

Research Article

Preparation of Alumina Nanoparticles and Coating with Polyvinylpyrrolidone to Treat Cadmium Contamination of Water

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Alumina nanoparticles were prepared by sol-gel method, where the obtained nanosize was 35 nm, and the nanomaterial was coated with PVP polymer, where the nanomaterial was dispersed by ultrasonic waves for half an hour, and then, the polymer was added, and under high magnetic stirring for 24 hours, it was dried at a temperature of 60°C for 24 hours. Cadmium salt solutions were prepared with different concentrations of 10, 30, and 60 ppm, and the nanomaterial was immersed in the prepared solutions at different times of 10, 30, and 60 minutes, and the measurement was done by an atomic absorption device. By means of the electronic scanner, a difference appeared in the nanosize, and this indicates that the packaging has completely occurred.

1. Introduction

Water pollution is defined as any change in the physical and chemical properties of water that affects living organisms and is considered unfit for drinking [1–5]. Heavy metals and dyes are among the most important sources of water pollution. A number of techniques have been used to treat water pollution, including nanofiltration and ion exchange. Adsorption processes for water treatment are nowadays one of the most important technologies in treating water pollution, where the adsorption process takes place through the link between the adsorbent material and the adsorbent surface regardless of

the nature of the adsorbent material and the adsorbent surface. Adsorption may occur between any two phases: liquid-solid, solid-gas, gas-liquid, and liquid-liquid [6, 7].

There are many factors that affect adsorption processes, including temperature, acid function, nature and quantity of adsorbing surface, solvent effect, and initial concentration. There are two types of physical and chemical adsorption and the difference between them is that the physical, the adsorbent, and the adsorbent are linked with weak physical forces, while the chemical bond is by strong chemical forces. Alumina nanoparticles have a large surface area, which is why they have been widely used in the treatment of water pollution. Because

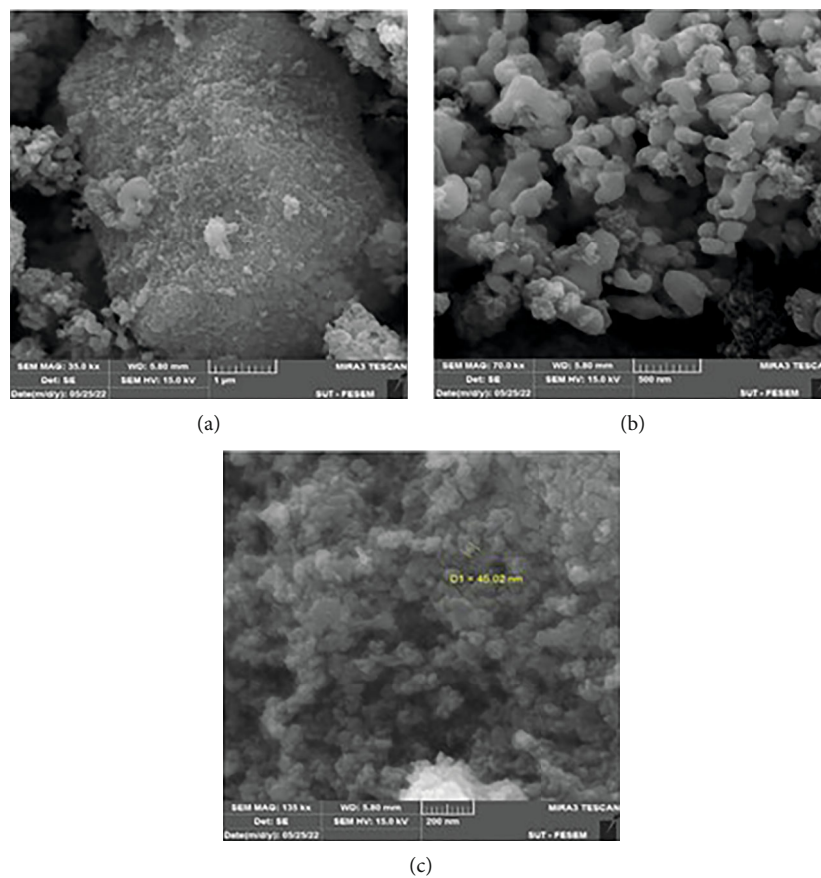


FIGURE 1: The alumina before packaging with different magnifications (a) with a magnification of 1 μm , (b) at a magnification of 500 nm, (c) at magnification and of 200 nm.

