Modern Chemistry & Applications
ISSN: 2329-6798

Research Article **Open Access**

Determination of Tellurium in Tellurium-Containing Organic Compounds by Microwave Plasma-Atomic Emission Spectrometry

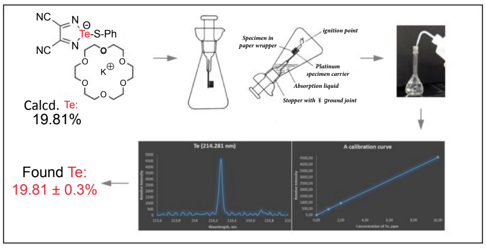
Lastovka AV[1,2], Fadeeva VP[1,2], Bazhenov MA[1,2] and Tikhova VD[1*]

[1]*NN Vorozhtsov Novosibirsk, Institute of Organic Chemistry, Siberian Branch of Russian Academy of Sciences, Russia*
[2]*Novosibirsk National Research State University, Russia*

Abstract

A method for determining tellurium in tellurium-containing organic compounds (TOC) by a microwave plasma-atomic emission spectrometer Agilent 4100 has been suggested. One of the sample decomposition methods - the oxygen flask combustion or the acid decomposition in a heating block-can be applied. Telluradiazole derivatives and some other TOC with 20 to 58% tellurium content have been analyzed. Elements such as nitrogen, sulfur, potassium, selenium present in the TOC do not prevent from determining tellurium. The relative error of the analysis is 1-5%.

Graphical Abstract (GA)



Telluradiazole derivatives and some other tellurium-containing organic compounds with 20 to 58% tellurium content have been analysed by MP-AES spectrometer Agilent 4100

Keywords: Tellurium containing organic compounds; Sample decomposition; Microwave plasma atomic; Emission spectrometry; Agilent 4100

Introduction

Chemistry of tellurium organic compounds (TOC) has intensively been developing in recent decades. The increased interest in this field is due to widely use of these substances as catalysts in organic reactions (e.g., rubber vulcanization), inhibitors of metal corrosion, insecticides, fungicides, components of special photographic materials, pharmaceuticals etc [1-5]. In view of great practical importance of these compounds for science and technology, a large number of analytical methods for the determination of tellurium in various objects were developed: gravimetric methods based on the precipitation of elemental tellurium by treating with inorganic and organic reducing agents, [6-8]; titrimetric methods based on redox reactions using iodide-anion, salts of iron(II), chromium(II) or titanium(III) as reducing agents, as well as potassium permanganate or dichromate as oxidizing agents for Te (IV), [9-11]; electrochemical methods, which allow one to determine the tellurium and selenium at simultaneous presence with a sensitivity being 10^{-5} M, [12-14]; spectrophotometric methods based on the formation of complexes with sulfur-containing organic reagents (diethyldithiocarbamate, thiurea, and their derivatives, bismuthiol II, and so on [15,16] or on the formation of ion pairs of tellurium acido complexes with organic bases-pyrazolone derivatives and rhodamine dyes [17-19]. Three spectrophotometric methods were used to determine small tellurium content in the environment (water, plant material, soil), and thin telluride films [20]. These methods are based on the formation of three differently colored Te-complexes. Magenta color was obtained by oxidation of 4-bromophenyl-hydrazine by tellurium in a basic medium followed by condensation of the product with N-(1-naphthyl) etylenediamine dihydrochloride. Red color was obtained by oxidation of 3-methyl-2-benzothiazolinone hydrazone hydrochloride followed by condensation with the chromotropic acid. Orange color was obtained by oxidation of 2,3-dimethoxystrichnidin-10-one in an acid medium. Beer's law was obeyed in the range of 1.0–25 mg mL^{-1} for magenta product, 0.7–20 mg mL^{-1} for red, and 0.3–15 mg mL^{-1} for orange. The authors noted that these methods were simpler and more sensitive than the other known ones, and standard deviations were 0.2–0.3%. Several dyes were proposed for the extraction-photometric determination of tellurium: victoria blue 4R, brilliant green, rhodamine 4C. The latter dye was used, for example, in the analyses of tellurium salt solutions and semiconductor films [21]. The extraction-photometric redox process was described for the selective determination of selenium(IV) and tellurium(IV) with the detection limit of $5 \cdot 10^{-5}$ mg L^{-1}, based on different oxidability of analytes by antimony(V) ion associates in acidic or alkaline media [22]. The method does not require either preconcentrating and separating analytes, or masking the associated components in analyte mixtures.The possibility of using benzal green as a reagent for the rapid determination of tellurium(IV) is shown by Amelin et al [23]. The dye was immobilized on viscose fabrics and it formed ion associate with molibdotellurous heteropolyacid with different color intensity. The range of detectable concentrations is 0.01-0.1 mg L^{-1} of Te(IV). Currently, spectrometric methods are most commonly used for the tellurium determination. Atomic absorption spectrometry was used in the analysis of geological samples (ores,

