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Determination of cobalt and chromium by Atomic Absorption Spectrometry (AAS) and comparison with Inductively Coupled Plasma Optical Emission Spectrometry (ICP OES)

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Abstract

Identifying individual elements can be done using different atomic spectroscopic (AS) methods. These methods vary mainly based on their sensitivity, selectivity, speed in processing samples, and cost. The reliability of these methods is checked during validation, and parameters like precision, accuracy, and detection limits are among the most commonly assessed. The book uses trace element techniques to measure the purity of reagent chemicals, including atomic absorption spectroscopy (AAS) and inductively coupled plasma-optical emission spectroscopy (ICP-OES). It's important to note that many labs now use inductively coupled plasma-mass spectrometry for detecting very small amounts of metals. The proposed method is recommended for the preconcentration and determination of cobalt (II) at minor and trace levels, and it's also used for analyzing real samples like industrial effluent.

Keywords: Cobalt (II), Cu (II), Pb (II), Fe (III), chromium (VI), high-resolution continuum source (AAS)

Introduction

Cobalt is a very important micronutrient for living organisms. It is essential for many life forms, including mammals, where it helps activate several enzymes. Cobalt is also key in the process of nitrogen fixation in plants by bacteria and is a vital component of the B-vitamin complex, specifically vitamin B12. Plants and various food sources have very low levels of cobalt. A lack of cobalt can lead to slow growth, loss of appetite, and pernicious anemia in humans. Just 3 micrograms per day can help prevent pernicious anemia. In animals, cobalt deficiency can cause several health issues. Too much cobalt can irritate the stomach and intestines, leading to nausea, diarrhea, and other problems. High levels of cobalt can significantly block the production of heme and stop enzyme functions. However, cobalt is harmful when ingested directly.

Besides its role in the body, cobalt has many uses in industry. Because of its strength and ability to resist corrosion in different environments, it is commonly used in high-speed tool steels, magnets, and high-temperature alloys. The metal is used in making aircraft, electromagnets, paints, and ceramics. Cobalt is also used as a catalyst in various industrial processes. The need to measure cobalt has increased because of its importance in both essential biological processes and industrial applications, as discussed earlier.

A detailed review of the literature shows that many different chemicals have been used to concentrate and measure cobalt (II) using atomic absorption spectroscopy. Various substances such as 2-nitroso-1-naphthol (1), Poly (ethylene mine) and its thiourea derivatives (2), thiocyanate (3), meso-tetra (P-sulphonato) prophine (4), 2-acetic pyridine benzoyl hydrazone (5), 2-(5-bromo-2-pyridylazo) 5 diethyl amino phenol (6), dithiocarbamate (7), natural waters (8), 8-hydroxy quinolene (9), dithizone in ethyl propionate (10), 1,10-phenanthroline (11), 1-nitroso-2-naphthol-3,6-disulfonic acid (12), nitroso-R salt (13), 2-(5-bromo-2-pyridylazo-5-diethylaminophenol (14) have been used as reagents to extract cobalt (II) with atomic absorption spectrometry.

In addition, several more atomic absorption spectrometric and extractive atomic absorption spectrometric methods have been developed (15-44) to measure cobalt.

A first study of the reaction between cobalt (II) and potassium benzyl xanthate (KBX) in a neutral solution showed that the solution becomes cloudy and the precipitate becomes more visible when the pH is lowered to 7.0. To understand the nature of this precipitate, an attempt was made to dissolve it into an organic phase using several solvents like n-butanol, benzene, methyl isobutyl ketone, n-amyl alcohol, isoamyl alcohol, carbon tetrachloride, chloroform, chlorobenzene, cyclohexane, nitrobenzene, and propyl acetate to study the extraction of the Co (II)-KBX complex. Among the solvents tested, methyl isobutyl ketone was found to extract the complex effectively. The organic phase, which is the solution of the precipitate in MIBK, is separated from the aqueous phase and then analyzed for cobalt (II) using atomic absorption spectrometry.

2. Results and Discussion

Various parameters such as pH, reagent concentration, shaking time, sample volume, metal ion concentration and the effect of foreign ones which influence quantitative recovery of cobalt (II) were studied.

