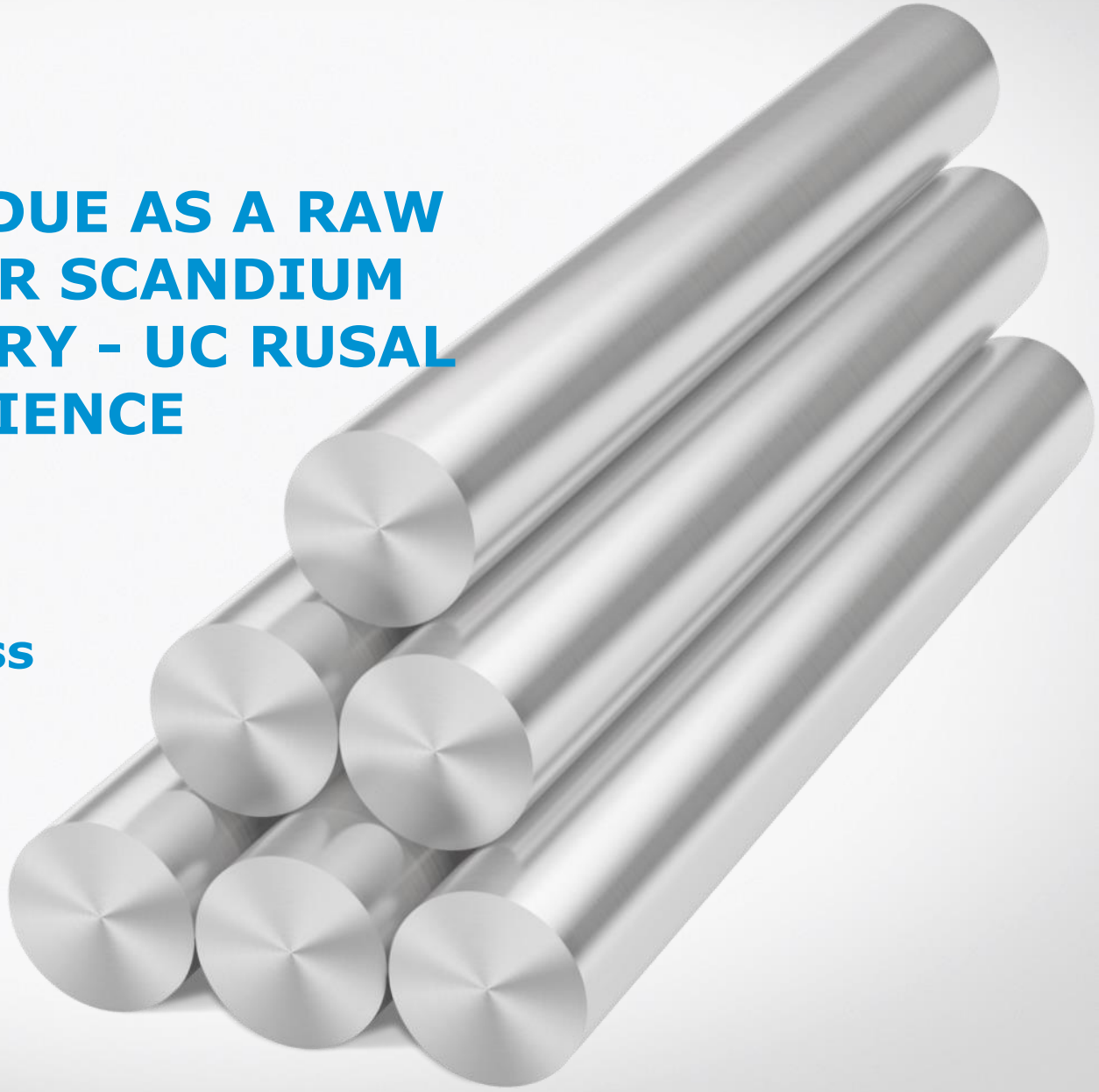
BAUXITE RESIDUE AS A RAW MATERIAL FOR SCANDIUM OXIDE RECOVERY - UC RUSAL EXPERIENCE



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1. Scandium sources

- scandium is an element widely dispersed in the Earth's crust and does not form industrially significant deposits of its own minerals. Average (bulk) scandium content in the Earth's crust amounts to 10 g/t (ppm);
- currently, scandium is produced as a by-product from the processing of Al-, Ti-, Zr-, U-, Ni- и W- containing ores.

Main Sc-containing ores in the world

Ores	Reserve, billion t	Sc, g/t	Scandium reserves,	
			KT	relat. %
Bauxites	**28.0**	**20-50**	**980**	**65**
Uranium ore	70.8	1-100	365	24
Titanium ore	0.8	10-150	64	4
Ni-Co laterite	0.6	50-500	90	6
Other	-	-	10	1
TOTAL	-	-	1509	100

1. Scandium sources

- over 60 % of the general expected reserves of scandium are concentrated in bauxite and laterite ores [1]. In the primary bauxite processing (the Bayer cycle), 95-98 % of scandium contained in the bauxite passes into bauxite residue – red mud (hereinafter – BR);
- scandium content in the bauxite depends on the geological material from which bauxite was formed during weathering. Ultrabasic and basic rocks (Gabro, basalts) contain 15-50 ppm S_2O_3; acidic and alkaline rocks (granites, syenites, nephelines) contain 1.5 ÷ 5 ppm) [2]. In course of the weathering process scandium is an inactive element as it tends to sorption.

