Chair of Physical Chemistry
TUM School of Natural Sciences
Technische Universität München

Master Thesis project

Probing electrocatalysis at the atomic scale

Single active sites under the fast electrochemical scanning tunneling microscope (EC-STM)

In our laboratory at the CRC, we have implemented an add-on electronics module for scanning probe microscopes (FastSPM) to follow dynamic processes on surfaces at the atomic scale and under full electrochemical potential control. One obtains seamless access to (a) video-rate movies, (b) cluster tracking under feedback with sub-ms time resolution, and thereby (c) high-speed reaction current detection under high lateral precision. This project has thus the potential to unravel fundamental reaction steps at single active sites in electrocatalysis in an unprecedented way.

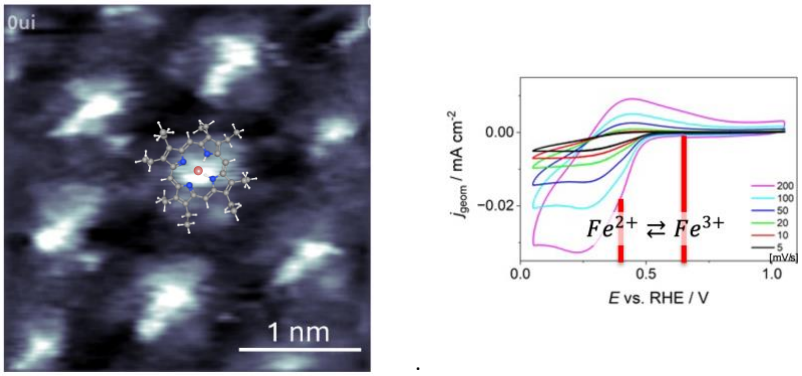

Fig.: Layer of iron porphyrin molecules. Frame extracted from an EC-STM movie recorded at 4 frames per second

The successful candidate will investigate the oxygen reduction reaction (ORR) *in situ* in acidic and neutral media by focusing on valuable model systems like metal porphyrins supported on gold or graphite electrodes. Here, active metal centers (e.g. Fe) are coordinated by the central pocket that exposes four nitrogen atoms. Imaging single centers at varying surface polarization and under different gas atmospheres (Ar, O_2) will allow us to distinguish redox and molecular adsorption processes of single metal centers and compare the individual and ensemble behavior. This field of time-resolved microscopy opens further opportunities in the second half of the thesis project towards possible *in situ* experiments on porphyrin/porphene metalation and cluster deposition processes and the subsequent exploration of cluster dissolution - how does solvation influence cluster stability?

We are looking for a motivated student who contributes to the fast EC-STM experiments and the subsequential video analysis using a home-built Python-based software. Practical lab experience in electrochemistry is required, previous knowledge of programming is desirable, but not a prerequisite. This project is co-supervised by Friedrich Esch (STM) and Hubert Gasteiger (electrochemistry).
If you are interested, please contact **friedrich.esch@tum.de.**

The lab is in the Catalysis Research Center close to the TUM Chemistry Department in Garching and is part of the e-conversion cluster of excellence.
https://www.ch.nat.tum.de/pc/research/solid-liquid-interface-ecstm