---

***Corresponding author:** Tikhova VD, NN Vorozhtsov Novosibirsk, Institute of Organic Chemistry, Siberian Branch of Russian Academy of Science, Russia, Tel: +73833306554; E-mail: tikhova@nioch.nsc.ru

Received June 24, 2017; **Accepted** July 06, 2017; **Published** July 10, 2017

Citation: Lastovka AV, Fadeeva VP, Bazhenov MA, Tikhova VD (2017) Determination of Tellurium in Tellurium-Containing Organic Compounds by Microwave Plasma-Atomic Emission Spectrometry. Mod Chem appl 5: 225. doi: 10.4172/2329-6798.1000225

minerals, rocks) with tellurium content 0.0-100 mg g^{-1}, [24], coal, [25], in lead and lead alloys [26], in the environment (water, plants, biological materials) [27-29]. Such techniques as atomic emission spectrometry (AES) with inductively coupled (ICP) or microwave (MP) plasma, in conjunction with mass spectrometry, [30-33], atomic fluorescence spectrometry, [34-36], the optical emission spectrometry [37] are used for the tellurium and tellurium trace analysis in various objects. In most of these works, tellurium is converted to the hydride before the spectrometric measurements to increase the sensitivity of the method. The atomic emission method with continuous hydride generation was used for the simultaneous determination of Sb, As, Bi, Ge, Se, and Te in a set of sediment samples [38]. The detection limit for Te was 6.5µg L^{-1}. The tellurium determination was made in the gold concentrate by ICP-AES [39]. It was shown that tellurium may be separated from the majority of interfering components (such as Ag, Pb, Zn, Si, Ca, Mg, Al, Fe) in the sample by coprecipitation with arsenic to eliminate the matrix effect. The detection limit of Te was 4.23 µg g^{-1}. Zhang et al. [40] investigated the possibility of group preconcentration of As, Cd, Se, and Te for the subsequent simultaneous determination of these elements by ICP-AES in the technogenic raw materials. Sorption of arsenic, selenium, tellurium, and cadmium oxyanions on iron, lanthanum, and magnesium hydroxides was used. The relative standard deviation of the method was 9–2.5% under the content of determined elements from 10^{-4} to 10^{-1}% mass. It was found that the presence of iron (> 500 µg mL^{-1}) can lead to 10% decrease of the Te (214.2 nm) signal. When new organotellurium compounds are synthesized they should be completely described. It requires quantitative determination of so-called basic biogenic elements (carbon, hydrogen, nitrogen) as well as tellurium. Unlike small tellurium content in the above-mentioned inorganic, biological and ecological objects of analysis, tellurium content in synthetic TOC may be up to tens of percent's. The first necessary step in TOC analysis is a complete decomposition of organic matter. In the few published studies on the analysis of TOC, they used wet decomposition in mineral acids, [41-43], burning in a stream of oxygen at 900950°C or the oxygen flask combustion. Afterwards, tellurium was determined by the methods of gravimetry potentiometry, [42], spectrophotometry [43]. The main disadvantages of all these methods are their long duration and tediousness. MP-AES method for the determination of tellurium in TOC has not previously been used, although it is characterized by high accuracy and selectivity, rapidity, efficiency, wide range of detectable concentrations, and it does not involve converting tellurium in a single analytical form. The aim of this work is finding the conditions for sample preparation (decomposition) and developing a procedure for quantitative determination of tellurium in synthetic multi-element tellurium-containing organic compounds by microwave plasma-atomic emission spectrometry using the Agilent 4100 spectrometer.