1. V.N. Lavrenchuk, A.V. Stryapkov, E.N. Kokovin "Scandium in bauxites and clays". Kamensk-Uralsky, 2004, p. 291.

2. V.V. Ivanov, O.E. Eshko-Zakharova et al. "Geological guide book on siderophile and chalcophylic rear metals", M., Nedra, 1989, p. 462.

2. Scandium in Russian bauxites

in the northern part of European Russia three bauxite deposits are explored and operated with total bauxite reserves amounting to >1 billion tonnes.

2. Scandium in Russian bauxites

Sc_2O_3 content in the bauxites from the northern part of European Russia is as follows:

- North Urals bauxite deposit (hereinafter - SUBR) - up to 90 ppm [3];
- North Onega bauxite deposit (hereinafter - SOBR) - up to 120 ppm;
- Middle Timan bauxite deposit (hereinafter - STBR) - up to 70 ppm [3];

3. L.Z. Bykhovsky, V.V. Arkhangelskaya et al. "Scandium in Russia: prospects of raw-materials base and production development", VIMS, 2007, p. 45.

2. Scandium in Russian bauxites

Scandium content in the bauxite in the North of Russia is high as the bauxites were formed mainly from ultrabasic magmatic rocks rich in Sc [2].

Boehmite and diaspore contain up to 60 % of scandium in the bauxite generated in the North of Russia.

During the digestion of Al-containing minerals scandium becomes soluble in soda solution and adsorbed on BR surface.

Reserves and Sc content in RUSAL bauxite residue

Plant	Sc_2O_3, g/t BR	BR volume, MT	Sc_2O_3 reserves, t
BAZ (Russia)	180	60	7000
UAZ (Russia)	140	66	7000
Bauxitogorsk (Russia)	Up to 350	20	Up to 7500

3. Bauxite residue – prospective Sc-containing raw material

Two UC RUSAL's alumina refineries located at the Urals (UAZ and BAZ) annually dispose ~ 2 mln. tonnes of BR. Bauxite residue contains over 200 tonnes Sc_2O_3.

BR from the Urals refineries are characterized by the following:

- high scandium content (140-220 ppm as Sc_2O_3);
- BR readiness for processing (no cost for mining, beneficiation, and grinding);
- available infrastructure (existing alumina refineries with BRDAs) etc.

Average chemical composition of bauxite residue (Bayer process, STBR bauxite, RUSAL UAZ).

Content, wt. %											
SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	CaO	MgO	Na_2O	MnO	SO_3	CO_2	LOI
11.4	13.6	46.2	4.6	0.66	8.7	0.75	4.4	0.51	1.4	1.8	6.0

4. Main stages of scandium production by bauxite residue carbonation leaching

Production of pure scandium oxide (3N) from bauxite residue comprises the following stages:

- carbonation leaching of red mad to produce the solution containing up to 15 mg/dm^3 Sc_2O_3;
- concentrating of scandium by sorption-desorption and hydrolysis to produce the concentrate containing 25-60 % of Sc_2O_3;
- purification of Sc-containing concentrate via double salt to produce commercial grade $Sc_2O_3 \geq 99.9$ wt. % (hereinafter designated as 3N);
- two-stage calcination of scandium oxalate.

5. Process flow diagram of carbonation technology for production of scandium concentrate from bauxite residue at pilot plant*

Red mud → Leaching

Digested red mud → Filtration → Disposal

Sc product liquor → Sorption

Spent liquor from sorption → To red mud leaching

Sorption → Desorption

Product regenerated Sc → Hydrolysis I

Hydrolysis I → Filtration

Liquor w/o impurities

Filtration → Hydrolysis II

Hydrolysis II → Filtration

Filtration → Sc-concentrate (25-60% Sc_2O_3)

