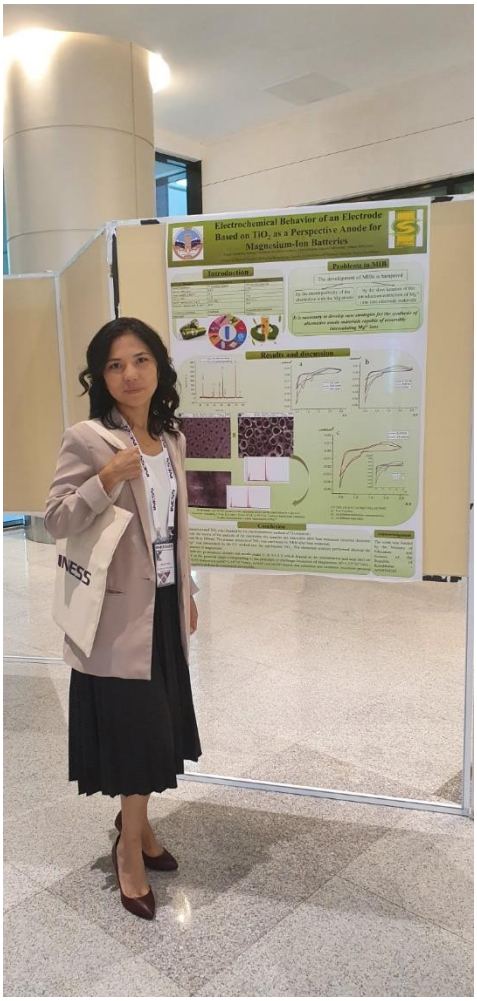
Brief information about the project

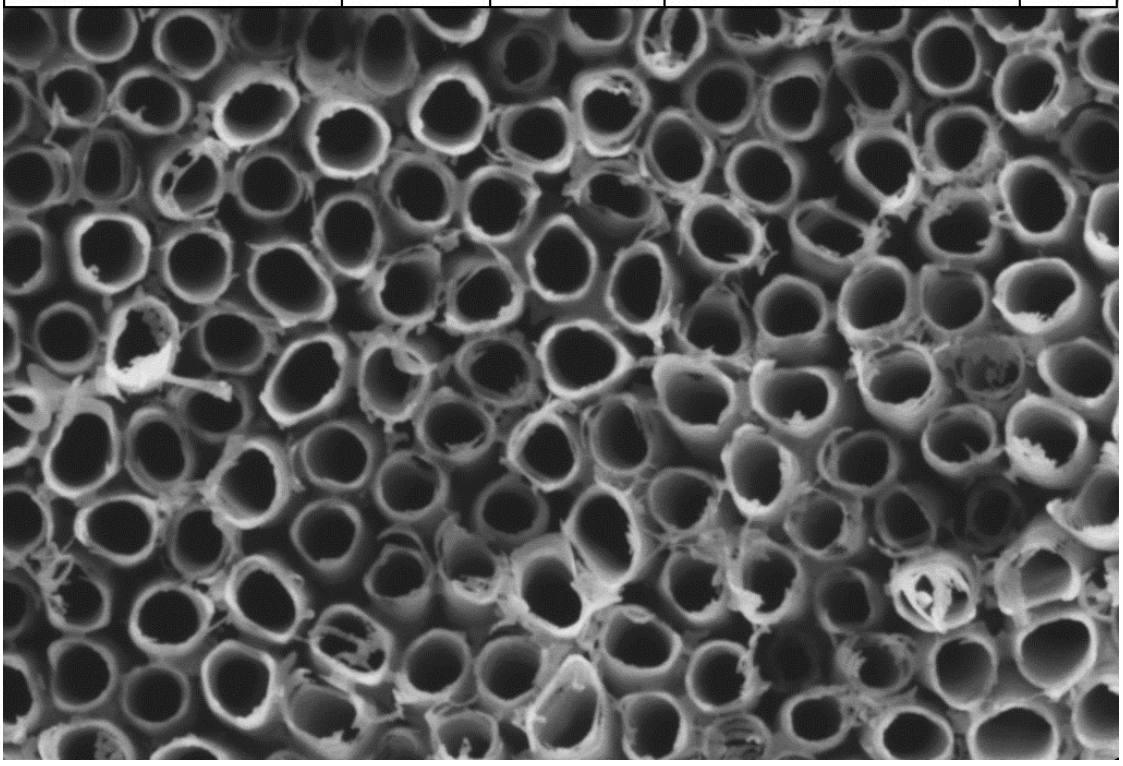
Name of the project	AP09260383 «Development of a reversible anode for magnesium ion batteries»
Relevance	The development of electronic technology (electric transport) and the appearance of a large number and varieties of gadgets in recent years is causing more and more interest in energy storage technologies. So far, lithium-ion batteries have been the solution to this problem. However, their explosiveness, insufficient ability to store energy, small operating temperature range, low resistance to overcharging and full discharge, difficulty charging at sub-zero temperatures, and relatively high cost makes it necessary to look for other alternatives. One of these alternative solutions is magnesium batteries. The advantages of magnesium are high density, a melting point of magnesium is higher than that of lithium, safety, the ability to hold a charge for a long time, availability, and prevalence in the earth's crust. In this project, nanostructured titanium oxide is proposed as the starting material for alternative anode active materials since it easily adsorbs magnesium on the surface and has a very high surface area. For magnesium batteries, this type of anode material is still poorly understood.
Purpose	This project aims to synthesize an intercalating anode for magnesium-ion batteries, which ensures the safety and high specific characteristics.
Objectives	1) Selection of the optimal composition of the anode material for chemical current sources and determination of their electrochemical characteristics using a complex of physical and chemical research methods. 2) Study of the effect of intercalation of magnesium ions on the composition and structure of the anode material and selection of optimal conditions. 3) Investigation of the electrochemical properties of magnesium intercalated anodes with the best energy and resource characteristics. Testing the anode.
Expected and achieved results	2021 – titanium oxide synthesis was carried out using hydrothermal synthesis, solid-phase synthesis, template method, and electrochemical anodizing of titanium. The composition of the anode material has been selected: active material (75-80%), acetylene soot, and binder (PVDF). Morphological characteristics of synthesized nanostructured electrodes have been determined. The kinetic parameters of the intercalation and deintercalation processes of magnesium ions into the synthesized anode electrode are calculated. 2022 – the effect of intercalation of magnesium ions on the crystal structure, phase composition, and morphology of the anode material was established using scanning electron microscopy, X-ray diffraction, and X-ray spectral analysis. Optimal conditions for synthesizing the anode with varying electrolyte concentration,