2.1. Effect of pH on the extraction of cobalt (II) KBX

The extraction behaviour of Co (II)-KBX complex was studied over a wide range of pH values. The pH studies were

carried out varying the pH from 2.0. to 9.0. In each case, a mixture containing 60µg of cobalt (II) in 100 ml of double distilled water, 2.0 ml of 0.5 per cent KBX solution was maintained constant and varying the pH values of the aqueous phase from 2.0 to 9.0 using suitable buffer solutions. The solution was shaken with 10.0 ml of methyl isobutyl ketone (MIBK) for 3.0 minutes. The organic phase was collected and the optical densities of the organic extracts were measured. The values are reported in the Table 1. From Fig. 1, it is observed that the extraction of cobalt (II) commenced at pH 2.0, reached a maximum at pH 4.0 and decreased beyond pH 4.0. Hence the optimum pH of 4.0 is recommended.

Table 1: Influence of pH on the extraction of Co (II) with KBX.

S. No	PH	Absorbance
		Co
1	2	0.254
2	3	0.368
3	4	0.459
4	5	0.394
5	6	0.373
6	7	0.298
7	8	0.193
8	9	0.174

Volume of water: 100 ml; [KBX]: 2.0 ml of 0.5%

Shaking time: 3.0 minutes; amount of each metal ion: 60µg

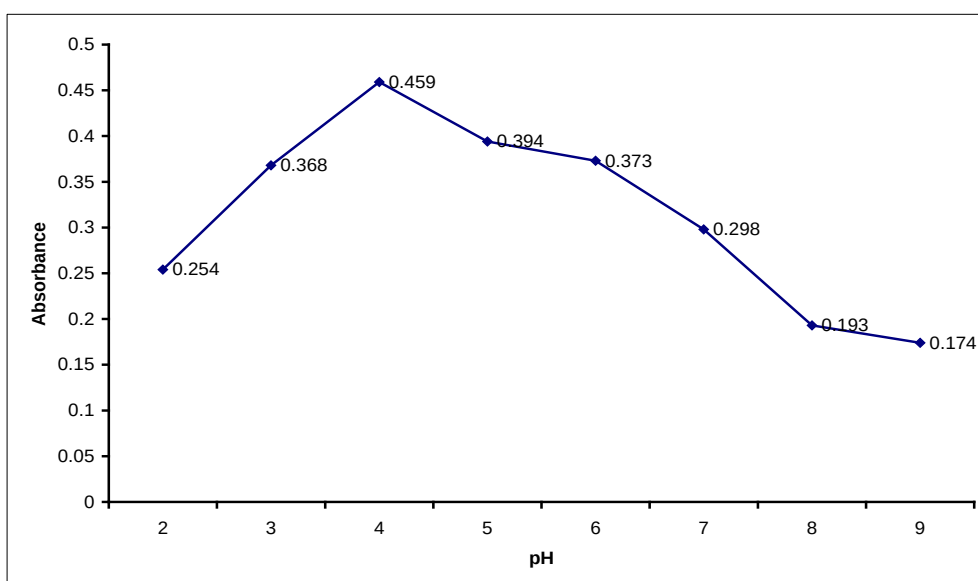


Fig 1: Influence of pH on the extraction of Co (II) with KBX.

1.2.2. Effect of sample volume on the extraction of cobalt with KBX

The extraction of cobalt (II) was studied using different volumes of the water sample from 100-300 ml. The study revealed that extraction was quantitative from 100-200 ml of the water sample. Hence, 100 ml of water was employed in the course of this study.

2.3. Effect of shaking time on the extraction of cobalt (II) with KBX

The effect of shaking time on the extraction of cobalt (II) was studied. The extraction remains constant for shaking time beyond two minutes. Hence, three minutes shaking time was employed in the course of this study.

