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SCIENCE & PROJECTS
ERC Consolidator Grant

Universität Bremen

ll ELECTRON- AND ION TRANSFER AT THE INTERFACE – EllonT

New tools and approaches for the analysis of electrochemical systems

Electrochemistry plays a fundamental role in modern everyday life: from the development of anticorrosion coatings for metallic components, up to personal health care and mobile power sources for electronic devices. However, its role will be even bigger in the future, as the energy sector is counting more and more on electrochemical devices in order to store electrical energy coming from renewable intermittent sources, such as solar and wind power. This is achieved by storing the electric energy in batteries or by using it to produce energy carriers and chemicals, such as hydrogen. Although the fundamental laws describing simple and ideal electrochemical systems have been well established since the 1980's, batteries, fuel cells and electrolysers, just to cite a few of the electrochemical systems for energy storage and conversion available in the market, are much more complex. Nowadays mostly empirical descriptions are used in order to predict and monitor their performance. It is therefore clear that, in order to achieve a better understanding of complex systems and of the materials used in these devices, it is necessary to develop new tools and a new approach to their analysis. The aim of the project "EllonT" is to develop a set of new analytical tools, which will allow unfolding the complexity of the reactions occurring in real electrochemical systems, and identify the deviation of the real world from the ideal one.

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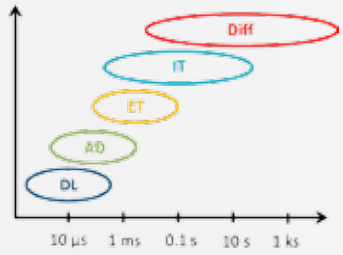
Electron- and Ion Transfer at the Interface – a Hyphenated Dynamic Multi-Frequency Approach

The first step in the direction of the goal of "EIIonT" will be to develop new electro-analytical tools capable of identifying and separating the different phenomena during an electrochemical reaction. These are occurring in a large range of time constants and they are often overlapping, thus making the identification and quantification of the single components very complex (see figures).



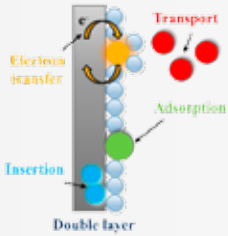


Figure: Time scale of different electrochemical phenomena.

DL: double layer charging;
AD: adsorption;
ET: electron transfer;
IT: ion-transfer;
Diff: diffusion and mass transfer.

A possible solution to this problem is the analysis of the frequency response of the system, which consists in stimulating the system with waves of different frequencies, and recording how the system responds to such stimuli. However, it is also important to identify the nature of the chemical species taking part in the reaction. This will be done by combining the frequency analysis with a quartz crystal microbalance, an apparatus able to measure extremely small changes in the weight of the materials, down to a few nanograms. These new tools will be at first tested with simple electrochemical systems, in order to validate their robustness, and later on more complex materials, in particular Prussian Blue derivatives. This family of compounds can easily capture and release ions from solution and can be used to store fast and efficiently energy from renewable sources. The large amount of data produced in the experimental part will be analysed by means of ad hoc developed software. The analysis of the data will give the opportunity to quantify the kinetic parameters influencing the reaction and to observe how such parameters are changing when the system passes from ideal conditions to real application. An attempt to generalize the approach will be done, in order to reach a phenomenological rigorous understanding of the effect of the real interactions between particles on the kinetic parameters. Collaboration with other groups from Chemical Physics, Biochemistry, Bioelectrochemistry, and Electrocatalysis is important, in order to use this approach also for other systems such as enzymatic fuel cells, bio-fuel cells, water and CO_2 reduction.

With the **ERC Consolidator Grant** the **European Research Council** funds individuals with 7 to 12 years research experience after their PhD with up to 2 million Euro, in order to consolidate their position in the scientific community.

EIIonT
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