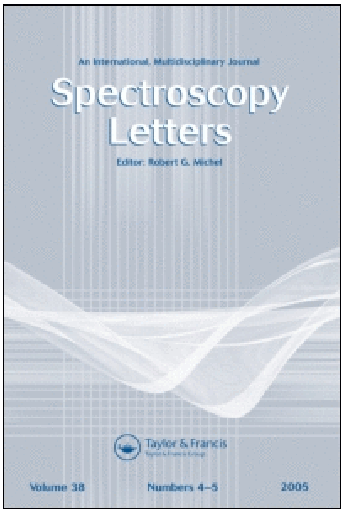

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Determination of Cadmium Separated Selectively with Ion Exchange Method from Solution by ICP- AES

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DETERMINATION OF CADMIUM SEPARATED SELECTIVELY WITH ION EXCHANGE METHOD FROM SOLUTION BY ICP- AES

Key Words: cadmium, heavy metals, ion exchange, ICP-AES

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ABSTRACT

The removal of heavy metals, such as cadmium, from solution was investigated by using modified asphaltite ash as an ion exchange. Analysis were determined using inductively coupled plasma atomic emission spectrometry (i.e., ICP- AES). The effect of time, temperature, pH and concentration of cadmium on the removal process of cadmium was examined. An optimum condition for complete removal of cadmium from solution has been found. Therefore pretreated asphaltite ash can be used as an alternative material for removal of cadmium from industrial waste waters.

INTRODUCTION

Cadmium is one of the more toxic trace metals. Water pollution due to heavy metals, such as cadmium, is a serious global problem. The problem of removing pollutants from water is important and becoming more so with the increase of industrial activity. The presence of priority pollutants, such as cadmium, in the effluent streams from several chemical and metal plating industries and neighboring municipalities was found. Mineral particles such as pyrites (1) and industrial by-products, (e.g., fly ash or red mud) have recently been proposed as alternative sorbents for the removal of toxic metal ions (2,3). Several materials have been suggested in the literature as suitable cadmium sorbents, such as: activated carbon (4), zeolites (5), goethite (6), hydrous aluminum oxides (7), adsorption of cadmium ions on calcite (at natural pH values around pH 8) (8) and sorption by hydroxyapatite (9). The material used in this work as ion exchange after leaching the asphaltite ash with H_2SO_4 can be regarded as a model for cleaning of water in industrial waste. These raw materials were treated with $CaCO_3$ and roasted at 720°C for 2 hours.

MATERIALS AND METHODS

The asphaltite was collected from the Şırnak region in the Southeast Anatolia and was ashed by burning in a muffle furnace (Heraeus K.R. 170 mod.) at 950°C. Then this ash was leached with H_2SO_4 to get rid of heavy metals. The residue was then filtered and dried in an oven at 110°C for 24 hours. This material was treated with $CaCO_3$ and was used for removal of cadmium from solution. This process was conducted by mixing 1g of material and a 10 ml solution containing 10 ppm cadmium and shaking at a constant temperature (25°C± 0.5°C) regulated with a circulating pump (Certomat WR.) for different periods. Then samples were centrifuged and the cadmium left in solution was quantitatively determined using a Jobin Yvon-Sequential Model Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES). The operating conditions are listed in Table 1. The selection of instrumental parameters and optical wavelengths were based on obtaining good sensitivity, reasonable detection limits and eliminating interferences. The general measurement conditions, optical wavelength used, and practical detection limit for cadmium are listed in Table 1.

RESULTS AND DISCUSSION

First, to find out the direct ion exchange property of pretreated asphaltite ash, (Mo, Ni, V and U were already removed), 1 g of ash was treated with a 10 ml solution containing 10 ppm cadmium. The amount of cadmium in solution was decreased to 9 ppm. The same experiment was also repeated with the ash roasted

Table 1.
Instrumentation and Operating Conditions For ICP-AES

Instruments:	
Spectrometer	JY24 (Jobin Yvon-Sequential)
Generator	40.68 MHz, 220 volts, 1kW
Operating Conditions	
Plasma gas	Argon, 11 L/min, 5.5 bars
Sheat gas	Argon, 0.25 L/min
Nebulizer gas	Argon, 0.30 L/min, 3.0 bars
Nebulizer	Meinhard, Type C 0.5
Torch	JY Ryton, demontable
PMT tube	160-800 nm
Monochromator	HR 640, 2400 g/mm, 64 cm focus Resolution:0.01 nm
Computer	Type: IBM-PS_{30}, Screen Type:8512
Printer	Type: Citizen 1200
Software	Version 3.45
Wavelength	228.802
Detection limit	0.1 ppb

Table 2.