2.4. Effect of reagent concentration on the extraction of cobalt (II) with KBX

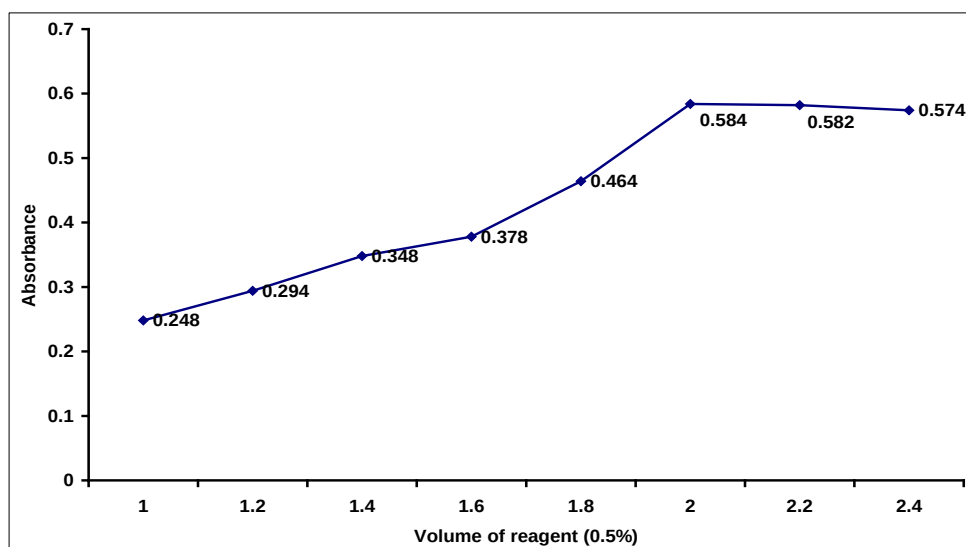
The effect of reagent concentration has been studied by using different solutions containing 60µg of cobalt (II) in 100 ml double distilled water and the pH was adjusted to 4.0 with acetic acid - sodium acetate solution. To this solution 1.0 to 2.4 ml of 0.5 per cent KBX was added. The metal complexes were extracted individually into 10.0 ml portions of MIBK. The absorbencies of these extracts were measured. The values are given in Table No.2 and Fig. 2. The above data reveals that 2.0 ml of 0.5 of the reagent (KBX) was sufficient for maximum extraction of co (II). Hence, this concentration was used for all further studies.

Table 2: Absorbencies of Extract.

Sl. No.	Volume of reagent (0.5 %) (ml)	Absorbance
		Co
1	1.0	0.248
2	1.2	0.294
3	1.4	0.348
4	1.6	0.378
5	1.8	0.464
6	2.0	0.584
7	2.2	0.582
8	2.4	0.574

Volume of water: 100 ml; pH: 4.0;

Amount of each metal ion: 60µg; shaking time: 3.0 minutes

**Fig 2:** Influence of reagent concentration on the extraction of Co (II) with KBX

2.5 Effect of foreign ions on the extraction of cobalt (II) with KBX

A known amounts of various cations and anions were added to fixed amounts of cobalt (II) (60 µg each) in order to study the effect of interference of such ions on the extraction and determination of cobalt (II) using the proposed procedure. The criterion for interference is an absorbance varying more than ± 2 percent from the expected value for Co (II) alone. The results are presented in Table 3.

During the determination of cobalt (II) with potassium benzyl xanthate by atomic absorption spectrometry, cations

like Cd(II), Se (IV) and Bi (III) do not interfere up to 3000µg, Ni (II) can be tolerated up to 2000µg Chromium (VI) and Hg (II) do not have any effect up to 1250 µg whereas Zn (II) can be tolerated up to 500µg. The Fe (III) and Pb (II) interfere severely in the present investigation. The interference due to Fe (III) and Pb (II) can be suppressed using 1.0 ml of 0.3% citrate solution. Anions like acetate, iodide up to 500 µg, citrate and oxalate up to 4500 µg, sulphate, bicarbonate up to 2500 µg, phthalate up to 1000 µg and tartrate up to 500 µg do not interfere in the determination.

Table 3: Effect of foreign ions on the extraction of Co(II)with KBX.

Ion	Source of Ion	Tolerance Limit µg/ml
		Co
Cd (II)	(CH ₃ COO) ₂ Cd. H ₂ O	3000,2500
Bi (III)	Bi (NO ₃) ₃ . 5H ₂ O	3000
Se(IV)	SeO ₂	3000
Ni(II)	(NH ₄) ₂ SO ₄ . NiSO ₄ .6H ₂ O	2000
Cr (VI)	K ₂ Cr ₂ O ₇	1250
Hg(II)	HgCl ₂	1250
Zn(II)	ZnSO ₄ .7H ₂ O	500,450
Fe(III) ⁺	FeCl ₃	-
Pb(II) ⁺	Pb(NO ₃) ₂	-
Sulphate	Na ₂ SO ₄	2500
Acetate	CH ₃ COONH ₄	5000
Phthalate	2-(COOH) C ₆ H ₄ COOK	1000
Citrate	(NH ₄) ₃ C ₆ H ₅ O ₇	4500
Bicarbonate	NaHCO ₃	2500
Oxalate	NaO ₂ CCO ₂ Na	4500
Tartrate	COOK.CHOH, CHOH. COONa.4H ₂ O	500
Iodide	KI	5000

