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Title: Novel asymmetric anion-exchange membranes for fuel cells

Acronym: NAMEAS

Consortium:

Energy and Nuclear research institute – IPEN

Commissariat à l'énergie atomique et aux énergies alternatives – CEA

Technion- Israel Institute of Technology

Sabancı University Nanotechnology Research and Application Center – SUNUM

ABSTRACT

Fuel-cell based technologies have the potential to substantially reduce emissions of harmful airpollutants, including the emission of greenhouse gases. In particular, when hydrogen is used as fuel, only water is emitted by the fuel-cell. Widespread applications of hydrogen fuel cells can only be possible when the existing limitations are solved. The relatively high costs of these technologies arise in large part from the fact that platinum is required in the most-developed approaches (fuel cells with proton-exchange membranes), as well as the expensive membranes. Therefore one of existing challenges is to develop technological solutions that do not need noble metals. One of current directions of research is focused on alkaline fuel-cells with anion-exchange membranes, in which the use of precious metals is not required. At high-pH conditions, however, the membrane-stability is low. Membrane decomposition follows from the reactions of OHanions with functional groups, involving quaternary ammonium cations, in the membrane material. The main goal of the NATIONAL project is to develop a new generation of highly-stable asymmetric anion-exchange membranes for fuel-cell applications.

The project will be carried out by an international consortium of research groups from Turkey (Sabancı University Nanotechnology Research and Application Center – SUNUM), Israel (TechnionIsrael Institute of Technology), Brasil (Energy and Nuclear Research Institute – IPEN), France (Francji (Commissariat à l'énergie atomique et aux énergies alternatives – CEA), and Poland (Jagiellonian University in Kraków, JU). The research within the project will be focused on various aspects, including the synthesis of polymer-materials with highly-stable novel functional groups, for the membranes, as well as their characterization with numerous experimental techniques, optimization of the novel membranes, and evaluation in electrochemical systems, particularly in fuel-cell conditions.

While foreign partners (SUNUM, Technion, IPEN, CEA) specialize in experimental techniques needed for various aspects of the project, the JU group complements the expertise of the consortium by providing theoretical methodology (quantum-chemical calculations, molecular dynamics simulations).

An effective combination of experimental and theoretical research is more, and more often a key factor for successful development of novel functional materials.

The research carried out by the JU group will be focused on understanding the details of the mechanisms of functional-group decomposition (at the molecular level), the influence of the substituents, as well as the influence of the hydration level (i.e. water : hydroxyl ratio) on their stability. It is known, from recent experimental and theoretical research, that the water concentration at the cathode- and the anode side in the alkaline fuel cell is different, and the hydration level may affect the rate of the decomposition reactions. Detailed theoretical characterization of the water-hydroxide structures that occur in the vicinity of various quaternary ammonium cations, and their reactivity, will be helpful for the experimental development of novel membrane materials. Theoretical results will also extend general knowledge about the decomposition reactions occurring in the fuel-cells.