of this high area, they have a high tendency to agglomerate. In addition, alumina nanoparticles have a high chemical activity because they are easily oxidized. The accumulation of the particles during preparation leads to giving larger volumes of measurement, and in order to prevent agglomeration and maintain the stability of the particles, they are protected by coating or coating their surface with appropriate polymeric materials, and coating the surfaces can lead to an increase in electrostatic stability and thus prevents the agglomeration of these particles [8, 9].

2. The Practical Part

The practical part is divided into three parts:

(1) Preparation of nanoalumina by sol-gel method:

Alumina nanoparticles were prepared by sol-gel method, where 18.76 g of aluminum nitrate was taken and dissolved with citric acid, where the molar ratio of citric acid and nitrate was 0.5. The resulting solution was heated at a temperature of 80° C under continuous stirring so that the solution turned into a gel. Then, the gel was dried at a temperature of 90° C for 12 hours, and then, the dry gel was taken and melted at a temperature of 1000° C to form a white powder.

(2) Coating of nanoalumina with pvp polymer:

The nanomaterial is encapsulated by taking 4g of the prepared alumina and adding to it 200 ml of nonionic water, and it is dispersed by ultrasound for the purpose of dispersing the precipitate for 15 minutes, then we take 1g of the PVP polymer and dissolve it in 20 ml of nonionic water 81 and then narrow the second solution to the solution. The first is with continuous stirring for 24 hours, and after the end of the time, the separation is carried out by a centrifuge with a number of cycles 6000 rpm. Upon completion of the separation, drying is carried out at 60° C for 24 hours [9].

(3) Prepare the solutions

A standard solution of cadmium ion at a concentration of 500 ppm was prepared by dissolving 0.25 g of mineral salt in 500 ml of nonionic water. Several solutions of different concentrations were prepared from the standard solution, where three concentrations were selected, namely, 10, 30, and 60 ppm. These solutions were prepared by the law of dilution.