Experimental

Instruments. Analysis was performed with Agilent 4100 MP-AES (Australia) microwave plasma – atomic emission spectrometer. The sample supply system was a self-adjusted one-piece quartz torch. Plasma was generated by igniting with auxiliary argon and maintained with nitrogen. The configuration of the plasma was vertically-oriented with axial observation and computer-control of the plasma viewing position. A Curny-Terner monochromator, self-adjusted, with a 600 mm focal length was used. Holographic gitter with 2400 lines mm^{-1} was used. The spectral range was 178–780 nm and spectral resolution was 0.050 nm. A High-speed CCD detector, having 532 × 128 pixels, with a quantum efficiency of >90% was used; it was cooled to 0°C with a Peltier element. A double-pass glass cyclonic spray chamber and a One-Neb micronebulizer were used. Hot Block™ Digestion System (25-Well 100 ml) Agilent 4107 (Australia) was applied for acid decomposition of organic samples.The samples and reagents were weighed with Mettler Toledo AT20 (Switzerland) microanalytical balance and Sartorius CP224S (Germany) analytical balance. Reagents. Solutions of H_2O_2, KNO_3, HCl, HNO_3 (by Reakhim) were prepared from reagent-grade and high-purity chemicals. Oxygen gas from a cylinder with a purity of 99.7% was used for burning. The specimen holder was made of platinum wire (Ø=0.6–1.0 mm) with a purity of 99.99%. Blue ribbon ash-free filters were cut into 3 × 3 cm squares with 1-cm branches, impregnated with a saturated KNO_3 solution and dried; an H-type polyethylene film; glycerol, polyurethane foam, twice-distilled water. Reference substance – Certified reference standard sample of tellurium(IV) ions solution-MCO 0529: 2003 (GSO 6082-91) (Russia).

Results and Discussion

Analytical wavelength selection. Comparative measurements of the Te standard solutions were made at 3 wavelengths: 214.281; 225.902; 238.578 nm. The calibration curves were constructed followed by measurement of the Te solution (5 ppm) **(Table 1)**. It is clear from **Table 1** that only two emission lines are appropriate for the measurements. Atomic line 214.281 nm was selected due to its maximal intensity, but the measurement at this wavelength should be carried out after the full nitrogen purge of monochromator. Although this emission line is influenced by vanadium, tantalum, and cadmium, however, such elements are not encountered in the studied synthetic organic compounds. The study of sample decomposition. A tellurium-containing organic compound, 3,4-dicyano-1,2,5-telluradiazole (C_4N_4Te), was used to study the methods of sample preparation. Composition and structure of this substance is confirmed by elemental analysis, NMR, IR and MS spectrometry. The purity of the compound is 99.9%. When using the oxygen flask combustion, we tested 3 different solutions for absorbing the combustion products: 1) 10 mL of 0.1 M HCl; 2) 3 mL of HNO_3 (conc.)+5 mL H_2O+2 mL H_2O_2; 3) 10 mL of HNO_3 (conc.). The best results were obtained with absorbing mixtures 1) and 3). When using the nitric acid (8 mL HNO_3 (conc.)+2 mL of 30% H_2O_2) decomposition in the heating block, we experimentally selected the temperature of the reaction (from 60 to 130 °C) and the duration (45 to 60 min) of the process. Finally, satisfactory results were obtained after decomposition of the sample for one hour at 130°C. The following results were obtained in the discussed conditions (P=0.95; n=6): with the oxygen flask combustion –55.5 ± 1.7%; with the acid decomposition in the heating block –55.5 ± 0.3%. The calculated tellurium content in 3,4-dicyano-1,2,5-tellurodiazole is 55.1%. Therefore, both methods can be used to decompose the TOC when analyzing tellurium.

