DESCRIPTION FOR THE GENERAL PUBLIC

The constantly growing demand for electricity brings a need for new solutions meeting elevated requirements. Current trends in the energy sector are moving towards renewable energy sources and efficient energy storage. It is due to the growing awareness of society regarding the adverse changes in the environment as a result of the heavy use of fossil fuels. It is expected that the use of renewable energy sources and energy storage will be inseparable elements of modern energy systems. Renewably sourced energy is defined as energy obtained from wind, sun, and water. In the case of water, its share in the energy industry is not only related to hydropower plants. Water has great potential also in terms of using to produce hydrogen in the electrolysis process. Energy obtained from hydrogen is considered perfectly clean, although over 95% is still based on non-renewable resources. Therefore, the growing trend of global hydrogen consumption requires developing a highly effective method of hydrogen production using renewable raw materials on a decidedly large scale. Among the various methods of producing hydrogen, electrolysis seems to be the most viable process to produce green hydrogen.

In the water electrolysis process, a reduction process takes place on the surface of a negatively charged cathode (hydrogen evolution reaction - HER) under the influence of the voltage applied between the cathode and anode located in the same electrolyte. In the electrolyte with alkalic pH, the product of reduction is gaseous hydrogen and OH^- ions. For the entire redox process to be complete, the anode must undergo an oxidation reaction with the evolution of oxygen (OER). A key point hindering the electrolysis process is the slow kinetics of the OER in the electron charge transfer reaction, which results in high reaction overpotentials. The overpotential is the additional voltage that must be applied to the electrodes to conduct electrolysis despite the presence of additional resistances in the system (e.g. electrical resistances). Efficient electric catalysts can accelerate the reaction kinetics, which results in a reduction of the overpotential. The most active catalysts are based on precious elements such as platinum (Pt) or iridium (in the form of an oxide: IrO_2). The high cost of their use forces researchers to minimize the amount of the catalyst used (without adverse effect on the catalytic activity) or to search for alternative catalysts (e.g. spinels, perovskites) to achieve a comparable electrolytic efficiency of the water-splitting reaction. Both approaches are aimed at reducing the cost of producing electrodes.

The task undertaken in the project is aimed to develop an electrically conductive hydrogel-based three-dimensional fibrous structure as support in which the electrocatalyst particles (e.g. MnCo2O4 spinel) will be suspended. As a result, materials based on hydrogels will be created. The strategy will ensure an increase in the efficiency of catalysts by increasing the degree of separation of their particles and thus the rise of their availability for the electrolyte. Hydrogels are a group of polymeric materials that can absorb and retain large amounts of water in their structure (up to 99 wt.%). The electrospinning technique will be used to produce hydrogel fibers. This technique involves the use of high voltage (up to 30 kV) to obtain micro- and nanofibers from a polymer solution. Hydrogel in the fibrous form will ensure better separation of the catalyst particles, preventing their aggregation into large clusters. The approach aims to increase the catalytically active surface involved in electrochemical processes while maintaining or reducing the concentration of the electrocatalyst. An increase in the active surface involved in the electrochemical process will translate into an increase in catalysts efficiency, thus increasing the amounts of hydrogen and oxygen released as products of the water-splitting reaction. Additionally, flexible electrically conductive hydrogel structures will be tested for suitability for energy storage as supercapacitors. For this purpose, appropriate tests will be conducted.

The knowledge gained during the project implementation will significantly contribute to broadening the knowledge efficiency of electrochemical processes impacted by the perfect separation of catalysts particles and thus increased active surface. The project is based on an interdisciplinary approach. It covers several fields of science, such as chemistry, electrochemistry, materials science, as well as biomedical engineering, where hydrogel materials have already taken the well-deserved lead. Moreover, the project will confirm that combining knowledge from many fields is the only right path of meeting critical challenges and problems the world is facing today, impossible to solve in a different, more narrow way.