

## ANNOTATION

Dissertations for the degree of Doctor of Philosophy (PhD) in educational program 8D07201– Metallurgy

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### **«PHYSICAL AND CHEMICAL STUDY OF THE PURIFICATION PROCESS OF ZINC SULPHATE SOLUTIONS WITH INCREASED IMPURITY CONTENT»**

#### **Relevance of the dissertation topic.**

The depletion of reserves of free-milling ores of non-ferrous metals, including zinc, observed throughout the world, in particular in Kazakhstan, is the reason why low-quality concentrates containing these metals have to be increasingly involved in the metallurgical processing process. In the process of processing such concentrates by the hydrometallurgical method, solutions are formed that are characterized by an increased content of impurities, especially iron. Iron is present in such solutions in the divalent and trivalent states. The processing of such solutions is currently very problematic.

The relevance of the dissertation lies in the development of a promising technology for the purification of sulfate zinc solutions of complex composition, formed as a result of atmospheric leaching of low-quality zinc raw materials. The amount of impurities in such solutions, especially the amount of iron, is 15-16 times higher than the amount of impurities in solutions obtained after traditional roasting. The work is aimed at expanding the raw material base of zinc hydrometallurgical production by involving low-quality raw materials in processing and increasing their environmental safety. The work also explored the possibility of additionally obtaining an environmentally safe product - hematite by precipitating iron released from impurities.

**The purpose of the dissertation work.** Physical and chemical research and development of technology for removing impurities from zinc sulfate solutions obtained after atmospheric direct leaching of low-grade zinc concentrates.

#### **Scientific novelty of the obtained results:**

- It was established that in the process of electrooxidation of Fe(II) ions to Fe(III) ions in a zinc sulfate solution in the anode chamber of the membrane electrolyzer, almost complete oxidation of iron occurs, the conversion depth was 99.8-99.9%.

- The rate of iron oxidation reaction was determined to be 2.7-3.1 g/dm<sup>3</sup>. It was established that the process occurs in the diffusion mode, since the rate depends on the intensity of the electrolyte supply.

- The content of iron (no more than 0.01 g/dm<sup>3</sup>) and copper (no more than 0.6 mg/dm<sup>3</sup>) in the zinc sulfate solution sent for electrolysis was determined.

- It was experimentally shown that the use of hematite ( $\text{Fe}_2\text{O}_3$ ) as a catalyst made it possible to significantly accelerate the iron precipitation process and ensure its completion within 180 minutes with the addition of 20-30 g of catalyst. - The filtration rate of the ferrous sediment is  $1.5\text{-}2 \text{ m}^3/\text{m}^2\cdot\text{h}$ , which allows eliminating the thickening operation from the process flow chart.

- Optimal parameters have been established for the process of electrocementation of copper and nickel contained in zinc sulfate solutions, ensuring copper extraction of more than 99%, and nickel extraction of up to 70% when they are reduced in the cathode chamber of the membrane electrolyzer.

#### **The main provisions submitted for defense.**

- hydroxide forms of Fe(III) form filterable precipitates, which allows eliminating the thickening operation from the process flow chart.

- results on the precipitation of iron (III) ions in a solution obtained by electrooxidation in the form of hematite under atmospheric conditions;

- results on the determination of the separation parameters of copper and nickel ions in a solution obtained after hydrolytic treatment in the cathode chamber of a membrane electrolyzer by the electrocementation method and the subsequent operation to obtain cathode zinc from an electrolyte solution purified from impurities.

#### **Practical significance of the work.**

- a technological scheme has been proposed for purifying low-grade zinc sulfate solutions from impurities using a membrane electrolyzer, providing a cathode zinc yield of 89%;

- a method is proposed for isolating iron in the form of hematite during the hydrolytic purification of zinc sulfate solutions, which ensures the environmental safety of the process;

- the possibility of using ferrous metallurgy slag has been shown, which opens up prospects for the recycling of industrial waste.

#### **Publications and approbation of the work.** The main scientific results of the dissertation 5 articles published, including:

Two articles in a journal included in the Scopus and web of science database.

- Liakyn L., Onalbayeva Zh.S., Kulenova N.A., Daumova G.K., Mamyachenkov S.V., Anisimova O.S. Research of the process of purification of sulfate zinc solution from iron ions using anodic oxidation // Metals. – 2023.13(1). P.88 URI: <https://www.mdpi.com/2075-4701/13/1/88> - Scopus (Q2 (2 квартиль), процентилі 76).

- Liakyn L., Onalbayeva Zh., Daumova G., Mamyachenkov S., Kulenova N., Anisimova O, A Novel Hematite-Catalyzed Approach for Iron Removal from Zinc Sulfate Solutions // ES Materials and Manufacturing. – 2025. 27. P.1436. DOI: <https://dx.doi.org/10.30919/mm1436> - Scopus (Процентилі 95).

Three articles in journals recommended by the Committee for Control in the Sphere of Higher Education and Science of the Ministry of Higher Education and Science of the Republic of Kazakhstan.

- Лиақын Л., Оналбаева Ж.С., Мамяченков С.В.,  $\text{Fe}^{2+}/\text{Fe}^{3+}$ - $\text{Zn}^{2+}$ - $\text{SO}_4^{2-}$ - $\text{H}_2\text{O}$  жүйесіндегі тепе-теңдікті Eh-pH (пурбэ диаграммасы) диаграммасы

арқыллы термодинамикалық зерттеу. Вестник ВКТУ им Д.Серикбаева. – 2020. №3. С.21–25.

- Лиакын Л., Оналбаева Ж.С., Мамяченков С.В., Куленова Н.А., Даумова Г.К.  $Fe^{3+}$  иондарын гидролитикалық тұндыру процесін потенциометриялық титрлеу әдісімен зерттеу // Наука и техника Казахстана. – 2024. № 1. С. 184–195.

- Liakyn L, Mamyachenkov S., Onalbayeva, Zh.S., Anisimova O.S., Daumova G.K. Purification of complex solution of zinc sulfate from copper ions by electrocementation method. Труды университета. – 2024. №4. С. 47–51.

The main results were presented at the international conference:

- Liakyn L, Onalbaeva Zh.S., Dusipkanova B.Ә., Nurmukhambetova M.M., Belgibaeva A.Zh. Review of methods for purifying zinc sulfate solutions with a high content of impurities Conference // Subsoil of Kazakhstan - the basis of stability and prosperity of the country: Materials of the International scientific and practical conference dedicated to the 120th anniversary of K.I. Satpayeva – Ust-Kamenogorsk: EKSTU, 2019. p.209-211

### **The structure and scope of the dissertation.**

The dissertation consists of an introduction, 4 chapters, conclusion, 3 appendices. The work is laid out in 129 pages of typewritten text, contains 16 tables, 63 figures. The list of used sources includes 100 titles.