Responsive MOF and MHOF framework materials for efficient proton conduction

The growing demand for clean and sustainable energy technologies requires the development of new materials capable of efficient proton transport, which are essential for devices such as fuel cells, solid electrolyte batteries and electrochemical sensors. Currently, leading materials, such as Nafion, perform only under well-defined conditions and have serious limitations: they are expensive, sensitive to moisture and elevated temperatures, and fail to meet ever-increasing application requirements.

The goal of this project is to develop a new class of “smart” materials - responsive metal-organic frameworks (MOFs) or metal-containing organic frameworks with hydrogen bonds (MHOFs). These materials are highly porous and composed of metal cations and organic molecules. Their uniqueness lies in their ability to adaptively change their spatial structure in response to external stimuli such as humidity, temperature or light. These changes can directly affect the way the material conducts, opening new possibilities for increasing the efficiency, stability and flexibility of renewable energy-based devices. The research will test various combinations of chemical building blocks to best control the conductive properties. In addition, the relationship between structural changes and their effect on proton conduction performance will also be investigated, contributing to the development of guidelines for even better systems in the future.

This project is pioneering in that it tackles the relatively understudied research area of creating responsive and switchable materials for proton conduction. It builds on the researchers' previous successes, including the development of flexible porous materials and unique synthetic methods that do not require harmful solvents. Combining innovative chemistry, green technologies and advanced materials engineering, the project seeks to establish new design principles for “smart” proton conductors that could revolutionize the energy technologies of the future.

Among the expected outcomes of the project are new types of membranes and materials for energy storage, fuel cells and environmental sensors - all supporting the global transition to cleaner, more sustainable energy solutions. The project fits perfectly with the priorities of the European Green Deal and the UN Sustainable Development Goals, supporting the development of affordable, efficient and climate-resilient technologies.