*Masked by using 1.0 ml of 0.3% citrate solution Amount of each metal ion:60µg; [KBX]:5.0 ml of 0.5; pH:4.0; Shaking time: 3.0minutes

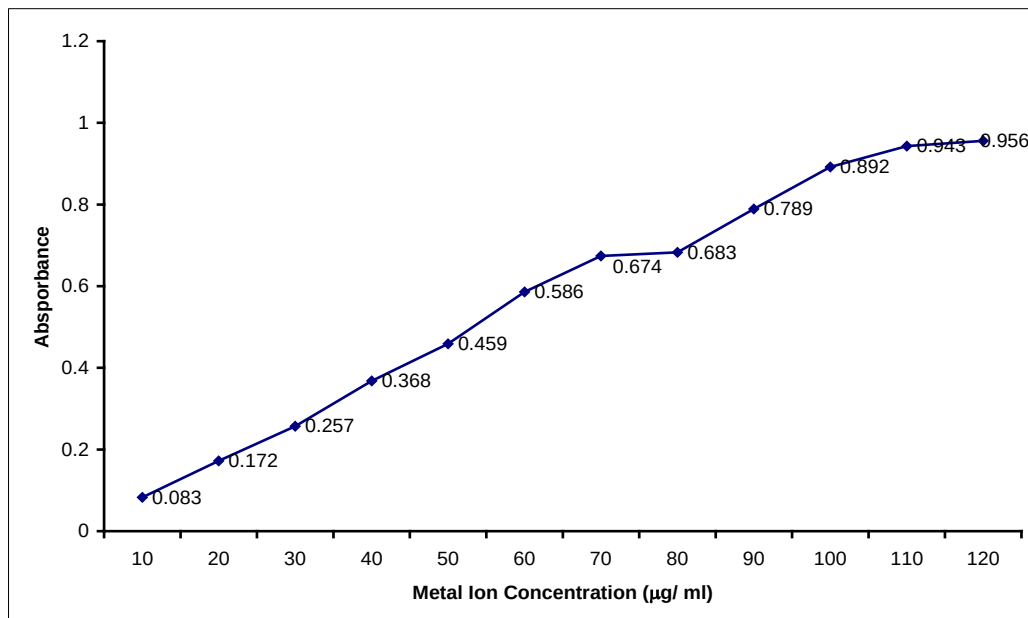


Fig. 3 Effect of metal ion concentration on the extraction of Co (II) with KBX

2.6 Effect of metal ion concentration on the extraction of cobalt (II) with KBX

Based on the optimum conditions described above, a calibration curve was constructed. To the 100 ml of water sample, metal ion solution containing 10-120 µg of cobalt (II) was added, and the analysis was carried out using the general procedure. The data is presented in Table 3 and the corresponding graph is shown in the Table 4 and Fig. 1. The sensitivity was found to be 9.4196 ng/ml for cobalt (II). The calibration plot discloses linearity in the concentration range 1.0 to 10.0 µg of cobalt (II) aliquots 8.0 µg/ml of cobalt (II) gave a standard deviation of 0.8426×10^{-3} while the coefficient of variation is 0.3286 per cent.

Table 4: Effect of metal ion concentration on the extraction of Co (II) with KBX.

Sl. No.	Cobalt	
	Amount of Cobalt µg	Absorbance
1	10	0.083
2	20	0.172
3	30	0.257
4	40	0.368
5	50	0.459
6	60	0.586
7	70	0.674
8	80	0.683
9	90	0.789
10	100	0.892
11	110	0.943
12	120	0.956

Volume of water : 100ml; pH :4.0; [KBX] : 5 ml of 0.5%
Shaking time: 3.0 minutes

2.7 Application of the developed method

The developed atomic absorption spectrometry methods for cobalt (II) was applied for determination industrial effluents

2.8 Analysis of spiked water samples for the determination of cobalt (II) using the proposed new method

The recovery of cobalt (II) from spiked water samples was examine using the general and recommended procedure. The results are given in table 5. The results show that the

developed method is applicable to analyses the spiked water samples with the percentage recovery being 99.5% this method was applicable for the analysis of real samples like fruit samples, industrial effluents samples.

