The growing global demand for electrical energy is simultaneously causing a rapid increase in the demand for more efficient energy storage technologies. Among them, the most versatile are electrochemical storage systems, such as Li-ion batteries. Over the past decades, they have become essential in almost every aspect of our lives related to electrical energy, ranging from consumer electronics like cell phones and laptops, to small electric devices like toothbrushes and shavers, electric tools, and even household and large-scale energy storage systems for grid regulation. They have also dominated the transportation market by popularizing electric cars, buses, and scooters. The widespread use of these technologies is attributed to their high efficiency, reliability, and ease of use. However, faced with growing demand, a challenge arises from the limited global lithium resources, especially as they are generally controlled by politically or economically unstable countries. This results in an increase in the prices of essential raw materials used in Li-ion battery production. Therefore, it is crucial to develop alternative technologies based on cheaper raw materials. The most promising alternative to Li-ion battery is Na-ion battery. This technology operates similarly to the lithium counterpart but uses sodium and its compounds. Despite slightly lower operating voltage, it is characterized by significantly lower production costs and, importantly, the very common occurrence of raw materials, including sodium compounds, which are found, unlike lithium, also in Poland.

Simultaneously, with the need to eliminate hard-to-access and expensive elements, we are compelled to continuously improve safety and operational parameters, such as energy storage density and battery power. Essentially, a Na-ion cell consists of three basic elements: an anode, a cathode, and an electrolyte. While cathode and anode materials are relatively well-known, it is the electrolyte that limits safety because currently used electrolytes are based on flammable liquid solvents. A breakthrough solution may be to replace the liquid electrolyte with a non-flammable solid material, which not only increases safety but also allows for improvements in terms of increasing battery power, charging speed, and energy density. However, for such improvement to be possible, it is necessary to develop new solid electrolyte materials that conduct sodium ions.

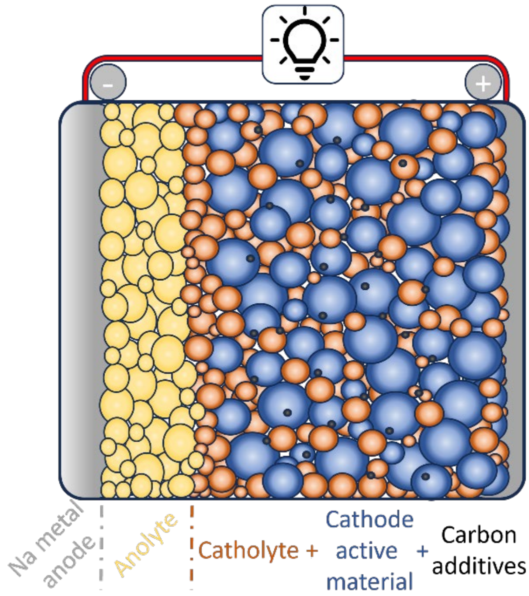

Fig. 1 Na-ion battery with catholyte and anolyte

As part of this project, research is planned on newly discovered materials based on sodium, aluminium, and chlorine. These materials have recently been described as potentially applicable in Na-ion cells, so the knowledge about them is very limited. The project aims to develop a method for synthesizing materials based on $NaAlCl_4$ and investigate the possibilities of modifying their chemical composition and microstructure. Subsequently, these materials will be tested in Na-ion batteries using an innovative cell architecture, where, instead of the three previously mentioned types of materials, four will be used (Fig. 1). This will be achieved by separating the electrolyte function into two separate materials - anolyte and catholyte, located on the anode and cathode sides, respectively. The research will utilize various analytical techniques such as X-ray diffraction, scanning electron microscopy, X-ray tomography, and many others.

The results obtained within the project will expand our knowledge about sodium cells and sodium ion conductivity in solid-state materials. As a result, it will be possible in the future to construct safe, affordable, and high-efficiency sodium cells.