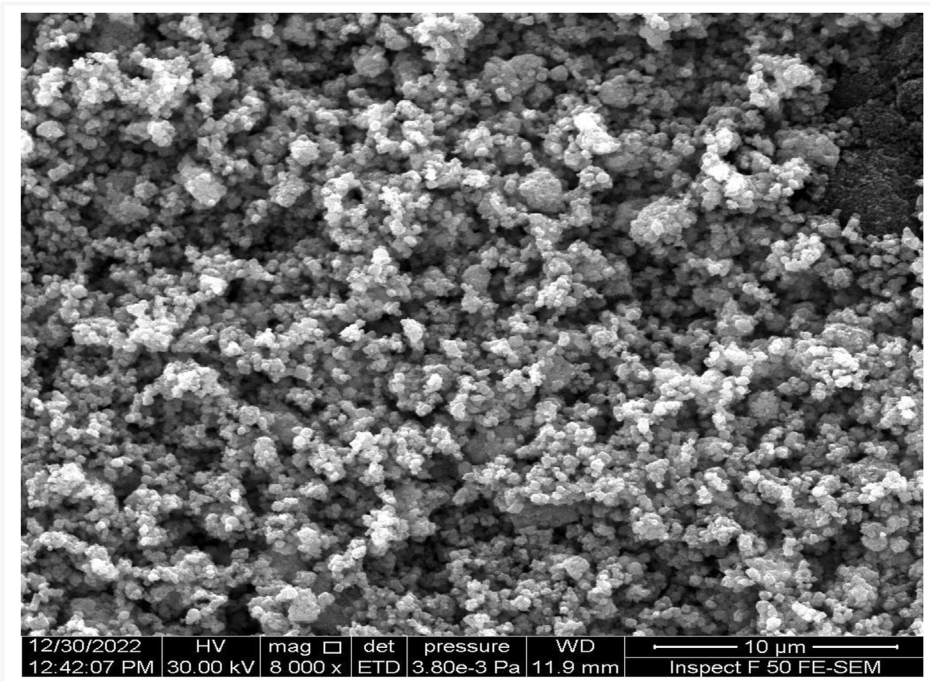

Fig. 2. Analysis (SEM) for the (AgNPs) sample.

Table 1. Adsorption results by applying the optimal conditions calculated for removal of the heavy metals.

Ions	C_0 mg/L	C_e mg/L	Removal %
Pb(II)	6.0	0.378	93.7
Cu(II)	6.0	0.594	90.1

Table 2. Adsorption results by applying the optimum conditions for removal of the heavy metals.

Ions	C_0 mg/L	C_e mg/L	Removal %
Pb(II)	0.12	0.036	70.0
Cu(II)	0.13	0.045	65.7

groups present in the composition of both the adsorbent and the adsorbent surface. It is known that heterogeneous the surface of the adsorbent contains sites with negative and positive charges, so changing the acidity value of the solution affects the process of repulsion and attraction with these sites may also affect the ionization of the adsorbed material. The acidity function is considered one of the factors affecting the environment, not only on the binding sites on the surface, but it also has a strong effect on the chemical solution of heavy metal ions [9].

6.2.2. Temperature

Adsorption in general is an exothermic process. Therefore, the amount of the adsorbed material

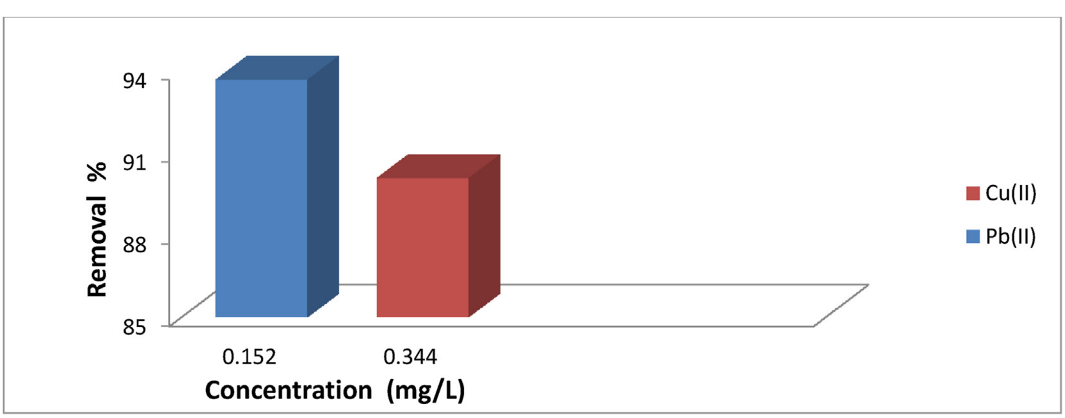

Fig. 3. Removal of the heavy metals Pb^{2+} & Cu^{2+} in distilled water sample using (AgNPs).