$$\text{PPM1} * \text{V1} = \text{PPM2} * \text{V2}. \quad (1)$$

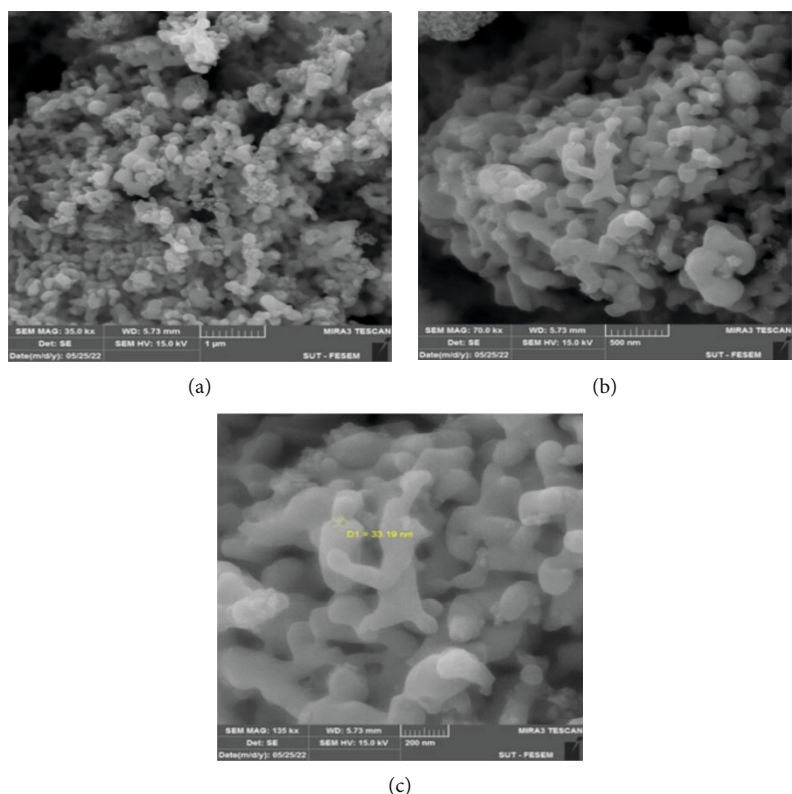


FIGURE 2: Alumina after coating with pvp polymer with different magnifications (a) with 1 μm magnification, (b) with 500 nm magnification, (c) with 200 nm magnification.

3. Results and Discussion

3.1. *Structural Examinations.* We note through the structural examinations of scanning force electron microscopy (SEM) in Figures 1 and 2 that there is a very big difference in the shape of the alumina nanoparticles before and after the PVP polymer coating, there is a very high accumulation of nanoparticles due to their high chemical activity, which leads to their oxidation easily, and this was clearly observed through the results of the tests, where white spots appeared, and this is evidence of oxidation. In Figure 3, in addition, the size of the formed nanoparticles is large compared to the coated material, where the resulting nanoscale size reached 45 nanometers, and this is due to the high accumulation of polymer particles due to the wide surface area, while in the nanocoated alumina, we notice that a very high dispersion occurs in the nanoparticles and thus leads to a reduction in the size of the nanoparticles, as the nanosize reached about 35 nanometers, and the reason for this is that the polymer coating leads to an increase in the electrostatic stability of these minutes and thus leads to the nonaccumulation of the particles and thus leads to a reduction in oxidation which occurs for alumina nanoparticles, where we notice the appearance of very few white spots in the polymer-coated minutes, and this is one of the ways to address the problem of oxidation in nanoparticles and nonagglomeration [10–12].

3.2. *Adsorption Assays.* A Japanese atomic adsorption device (Shimadzu aa/6200) was used to measure the adsorption of

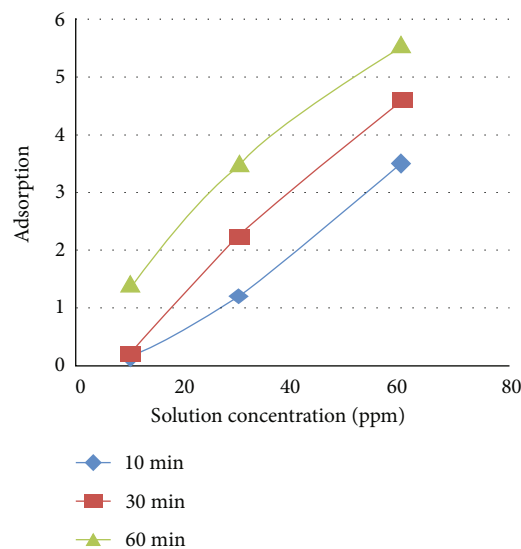


FIGURE 3: The relationship of concentrations of solutions with adsorption for different times at the pH 6.

cadmium in the previously prepared solutions. The effect of the following variables on the adsorption values was studied.

3.2.1. *Effect of Acid Function on Adsorption Capacity for Different Times.* We notice from Tables 1–3 that the lower the acidic function, the greater the amount of adsorption of the

TABLE 1: The amount of cadmium that was adsorbed with the change of the pH function and the immersion time in a 10 ppm solution.

pH	Capacity		
	Time 10 (min)	Time 30 (min)	Time 60 (min)
2	1.79	1.92	2.6
4	1.62	1.79	1.92
6	0.1	0.2	1.41

TABLE 2: The amount of cadmium that was adsorbed with the change of the acidity function and the immersion time in a solution of concentration 30 ppm.

pH	Capacity		
	Time 10 (min)	Time 30 (min)	Time 60 (min)
2	2.23	4.78	6.17
4	1.75	4.70	5.08
6	1.20	2.23	3.50

TABLE 3: The amount of cadmium that was adsorbed with the change of the acidity function and the immersion time in a solution of 60 ppm.

