

## As(V) Adsorption using $MFe_2O_4$ ( $M=Cd^{2+}$ , $Ni^{2+}$ ) Ferrite Nanoparticles

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### Abstract

The paper present the possibilities of arsenic removal from aqueous solutions using as adsorbent  $MFe_2O_4$  ( $M=Cd^{2+}$ ,  $Ni^{2+}$ ) ferrite nanoparticles due to the affinity of arsenic towards iron ions. The ferrites were obtained after a heating treatment of the cadmium respectively nickel ferrioxalate coordination compounds, as precursors, at 500°C. From the two studied adsorbent material the nickel ferrite developed a higher maximum adsorption capacity (132  $\mu\text{g As(V)/g}$  of ferrite) than the cadmium ferrite (109  $\mu\text{g As(V)/g}$  of ferrite) in the removal process of As(V) from aqueous solutions. In both cases the equilibrium between the adsorbent and adsorbate was achieved in 60 minutes.

**Keywords:** ferrite, adsorption, oxalate, arsenic

### Introduction

The main source of drinking water for many countries in the world is the ground water. These waters in most of the cases contain as a natural fond a concentration of arsenic higher than the maximum acceptable concentration by the World Health organization (WHO) of 10  $\mu\text{g/L}$  [1, 2]. The presence of arsenic in drinking water has serious adverse effects on human health and other living organisms [3-5], therefore the development of an adequate removal process of arsenic from drinking water is an issue relevant to almost all countries. From the many techniques studied for the arsenic removal from drinking water, adsorption proved to be the most efficient due to its simplicity and feasibility even for low arsenic concentrations [2, 4, 5]. Because it was proved that the iron compounds present a high affinity for arsenic, these were intensive studied as possible adsorbents materials for arsenic removal from aqueous solutions [6-9]. In this paper we studied and compared the performance of two nanoferrites used as adsorbent material in the removal process of arsenic form aqueous solutions. The ferrites have the advantages that are reusable adsorbents because these can be efficient and economic separated from solutions due to their ferromagnetic or supermagnetic properties [10-15].

### Experimental

For the synthesis of  $MFe_2O_4$  ( $M=Cd^{2+}$ ,  $Ni^{2+}$ ) was used the thermal decomposition of cadmium respectively nickel ferrioxalate precursors, it represents an efficient route of various ferrites synthesis [16]. The oxides were obtained after heating treatment of the precursor at 500°C for one hour, with a heating rate of 5°C/min. The SEM images were recorded using a Quanta FEG 250 microscope, equipped with an EDAX ZAF quantifier.

The obtained ferrites were used in the removal process of As(V) from aqueous solutions. In order to compare their adsorption performance in the removal process of As(V) from aqueous solutions, the dependence of the adsorption capacity function of S:L ratio, stirring time and As(V) initial concentration was determined. The adsorption performance of the studied material was expressed as arsenic metal uptake ( $\mu\text{g/g}$ ) eq.1. [1-5]:

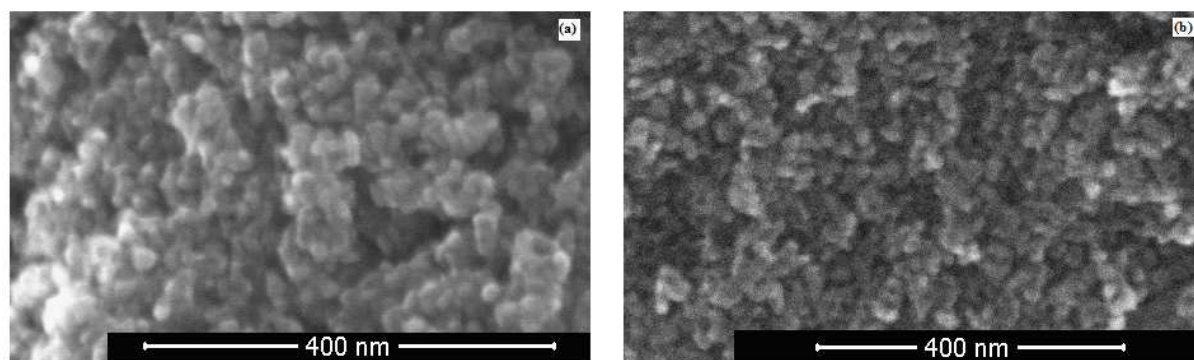
$$q_e = \frac{(C_0 - C_e) \cdot V}{m} \quad (1)$$

where:  $C_0$  and  $C_e$  are the concentrations of arsenate ( $\mu\text{g/L}$ ) in the solution, initially ( $t=0$ ) and at equilibrium, respectively,  $V$  is the volume of the solution and  $m$  is the mass of adsorbent.

