Brief information about the project

Name of the project	AP09058354 «Hybrid electrodes based on MXene and battery material for super-fast high energy storage devices based on water solutions»
Relevance	The nature of the project is to create a hybrid electrode for Li or beyond Li ion batteries based on water electrolytes which possess both capacitive and intercalation charge accumulation mechanism and to investigate fundamental aspects of this electrode to optimize its power and energy density. This type of hybrid electrode can be used for super-fast high energy storage devices. Research is planned to be carried out in the Laboratory of electrochemical production technology in the Center of Physical-Chemical Methods of Research and Analysis under the supervision of PhD Malchik Fyodor Igorevich who is specialized in the field of energy storage materials especially in Li and Na aqueous battery.
Purpose	The aim of the project is to develop and investigate a hybrid electrode composed of MXene capacitive material also serving as a binder and some intercalation material for super-fast high energy storage devices.
Objectives	The development of a hybrid electrode for high-energy storage devices with both a capacitive and intercalation charge storage mechanism is a comprehensive fundamental study and is determined by several coordinated steps when the next step directly depends on previous results. Nevertheless, the vast experience of our laboratory in both capacitive and intercalation materials for energy storage devices, an extensive literature base on this topic allows us to create a preliminary plan for the implementation of the project: a) Optimization of MXene (Ti3C2T-x) synthesis. b) Electrolyte selection with a broad potential window for MXene electrode. c) Synthesis of intercalation compounds for hybrid electrode. d) Selection of suitable intercalation material for hybrid electrode. e) Investigation and optimization of electrochemical properties of hybrid electrode.
Expected and achieved results	A hybrid electrode consisting of intercalation (Red/Ox) material and a material with a faradaic charge storage type has been obtained. This electrode exhibits high specific energy density and power, as confirmed by modeling results. The obtained results allow for a deeper understanding of the charge storage mechanism in hybrid systems, which is critically important for the scientific field of energy storage technologies. They also provide a basis for further research and development of hybrid electrodes and devices.

	The optimized hybrid electrode demonstrates potential for practical application in superfast energy storage devices based on aqueous electrolytes. Due to its high energy and specific power, it can be effectively combined with various types of counter electrodes to create hybrid devices. These results are expected to have significant scientific impact and contribute to the development of the field of energy storage.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	• Malchik Fyodor Scopus Author ID - 57196147903, ResearcherID: D-5721-2015, ORCID: 0000-0001-6381-0738 • Kokhmetova Saule Scopus Author ID - 56436662100, Researcher ID - CAF-3171-2022, ORCID - 0000-0003-3932-8612 • Vysotskaya Alexandra • Nurahmet Erlan • Zhigalenok Yaroslav Scopus Author ID - 57862139800, Researcher ID - GSC-9737-2022, ORCID - 0000-0003-1452-1248 • Kaupbay Olzhas - Scopus Author ID - , Researcher ID - JCK-9431-2023, ORCID - 0000-0003-0553-4477
List of publications with links to them	
Patents	

