Project name: IRN AP1487188 «Development of technology for obtaining an efficient 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, as well as in alternative energy systems. But the limited reserves of lithium on earth, its high cost and growing demand require the creation of chemical current sources (CPS) based on other cheap and common metals, for example, sodium for creating sodium-ion batteries (SIB). The relevance of developing a technology for obtaining efficient cathode materials for SIB is due to the fact that they are the key components of the CPS, which mainly determine the final energy density and cost of the battery. But the cathode materials in LIBs generate lower energy densities compared to LIBs, since Na+ ions have a large ionic radius and redox potential. Therefore, it is necessary to develop a technology for obtaining more efficient sodium-containing cathode materials for SIB.

Purpose: to develop a technology for obtaining an efficient cathode material, including a nanomaterial capable of increasing the capacitive, specific energy parameters of existing SIB to the level of LIB.

Expected and achieved results:

1. A conceptual model of a competitive SIB will be created by increasing the efficiency of the cathode material.
2. Technologies will be developed for obtaining efficient cathode materials for SIB by the methods of mechanical and solid phase synthesis.
3. Technologies will be developed for obtaining efficient cathode materials for SIB by methods of exposure to optical, microwave and laser radiation.
4. A technology for obtaining efficient composite cathode materials for SIB will be developed.э
5. A technology for nanostructuring cathode materials will be developed to obtain homogeneous-mixed nanomaterials with specified particle sizes for SIB.
6. The structures and electrophysical parameters of the synthesized samples will be investigated.
7. The electrochemical parameters and characteristics of cathode materials in the composition of SIB will be investigated.
8. A physicochemical analysis of the synthesized samples will be carried out in order to identify criteria for the search for effective cathode materials for SIB.
9. Cathodes based on synthesized materials and a laboratory model of SIB will be manufactured. Test tests of cathodes as part of NIB will be carried out, including life tests. Based on the results obtained in the project, at least 3 (three) articles or reviews will be published in peer-reviewed scientific journals, indexed in the Science Citation Index Expanded Web of Science database or having a CiteScore percentile in the Scopus database of at least 50 (fifty), and not less than 1 (one) article or review in a peer-reviewed foreign or domestic publication recommended by COXON. The results of the work will be reported at international conferences. On this topic, it is planned to file a patent with the Kazakh or Eurasian patent bureau and publish a book or chapter of a book in foreign or Kazakh publishing houses.

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Information for potential users: Of practical interest are cathode materials capable of generating a specific energy capacity of 145–200 mAh/g in the voltage range from 2.3 to 4.5 V as part of SIB. There are currently no such sodium-containing cathode materials. Therefore, it is necessary to increase the efficiency of cathode materials for SIB. We plan to create a SIB model based on the developed cathode materials with a specific energy consumption of at least ~ 145 mAh/g in a wide voltage range. The creation of effective sodium-containing cathode materials will help reduce the cost of SIB. Technology for obtaining efficient cathode materials for NIA is planned to be protected by a patent. The presence of a patent can facilitate the launch of production facilities for the production of competitive NIB in large cities of the Republic of Kazakhstan, where there are production facilities for the production of lead-acid batteries. Additional Information: To assess the efficiency of using sodium and lithium materials in metal-ion batteries (MIB) as a cathode material, the main parameters of these two types of MIB were compared in [1] (Table 1).

Table 1 - Main characteristics of cathode materials Na and Li in MIB

Parameters	Cathode - sodium (Na)	Cathode - lithium (Li)
Price	0.07–0.37 evro $кg^{-1}$	4.11–4.49 евро $кg^{-1}$
Energy intensity	1.16 Ah/g^{-1}	3.86 Ah/g^{-1}
Working voltage	– 2.7 В	– 3.0 В
Ionic radius	0.98 Å	0.69 Å
Melting temperature	370.7 K	823.5 K
Note - Compiled according to the source [1]		

It follows from the tabular data that if the energy intensity in NIA is increased to LIB, then the cost of NIA will be significantly lower than LIB. Therefore, NIAs may be more competitive than LIBs.

Literature

1 Thackeray M.M., Wolverton C., Isaacs E.D. Electrical energy storage for transportation – approaching the limits of, and going beyond, lithium–ion batteries. Energy & Environ. Sci. – 2012. – Vol. 5, №7. – P. 7854-7863.