Table 5: Determination of Cobalt (II) in spiked water samples with Potassium benzyl xanthate.

Sl. No.	Amount of Co added (µg)	Amount of Co found (µg)	Percent recover
1	15	14.76	98.4
2	30	29.86	99.5
3	45	44.39	98.5
4	60	59.35	99.3

Volume of water: 100 ml; pH 4.0; [KBX]: 5 ml of 0.5%
Shaking time: 3.0 min

2.9 Analysis of Industrial Effluents for the determination of cobalt (II)

The proposed method was applied for the determination of cobalt (II) in industrial effluents. Industrial effluents were collected in different industrial areas in Kurnool town (India). The analysis of was carried out according to the recommended procedure.

The data is presented in Table 6. The results obtained by the present method are in good agreement with ICOPES. Of the six sample analysed all the samples contain cobalt (II) in the concentrations from 0.396 ppm to 1.683 ppm.

Table 6: Determination of Cobalt (II) in industrial effluent using the Proposed New Method.

Name of the area Kurnool	Metal ion found (ppm) (Average value of these determination)	
	Cobalt	
	Present Method	ICPOES Method
Sample 1	1.39	1.392
Sample 2	1.68	1.683
Sample 3	1.312	1.312
Sample 4	0.396	0.396
Sample 5	0.734	0.734
Sample 6	0.864	0.864

Volume of water: 100 ml; pH 4.0; [KBX]: 5 ml of 0.5%
Shaking time: 3.0 min

2.10 General and recommended procedure

To the 100 ml of water sample, an aliquot of standard metal ion solution containing 10-120 µg of cobalt (II) was added the pH was adjusted to 4.0 with acetic acid – sodium acetate buffer solution. The solution was transferred into a separator funnel. To this, 5.0 ml of 0.5 percent potassium benzyl

xanthate (KBX) was added and the mixture was shaken vigorously for 3 minutes with 10.0 ml of methyl isobutyl ketone (MIBK). The two phases were allowed to separate, the organic layer was collected and analysed for cobalt (II) by atomic absorption spectrometry. The metal content was estimated at the conditions mentioned in Table 7.

Table 7: Conditions Employed for flame Atomic Absorption Spectrometer.

S. No	Element	Lamp Current (mA)	Wavelength (nm)	Slit (nm)	Flame gas
1	Co	30	240.7	0.2	A-AC

A-AC- Air acetylene

3. Conclusions

The results from the validation process show that this method is effective. The method was tested throughout every stage of the analytical process. This is the first time this adsorbent has been used to extract heavy metal ions. Flame atomic absorption spectrometry was used to measure the levels of the elements being studied. A detailed study was conducted to find the best conditions for the extraction process. Adsorption isotherms were created to determine how much metal can be adsorbed. This method has several advantages, including being simple, fast, and cost-effective, along with being sensitive. Several other elements do not interfere with the analysis. The selectivity of the reagent is improved by using suitable masking agents, which help reduce interference from ions like Fe (II), Fe (III), and Pb (II). Therefore, this method is recommended for the preconcentration and determination of cobalt (II) using AAS, especially at minor and trace levels, and it can also be used for analyzing real samples or industrial effluents.

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Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Informed consent statement:

Not applicable.

Data and materials availability

The data will be available upon request.