Procedures for the decomposition of tellurium-containing organic compounds

The oxygen flask combustion: A portion of 0.1M HCl (10 mL) was placed into a 500 mL Erlenmeyer's flask which was filled with oxygen from a cylinder. A weighed portion of a tellurium-containing compound (~2.0–3.0 mg) wrapped into a small square of a potassium nitrate-impregnated ash-free filter with a piece of polyethylene film was fixed on a Pt wire; the branch of the filter was ignited, placed into the flask, and burned. The combustion having been completed, the flask was thoroughly shaken for 5 min and placed into a fridge for 40 min to complete the absorption of combustion products. The acid decomposition in a heating block: A weighed portion of a tellurium-containing compound (~2.0–3.0 mg) was placed in polypropylene 100 mL vessel. HNO_3 (8 mL) and 30% H_2O_2 (2 mL) were added to the probe. The vessel was covered with a lid (not tightly) and placed in a heating block HotBlock™ Digestion System, Agilent 4107. It took 60 min at 130ºC to complete decomposition of the substance.

Citation: Lastovka AV, Fadeeva VP, Bazhenov MA, Tikhova VD (2017) Determination of Tellurium in Tellurium-Containing Organic Compounds by Microwave Plasma-Atomic Emission Spectrometry. Mod Chem appl 5: 225. doi: 10.4172/2329-6798.1000225

λ, nm	214.281	225.902	238.578
I, rel.	4885.9	1147.2	2127.8
The equation of the calibration curve	565.81 c_i-3.46	(80.98 c_i)/(1-0.04 c_i)	201.37 c_i-4.81
Approximation	linear	rational	linear
r (correlation coefficient)	1.00000	1.00000	0.99999
Found Te, ppm	5.04 ± 0.02	4.33 ± 0.11	5.08 ± 0.04

Table 1: The results of determining 5 ppm Te at three emission lines (P=0.95; n=7).

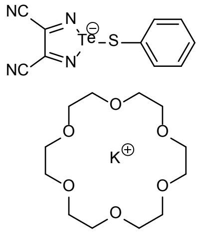
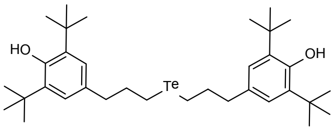
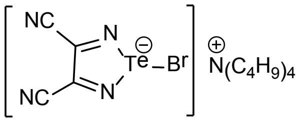
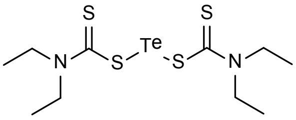
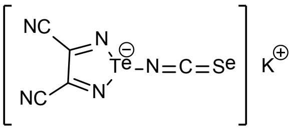
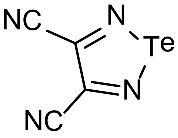
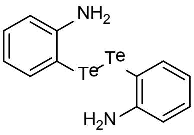
Substance	**Empirical formula**	**Calculated, % Te**	**Found, % Te**	
			The oxygen flask combustion	**The acid decomposition in heating block**
 1-Thiophenyl-3,4-dicyano-1,2,5-tellurodiazole 18-crown-6 potassium salt complex	$C_{22}H_{29}KN_4O_6STe$	19.81	19.81 ± 0.3	19.92 ± 0.3
 4,4'-(Tellurobis(propane-3,1-diyl)) bis(2,6-di-tert-buthylphenol)	$C_{34}H_{54}O_2Te$	20.50	20.72 ± 0.6	*
 Tetrabuthylammonium 1-bromo-3,4-dicyano-1,2,5-telluradiazolide	$C_{20}H_{36}N_5BrTe$	23.0	23.3 ± 1.0	23,6 ± 1.7
 bis(Diethylamino-thioxo-methanesulfenyl)tellane	$C_{10}H_{20}N_2S_4Te$	30.08	30.22 ± 0.13	29.9 ± 0.3
 Potassium 1-isoselenocyanato-3,4-dicyano-1,2,5-telluradiazolide	C_5N_5KSeTe	34.0	*	33.5 ± 1.2
 3,4-dicyano-1,2,5-tellurodiazole	C_4N_4Te	55.1	55.5 ± 1.7	55.5 ± 0.3
 2,2'-Ditellanediyldianiline	$C_{12}H_{12}N_2Te_2$	58.07	57.99 ± 0.18	57.89 ± 0.05

