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Study of the effect of humic substances on the position of calibration graphs in the determination of silicon in water by high-resolution electrothermal atomic absorption spectrometry with a continuous spectrum source

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Abstract. *The paper considers the influence of natural compounds, humates, on the position of the calibration curves when determining the mass concentration of Si (IV) ions in water by high-resolution electrometric atomic absorption spectrometry with a continuous spectrum source. The analysis of the results obtained using the calibration dependences* $A_{int}=f(C_{Si})$ *in various systems: Si (IV) ion - water; Si (IV) - HA ion at a silicon resonance line of 251.611 nm and a decision was made about the possibility of determining the dissolved forms of silicon in the presence of humic substances with an acceptable error.*

Keywords: *spectrometry, ETAAS, silicon, calibration curve, water, continuous spectrum source.*

In the course of the natural cycle, natural waters come into contact with a large number of various minerals, organic compounds and gases, dissolving them. Therefore, the chemical composition of natural waters means the entire complex of dissolved gases, various mineral salts and organic compounds [1]. The binding of Si (IV) ions in an aqueous medium with dissolved organic substances, humic (HA) and fulvic (FA) acids refers to natural processes occurring in natural (surface and ground) water. The relevance of studying the effect of natural compounds, humates, on the determination of silicon in water by high-resolution electrometric atomic absorption spectrometry with a continuous spectrum source (HD CS ETAAS) is beyond doubt.

To study the effect of HA in the determination of silicon by the HD CS ETAAS method, the calibration dependences $A_{\text{int}}=f(C_{\text{Si}})$ in water and an aqueous solution of HA were studied. The research methodology consisted in the determination of silicon in natural surface waters using the calibration dependences $A_{\text{int}}=f(C_{\text{Si}})$ in various systems. The following solutions were used as such systems: Si (IV) ion - water; Si (IV) - HA ion.

The silicon concentration in the calibration solutions was varied in the range from $3.56 \cdot 10^{-6}$ to $35.60 \cdot 10^{-6}$ mol/dm^3 (or 0.10-1.00 mg/dm^3), the HA concentration was kept constant at 5 mg/dm^3. The concentrations of silicon and HA in the model solutions corresponded to the average content of these components in natural waters of the Sverdlovsk Oblast (Russia) in the summer period of the calendar year.

The study of the influence of the matrix components of water on the determination of silicon was carried out on a high-resolution atomic absorption spectrometer with a continuous spectrum source of the ContrAA® 700 model with an electrothermal technique for atomization of samples, manufactured by Analitik Jena AG, Germany. The temperature-time program and instrumental parameters for the determination of dissolved forms of silicon by the HD CS ETAAS method are published in [2].

The effect of humic substances on the position of the calibration curves in the determination of silicon in water by the HD CS ETAAS method is shown in fig. 1.

