

DETERMINATION OF THE CONTENT OF HF IN ZIRCONIUM ALLOYS WITH USING A WIDE BAND X-RAY EMISSION FILTER

O.P. OMELNYK, V.V. LEVENETS, A.YU. LONIN, I.V. SHEVCHENKO, A.O. SHCHUR

References:

1. Brown N.R., Todosow M., Cheng L Y., Cuadra A. Screening of Reactor Performance and Safety of Fuel and Cladding Candidates with Enhanced Accident Tolerance. TopFuel 2015 Conference Proceedings - oral presentations Part 1. Zurich, Switzerland 13-17 September 2015, 10 20.
2. Voevodin V.N., Neklyudov I.M. Problemy radiatsionnoi stoikosti konstruktsionnykh materialov yadernoi energetiki. *Visnik Kharkivs'kogo universitetu. Seriya fizichna «Yadra, chastinki, polya»*. 2006, 746, pp. 3-22 (in Russ.).
3. Zaimovskii A.S., Nikulina A.V., Reshetnikov N.G. Tsirkonievye splavy v yadernoi energetike. M.: Energoatomizdat, 1994. 252 p. (in Russ.).
4. Pilipenko N.N. Konstruktsionnye materialy dlya elementov oborudovaniya yaderno-energeticheskikh ustanovok. *Visnik Kharkivs'kogo universitetu. Seriya fizichna «Yadra, chastinki, polya»*. 2009, 859, pp. 44-50 (in Russ.).
5. Azhazha V.M., V'yugov P.N., Lavrinenko S.D., Lindt K.A., Mukhachev A.P., Pilipenko N.N. Tsirkonii i ego splavy: tekhnologii proizvodstva, oblasti primeneniya. Obzor. Khar'kov: NNTs KhFTI, 1998. 89 p. (in Russ.).
6. Gotvyans'kii Yu.Ya. Rokozhitsya N.M. Printsipi otrimannya yaderno-chistogo tsirkoniyu. Spetsial'na metalurgiya: vchora, s'ogodni, zavtra. Kiiv: NTUU «KPI». 2010, pp. 64-70 (in Ukrain.).
7. Pilipenko N.N. Issledovaniya i razrabotki po polucheniyu yaderno-chistogo tsirkoniyu i splava na ego osnove. *Voprosy atomnoi nauki i tekhniki. Seriya «Vakuum, chistye materialy, sverkhprovodniki»*. 2009, 6(18), pp. 12-18 (in Russ.).
8. Bezumov V.N., Dunaev A.I., Titov G.N. Issledovanie i razrabotka elektroliticheskoi tekhnologii polucheniya tsirkoniyu s nizkim (<0,01%) sodержaniem gafniya. *Voprosy atomnoi nauki i tekhniki. Seriya «Fizika radiatsionnykh povrezhdenii i radiatsionnoe materialovedenie»*. 1999, 2(77), pp. 14-19 (in Russ.).
9. Tumanov Yu.N. Plazmennye i vysokochastotnye protsessy polucheniya i obrabotki materialov v yadernom toplivnom tsikle: nastoyashchee i budushchee. M.: Fizmatlit, 2003. 760 p. (in Russ.).
10. Azhazha V.M., Borts B.V., Butenko I.M., V'yugov P. M., Voevodin V. M., Lavrinenko S. D., Neklyudov I. M., Pilipenko M. M., Vakhrusheva V. S., Buryak T. M., Sukhomlin G. D., Blagova V. O., Lindt K. A., Popov V. I., Ladokhin S. V., Chernyavs'kii V. B. Vyrobnystvo partii trubnikh zagotovok treks-trub ta vygotovlennya doslidno-promislovoi partii tvел'nikh trub zi splavu Zr1Nb iz vitchiznyanoi syrovyny. *Nauka ta innovatsii*. 2006, 6, pp.18–30 (in Ukr.).
11. Vakhrusheva V.S. Problemy sozdaniya proizvodstva tsirkonievogo prokata v Ukraine. *Voprosy atomnoi nauki i tekhniki. Seriya «Fizika radiatsionnykh povrezhdenii i radiatsionnoe materialovedenie»*. 2014, 2(103), pp. 62-68 (in Russ.).
12. Zats A.V., Levenets V.V., Omelnik A.P., Pistryak V.M., Shchur A.A.. Yaderno-fizicheskie metody v issledovanii materialov i izdelii tsirkonievogo proizvodstva. *XX mezhdunarodnaya konferentsiya po fizike radiatsionnykh yavlenii i radiatsionnomu materialovedeniyu, 10-15 sentyabrya 2012 g.: trudy konferentsii. Alushta, Krym, Ukraina*. 2012, pp. 142-143 (in Russ.).
13. Anil K. Mukherji. Analytical Chemistry of Zirconium and Hafnium. International Series of Monographs on Analytical Chemistry. 1970, 40, 283 p.
14. Azarenkov N.A., Kirichenko V.G., Levenets V.V., Neklyudov I.M. Yaderno-fizicheskie metody v materialovedenii: uchebnoe posobie Khar'kov: KhNU imeni V. N. Karazina, 2013. 300 p. (in Russ.).
15. Elinson S.V., Petrov K.I. Analiticheskaya khimiya tsirkoniyu i gafniya. M.: Nauka, 1965. 241 p. (in Russ.).
16. Brookes A. Studies on the analytical chemistry of hafnium and zirconium. Part II. Fluorimetric determination of hafnium in the presence of zirconium by using quercetin. *Analyst*. 1970, 95, 781-785.
17. Zel'tser L.E., Talipov Sh.T., Morozova L.A. Lyuminestsentnoe opredelenie tsirkoniyu i gafniya pri sovместnom prisutstvii. *Zhurnal analiticheskoi khimii*. 1980, 9(35), pp. 1747–1750 (in Russ.).
18. GOST 13997-68. Tsirkoniyu dnuokis' (tekhnicheskaya), tsirkonovyi kontsentrat i ogneupory na ikh osnove. Metody analiza. Ogneupory i ogneupornye izdeliya. M.: Izd.-vo standartov, 1975, pp. 605-660 (in Russ.).
19. Stempel. G. D. Emission Spectrographic Determination of Hafnium in Zirconium Dioxide. *Applied Spectroscopy*. 1973, 27(2), 129-132.
20. Baluch N. Z., Anwar K., Ifzal S. M., Mohammad D. Determination of hafnium in zirconium oxide using inductively coupled plasma emission spectrometry. *Journal of Radioanalytical and Nuclear Chemistry*. 1990, 141(2), 417-428.
21. Nabi Mehdi, Pouyan Shahbazi. A simple method for determining Hf in Zr and Zr alloys by ICP-AES. *Nuclear Science and Techniques*. 2009, 20, 340 343.