Table 2: Results of tellurium determination in TOC using two methods of sample preparation (P=0.95, n=5).

After the decomposition, the content of the flask or vessel were quantitatively transferred to a 100 mL volumetric flask rinsing its walls, stopper, wire or vessel with twice-distilled water and diluted to the mark. The tellurium content in the resulting solution was determined by MP AES using a preliminarily constructed calibration curve. Construction of calibration curves. The calibration curve was made using the solutions obtained with dilution of Certified reference standard sample of tellurium(IV) ions solution MCO 0529:2003 (GSO 6082-91) (Russia). We used 4 concentrations of Te(IV)–1, 5, 10, 15 ppm. The intensity of Te emission line at 214.241 nm was recorded on the spectrometer. The data were processed using the Agilent MP Expert software (version 1.4.0.4317). The conditions of measurements on the spectrometer were as follows: pressure in the spray chamber was 100 kPa, uptake delay–15 s, read time–3 s, stabilization time–15 s, pump speed–15 ppm, number of replicates–3, automatic background correction. A linear intensity dependence of the recorded signal (r ≥ 0.99998) was observed for reference substance solutions in this concentration range. Various tellurium-containing organic compounds have been analyzed according to the developed technique **(Table 2)**.

Conclusion

Thus, the method for the tellurium determination has been proposed. It combines the oxygen flask combustion or acid decomposition followed by measuring Te content by the MP-AES method. Such elements as nitrogen, sulfur, potassium, selenium, included in the TOC do not influence the quantitative determination of tellurium. Statistical processing was performed on the results obtained by the decomposition of 5–6 weighed portions of each substance. The relative error is in the range of 1–5%.

Acknowledgements

We are grateful to Prof. AV Zibarev and employees of the Laboratory of Heterocyclic Compounds (NIOCH SB RAS) for the samples provided for our study.

