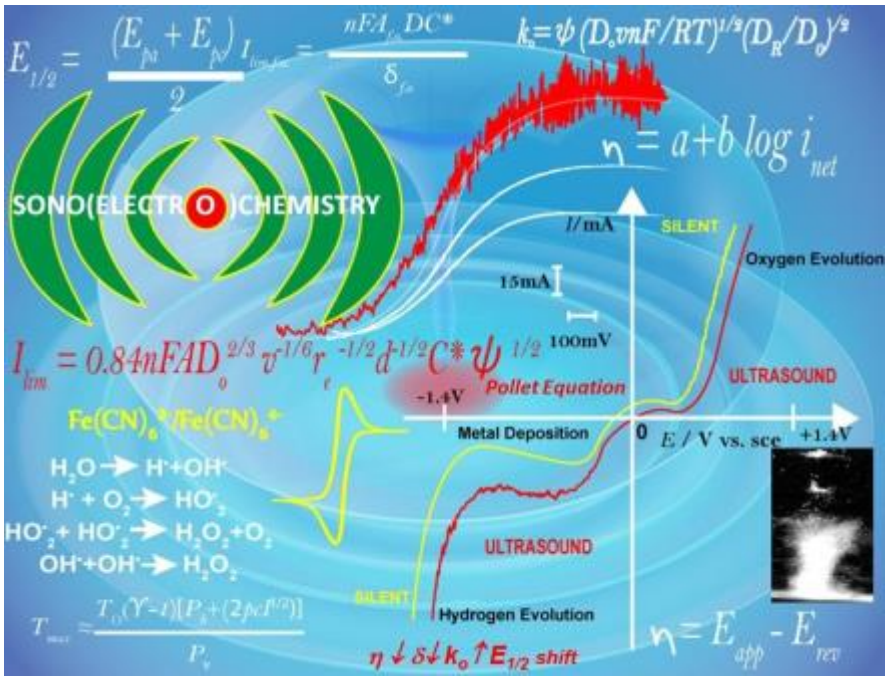
Introduction to Sono-electrochemistry:
The Effect of Power Ultrasound on Electrochemical Parameters

Bruno G. Pollet
Department of Energy and Process Engineering, Faculty of Engineering,
Norwegian University of Science and Technology (NTNU), NO-7491 Trondheim, Norway
bruno.g.pollet@ntnu.no - www.brunogpollet.com

For over 80 years, nearly 3,000 papers have been written on the subject with many original work, general reviews in sonoelectrochemistry, organic sonoelectrosynthesis, sonoelectroanalysis, sonoelectrochemical production of nanomaterials, and recently the sonoelectrochemical production of hydrogen and fuel cell materials [1,2]. In all these papers and reviews, it was clearly shown that the effects of high intensity ultrasonic irradiation on electrochemical processes lead to both chemical and physical effects, for example, mass-transport enhancement, surface cleaning and radical formation. Many workers have also investigated the distribution of ultrasonic waves or energy in various electrochemical reactors operating in the ultrasonic frequency range (20-1,000 kHz) and at high ultrasonic powers [2].



The use of ultrasound in electrochemistry is known for its capacity to promote especially heterogeneous reactions mainly through extremely increased mass-transport, interfacial cleaning and thermal effects. In addition, homogeneous chemical reactions have been reported to be affected and the generation of highly radical species e.g. the production of H• and OH• radicals by sonolysis in intense sound fields is an important aspect. The vast variety of ultrasonically induced effects observed in sonoelectrochemistry may be ascribed to the generation, pulsation and collapse of cavitation bubbles in the electrolyte medium near the electrode surface. This ultrasonic cavitation occurs at low to high ultrasonic powers. A pulsating cavitation bubble close to the electrode surface generates microstreaming, and when the cavitation bubble reaches a resonant size, it collapses asymmetrically leading to the formation of high velocity jet of liquid toward the surface (up to 200 m/s). This phenomenon leads to a thinning of the diffusion layer (δ) in turns improving the overall mass-transfer and hence reaction rates [2]. Since most of the observed effects of ultrasound in electrochemical processes are thought to be due to the cavitation effect together with micro-streaming, the application of ultrasound is known to be very beneficial in the electrochemical industry. This has led to investigations into mass-transport, electron-transfer processes and electrode surface adsorption [2].

This presentation highlights the aspect of electrochemistry combined with ultrasound and explains the various electrochemical phenomena occurring at the electrode surface when a potential is applied. For this purpose, electrode kinetic and mass-transport parameters are defined.

References:

[1] https://en.wikipedia.org/wiki/Sonoelectrochemistry
[2] Power Ultrasound in Electrochemistry: From Versatile Laboratory Tool to Engineering Solution, Ed. B.G. Pollet, John Wiley & Sons. January 2012, DOI: 10.1002/9781119967392.ch.