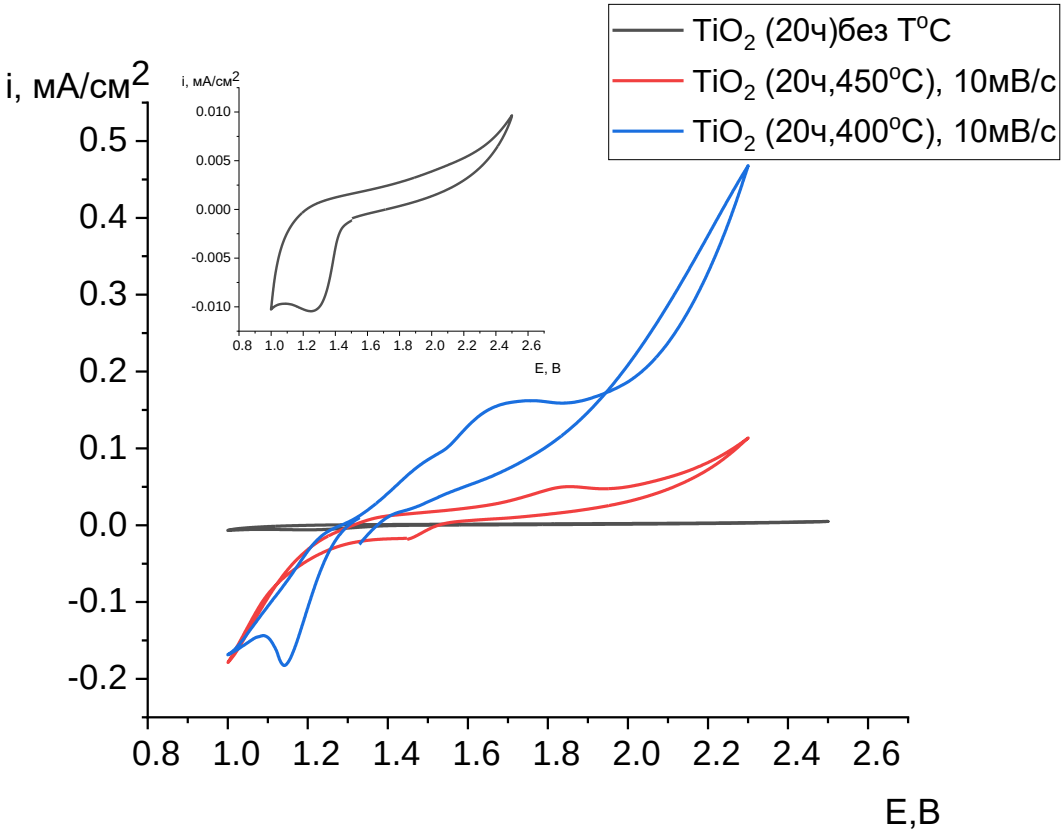
	scanning speed, and cycles using electrochemical research methods have been selected. The morphological properties of the surface of the anode material after the intercalation of magnesium ions are investigated. 2023 – the optimal temperature for heat treatment of synthesized titanium oxide was selected. The values of the velocity constant, charge transfer coefficients (α) for the processes of oxidation and reduction, as well as the diffusion coefficient of magnesium ions, were determined based on the results of cyclic voltammetry. The anode material was tested by the galvanostatic charge-discharge method. The surface characteristics of the anode after testing have been determined.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	Argimbayeva Akmaral, project manager, Scopus Author ID: 56436828200, ORCID: 0000-0002-2467-8241, Researcher ID: AAQ-3743-2020 https://www.scopus.com/authid/detail.uri?authorId=56436828200 https://www.webofscience.com/wos/author/record/2018058 Rakhymbay Gulmira, Senior Researcher, Scopus Id: 56436642400, ORCID: 0000-0002-8814-9752, Researcher ID: A-5356-2015. https://www.scopus.com/authid/detail.uri?authorId=56436642400 https://www.webofscience.com/wos/author/record/825115 Avchukir Khaisa, Senior Researcher, Scopus ID: 57207207777, ORCID: 0000-0001-6612-0775, Researcher ID: P-5738-2017 https://www.scopus.com/authid/detail.uri?authorId=57207207777 https://www.webofscience.com/wos/author/record/1708940 Abildina Ainaz, Researcher, Scopus Author ID: 000008658764, ORCID: 0000-0003-1761-7691, Researcher ID: P-6568-2017. https://www.scopus.com/authid/detail.uri?authorId=57215421044 https://www.webofscience.com/wos/author/record/831699 