References

1. Comasseto J, Barrientos AR (2000) Add a Little Tellurium to Your Synthetic Plans. Aldrichimica Acta 33: 66-102
2. Petragrani N, Stefani H (2005) Advances in Organic Tellurium Chemistry. Tetrahedron 61: 1613-1679.
3. Petragrani N, Stefani H (2007) Tellurium in Organic Synthesis. London, UK: Academic Press.
4. Princival J, Dos SA, Comasseto J (2010) Reactive Organometallics from Organo tellurides: Application in Organic Synthesis. J Braz Chem Soc 21: 2042-2054.
5. Wei C, Lu W, Huaping Xu (2015) Selenium/Tellurium Containing Polymer Materials in Nanobiotechnology. Nano Today 10: 717-736.
6. Wang J, Cheng K (1970) Precipitation of Tellurium with Bismuthiol II. Microchem J 15: 607-621.
7. Asuero A (1979) Analytical Uses of Phenylhydrazines and Phenylhydrazones. I Microchem J 24: 217-233.
8. Singh N, Rastogi K, Agrawal R. (1985) Separation and Determination of Selenium(IV) and Tellurium(IV) by using Morpholine-4-carbodithioate. J Indian Chem Soc 62: 394-396.
9. Johnson R, Frederickson D (1952) Titration of Quadrivalent Tellurium with Thiosulfate. Anal Chem 24: 866-867.
10. Geiersberger K, Durst A (1952) A contribution to tellurium selenium analysis. Z Analyt Chem 135: 11-14.
11. Lenher V, Wakefield H (1923) The Volumetric Determination of Tellurium by Dichromate Method. J Am Chem Soc 45: 1423-1425.
12. Ivanova Z, Ignatenko E, Tarasova V (1973) Potentiometric and Amperometric Titration of Selenium and Tellurium using Ascorbic Acid. J Anal Chem 28: 1980-1984.
13. Locatelli C (2005)Overlapping Voltamperic Peaks - an Analytical Procedure for Simultaneous Determination of Trace Metals. Application to Food and Environmental Matrices. Anal Bioanal Chem 381: 1073-1081.
14. Terpinski E (1988) Spectrophotometric Determination of Trace Amounts of Tellurium(IV) with Tetramethylthiourea. Analyst 113: 1473-1475.
15. Yoshida H, Taga M (1966) Spectrophotometric Determination of Small Amounts of Tellurium with Bismuthiol II. Talanta 13: 185-191.
16. Nazarenko I, Ermakov A (1971) Analiticheskaya Chimiya Selena i Tellura. (Analytical Chemistry of Selenium and Tellurium). Moscow, USSR.
17. Balogh I, Andruch V(1999) Comparative Spectrophotometric Study of the Complexation and Extraction of Tellurium with Various Halide Ions and N,N′-di(acetoxyethyl)indocarbocyanine. Analyt Chim Acta 386: 161-167.
18. Suvardhan K, Krishna P, Puttaiah E, Chiranjeevi P (2007) Spectrometric Determination of Tellurium(IV) in Environmental and Telluride Film Samples. J Analyt Chem 62: 1032-1039.
19. Kish P, Balog I, Andrukh V, Goloib M (1990) Complex Formation and Solvent Extraction of Chlorotellurite with Cationic Violet. Zh Anal Khim 45: 915-919.
20. Sergeev G, Shlyapunova E. (2006) Highly Sensitive Determination of Selenium(IV) and Tellurium(IV) using Extraction-Photometric Redox Method. Analitika i Kontrol 10: 195–199.
21. Amelin V, Koroleva O (2009) Fabrics and Papers Modified with Analytical Reagents for the Test Determination of Selenium(IV) and Tellurium(IV). J Anal Chem 64: 1275-1278.
22. Torgov V, Vall G, Demidova M, Yatsenko V(1995) Extraction-Atomic Absorption Method for the Determination of Arsenic, Antimony, Selenium and Tellurium in Geological Samples. Chemical Geology 124: 101-107.
23. Oda S, Arikawa Y (2005) Determination of Tellurium in Coal Samples by Means of Graphite Furnace Atomic Absorption Spectrometry after Coprecipitation with Iron(III) Hydroxyde. Bunseki Kagaku 54: 1033-1037.
24. Mesko M, Pozebon D, Flores E, Dressler V (2004) Determination of Tellurium in Lead and Lead Alloy using Flow Injection–Hydride Generation Atomic Absorption Spectrometry. Analyt Chim Acta 517: 195-200.
25. Najafi N, Tavakoli H, Alizadeh R, Seidi S (2010) Speciation and Determination of Ultra Trace Amounts of Inorganic Tellurium in Environmental Water Samples by Dispersive Liquid-Liquid Microextraction and Electrothermal Atomic Absorption Spectrometry. Analyt Chim Acta 670: 18-23.
26. Kaplan M, Cerutti S, Salonin J, Gasguez J, Martinez L, et al. (2005) Preconcentration and Determination of Tellurium in Garlic Samples by Hydride Generation Atomic Absorption Spectrometry. J of AOAC International 88: 1242-1246.
27. Grotti M, Abelmoschi M, Soggia F, Frache R (2003) Determination of Ultratrace Elements in Natural Waters by Solid-Phase Extraction and atomic spectrometry methods. Anal Bioanal Chem 375: 242-247.
28. Yu C, Cai Q, Guo Z, Yang Z, Khoo S, et al. (2003) Speciation analysis of tellurium by solid-phase extraction in the presence of ammonium pyrrolidine dithiocarbamate and inductively coupled plasma mass spectrometry. Analyt Bioanal Chem 376: 236-242.
29. Quadros D, Borges D (2014) Direct analysis of alcoholic beverages for the determination of cobalt, nickel and tellurium by inductively coupled plasma mass spectrometry following photochemical vapor generation. Microchem J 116: 244-248.
30. Yang G, Zheng J, Tagami K, Uchida S (2013) Rapid and sensitive determination of tellurium in soil and plant samples by sector-field inductively coupled plasma mass spectrometry. Talanta 116: 181-187.
31. Yu S, Zhang H, Jin Q (1999) Study on determination of Tellurium by MIPAES. Gaodeng Xuexiao Huaxue Xuebao 11: 84-86.
32. Cava MP, Cervera M, Pastor A, Guardia M (2003) Hydride generation atomic fluorescence spectrometric determination of ultratraces of selenium and tellurium in cow milk. Analyt Chim Acta 481: 291-300.
33. Wang F, Zhang G (2011) Simultaneous Quantitative Analysis of Arsenic, Bismuth, Selenium, and Tellurium in Soil Samples using Multi-channel Hydride-Generation Atomic Fluorescence Spectrometry. Appl Spectr 65: 315-319.

