Exploring the Advantages of Neutron Scattering combined with in-situ Electrochemistry

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Nowadays, synchrotron techniques are being used quite frequently for exploring electrochemical problems. Sample cells allowing for in-situ electrochemical measurements while exposing the sample to X-rays are quite common. This is much less the case for neutron scattering. While the use of neutron scattering combined with in-situ electrochemical setups is on the rise, it is still nowhere near being fully exploited. The one exemption to this statement are perhaps neutron imaging techniques such as radiography that have been applied for at least a decade in the area of batteries and fuel-cells. With the high-intensity neutron sources coming online world-wide, neutron scattering is becoming attractive for researchers interested in in-situ techniques due to faster data acquisition rates. A growing interest from the electrochemistry community in using neutron scattering is demonstrated in the steady increase of beam-time proposals for neutron scattering experiments.

This talk will focus on research performed using in-situ electrochemistry combined with neutron scattering at various neutron scattering sources world-wide. The talk will cover the basics of the respective neutron scattering techniques such as Small Angle Neutron Scattering (SANS), Neutron Reflectometry (NR), Neutron Diffraction (ND) and Pair-Distribution Function (PDF), Quasi-elastic Neutron Scattering (QENS) and Neutron Vibrational Spectroscopy (NVS). Scientific results achieved through the use of in-situ electrochemistry and the above mentioned neutron scattering techniques will elucidate what the benefits of neutrons for this research community are in comparison to light- and X-ray scattering. The figure below illustrates two of the main advantages of neutrons: the increased neutron cross-section of hydrogen and the penetrability of neutrons through matter. Research questions connected to the movement of protons such as proton-conductivity benefit greatly from the use of neutrons while the sample cell design is simplified by the possibility to use metals for in-situ electrochemical cells even in line-of-sight of the neutron beam.

Figure 1: X-ray (scaled by 0.67) and neutron cross sections of chosen elements (left) show the advantage of using neutrons when investigating hydrogen-containing compounds. An example of an electrochemical cell for impedance measurements in-situ with inelastic neutron scattering which is assembled without optical window illustrating the advantage of neutrons penetrating even high-Z materials easily.

The electrochemical setups currently available at neutron scattering instruments cover quite a wide range, from impedance spectroscopic setups to potentiostatic voltammetry sample holders as well as corrosion cells to name a few. The use of these in-situ sample cells and the potential future developments will be discussed, always with the emphasis on what scientific problems can be addressed with the respective setup.