References

- Motojima K, Tetenuma K, Uchino K, Yonetani A. Analytical Sciences. 1988;4(3):287.
- Shkinev VM, Gomolitskii VN, Spivakov BYa, Geckeler KE, Bayer E. Talanta. 1989;36(8):861.
- Shimizu T, Koyanagi H, Shijo V, Saki K. Chemical Letters. 1986;3:319.
- Corsini A, Di Fruscia R, Harrmann O. Talanta. 1985;32(8B):791.
- Gareia V, Hernandez AM, Perez BJA. Analytica Chimica Acta. 1984;157(2):363.
- Satake M, Nagahiro T, Pura BK. Analyst. 1993;118(1):85.
- Danielsson LG, Magnusson B, Westerlund S, Zhang K. Analytica Chimica Acta. 1982;144:183.
- Ryabinin AI, Lammreva EA. Zhurnal Analiticheskoi Khimii. 1979;33(2):298.
- Gulp JH, Windham RL, Whealy RD. Analytical Chemistry. 1971;43(10):1321.
- Sachdev SL, West PW. Analytica Chimica Acta. 1969;44(2):301.
- Ali A, Yin X, Shin H, Ye M, Gu X. Analytica Chimica Acta. 1999;392(2):283.
- Kenderzder E, Turker AR. Analytica Chimica Acta. 2003;480(2):259.
- Taher MA. Asian Journal of Chemistry. 2003;15(3-4):1266.
- Mohammad Ali T, Ali M, Taherch R. Asian Journal of Chemistry. 2003;15(3-4):1331.
- Ueda K, Kubo K, Yoshimura O, Yamamoto Y. Bulletin of the Chemical Society of Japan. 1988;61(8):279.
- Nakashima S, Sturgeon PE, Willie SN, Berman SS. Analytica Chimica Acta. 1988;207(1-2):291.
- Kumamaru T, Okamoto Y, Kara S, Matsuo H, Kiboku M. Analytica Chimica Acta. 1989;218(1):173.
- Lachowicz E, Kaliszuk A. Analytical Chemistry. 1986;323(1):54.
- Donaldson EM. Talanta. 1989;36(5):543.
- Nebot J, Figuerola E. International Journal of Environmental Analytical Chemistry. 1989;36(4):241.
- De la Guardia M, Vital MT. Talanta. 1984;31(10A):799.
- At Suya I, Aryu K, Zhang Q. Analytical Sciences. 1992;8(3):433.
- Liu ZS, Huang SD. Analytica Chimica Acta. 1992;267(1):31.
- Borggaard OK, Christensen HEM, Nielson TK, Willems SM. Analyst. 1982;107(1281):1479.
- Darnemann A, Kleist H. Zeitschrift für Analytische Chemie. 1978;291(5):349.
- Sturgeon RE, Berman SS, Dasaulniers A, Rusdl DS. Talanta. 1980;22(2):85.
- Frigge C, Jackwerth E. Analytica Chimica Acta. 1993;271(2):299.
- Elci L, Sahin U, Ulgen A. Trace Elements and Electrolytes. 1998;15(2):106.
- Abdellatif HE, Ayad MM, Taha EA. Journal of Pharmaceutical and Biomedical Analysis. 1999;18(6):1021.
- Gucler K, Hugul M, Demirci Cekic S, Resat A. Talanta. 2000;53(1):213.
- Miller K, Mayer E, Haritz E, Wieteska E, Zioek A, Dizewinska A. Analytica Chimica Acta. 1996;330(2):251.

32. Edel H, Quick L, Cammann K. *Analytica Chimica Acta*. 1995;310(1):181.
33. Lazak A, Soltyk K, Ostapczuk P, Fijalek Z. *The Science of the Total Environment*. 2002;289(1):33.
34. Anzano JM, Gonzalez P. *Microchimica Journal*. 2000;64(2):141.
35. Satake M, Kano G, Puri BK, Usami S. *Analytica Chimica Acta*. 1987;199:209.
36. Kumamaru T, Okamoto Y, Yamamoto M, Obata Y, Onizuku K. *Analytica Chimica Acta*. 1990;232(2):389.
37. Capeool JL, Filgueiras AV, Lavilla L, Bendicho C. *Talanta*. 1999;50(4):905.
38. Kumar TP, Kumar Singh A. *Analyst*. 1999;124(1-2):1847.
39. Edel H, Quick L, Cammann K. *Analytica Chimica Acta*. 1995;310(1):181.
40. Komarek J, Stavinoha P, Gomiscek S, Somnier L. *Talanta*. 1996;43(8):1321.
41. Pena YPD, Lopez W, Burguera JL, Burguera M, Galignani M, Brunette R, *et al.* *Analytica Chimica Acta*. 2000;403(1-2):249.
42. Mandi CM, Mesaric S. *Zeitschrift für Analytische Chemie*. 1982;313(5):403.
43. Vidal Gandia MT, De la Guardia CM. *Analysis*. 1983;13(5):233.
44. Bhattacharya S, Das AK. *Journal of the Indian Chemical Society*. 1988;65(1):71.

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