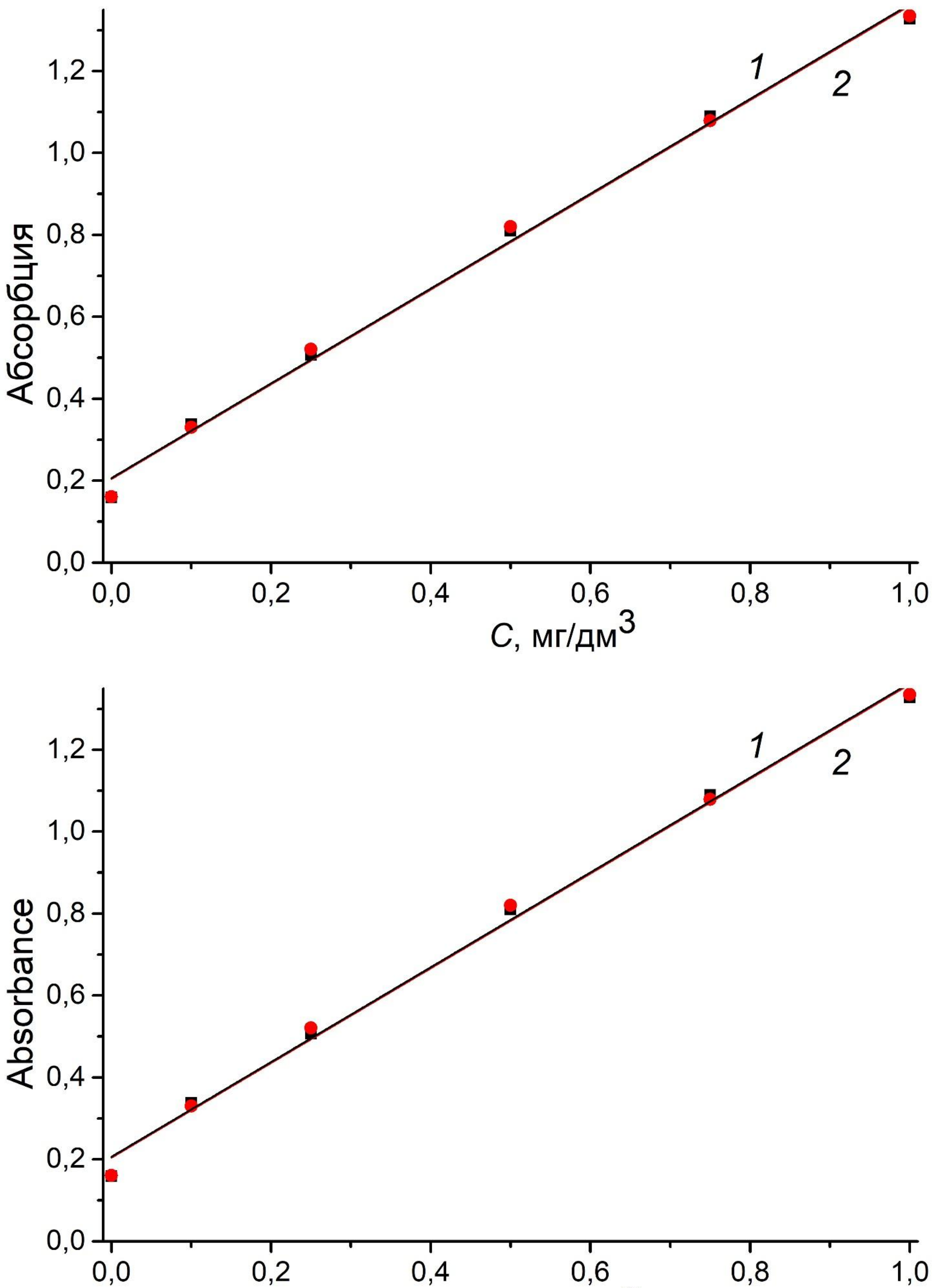

Fig. 1 – Influence of humic substances on the position of the calibration curves in the determination of silicon in water by the HD CS ETAAS method: 1) Si (IV) - HA ion;

2) Si (IV) ion - water. The concentration of HA is 5 mg/dm^3.

The mass concentration of silicon (X, mg/dm^3) in a single sample was calculated by the formula:

$$X= (CSi(IV)- Cblnk.)\cdot ŋ \ (1)$$

where $C_{Si(IV)}$ –mass concentration of silicon in the analyzed water sample, established by the calibration characteristic, mg/dm^3;

$C_{blnk.}$ - mass concentration of silicon in the blank sample established by the calibration characteristic, mg/dm^3;

ŋ – dilution ratio.

A comparative assessment of the results of determining silicon in natural surface waters is given in tab. 1.

Table 1

Determination of silicon by HD CS ETAAS in natural surface water

Sample name	Mass concentration of silicon, ($X_{av.} \pm \Delta$), mg/dm^3 at P = 0.95	
	Calibration characteristic in the system:	
	Si (IV) – HA ion	Si (IV) ion - water
Water from the Volchikhinsky reservoir, Sverdlovsk Oblast, Russia	2.45±0.22	2.39±0.22
Water from the river Istok, Sverdlovsk Oblast, Russia	0.51±0.09	0.52±0.09
Water from the Bobrovka River, Sverdlovsk Oblast, Russia	7.76±0.70	7.50±0.68

Comparison of the results obtained by the calibration dependences $A_{int}=f(C_{Si})$ in various systems shows that the found concentration values are in good agreement with each other within an error of up to 3.41%, while the index of intralaboratory precision (reproducibility) does not exceed the previously established value in the method [3].

Based on the results of the studies obtained, it can be concluded that it is possible to determine the dissolved forms of silicon in the presence of HA by the HD CS ETAAS method with an acceptable error.

References

1. Linnik P.N., Nabivanets B.I. Forms of metal migration in fresh surface waters. – L.: Gidromethioizdat, 1986. – 270 P.

2. Shtin T.N., Neudachina L.K., Shtin S.A. Determination of dissolved forms of silicon in natural water by high-resolution electrothermal atomic absorption spectrometry with a continuous spectrum source / Factory laboratory. Diagnostics of materials. 2021. V. 87, № 3. P. 48 – 56.
3. FR.1.31.2020.37835. Methodical instructions. Control methods. Chemical factors. Method for measuring the mass concentration of silicon contained in its dissolved forms in water by electrothermal atomic absorption spectrometry. – Yekaterinburg: Federal Budgetary Institution of Science "Yekaterinburg Medical – Scientific Center for Prevention and Health Protection of Industrial Workers", 2020. – 50 P.