

Detection of arsenic ions with preliminary concentrating on magnetic sorbent

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Abstract - In represented work a method of arsenic ions concentrating is presented by means of sorption with application of synthetic magnetite, which is successfully used for atomic absorption detection of arsenic in natural waters.

Key words - heavy metals, sorption, concentrating, magnetite, arsenic.

One of the most acute problems is environment contamination by heavy metals because of their high biological activity, toxicity, carcinogenicity and mutagenicity. Reviewed big machine building complex of Naberezhnye Chelny city - KAMAZ OJSC - is one of the main stationary contaminators of surrounding environment. Significant quantity of harmful substances, which get into natural environment locations from machine building enterprises, represent metal compounds, their quantitative chemical analysis is complicated by a number of circumstances, the main factor is their low content. In its turn traditional physical and physicochemical methods fail to fully provide detection of trace quantity of metals and their compounds in natural environment locations and all the more detect their quantitative content.

Sample preparation plays an important role in acquisition of credible results. Entirely it allows to adjust the sample to analyzer device, decrease the lower limit of detection, single out and strengthen analytical signal, provide its correct and authentic registration, to simplify graduation upon condition of minimal range of samples for comparison.

Usage of combined analysis methods including concentrating of micro-components and their consequent physicochemical detection is quite perspective. Among concentrating methods sorption method is the most effective one that allows to perform concentrating of trace components out of big volume of solutions on a relatively small mass of sorbent. However at that, consequently, process of sorbent separation from solution using conventional methods of filtration and gravity thickening become more difficult. That is why an important task is acquisition of sorbents which along with good sorption properties could be easily separated from the solution. This task can be solved if powder of small magnetic particles is used as sorbent, which after the process of contaminating agents sorption can be separated under the action of gradient magnetic field. One of the examples of magnetic sorbent is magnetite. In view of abundance of magnetite both in nature and in residuals of metallurgical production, it is rational to research the opportunity of its usage for concentrating of ions of heavy metals.

The aim of this work consists in the method of increase of detection limit (and quantitative analysis) of arsenic in natural waters or atmospheric condensation by means of its concentrating in the process of magnetite sorption.

Arsenic is one of the most top-priority contaminating agents. In 2006 World Health Organization and international community paid attention to the problem of drinking water contamination by arsenic compounds, having decreased admissible concentration limit from 50 µg/l to 10 µg/l. Serious researches in different regions of the planet preceded to adoption of this decision, as well as crisis of drinking water in countries of South Asia (Bangladesh etc.) having resulted in several fatal cases. At the present moment there is practically no universal method of analysis, allowing to perform control of arsenic content in different natural objects, that is why creation of productive and efficient methods of arsenic detection in natural objects is a crucial task of analytical chemistry.

Within the limits of introduced work researches of possibility of magnetite usage for concentrating and further atomic absorption detection of ions of trivalent arsenic (As^{3+}) in water objects are presented. For execution of concentrating experiments, test solutions were prepared with different initial content of arsenic in which sample weight of ultrathin powder of magnetite was placed after which the solutions were mixed in jolt rammer during 30 minutes. After sorption division of solution and sorbent was performed with the help of magnetic remover. For desorption an alkali solution was added to a minute volume into the bottle with magnetite that has absorbed arsenic and also underwent the process of mixing during 30 minutes. Concentration factor is equal to 10. Results are given in Table I.

TABLE I

CONCENTRATING OF ARSENIC IONS OUT OF TEST SOLUTIONS

No	Initial concentration $n As^{3+}$, µg/l	Absolute content As^{3+} in a sample (q_{np}), µg	Absolute content As^{3+} in concentrate (q_k), µg	Concentrating efficiency coefficient
1	1	0,68	0,55	0,81
2	10	5,3	5,0	0,94
3	100	51	49	0,96

In accordance with acquired results it is stated that at initial low content of arsenic coefficient of concentrating efficiency (q_k / q_{np}) amounted to 0,81, at the increase of concentration from 10 µg/l and up the value of concentrating efficiency is close to 1.

Also during work experiments by definition of optimum conditions of adsorption of arsenic depending on pH, temperature and contact time are made. It is established that with increase efficiency of adsorption decreases with increase pH, peak efficiency is observed in a range 4-7 pH (Fig. 1).