34. Chen Y, Alzahrani A, Deng T, Belzile N (2016) Valence Properties of Tellurium in Different Chemical Systems and Its Determination in Refractory Environmental Samples using Hydride Generation Atomic Fluorescence Spectroscopy. Analyt Chim Acta 905: 42-50.
35. Kaplan M, Cerutti S, Moyano S, Olsina R(2004) On-line Preconcentration System by Coprecipitation with Lanthanum Hydroxide using Packed-bed Filter for Determination of Tellurium in Water by ICP-OES with USN. Instrumentation Sciences&Technology 32: 423-431.
36. Morrow A, Wiltshire G, Hursthouse A (1997) An Improved Method for the Simultaneous of Sb, As, Bi, Ge, Se, and Te by Hydride Generation ICP-AES: Application to Environmental Samples. Atomic Spectroscopy 18: 23-28.
37. Zhang H, Ni W, Xiao F, Mao X (2016) Determination of Selenium and Tellurium in Gold Concentrate by Arsenic Coprecipitation-Inductively Coupled Plasma Atomic Emission Spectrometry. Yejin Fenxi/Metallurgical Analysis 36: 32-36.
38. Doronina M, Shiryaeva O, Filatova D, Baranovskaya V (2013) Determination of Arsenic, Cadmium, Selenium, and Tellurium in the Technogenic Raw Materials after the Sorption Concentration on Hydroxydes using Atomic Emission Spectrometry with Inductively Coupled Plasma. Zavodskaya Laboratoriya Diagnostika Materialov 79: 3-7.
39. Kruse F, Sanftner R, Suttle J (1953) Volumetric Determination of Tellurium in Organic Compounds. Anal Chem 25: 500-502.
40. Masson M (1976) Microdetermination of Selenium, Tellurium, and Arsenic in Organic Compounds. Mikrochim Acta 65: 399-411.
41. Thavornyutikarn P (1973) Tellurium Analysis in Organotellurium Compounds by Atomic Absorption Spectroscopy. J Organomet Chem 51: 237-239.
42. Anisimova G, Klimova V (1980) Tellurium Determination in Organic Compounds. J Anal Chem 35: 607-609.
43. Clark E, Turaihi M (1976) A Rapid Procedure for the Determination of the Tellurium Content of Organotellurium Compounds. J Organomet Chem 118: 55-58.