pH	Capacity		
	Time 10 (min)	Time 30 (min)	Time 60 (min)
2	5.92	6.61	8.76
4	5.08	5.54	6.26
6	3.50	4.61	5.54

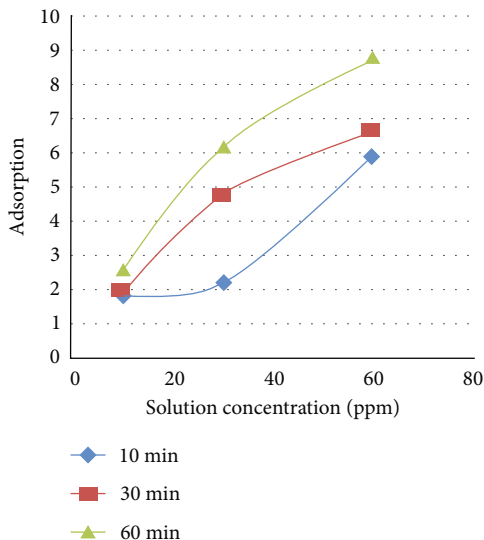


FIGURE 4: The relationship of concentrations of solutions with adsorption for different times at the pH 2.

pollutant, because the positive charge on cadmium increases, and thus, the competition with the positive charge released from the acid increases.

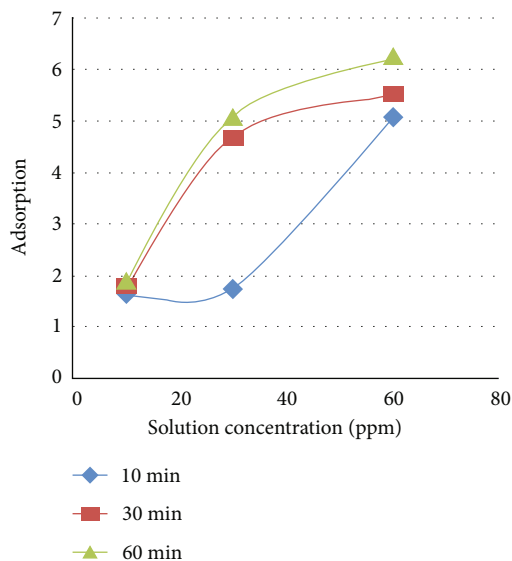


FIGURE 5: The relationship of the adsorption concentrations of solutions for different times at the pH 4.

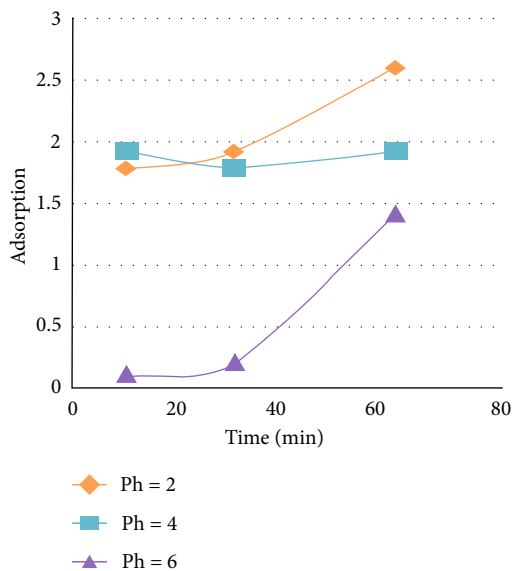


FIGURE 6: The relationship of time to adsorption for different values of the acidity function at a concentration of 10 ppm.

Therefore, the lower the acidic function, the greater the charge. The positive charge in the solution and the negative charge in the solution decreases, and since the target in the pollution treatment process is cadmium, which carries the positive charge, and the adsorbing surface is charged with the negative charge, the process of getting rid of it is very easy because of the increase in the positive charge, and this agrees with the researcher [13, 14] for other materials, as well as we note from Table 3 that with the stability of the other variables (concentration, time), the highest value of adsorption is (8.76) at the acidity function [15–17].