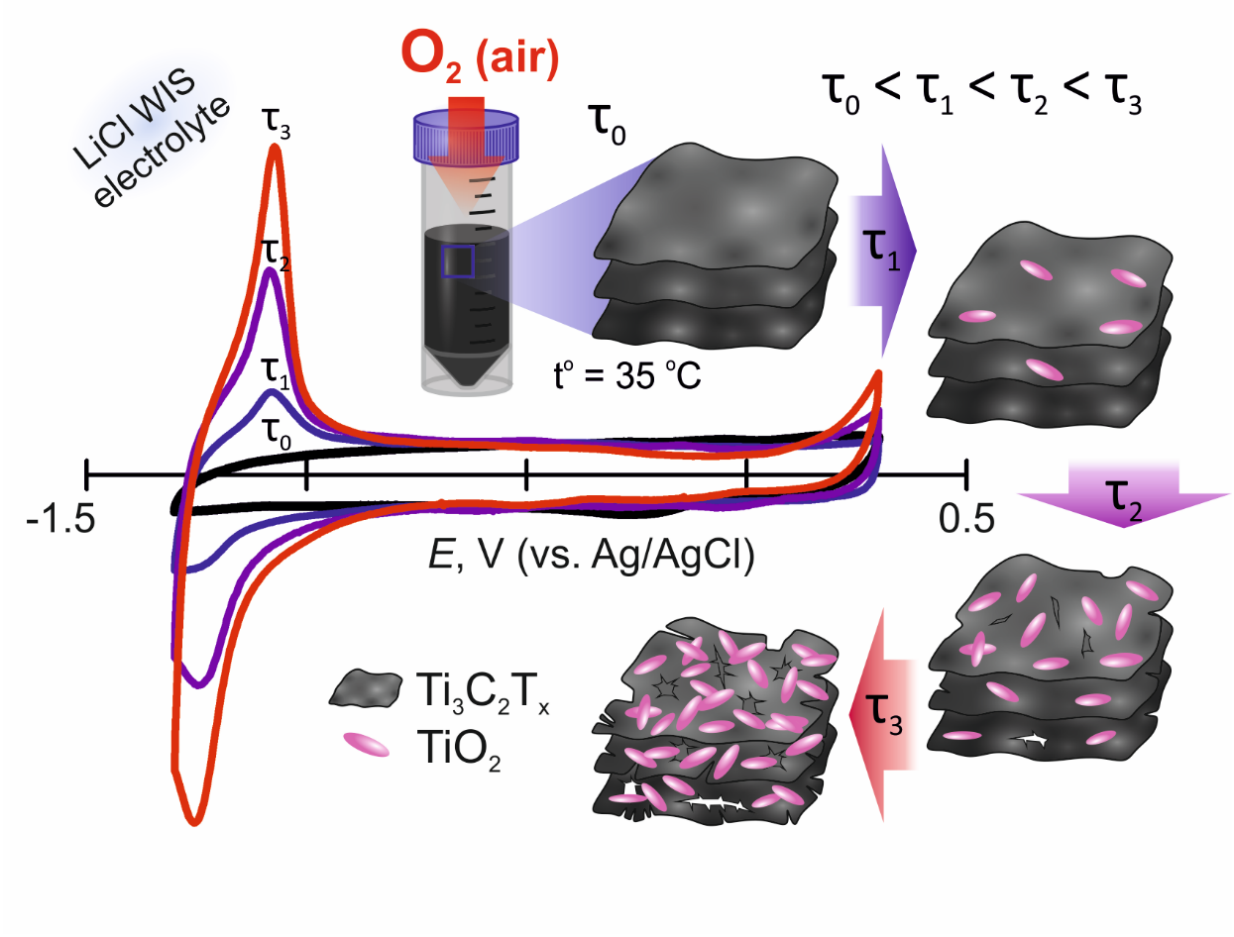

Figure 1 – Schematic representation of MXene air oxidation

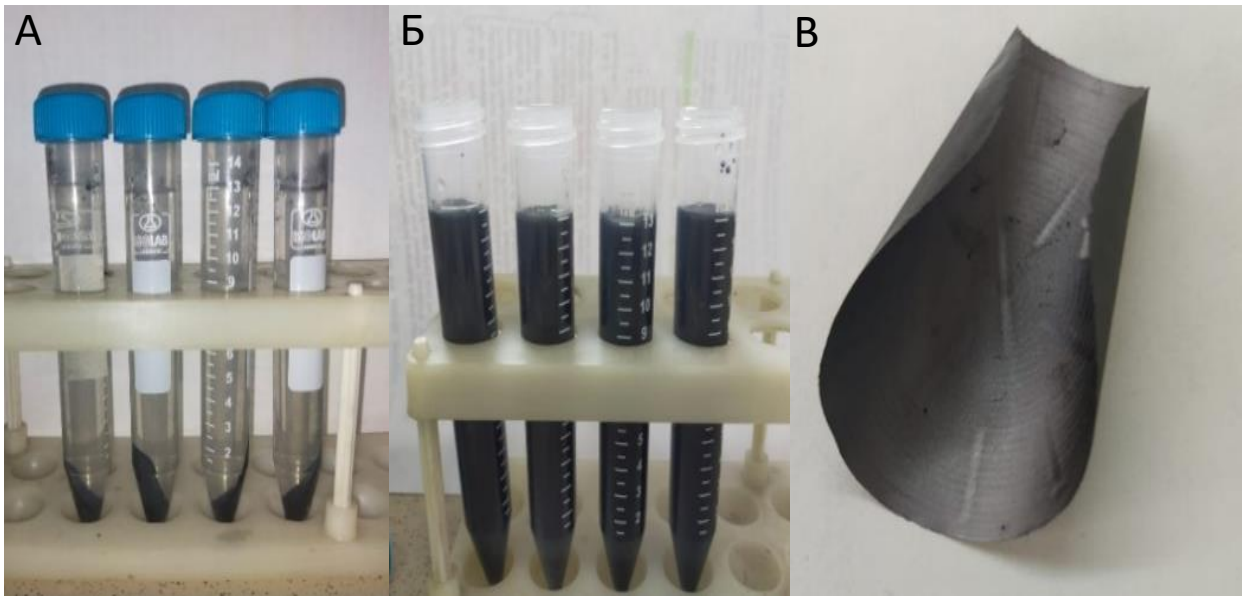

Figure 2 – Synthesized MXene samples