bi_O_2 project - Oxygen reduction in the binary solvent mixture systems

Fuel cells are electrochemical devices that directly convert the chemical energy of a fuel (e.g. hydrogen) and an oxidant (oxygen) into electrical energy. Although fuel cells are commonly associated with modern technology and innovativeness, in fact they were invented over 150 years ago. The biggest barrier for their wide implementation is the necessity to use expensive catalysts (predominantly based on platinum) required to accelerate intrinsically sluggish oxygen reduction reaction (ORR) at the cathode.

ORR process is generally considered as a bottleneck in the fuel cell industry. For this reason, tremendous effort has been devoted to searching for new low-cost catalysts towards ORR process. Recent progress suggests that durable carbon materials can be considered as potential substitutes for Pt-based catalysts in alkaline media.

The main problem with carbon materials used as ORR catalysts is the fact that most of them do not provide complete oxygen reduction, what negatively impacts the efficiency of energy conversion. To improve the performance of carbon materials, various techniques regulating their electronic properties have been proposed. Engineering strategies include doping with heteroatoms (N, B, O etc.) or enrichment in geometric defects (edge, crystal distortion etc.). By comparison, little attention is paid to the impact exerted by an electrolyte on ORR process.

The aim of bi_O_2 project is to investigate ORR process on carbon electrode in novel alkaline electrolytes based on water-aprotic solvent binary mixtures. Such electrolytes might offer new opportunity in comparison with purely aqueous electrolytes. The characteristic feature of water-aprotic solvent binary mixtures is the fact that the properties of the mixture are not the average of properties demonstrated by its components. Such a behavior is triggered by strong interaction between aprotic solvent and water molecules. Water is hydrogen bond donor, while aprotic solvent acts as hydrogen bond acceptor. In result, intermolecular complexes of high dipole moment are formed between solvent and water molecules.

The studies on ORR process in electrolytes based on water-aprotic solvent binary mixtures will be performed in two systems: (i) using solid carbon electrode, i.e. at conventional electrode/electrolyte interface (Figure 1a) and (ii) at the interface between two immiscible electrolyte solutions (ITIES), i.e. at interface analogous to the one that is formed when, for instance, water and olive oil are put together. If chemical components in these two phases are selected properly, ITIES system can be polarized (segregation of electric charges occurs) and it is possible to control the electron transfer reaction from organic phase to the aqueous phase, where oxygen (being an electron acceptor) will undergo reduction. The ORR process will be carried out both at bare ITIES (Figure 1b) and ITIES system with various carbon materials deposited at liquid-liquid interface (Figure 1c).

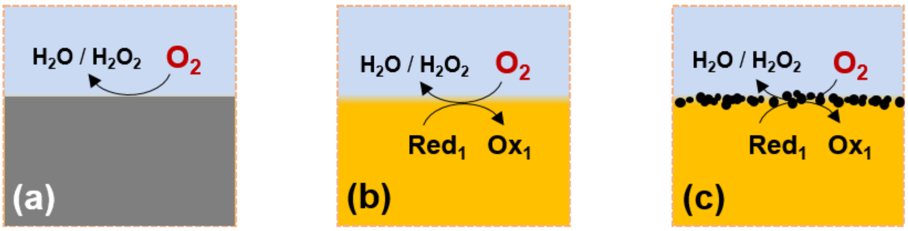

Figure 1. *ORR process at (a) an electrode/electrolyte interface, (b) bare ITIES and (c) ITIES decorated with carbon materials.*

During project realization, different research techniques (apart from electrochemical ones) will be used, including viscosimetry, UV-Vis spectrophotometry and other spectroscopic methods (e.g. X-ray photoelectron spectroscopy).

Novel electrolytes tested in **bi_O_2** project can potentially improve the efficiency of energy conversion during ORR process on carbon electrode. This, in turn, can pave the way for wide use of carbon materials as ORR catalysts in alkaline fuel cells.