Unveiling the solid-liquid interface through surface sensitive studies

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The electrified electrode electrolyte interface is notoriously difficult to study during electrochemical (EC) reactions. Most traditional surface science techniques are disqualified due to the use of electrons, on the other hand, several new in-situ experimental methods have been developed recently. Examples are Electro Chemical X-ray Photoelectron Spectroscopy (ECXPS), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), High Energy Surface X-Ray Diffraction (HESXRD) [4] and EC-IRAS [5]. However, each of these methods has limitations in the EC environment. To better understand the electrode surface development and dynamics during EC reactions, a combination of methods is necessary.

In the first part of the talk, the corrosion of an industrial Ni base Ni-Cr-Mo alloy will be addressed. A comprehensive investigation combining several synchrotron-based techniques are used to study the surface region of a Ni-Cr-Mo alloy in NaCl solutions in situ during electrochemical polarization. X-Ray Reflectivity (XRR) and ECXPS were used to investigate the thickness and chemistry of the passive film. Grazing Incidence X-ray Diffraction (GIXRD) was used to determine the change in the metal lattice underneath the passive film. X-Ray Fluorescence (XRF) was used to quantify the dissolution of alloying elements. X-ray Absorption Near Edge Structure (XANES) was used to determine the chemical state of the dissolved species in the electrolyte. Combining these techniques allowed us to study the corrosion process, detect the passivity breakdown in situ, and correlate it to the onset of the Oxygen Evolution Reaction (OER) [6].

In the second part, an alternative approach to study the development of a model electro catalyst surface is presented. By using a combination of Grazing Incidence X-ray Absorption Spectroscopy (GIXAS) [7], 2D Surface Optical Reflectance (2D-SOR) [8] and Cyclic Voltammetry (CV) and a Au(111) electrode model surface, direct surface information during real-time CV can be obtained. Using H_2SO_4 as an electrolyte, our study demonstrate that a thin, passive Au oxide is formed at potentials corresponding to the oxidation peak in the Au CV. This oxide prevents further oxidation of the surface, and not until the onset of the OER, further oxidation of the Au surface occurs leading to the formation of a thick Au oxide.

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Bio

Edvin Lundgren is a professor at the physics institute at Lund University, Sweden. Lundgren received his PhD at Lund University 1996 and spent 2 years at the ESRF, France and 3 years at TU-Wien, Austria before returning to Lund. His research is focused on surface structures on the atomic scale and applying in situ techniques to material systems under working conditions. The research has led to the discovery of a new set of ultrathin oxides on late transition metals, atomic scale views on nano structures such as quantum dots and nanowire surfaces and pioneering work on in situ studies of model catalysts and electrodes at work.