Project name: IRN AP1487188 “Development of technology for producing effective cathode material for creating competitive sodium-ion batteries”

Relevance: The rapidly growing demand in the world for lithium-ion batteries (LIB) is associated with the use of LIB in mobile electronic devices, hybrid and electric vehicles, and in systems of alternative energy sources. But the limited supply of lithium on earth, its high cost and increasing needs require the creation of chemical current sources (CHS) based on other cheap and abundant metals, for example, sodium to create sodium-ion batteries (SIB). The relevance of developing technology for producing effective cathode materials for scientific research is due to the fact that they are key

HIT components, which mainly determine the final energy density and cost of the battery. But cathode materials in NIB generate lower energy densities compared to LIBs, because Na+ ions have a large ionic radius and redox potential. Therefore, it is necessary to develop a technology for producing more efficient sodium-containing cathode materials for scientific research.

Goal: to develop a technology for producing effective cathode material, including nanomaterial, capable of increasing the capacitive and specific energy parameters of existing sodium-ion batteries (SIA) to the level of lithium-ion batteries (LIB).

Expected and achieved results:

As a result of the research work carried out, a technology for producing effective polycrystalline cathode materials for scientific research will be developed. A technology has been developed for obtaining

glass-crystalline phase of sodium iron orthophosphates by the melt method under the influence of concentrated optical radiation. Polycrystals of sodium iron orthophosphate obtained from the glass phase are characterized by improved texture, pronounced crystallinity and higher ionic conductivity than polycrystals synthesized by the solid phase method. Moreover, it was established that the rate of formation of polycrystalline phases increased by 2 times compared to the solid-phase method. It has also been established that the ionic conductivity of polycrystalline samples of sodium iron orthophosphates increases when doped with chromium atoms in the concentration range $0 \leq x \leq 0.06$. In addition, a technology for producing sodium iron and chromium orthophosphates by microwave synthesis was established.

All tasks planned according to the calendar plan have been fully completed. The following publications have been published for 2023.

1. Structure and electrochemical properties of a cathode based on $NaFePO_4F$ polycrystalline in sodium ion batteries. Vestnik PGU im. S. Toraigyrova. 2023, No. 2, pp. 241-247 (**KOKSON**).

2. Nogai A.S., Nogai A.A., Nogai E.A., Bush A.A., Uskenbaev D.E. Influence of substitutions on the structure of ionic conductivity and phase transition in the

system of $Na_3Fe_{2(1-x)}Sc_{2x(}PO4)_3$ (0x0.06) solid solutions. Eurasian Journal of Physics and Functional Materials. 2023, V.7, No.2, P. 107-114. (**Scopus. Percentile 20**).

3. A.S. Nogai, A.A., Nogai, D.E. Uskenbaev, A.B. Utegulov, E.A., Nogai and D.D. Toleugulov. Features of Structures and Ionic Conductivity of $Na_3Fe_2(PO_4)_3$ Polycrystals Obtained by Solid Phase and Melte Methods. Ceramics 2023, V. 6, pp. 2295–2230. (**Scopus and WoS, Q2**)

Conference materials:

4. Toulegaliev D.D., Nogai A.A., Nogai A.S. Synthesis of samples of $Na_3Fe_{2(1-x)}Cr_{2x}(PO_4)_3$ ($0\leq x\leq 0.06$) solid solutions and their conductive properties. .International scientific and practical conference "Seifullin Readings – 19: dedicated to the 110th anniversary of M.A. Gendelman. Astana, 2023, volume I, Part V, pp. 145-147.

5. Nogai A.S., Nogai A.A., Nogai E.A. Toleugol D.D., Bush A.A., Utegulov A.B. The influence of technological factors during the synthesis of Na3Fe2(PO4)3 polycrystals on their structure. Collection of reports of the XIII Issyk-Kul International School-Conference on Radiation Physics, dedicated to the 90th anniversary of A.A. Alybakov - founder of solid state physics in the Kyrgyz Republic, Bishkek, 2023, pp. 124 – 127.

Research team members:

1. Project manager – Nogai Adolf Sergeevich.
2. Leading researcher of the project – Bush Alexander Andreevich.
3. Senior researcher of the project – Daniyar Uskenbaev. Yesenkulovich.
4. Project researcher – Artur Adolfovich Nogai.
5. Project researcher – Arman Bolatbekovich Utegulov.
6. Junior researcher of the project – Sakipov Nazhmitden Berekeliuly.
7. Project laboratory assistant – Uskenbaev Alisher Daniyarovich
8. Project laboratory assistant – Toleugaliev Damir Darkhanovich

Information for potential users:

Of practical interest are cathode materials capable of generating a specific energy capacity of 145 - 200 mAh/g in the composition of NIA in the voltage range from 2.3 to 4.5 V. There are currently no such NIA, because There are no effective sodium-containing cathode materials.