Project 3.5. Catalysis at the nanoscale: localization of active sites at nanostructured materials and surfaces modified with enzymes

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Background:

Analysis of ensembles of nanostructured catalysts suggests increased activity towards specific processes at corners and edges of these nanostructures. Some other processes seem to occur favorably at exposed facets of nanocrystals. However, this hypothesis is not confirmed experimentally. To solve this problem, one needs to perform mapping of activity with nanoscale resolution. This project is on nanoscale imaging of fluxes of reactants generated and consumed upon electrocatalytic water electrolysis, i.e., oxygen evolution reaction and hydrogen evolution reaction, at nanostructured materials obtained by localized electrodeposition and cathodic corrosion. Another important aspect, which can be solved by analyzing images of oxygen fluxes, is the unknown distribution of biocatalytic activity among individual enzyme molecules. Enzymes are gradually deactivating due to denaturation of polypeptide chains, loss of prosthetic groups, or poisoning. A detailed mechanism of loss of catalytic activity of the enzyme at the molecular level (gradual or instantaneous) is also unknown since it cannot be solved by analyzing ensembles containing millions of molecules. For this part, we will perform imaging of oxygen fluxes generated by immobilized catalase molecules. We will improve and utilize nanoscale scanning techniques and catalyst preparation methods published in our previous works: Nanoscale Adv. 1 (2019) 2645, J. Electroanal. Chem. 815 (2018) 231, Anal. Chem. 87 (2015) 11641.

Aim:

The project's primary goals are to localize active sites on catalytic nanostructures and evaluate the activity of individual molecules of catalase immobilized on a solid surface. The PhD student will develop procedures of preparation of nanoelectrodes and nanopipettes for detection of ionic fluxes and products of water electrolysis, nanoscale activity mapping, immobilization of proteins and perform analysis of samples by scanning microscopies with obtained nanoprobes.

Requirements:

- Master's degree in chemistry or physics,
- Self-motivation for scientific work (goal-oriented),
- Experience in experimentation,
- Participation in scientific projects,
- Creativity,
- Analytical thinking and problem-solving skills,
- Ability to work independently as well as in a group
- Knowledge of basics of physical chemistry,
- Knowledge of electrochemistry will be appreciated,
- Communication, organization and time management skills,
- Good knowledge of English (Polish language is not mandatory).