The effect of the amount of $CaCO_3$, and time on removal of cadmium from a solution containing 10ppm, initial concentration of Cd^{+2}

	(Cd^{+2})*, ppm				
t(min)/g**	0.2	0.3	0.4	0.5	%RSD
5	1.38 (6.77)	0.39 (7.48)	0.024 (7.61)	— (7.69)	0.17
10	1.39 (6.90)	0.29 (7.61)	— (7.62)	— (7.70)	0.26
20	1.19 (7.15)	0.29 (7.60)	— (7.63)	— (7.70)	0.20
30	1.19 (7.12)	0.28 (7.58)	— (7.65)	— (7.72)	0.22
45	1.19 (7.13)	0.27 (7.58)	— (7.64)	— (7.71)	0.26
60	1.19 (7.13)	0.27 (7.58)	— (7.68)	— (7.69)	0.26

%RSD: Relative Standart Deviation

* The amount of cadmium remaining in solution. The numbers in brackets represent the pH of cadmium solution after treating with ash.

** The amount of $CaCO_3$ treated with 4 g of ash

— Not detectiable

Table 3.

The effect of temperature and time on removal of cadmium from a solution containing 10ppm, initial concentration of Cd^{+2}

$(Cd^{+2})^*$,ppm			
Time(h)/T°C	720	750	800
2	—(7.62)	0.018 (7.48)	0.062 (7.67)
3	— (8.46)	0.013 (7.59)	0.070 (7.87)
4	— (8.32)	0.012 (7.71)	0.085 (7.78)

at 720°C, and only around 8 ppm of cadmium remained in solution. Asphaltite ash was treated with $CaCO_3$ at various amounts and roasted at 720°C for 2 hours. 1 g of modified ash was used for removal of cadmium as repeated above. The results using modified ash for the removal of cadmium are shown in Table 2.

As seen from Table 2, 0.4 g of $CaCO_3$ was sufficient to remove cadmium from solution at 10 minutes. The experiments were carried out with the ash treated with $CaCO_3$ roasted at different temperatures and times. The results are summarized in Table 3.

As seen from Table 3, the ash treated with $CaCO_3$ roasted at 720°C for 2 hours was employed to remove cadmium from solution. This may be ascribed to the release of crystal water from the ash at 720°C (10). The effect of concentration of cadmium on the removal of cadmium was also studied, as seen in Table 4. In this process, the amount of cadmium in solution decreased to 21.62 ppm from 50 ppm. However, when the effect of the amount of modified asphaltite ash is examined, the concentration of cadmium remaining in solution was decreased to 3 ppm, (see Table 5).

In our previous study, lead was removed using pretreated asphaltite ash from industrial waste waters (10). In our work, we have used modified asphaltite ash to remove cadmium from solution based on an ion exchange reaction.

$$H_nR \quad + \quad M^{+2} \quad \Rightarrow \quad H_{n-2}MR \quad + \quad 2\,H^+$$

$$CaCO_3 \quad + \quad M^{+2} \quad \Rightarrow \quad Ca^{+2} \quad + \quad MSiO_3$$

Table 4.

The Effect of cadmium concentration on removal of cadmium from the solution

Concentration of Cadmium(ppm)	$(Cd^{+2})^*$,ppm	PH
10	—	7.69
20	—	7.71
50	21.61	8.54
100	67.32	8.42

Table 5.

The effect of amount of modified asphaltite ash at 50ppm, initial concentration of Cd^{+2}

Solid Amount(g)	$(Cd^{+2})^*$,ppm	PH
1	20.2	8.50
1.5	4.83	8.52
2	3.82	8.48

R: Indicates silicate anion

The results of the experiment show that the above two chemical equilibrium relationships occur due to the decreasing initial pH of solution, and the calcium ions passing into solution. Another advantage shown by this study is that the colloidal species doesn't occur in the solution. Modified asphaltite ash proved suitable for effectively removing dilute concentrations of cadmium and possibly of other metal cations from aqueous solutions, i.e., waste waters.

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