Development of the Certified Reference Materials in the field of physical and chemical analysis. Reference Materials of the composition of aqueous solutions of yttrium and scandium ions

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Abstract. In this work is described to study on rare-earth elements scandium and yttrium were, the development of certified reference materials of aqueous solutions of yttrium and scandium ions.

In modern industry, the application and production of rare-earth metals (REM) is actively developing, due to the need for new highly efficient materials. The mineral resource reserves of rare and rare-earth metals in Russia take a one of leading place in the world. The quality of domestic deposits in the content of useful components, as well as a manufacturability, mining and processing conditions and availability not so good. At first, to prepare a rare-earth concentrate from crude ores, then it is sent to separation of individual elements.

In this work rare-earth elements scandium and yttrium were studied on.

Scandium (Sc) is mainly used to increase the strength of aluminum alloys, since has the same density with aluminum, but having a much higher melting point. Aluminum-scandium alloys are used in aviation and aerospace rocket production, as well as for the production of automobile engines. An important area of scandium oxide application is the computer ferrites production. Such ferrites less heat during magnetization reversal, which increases the speed of the computer’s magnetic memory. Scandium hydride is used in nuclear engineering as a high-temperature neutron moderator.

Yttrium (Y) is widely used in ferrous and non-ferrous metallurgy; it increases the electrical conductivity of aluminum, the heat resistance of nickel-chromium alloys, the hardness and wear resistance of cast iron, and improves the mechanical and magnetic properties of steel. Yttrium has high tensile strength and melting point; therefore, it is able to replace titanium in any its application. Yttrium alloys are used in the aerospace industry, nuclear power plants, the automotive industry and in gas-phase rocket engines.

According to the Federal Law of January 10, 2002 No. 7-FZ “On Environmental Protection”, the production of rare-earth metals is included in category I, which is mean that such enterprises have negative influence on the environment. Modern measuring instruments play an important role in this field [1]. So, the development of the reference materials for the modern measuring instruments to control the environmental pollution and rational use of the resources have been actual in Russia.

VNIIOFI has carried out the development of reference materials for the composition of aqueous solutions of yttrium and scandium ions in order to ensure traceability of measurements of these elements.
At first, foreign and domestic reference materials of the elements selected by VNIIOFI were analyzed. Characteristics of the domestic reference materials are shown in Table 1. Characteristics of the foreign reference materials are shown in Table 2.

**Table 1.** Characteristics of the domestic reference materials.

| Registration number | Name                                      | The certified characteristic (mass fraction), % | Accuracy of the certified value (at P = 0.95), % |
|---------------------|-------------------------------------------|-----------------------------------------------|--------------------------------------------------|
| GSO 6649-93, validity period of the UTSO certificate until 2012. | Standard sample of the mass fraction of yttrium in a solid base (SRM-165) | 1.00                                           | 0.02                                             |
| GSO 6604-93, validity period of the UTSO certificate until 2012. | Standard sample of the mass fraction of scandium in a solid base (SRM-89) | 1.00                                           | 0.03                                             |

**Table 2.** Characteristics of the foreign reference materials.

| Number and manufacturer | Name                                      | Certified performance (mass concentration) | Extended uncertainty (for k = 2) |
|-------------------------|-------------------------------------------|---------------------------------------------|---------------------------------|
| 40523 «Sigma-Aldrich Production GmbH» | Yttrium Standard for AAS (Yttrium Oxide) | 1000 mg / l                                 | ±6 mg / l                       |
| 68418 «Sigma-Aldrich Production GmbH» | Scandium Standard for AAS (Scandium Oxide) | 1001 mg / l                                 | ±6 mg / l                       |
| SRM 3167a, NIST         | Standard solution of yttrium (yttrium oxide) | 9,993 mg / g                                 | ±0,025 mg / g                   |
| SRM 3148a, NIST         | Standard solution of scandium (yttrium oxide) | 9,969 mg / g                                 | ±0,030 mg / g                   |

Our reference materials of the aqueous solutions of yttrium and scandium ions were developed by dissolving chips of high-purity rare-earth metals in 3M nitric and 1M hydrochloric acids. In the manufacture of the reference materials was used Russian raw materials:
- yttrium metal grade ItM-1 according to TU 48-4-208-72 with a mass fraction of yttrium of at least 99.8%.
- scandium metal distillate of the SKM-1 brand according to TU 48-4-483-87 with a mass fraction of scandium of at least 99.992%.

The mass fraction of the main component in them was calculated as the difference between 100% and the total content of impurities. The determining the purity of the carrier of the certified element was carried out on a Quantum-Z atomic absorption spectrometer. ETA-T (Kortek LLC, Moscow), which is part of the GET 196-2015. The values of the mass concentration of yttrium and scandium ions were calculated according to the preparation procedure and then confirmed by measuring on an optical emission spectrometer with inductively coupled plasma Ultima 2 (Horiba Jobin Yvon), which is a part of the Steat Prymary Standard GET 196-2015. The procedure measurements
"Reference method for measuring the mass fraction and mass concentration of rare-earth elements in alloys based on aluminum and nickel" was used.

The study of the instability of the reference materials was carried out in accordance with RMG 93-2015 “State system for ensuring the uniformity of measurements. Assessment of the metrological characteristics of the reference materials” by the isochronous method [2].

As a result of the studies values of mass concentration of the rare-earth metal ions and expanded measurement uncertainty were obtained (Table 3).

Table 3. Values of mass concentration of the rare-earth metal ions and measurements uncertainty

| Name                                      | Mass concentration g / dm³ | Extended uncertainty (at k = 2), % |
|-------------------------------------------|---------------------------|-----------------------------------|
| Reference material of the yttrium ions solution | from 0.95 to 1.05       | 1.0                               |
| Reference material of the scandium ions solution | from 0.95 to 1.05       | 1.0                               |

The VNIIOFI reference materials of the yttrium and scandium ions solutions will be produced in ampoules with volumes of 5 and 10 cm³ and can be used for calibration and verification of measuring instruments (used methods: atomic absorption, atomic emission, photometric, X-ray fluorescence and others), testing of measuring instruments to type approval, accuracy control of measurement results, certification procedure.

References.
[1] Federal Law dated 10.01.2002 No. 7-FZ “On Environmental Protection” (as amended on 12/27/2018)
[2] RMG 93-2015 “State system for ensuring the uniformity of measurements. Evaluation of the metrological characteristics of standard samples” (Moscow: Standartinform) 2016 32