To produce 99.9 % Sc_2O_3

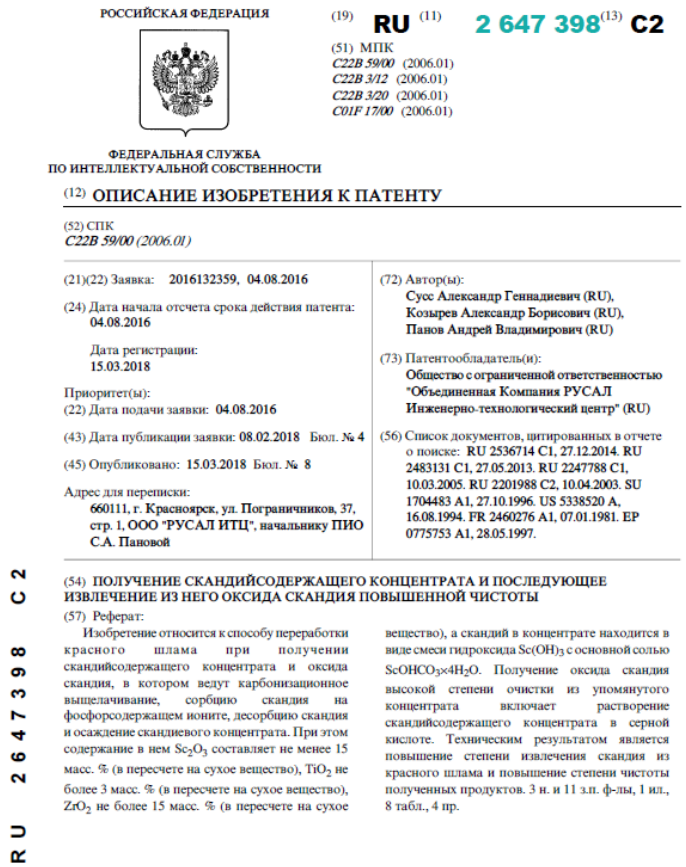
*the process is implemented at RUSAL – Kamensk-Uralsky (Urals aluminium smelter)

6. Sc concentrate purification process

To produce commercial Sc_2O_3 complying with market requirements the technology for scandium concentration and purification was developed, based on the solubility of scandium hydroxide in sulphuric acid to form the following compound type:

$$[Sc(SO_4)_3]^{3-}$$

The technology is covered by a patent (Figure 1) and implemented at UAZ Pilot Plant.



РОССИЙСКАЯ ФЕДЕРАЦИЯ

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(54) **ПОЛУЧЕНИЕ СКАНДИЙСОДЕРЖАЩЕГО КОНЦЕНТРАТА И ПОСЛЕДУЮЩЕЕ ИЗВЛЕЧЕНИЕ ИЗ НЕГО ОКСИДА СКАНДИЯ ПОВЫШЕННОЙ ЧИСТОТЫ**

(57) Реферат:

Изобретение относится к способу переработки красного шлама при получении скандийсодержащего концентрата и оксида скандия, в котором ведут карбонизационное выщелачивание, сорбцию скандия на фосфорсодержащем ионите, десорбцию скандия и осаждение скандиевого концентрата. При этом содержание в нем Sc_2O_3 составляет не менее 15 масс. % (в пересчете на сухое вещество), TiO_2 не более 3 масс. % (в пересчете на сухое вещество), ZrO_2 не более 15 масс. % (в пересчете на сухое вещество), а скандий в концентрате находится в виде смеси гидроксида $Sc(OH)_3$ с основной солью $ScOHCO_3 \times 4H_2O$. Получение оксида скандия высокой степени очистки из упомянутого концентрата включает растворение скандийсодержащего концентрата в серной кислоте. Техническим результатом является повышение степени извлечения скандия из красного шлама и повышение степени чистоты полученных продуктов. 3 н. и 11 з.п. ф-лы, 1 ил., 8 табл., 4 пр.

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Стр.: 1

Figure 1 RU 2 647 398 Patent

7. Benefits of carbonation-sorption technology for production of scandium oxide developed by UC RUSAL

- supply of own raw materials;
- the technology was developed using the proprietary raw materials and it is protected by patents;
- this is the world's only current technology implemented to produce scandium oxide from bauxite residue;
- scandium production process does not provide for the use of acids at the stage of extraction and concentration of scandium; therefore, it does not have any acid and salt effluents;
- Bauxite residue, from which scandium was extracted, is prepared for further processing into other commercial products or for storage in an 'ultra-dry' way, which allows reducing the capital expenditures for the construction of BR disposal areas by approximately 30%;
- the application of kiln gases as reagents provides for decrease of the operating costs and reduction of carbon dioxide emissions (greenhouse gases);
- scandium oxide of the specified quality can be produced for the needs of own production of Al-2%Sc master alloys and Al-Sc alloys;
- it is possible to flexibly increase production as the market for scandium develops.

8. Conclusions

1. The process of 3N Sc_2O_3 production has been proven at a pilot scale by operation of the pilot plant at UC RUSAL's alumina refinery.
2. The developed technology enables the production of scandium oxide at c/c ~ 472 US$/kg that is significantly lower than the current market value (~ 1000 US$/kg).
3. Availability of UC RUSAL's own facilities for scandium oxide production and efficient technology for production of Al-2%Sc master alloys and Al-Mg-Sc alloys with low Sc content provide for reduction of expenditures for alloy production by ≥ 2 times.
4. UC RUSAL is ready to consider various options for cooperation including the following:
    - sale of a license for the developed suite of technologies;
    - establishment of the facilities for joint production of scandium oxide, master alloys, alloys, etc. with prospective customers.

Thank you for your attention!
Questions please?

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