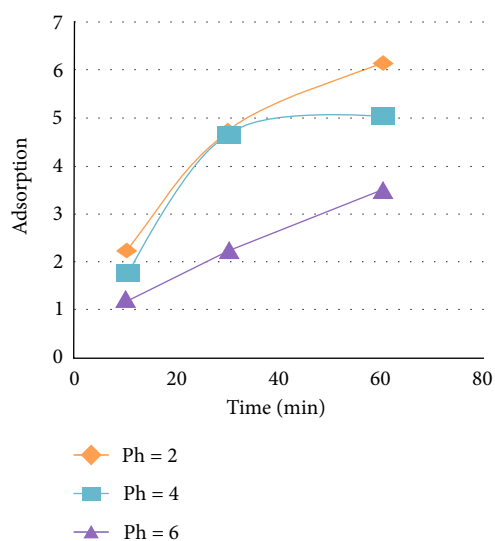


FIGURE 7: The relationship of time to adsorption for different values of the acidity function at a concentration of 30 ppm.

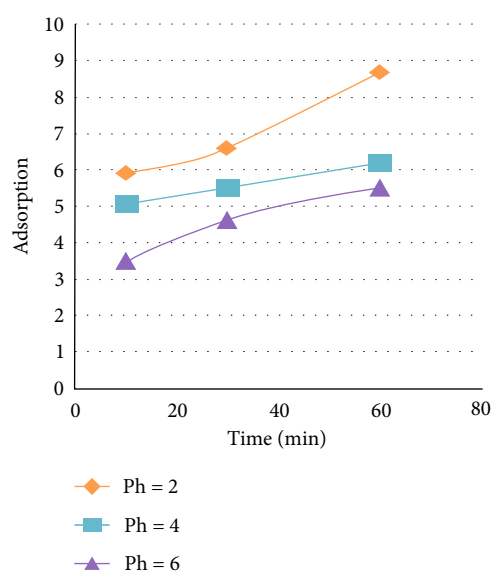


FIGURE 8: The relationship of time to adsorption for different values of the acidity function at a concentration of 60 ppm.

3.2.2. Effect of Different Concentrations on Adsorption for Different Times. From Figures 3–5, we note the direct relationship between the increase in the concentration of solutions and the increase in the adsorption of cadmium from these solutions with the stability of the acidity function and time, and from Table 3, we obtained the highest value of adsorption (8.76) at a concentration of 60 ppm and a time of 60 min when the acidity function; Table 1 shows the lowest value of adsorption was (0.1) obtained at a concentration of 10 ppm and a time of 10 and at the pH function 6, and this decrease is attributed to the increase in negative charges available in the solution.

3.2.3. Effect of Different Times on Adsorption with

(1) *Different pH Values.* The direct relationship between time and adsorption was shown in Figures 6–8 with the proof of all other variables, and this relationship resulted from giving sufficient time for positive and negative charges to reach the state of equilibrium and thus to reach an increase in the adsorption values, and we also note that the time factor has an effect large at high concentrations, and this is due to the abundance of negative and positive charges and sufficient time, thus providing the ideal circumstance for adsorption to occur with very large values.

4. Conclusion

We can treat water contaminated with heavy metals through nanomaterials, and the effect of the value of the pH was very large, as the lower the value of the acid value of pH, the greater the adsorption of the heavy element. Effect of the time factor and the concentration of the solutions played the same role to some extent; as with their increase, the adsorption factor increased.

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

Authors' Contributions

Emaad Muhamme Awsaj and Foud Nihad Abe conceived of the presented idea. Shaymaa Mohammed Fayyadh and Samar S. Mohammed contributed to the research design and implementation, the analysis of the results, and the writing of the manuscript. Mustafa Mahdi Abdulridha, A. Abdullah H. Mohamad, and Foud Nihad Abe carried out the experiment. Sameer Alshehri, Gashaw Tadele, and Wegayehu Enbeyle developed the theoretical formalism. Sameer Alshehri, Gashaw Tadele, Wegayehu Enbeyle, and Emaad Muhamme Awsaj performed the analytic calculations and performed the numerical simulations. All authors contributed to the sample preparation.

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