Jumanova Raigul, Reseaecher, Scopus ID: 57188622123, ORCID: 0000-0003-3826-3474, Researcher ID AAS-6004-2020 https://www.scopus.com/authid/detail.uri?authorId=57188622123 https://www.webofscience.com/wos/author/record/48816412 Bakhytzhan Yeldana, Researcher, Scopus ID: 57221333561, ORCID: 0000-0002-3217-5927, Researcher ID: AAS-4650-2020 https://www.scopus.com/authid/detail.uri?authorId=57221333561 https://www.webofscience.com/wos/author/record/2409580
List of publications with links to them	1. Gulmira Rakhymbay, Khaisa Avchukir, Yedil Konysbay, Florence Vacandio, Raigul Jumanova, Yeldana Bakhytzhan, Ainaz Abildina, Akmaral Argimbayeva. Influence of LiCl on the kinetics of Mg2+ insertion into TiO2 prepared // Journal of Solid State Electrochemistry by solid-state chemical reaction. – 2023. Vol. IF=2.5, https://doi.org/10.1007/s10008-023-05742-0 2. Jumanova R., Rakhymbay G., Abildina A., Avchukir Kh., Bakhytzhan, Ye., Vacandio F., Argimbayeva A., Nanostructured TiO2 as anode material for magnesium-ion batteries// Journal of Solid State Electrochemistry. – 2023. – Vol. 27. – P. 223 – 233. DOI:10.1007/s10008-022-05307-7 https://link.springer.com/article/10.1007/s10008-022-05307-7

Patents	No



ZEISS 100 nm Gemini SEM 500 70-04	EHT = 5.00 kV WD = 3.7 mm Signal A = InLens	Mag = 50.00 K X Pixel Size = 2.233 nm B = 46.0 % C = 38.9 %	Noise Red. = Drift Comp. Frame Avg. Scan Speed = 0 P = 2.36e-06 mbar Cycle Time = 3.6 Secs Ap. Size = 20.00 µm	29 Apr 2022 17:37:25




TiO2 (20ч)без T°C
TiO2 (20ч,450°C), 10мВ/с
TiO2 (20ч,400°C), 10мВ/с
i, мА/см2
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6
E,В
i, мА/см2
0.010
0.005
0.000
-0.005
-0.010
0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6
E, В