For the study of the S:L influence various quantities of ferrites (0.05, 0.1, 0.2, 0.3, 0.4 and 0.5 g) were treated with 25 mL of As(V) aqueous solutions containing a concentrations of 100  $\mu\text{g/L}$ . The samples were shaken for 1 hour (using a Julabo SW 23 shaker), and after the time elapsed were filtrated and in the resulted solutions was determined the residual concentration of As(V) ) through atomic absorption spectrometry using a Varian SpectrAA 110 atomic absorption spectrometer with a Varian VGA 77 hydride generation system. When the effect of the initial As(III) concentration (range: 100 – 700  $\mu\text{g/L}$ ) was studied, in each experiments 0.1 g of adsorbent was suspended in 25 mL of As(V) solutions. To study the effect of contact time on adsorption, the experiments were carried out with samples of 0.1 g studied materials in 25 mL of 100  $\mu\text{g/L}$  As(V) solutions. The suspensions were stirred for various periods of time: 15, 30, 45, 60, 90 and 120 (min).

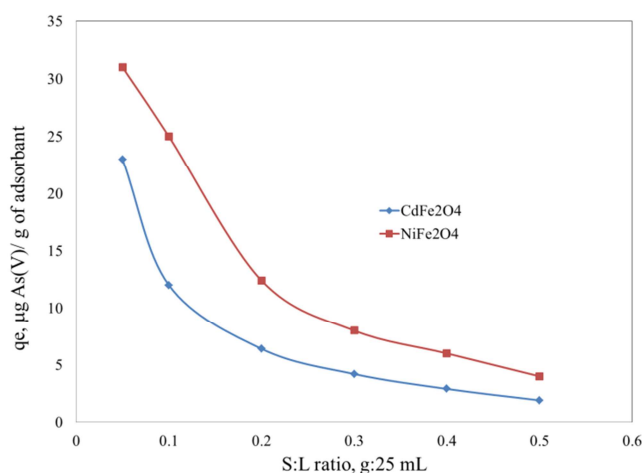
### Results and discussion

The size of the nanoparticles evaluated from SEM images (Fig. 1) was found to be in the range of 20-50 nm, almost homogeneous as shape and size. The nickel ferrite present a higher porosity than the cadmium ferrite. This may conducte to a higher adsorption capacity in the removal process of As(V) from aqueous solutions. Qualitative and quantitative EDX analyses showed a high purity and suitable stoichiometry of the investigated ferrites.



**Figure 1.** SEM images of  $M\text{Fe}_2\text{O}_4$  ferrites: (a)  $\text{CdFe}_2\text{O}_4$  and (b)  $\text{NiFe}_2\text{O}_4$

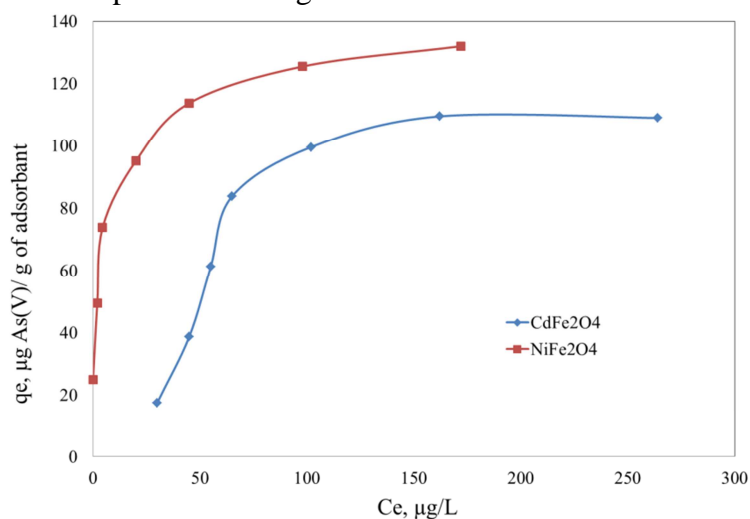
The influence of the S:L ratio upon the adsorption performance of the studied ferrites is presented in figure 2.