Efficiency of process of adsorption with temperature increase decreases. The maximum speed of process is observed in an initial interval of time (0-30 min), with increase in time of contact the adsorption size changes slightly (Fig. 2).

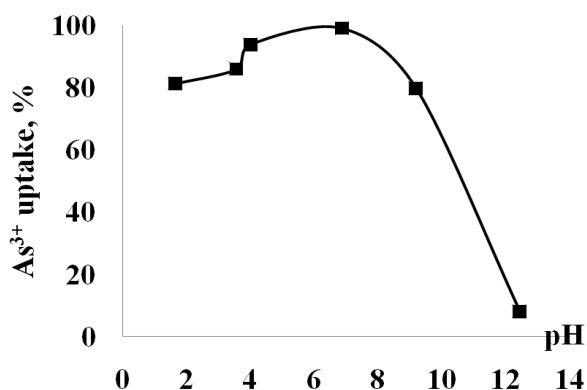


Fig 1. Effect of pH on As³⁺ uptake (%)

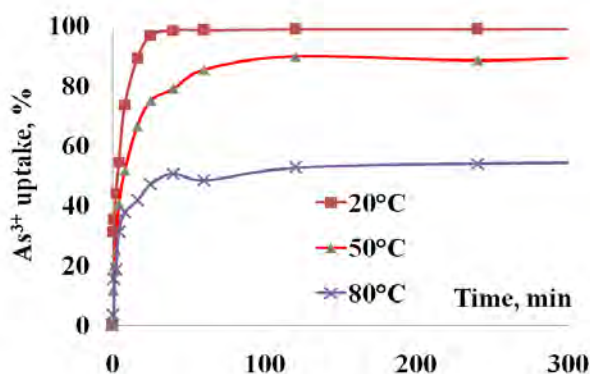


Fig 2. Effect of temperature (°C) and time (min) on As³⁺ uptake (%)

For approbation of the suggested methodology in accordance with [1] samples of snow cover on the territory of the Foundry plant of KAMAZ OJSC were collected and analyzed to detect the content of arsenic. Acquired initial amount of concentrations (less than 5 µg/l) in melt water of snow cover in accordance with [2] are included into the range of concentrations, demanding concentrating (Table 2).

After correspondent sample preparation experiments on arsenic concentrating out of melt water of snow cover are carried out. Results are given in Table 3.

As it is obvious from the results, suggested method of preliminary concentrating allowed to detect content of arsenic less than 5 µg/l, at that concentrating efficiency coefficient on the average amounted to 0,94.

Suggested method of concentrating allows to quite efficiently derive arsenic ions out of test solutions and melt water of snow cover, increasing sensitivity of atomic absorption detection of arsenic without essential increase of limits of relative error.

TABLE II

Element	Range of measured concentrations, mg/l		Range of concentrations, demanding concentrating, mg/l	Range of concentrations, demanding dilution, mg/l
	drinking and natural	drainage		
Arsenic	0,0005 -0,3	0,005 -5	0,0005 - 0,005	0,1 - 5

TABLE III

CONCENTRATING OF ARSENIC OUT OF MELT WATER OF SNOW COVER

Initial concentration As ³⁺ , µg/l	Content of As ³⁺ in concentrate after desorption, µg/l	Absolute content As ³⁺ in the sample (q _{mp}), мкг	Absolute content As ³⁺ in the concentrate (q _c), µg	Concentrating efficiency coefficient
1,5 ± 0,9	14,6	0,75	0,73	0,97
1,8 ± 1,1	17,9	0,90	0,90	0,99
1,7 ± 1,0	18,2	0,85	0,91	1,07
1,8 ± 1,1	14,3	0,90	0,72	0,79
1,4 ± 0,8	12,1	0,70	0,61	0,86

References

- [1] Nature preservation. Hydrosphere. General requirements to sample collection of surface and sea waters, ice and atmospheric condensate. GOST 17.1.5.05-85, 1985
- [2] Quantitative chemical analysis of waters. Method of metering of mass concentration of heavy metals by means of atomic absorption spectrometry. Federal environment protection regulatory document 14.1.2:4.140-98, 1998.