22. Smolik M., Jakóbk-Kolon A. Determination of microamounts of hafnium in zirconium using inductively coupled plasma atomic emission spectrometry and inductively coupled plasma mass spectrometry during their separation by ion exchange on Diphonix chelating resin. *Analytical Chemistry*. 2009, 81(7), 2685-2687.
23. Lura J. Powell, Paul J. Paulsen. Determination of hafnium in zirconium metal and Zircaloy 4 metal standard reference materials by isotope dilution spark source mass spectrometry. *Analytical Chemistry*. 1984, 56(3), 376-378.
24. Pitrus R.K. Determination of hafnium in zircaloy clad by means of INAA. *Journal of Radioanalytical and Nuclear Chemistry, Letters*. 1988, 127(4), 283-288.
25. Acharya R., Nair A.G.C., Reddy A.V.R., Goswami A. Standard-less analysis of Zircaloy clad samples by an instrumental neutron activation method. *Journal of Nuclear Materials*. 2004, 326, 80-85.
26. Smolik Marek, Polkowska-Motrenko Halina, Hubicki Zbigniew et al. Determination of hafnium at the 10-4% level (relative to zirconium content) using neutron activation analysis, inductively coupled plasma mass spectrometry and inductively coupled plasma atomic emission spectrometry. *Analytica Chimica Acta*. 2014, 806, 97-100.
27. Agrawal R. M., Jha S.N., Kaimal Rugmini et al. Determination of small concentrations of hafnia in zirconia by selective excitation energy dispersive X-ray emission spectrometry. *Fresenius' Journal of Analytical Chemistry*. 1994, 349(6), 434-437.
28. Levenets V.V., Omelnik A.P., Usikov N.P., Chernov E.A., Shchur A.A. Sistema rezheksii spektrometricheskikh impul'sov s elektrostatcheskim otkloneniem puchka protonov. *Zbirnik naukovikh prats' SNUYaEtaP*. 2008, 4(28), pp. 143-149 (in Russ.).
29. Levenets V.V., Omelnik A.P., Shchur A.A., Chernov E.A.. Ispol'zovanie rentgenovskogo fil'tra iz piroliticheskogo grafita pri opredelenii zheleza v tetrafluoride tsirkoniya. *Visnik Kharkivs'kogo universitetu, ser. "Yadra, chastinki, polya"*. 2007, vip.2(34), №777, pp. 84-88 (in Russ.).
30. Hasany S.M., Rashid F., Rashid A., Rehman H. Determination of traces of hafnium in zirconium oxide by wavelength dispersive X-ray fluorescence spectrometry. *Journal of Radioanalytical and Nuclear Chemistry, Articles*. 1990, 142(2), 505-514.
31. Afzal M., Hanif Javed, Hanif Imtiaz. Determination of zirconium and hafnium in solution by X-ray fluorescence spectrometry. *Journal of Radioanalytical and Nuclear Chemistry, Articles*. 1990, 139(2), 203-214.
32. Levenets V. V., Lonin A. Y., Omelnik O. P., Shchur A. O. PIXE in the studies of stable cesium sorption from water solutions. *X-Ray Spectrometry*. 2015, 44 (6), 447-450. DOI 10.1002/xrs.2626.
33. Levenets V. V., Lonin A. Y., Omelnik O. P., Shchur A. O. Comparison the sorption properties of clinoptilolite and synthetic zeolite during sorption strontium from the water solutions in static conditions: Sorption and quantitative determination of strontium by the method PIXE. *Journal of Environmental Chemical Engineering*. 2016, vol. 4, iss. 4PA, 3961-3966.
34. Anderson A.A., Vladimirkii Yu.B., Evgrafov A.A., Kogan M.T., Lyukshin E.N. Rentgenovskii monokhromator iz piroliticheskogo grafita. *Apparatura i metody rentgenovskogo analiza*. 1972, vyp. XI, pp. 32-38 (in Russ.).