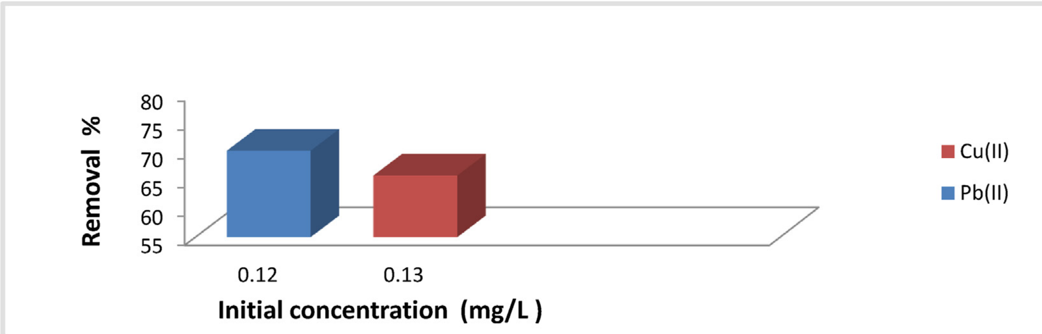

Fig. 4. Removal the heavy metals Pb^{2+} & Cu^{2+} from wastewater samples using (AgNPs).

Table 3. Adsorption results by applying the optimum conditions for removal of the heavy metals.

Ions	C_0 mg/L	C_e mg/L	Removal %
Pb(II)	0.28	0.087	68.9
Cu(II)	0.32	0.118	63.1

decreases with increasing temperature at a certain equilibrium state, as the increase in temperature increases the energy of the adsorbed molecule, which helps in its separation from the adsorbent surface. When the adsorption process is endothermic, an increase in temperature leads to an increase in the amount of the adsorbed material, as increasing the temperature increases the energy of the molecule, to reach the adsorption activation energy [10].

5.3. Removal heavy metals from distilled water sample

Applied optimal conditions (temperature 30 °C, pH = 6, pH = 8 for Pb^{2+} & Cu^{2+}, respectively, initial concentration 6.0 $mg \cdot L^{-1}$ and contact time 40 min, adsorbent dosage 0.5 g) to achieve the highest removal of heavy metals Pb^{2+} & Cu^{2+} in a sample of distilled water by (AgNPs) as shown in Table 1 (Fig. 3).

5.4. Applications of adsorption

5.4.1. Wastewater samples

Applied optimal conditions temperature 30 °C, pH = 6, pH = 8 for Pb^{2+} & Cu^{2+}, respectively, contact time 40 min and adsorbent weight 0.5 g) to achieve the highest removal of heavy metals Pb^{2+} & Cu^{2+} in a sample of wastewater by (AgNPs) as shown in Table 2 (Fig. 4).

5.4.2. Industrial wastewater samples

Applied optimal conditions (temperature 30 °C, pH = 6, pH = 8 for Pb^{2+} & Cu^{2+}, respectively, contact time 40 min and adsorbent weight 0.5 g) to achieve the highest removal of heavy metals Pb^{2+} & Cu^{2+} in a sample of industrial wastewater by (AgNPs) as shown in Table 3 (see Fig. 5).

The removal of heavy metals in the distilled water sample was high due to the availability of

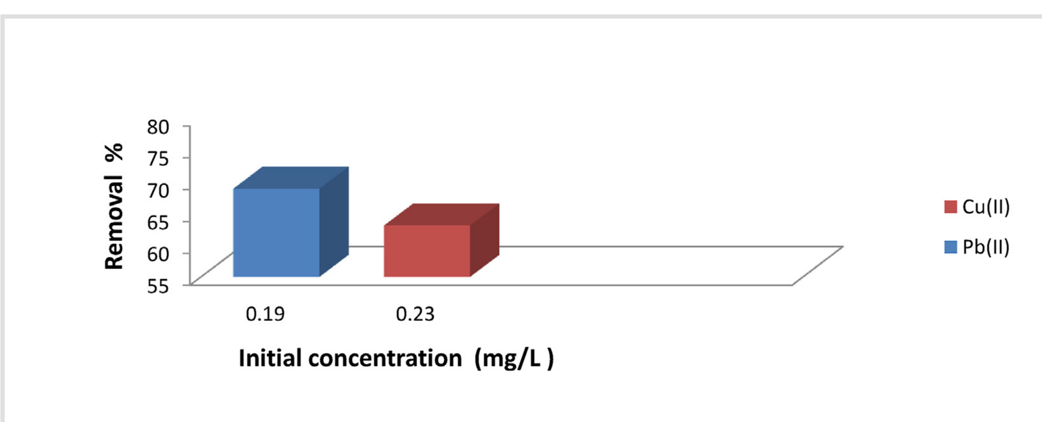

Fig. 5. Removal the heavy metals Pb^{2+} & Cu^{2+}in industrial wastewater samples using (AgNPs).

suitable removal conditions and the adsorption sites on the surface were numerous, as shown in Table 1.

Because of the competition for the effective sites responsible for removing the pollutants under study and the heavy metals already present in the water, this led to a reduction in the removal rate when compared to the distilled water sample as shown in the Table 2 and Table 3.

The removal order of water sampling was as follows:

Industrial wastewater < Wastewater.

5.5. Conclusion

In this study the results obtained indicate it is possible to using the silver nanoparticles prepared by extract of plants available in the environment as "*Albizia odoratissima*" plant as a reducing agent and using in the removal of water pollution in heavy metals Pb^{2+} & Cu^{2+} were found to be in the following order: Pb(II) > Cu(II).

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