**Figure 2.** S:L influence on the adsorption process

It can be observed that a higher quantity of adsorbent material lead to the decreasing of the adsorption capacity, because the adsorbent capacity is related to the amount of adsorbent. Therefore in order to obtain both maximum values for removal degree but also for adsorption capacity for the future experiments a S:L ratio of 0.1 g of ferrites compounds : 25 mL of As(V) solution was used.

The experimental data regarding the dependence of As(V) uptake function of the As(V) equilibrium concentration are presented in figure 3.

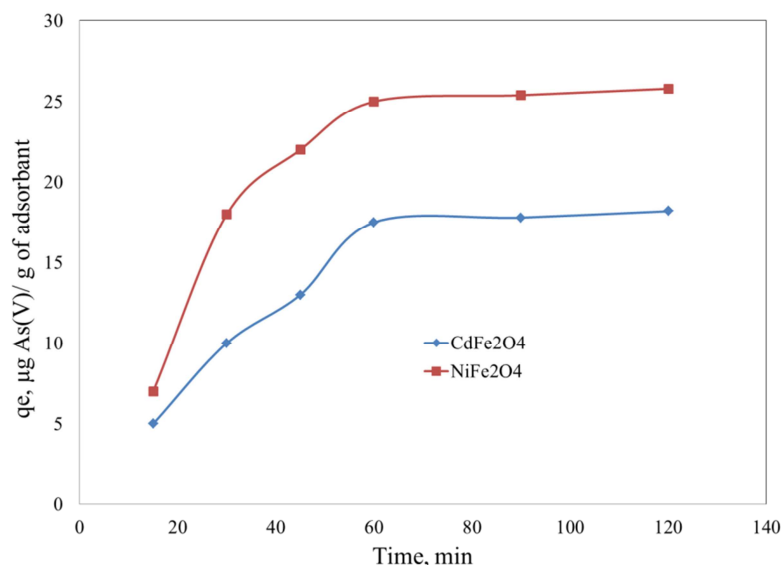


**Figure 3.** As(V) initial concentration influence on the adsorption process

The adsorption capacity of studied ferrites in the removal process of As(V) increased with increasing equilibrium concentration of As(V), and then it approached a constant value at higher equilibrium concentrations. It can be observed that the nickel ferrite developed a higher maximum adsorption capacity (132 µg As(V)/ g of ferrite) than the cadmium ferrite (109 µg As(V)/g of ferrite) in the removal process of As(V) from aqueous solutions. This is in accordance with the conclusion raised from the SEM analysis.

The As(V) adsorption behavior onto studied ferrites was studied by the variation of the equilibrium time in the range of 15 - 120 min. The adsorption capacity of the As(V) as a function of contact time is plotted in figure 4. It can be observed that the adsorption capacity of As(V) increase with the stirring time increasing for the both studied ferrite. The highest

amount of As(V) uptake occurs in the first 60 minutes.



**Figure 4.** Stirring time influence on the adsorption process

### Conclusion

MFe<sub>2</sub>O<sub>4</sub> (M=Cd<sup>2+</sup>, Ni<sup>2+</sup>) ferrite nanoparticles were obtained by thermolysis of oxalate coordination compounds at 500°C. The SEM and EDX analysis a high purity and suitable stoichiometry of the investigated ferrites. The results showed that MFe<sub>2</sub>O<sub>4</sub> (M=Cd<sup>2+</sup>, Ni<sup>2+</sup>) ferrite nanoparticles can be used with good results as adsorbent material in the removal process of As(V) from aqueous solutions. The use of these materials present the advantages compared with other adsorbents that present a very good efficiency, can be easily removed from the aqueous solutions and can be regenerated. From the two studied adsorbent material the nickel ferrite developed a higher maximum adsorption capacity (132 µg As(V)/g of ferrite) than the cadmium ferrite (109 µg As(V)/g of ferrite) in the removal process of As(V) from aqueous solutions. In both cases the equilibrium between the adsorbent and adsorbate was achieved in 60 minutes.

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